PROCEEDINGS

of the

United Nations Scientific Conference on the Conservation and Utilization of Resources

17 August—6 September 1949, Lake Success, New York

Volume I, Plenary Meetings

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The Proceedings of the United Nations Scientific Conference on the Conservation and Utilization of Resources are being issued in eight volumes as follows:

Volume I:	Plenary Meetings
Volume II:	Mineral Resources
Volume III:	Fuel and Energy Resources
Volume IV:	Water Resources
Volume V:	Forest Resources
Volume VI:	Land Resources
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FOREWORD

This is the first volume of the Proceedings of the United Nations Scientific Conference on the Conservation and Utilization of Resources, which brought together over 700 scientists from fifty countries to consider more than 500 scientific papers. With the publication of these Proceedings, the ideas and the knowledge presented at Lake Success, in August and September 1949, will be made available throughout the world.

The conservation of resources has pressed its claim for attention with increasing vigour in recent years. It has become evident that in a number of countries high levels of production have too often involved the wasteful and improvident use of resources. Nor have the less-developed countries of the world been spared. Poverty has frequently hastened the depletion of the very resources upon which such countries must rely to attain higher living standards. The sense of this Conference was that resources could be conserved and production increased to the necessary levels if ways were found to apply the knowledge and methods which man now has at his command.

Such an end could not be achieved if conservation were to be regarded as an end in itself. To achieve higher living standards natural resources must be drawn upon far more wisely, if not more heavily, than heretofore. The knowledge of the best methods to use and conserve resources is in itself a great resource; one, moreover, which grows with use and is enlarged by sharing. These Proceedings should constitute a contribution to the mobilization and organization of that knowledge.

But these Proceedings are more than this. They can also serve as the opening of a notable chapter in the history of the United Nations. This Conference was the first occasion on which the United Nations invited the scientists of the world from many disciplines to meet together at its Headquarters to present their views. For three weeks the conference chambers at the United Nations Headquarters, normally occupied by the meetings of diplomatic representatives, were devoted to the discussions of scientists. For many of the participating scientists, this opportunity to discuss common problems with colleagues from many other fields and from other countries was a major value of the Conference. The presence at the Conference of the President of the Economic and Social Council of the United Nations, the Chairman of the Economic Committee of the General Assembly and the Heads or senior members of several Delegations to the United Nations provided a link between the Conference and the Council which will be valuable to both. From the standpoint of the United Nations, this chance to meet and know these scientists will, I am sure, prove invaluable particularly in the development of the new and growing programme of technical assistance to the economically less-developed countries, on which the United Nations is now embarking.

This has been one of the important immediate benefits of the Conference. Yet its principal value may well be as a starting point. Man's scientific knowledge of the world is growing and changing. Equally, the needs of the United Nations will grow and change as it meets the challenge of its tasks of preserving the peace and creating the basis for better standards of life. The need for co-operation, however, between the United Nations and the world of science, to realize the ends of both, will remain unchanging. Having begun this co-operation, we must make sure that it continues. The chief importance of these Proceedings for the future may well be that of the pioneer effort toward this co-operation.

Secretary-General

Lake Success, New York
8 February 1950

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UNITED NATIONS SCIENTIFIC CONFERENCE ON THE CONSERVATION AND UTILIZATION OF RESOURCES

BACKGROUND AND OBJECTIVES OF THE CONFERENCE

The development of modern advances in technique and administration is the work of many experts of many kinds throughout the world. No country has a monopoly of the best methods; every part of the world has contributions to make and significant experience from which those responsible for the use of natural resources have much to learn. This store of scientific and practical knowledge is itself one of the world's great resources. It is a resource that grows with use and is enlarged by sharing. The fullest possible mobilization of this knowledge is essential to equip the nations of the world for the task of raising and maintaining the living standards of their people. The United Nations Scientific Conference on the Conservation and Utilization of Resources was intended as a step in that mobilization.

Proposal for a Scientific Conference

In a letter dated 4 September 1946 (E/139)[1] addressed to the United States representative on the Economic and Social Council, President Harry S. Truman of the United States suggested that the United States representative to the Council "propose to that organization at its meeting in September that it sponsor an international scientific conference on the conservation and utilization of natural resources, and express my hope that it will be held in this country in the autumn of 1947".

In his letter the President of the United States stated:

"It is my belief that the need for such an exchange of thought and experience was never greater. Warfare has taken a heavy toll of many natural resources; the rebuilding of the nations and the industrialization of under-developed areas will require an additional large depletion of them. Waste, destruction and uneconomic use of resources anywhere damage mankind's common estate. The real or exaggerated fear of resource shortages and declining standards of living has in the past involved nations in warfare. Every Member of the United Nations is deeply interested in preventing a recurrence of that fear and of those consequences. Conservation can become a major basis of peace. Modern science has itself become a major international resource which facilitates the use of other resources. Their adequate utilization can become a major basis of world prosperity.

"It is my hope that such a scientific conference would bring together all the new techniques of resource conservation and utilization, particularly for the benefit of under-developed areas, since the problems of these areas represent the hopes of millions of people for freedom from starvation and for opportunity in life. The conference could properly and usefully evaluate the outstanding developments in the resource field as aids to under-developed regions, to areas suffering from resource depletion, and also to areas subject to rapid post-war change in their patterns of resource use. I believe that the possible peaceful uses of atomic energy within the next few decades might well be examined in this connexion. It is also my hope that such a scientific conference would examine the world's expected resource needs.

"It is my belief that a conference composed of engineers, resource technicians, economists and other experts in the fields of physical and social science would offer the most desirable method of presenting and considering the definite problems now involved in the resource field. It is my thought that these experts would not necessarily represent the views of the governments of their nations, but would be selected to cover topics within their competence on the basis of their individual experience and studies. I am sure that such a scientific conference can be helpful to the basic organizations of the United Nations without impinging upon the valuable work which they are undertaking. Its success will, of course, depend upon the active co-operation of all the participating nations, and of the staff of already established organizations of the United Nations, including particularly the Food and Agriculture Organization, which should be considered in the development of part I of the programme.

"I am attaching for your use and reference a preliminary and condensed programme outline prepared by the resource agencies of this Government."

In a letter dated 13 September 1946 (E/139) addressed to the Acting President of the Economic and Social Council, the representative of the United States to the Council proposed that such a scientific conference be held by the United Nations. The letter was accompanied by: a draft resolution, the text of President Truman's letter of 4 September 1946 and a tentative programme prepared by the departments of the United States Government concerned with resources.[2]

The United States proposal was introduced at the third session of the Economic and Social Council on 21 September 1946. The Council decided to retain the item on the agenda but to postpone decision on the proposal until its fourth session, so that the interim period could be used for consultations among the Member Governments, the specialized agencies concerned and the Secretariat.[3]

Consultation with Member Governments and Specialized Agencies

On 5 December 1946 the Secretary-General wrote to the Member Governments of the United Nations, and to the specialized agencies concerned,[4] a letter calling their

[1]This and similar references which follow refer to United Nations document symbols.

[2]*Official Records of the Economic and Social Council,* Second Year, Fourth Session, page 262.

[3]*Official Records of the Economic and Social Council,* First Year, Third Session, Fifth and sixth meetings, 21 September 1946.

[4]International Labour Organisation (ILO), Food and Agriculture Organization (FAO), United Nations Educational, Scientific and Cultural Organization (UNESCO) and the International Bank for Reconstruction and Development (BANK).

attention to the proposed scientific conference on resource conservation and utilization and offering his services to assemble any comments they cared to make. Replies were received from nineteen governments and from the FAO and the BANK. Some replies expressed support of the proposal. Others expressed certain reservations. For example, it was suggested that it would not be possible to hold the conference in 1947 in view of the already heavy programme of international conferences, that preparatory work should be undertaken either by an expert committee or by preparatory meetings on specific subjects, and that the conference should not be intended to lead to any explicit programme of government action. The United States representative, in a letter to the Secretary-General (E/279/Add.1), requested that, since the consideration of peacetime as well as military applications of atomic energy had been assigned to the Atomic Energy Commission, the item "Major economic uses of atomic energy, by areas, based on varying assumption of production cost" should be deleted from the items proposed for the agenda. Certain items relating to irrigation problems, it was suggested, should be added in its place.

Council Decision to Convene Conference

The Economic and Social Council considered the matter again at its fourth session in February to March 1947. General agreement with the idea of holding the conference, provided it was not held before 1948, was expressed.

On 28 March 1947 the Council adopted the following resolution (32(IV)):

> *The Economic and Social Council,*
>
> *Recognizing* the importance of the world's natural resources, particularly due to the drain of the war on such resources, and their importance to the reconstruction of devastated areas, and recognizing further the need for continuous development and widespread application of the techniques of resource conservation and utilization,
>
> *Decides* to call a United Nations Scientific Conference on the Conservation and Utilization of Resources for the purpose of exchanging information on techniques in this field, their economic costs and benefits, and their inter-relations; such conference to be held not earlier than 1948;
>
> *Decides* that the Conference be devoted solely to the exchange of ideas and experience on these matters among engineers, resource technicians, economists and other experts in related fields;
>
> *Requests* the Secretary-General
>
> (a) To undertake the necessary preparatory work related to the scope and organization of the Conference programme and to the consideration of the place and date of the Conference;
>
> (b) In carrying out the task entrusted to him under paragraph (a), to consult with the representatives of the specialized agencies having important responsibilities in the fields related to the Conference programme, and to consider suggestions which may be submitted to him by Members of the United Nations;
>
> *Authorizes* the Secretary-General, if he deems it appropriate, to convene a preparatory committee of experts who in his judgment will assist him in carrying out the work described in paragraph (a);
>
> *Requests* the Secretary-General to keep the Council informed of his activities under this resolution.

In pursuance of the above resolution, the Secretary-General prepared a report (E/605) which he submitted to the sixth session of the Council. The report stated, *inter alia,* that in the preparatory work undertaken, the Secretary-General had been assisted by an advisory committee which consisted of representatives of specialized agencies having important responsibilities in the fields related to the Conference programme and other experts.

In his report, the Secretary-General recommended that the Conference be convened in May 1949 at Lake Success or possibly some other convenient location in the United States.

The Secretary-General contemplated four main classes of participants in the Conference, as follows:

(i) Representatives for governmental services, members of non-governmental organizations and individuals to be selected by Member Governments;

(ii) Individual specialists selected with the advice of the Preparatory Committee to prepare papers or to lead discussion for the Conference to be invited by the Secretary-General, in consultation with the governments concerned.

(iii) Representatives of the United Nations and its specialized agencies;

(iv) Representatives of interested international organizations and learned societies, and distinguished members of the professions to be admitted at the discretion of the Secretary-General.

The Secretary-General proposed to expand the existing advisory committee on the Conference as a standing Preparatory Committee to include representatives of the specialized agencies and other experts serving in their individual capacities.

The Secretary-General's report (E/605) was considered by the Economic and Social Council, during its sixth session. The Council adopted on 11 February 1948 a resolution (109(VI)) which took note of the Secretary-General's report and which requested him to proceed with plans for the Conference, "keeping in mind that the task of the Conference is to be limited to an exchange of experience in the the techniques of the conservation and utilization of resources . . ."

PREPARATORY WORK

The first step in Conference preparations had been the formulation of a provisional Conference programme (E/Conf.7/1) by the Secretary-General with the assistance of an advisory committee (E/792, E/792/Add.1, E/792/Add.2), which was sent to the Member Governments of the United Nations on 19 March 1948 for their comments and suggestions.

Pursuant to the resolution of the Council, the Secretary-General appointed the Preparatory Committee of the United Nations Scientific Conference on the Conservation and Utilization of Resources, consisting of experts nominated by FAO, ILO, UNESCO and the Interim Commission of WHO, and experts appointed by the Secretary-General from nine countries, to serve in their individual capacities.

The Preparatory Committee, from its inception, worked in close co-operation with the specialized secretariat within the United Nations Department of Economic Affairs, which, under the direction of the Secretary-General, was responsible for the Secretariat functions connected with the preparation and administration of the Conference.[5]

The members of the Preparatory Committee, in addition to their more formal functions as a group making recommendations to the Secretary-General, also provided advice and assistance as individuals or through informal sub-groups throughout the preparations for the Conference. During the Conference the members of the Committee assisted in its administration and provided the Programme Director and Programme Officers for the majority of the meetings. The Preparatory Committee also served to co-ordinate the activities on behalf of the Conference of the specialized agencies most directly concerned, FAO, UNESCO, WHO and ILO, which had nominated Committee members. A very large portion of the Conference programme was concerned with subjects in the field of special competence of the Food and Agriculture Organization and that organization was therefore called upon to—and did in fact—co-operate more extensively in Conference preparations than other specialized agencies.

The Preparatory Committee held meetings at Lake Success, New York, in June and July 1948 and considered the provisional programme of the proposed Conference (E/Conf.7/1), together with comments and suggestions from 21 governments received in response to a letter sent out by the Secretary-General on 12 March 1948. It also received suggestions from FAO, UNESCO, ILO and the World Power Conference. In accordance with these suggestions, the Committee reduced considerably the size and complexity of the programme, eliminating a number of the proposed section meetings and adjusting the content of others (E/869).

The Secretary-General submitted a report to the seventh session of the Economic and Social Council (E/827/Rev.1) stating that Members of the United Nations and other governments participating in the regional economic commissions of the United Nations would be invited to select individuals to attend the Conference, in addition to which he might invite representatives of non-governmental organizations, other interested international organizations and learned societies, and distinguished individual experts.

The Secretary-General's report (E/827/Rev.1) and the report of the Preparatory Committee (E/869) were considered by the Economic and Social Council at its seventh session in July and August 1948. The Council approved (resolution 141 (VII)) the Secretary-General's recommendation that the Conference should be held for fifteen working days during May-June 1949 and requested that the required preparatory work should proceed. The Interim Committee on Programme of Meetings of the Economic and Social Council, at a meeting held on 24 February 1949, decided, for reasons of programming, that the Conference should convene during the latter half of August 1949 at Lake Success.

On 6 October 1948 a revised programme (E/Conf.7/2) was prepared and this was used as the basis for the issuance of invitations to individual authors, selected with the advice and assistance of the Preparatory Committee, to prepare papers for the Conference. In addition, Member Governments were invited to nominate authors for papers on specified subjects. The Preparatory Committee met at intervals for further consideration of the programme in the light of acceptances and refusals of invitations to prepare papers; further minor modifications were made in the programme accompanying the announcement of the Conference in March 1949 (E/Conf.7/4). Finally, the number of section meetings was reduced still further in the final programme issued at the time of the Conference (E/Conf.7/6).

In March 1949, pursuant to resolution 141 (VII) of the Economic and Social Council, the Secretary-General invited all Member Governments of the United Nations and other governments participating in the regional economic commissions of the United Nations to arrange for the attendance at the Conference of groups of participants selected by them. In addition, the Secretary-General invited learned societies concerned with the subject matter of the Conference to send experts to participate in the Conference.[6] The non-governmental organizations having consultative status with the Economic and Social Council were invited to send observers to the Conference. The Secretary-General issued individual invitations to each author and each participant selected by a government or organization, making it clear that each expert was participating in an individual capacity.

In extending invitations to participate in the Conference, the Secretary-General informed governments, organizations and individuals that he was not authorized to bear the travel or attendance expense of participants.

Response to Invitations

In response to the Secretary-General's invitations to authors to prepare papers, 550 contributions were received from individuals in the following 48 countries: Argentina, Australia, Austria, Belgium, Bolivia, Brazil, Burma, Canada, Chile, China, Colombia, Costa Rica, Cuba, Czechoslovakia, Denmark, Egypt, El Salvador,

[5]See page xxv for membership of the Preparatory Committee, and principal officers of the Conference Secretariat.

[6]Due to the widespread interest in the Conference and the facility with which representatives of learned societies in the United States could attend, a group of learned societies in the United States were invited to send observers, in addition to those societies originally invited to send participants. See list on page liii.

Finland, France, Greece, Guatemala, Haiti, India, Indonesia, Iran, Iraq, Israel, Italy, Japan, Liberia, Mexico, Netherlands, New Zealand, Nicaragua, Norway, Pakistan, Peru, Philippines, Poland, Sweden, Switzerland, Thailand, Union of South Africa, United Kingdom, United States, Uruguay, Venezuela, Yugoslavia.[7]

In response to the Secretary-General's invitations to attend the Conference, there were 706 participants (including attending authors) from the following 52 countries: Argentina, Australia, Belgium, Bolivia, Brazil, Burma, Canada, Chile, China, Colombia, Costa Rica, Cuba, Denmark, Ecuador, Egypt, El Salvador, Finland, France (including Kingdom of Laos, Kingdom of Cambodia), Greece, Guatemala, Haiti, India, Indonesia, Iran, Iraq, Israel, Italy, Korea, Lebanon, Liberia, Mexico, Netherlands, New Zealand, Nicaragua, Norway, Pakistan, Panama, Peru, Philippines, Portugal, Sweden, Switzerland, Thailand, Turkey, Union of South Africa, United Kingdom, United States, Uruguay, Venezuela, Yugoslavia.[8]

The following governments arranged for the attendance of groups of participants selected by them: Argentina, Australia, Belgium, Bolivia, Canada, Chile, China, Denmark, Dominican Republic, Egypt, France, Greece, Haiti, India, Iran, Iraq, Israel, Italy, Lebanon, Liberia, Mexico, Netherlands, New Zealand, Nicaragua, Norway, Pakistan, Panama, Peru, Philippines, Sweden, Switzerland, Turkey, United Kingdom, United States, Venezuela, Yugoslavia.

In addition, 22 non-governmental organizations were represented by observers and 152 learned scientific societies and institutions participated by sending representatives to the Conference.[9]

[7]See list of authors of Conference papers and other participants, page xxix.

[8]*Ibid.*

[9]See lists of these organizations, pages li and liii.

INFORMATION SERVICES

Prior to the Conference, the technical press, daily press and radio services were furnished with many of the pre-Conference prints of papers which were being distributed to the participants, and, at the time of the Conference itself, the daily press and radio coverage was extensive in many countries and supplemented the substantial space devoted to the Conference in important technical and scientific publications. Radio programmes dealing with the Conference were broadcast in sixteen languages.

PROGRAMME OF MEETINGS

The Programme of the Conference was subdivided into six major sections corresponding to the following principal resource fields: minerals, forests, fuels and energy, water, land, and fish and wildlife resources. In addition there was a series of plenary meetings which considered broader problems of resource development such as the interdependence of resources, resource techniques for less-developed countries, and education for conservation, and which also served to give a common spirit and purpose to the entire Conference.

The Conference was in session at Lake Success for 15 working days during the period 17 August to 6 September 1949, and met in 72 plenary and section meetings. The first two days and the last two days were devoted to morning and afternoon plenary meetings. In the intervening period five section meetings were customarily held during the morning while in the afternoon the participants assembled in plenary meeting.

Simultaneous interpretation facilities in English and French were provided for all meetings. Spanish was provided for all plenary meetings and a number of the section meetings.

In the following pages, the 18 plenary and 54 section meetings are listed and identified by subject and date of meeting. The plenary meetings are listed separately as are the meetings for each of the six sections of the Conference. The order used in each list of section meetings is that which is being followed in the printing of the Conference proceedings rather than a strictly chronological one.

During the middle two weeks of the Conference films dealing with resource subjects were shown for a period of approximately 45 minutes immediately prior to each afternoon plenary meeting. The list of films shown follows immediately after the list of meetings.[10]

The International Technical Conference on the Protection of Nature, sponsored jointly by the International Union for the Protection of Nature and the United Nations Educational, Scientific and Cultural Organization (UNESCO), met at Lake Success during the period 22 August–1 September 1949.

During the preparatory work for both the Conference on the Protection of Nature and UNSCCUR, because of common subject matters and interest in certain phases of their programmes, the schedules of meetings were so drafted as to afford participants the opportunity of attending both. All participants in the Conference on the Protection of Nature were especially invited to attend the UNSCCUR plenary meeting which was held on 30 August and dealt with "Education for Conservation". This latter meeting had been arranged with the cooperation of UNESCO, which had nominated the authors of the background papers contributed to this meeting and in many cases secured their contributions.

[10]An international catalogue of films dealing with resource subjects, prepared in connection with the Conference, has been issued (E/Conf.7/3).

Plenary Meetings

Introductory and Welcoming Addresses—17 August
The World Resources Situation—17 August
A World Review of Critical Shortages—18 August
The Interdependence of Resources—18 August
Soils and Forests—19 August
Fuels and Energy—22 August
Metals and Minerals—23 August
Creatable Resources: The Development of New Resources by Applied Technology—24 August
Methods of Resource Appraisal—25 August
The Adaptation of Resource Programmes—26 August
Assessing Resources in Relation to Industrialization Plans—29 August
Education for Conservation—30 August
Resource Techniques for Less-Developed Countries: A Symposium—1 September
Labour and Public Health Techniques—2 September
The Integrated Development of River Basins: The Experience of the Tennessee Valley Authority—5 September
The Integrated Development of River Basins: A Symposium on Public Policy—5 September
Review of the Conference: A Symposium on Future Lines of Study and Directions for Progress—6 September
Concluding Addresses—6 September

Meetings of the Mineral Resources Section

Mineral Supplies and Their Measurement—23 August
The Outlook for Future Discovery—31 August
Increasing Mineral Resources by Discovery—24 August
Conservation in Mining and Milling—30 August
Conservation in Manufacture—25 August
Conservation by Corrosion Control—1 September
Conservation by Substitution—2 September
Inorganic Fertilizers in Conservation—26 August

Meetings of the Fuel and Energy Resources Section

Techniques of Oil and Gas Discovery and Production—25 August
New Techniques for Increasing Production of Oil and Gas—26 August
Oil Chemistry—29 August
Coal Mining—19 August
Coal Preparation—24 August
Underground Gasification of Coal—22 August
Coal Carbonization—23 August
Conservation in Utilization of Fuel for Space Heating—1 September
The Integrated Power System—30 August
New Developments in Production and Utilization of Energy—31 August

Meetings of the Water Resources Section

The Appraisal of Water Resources—19 August
Water Supply and Pollution Problems—22 August
Comprehensive River Basin Development: A Symposium—23 August
Drainage Basin Management—24 August
Water Control Structures—26 August
Flood Control and Navigation—29 August
Irrigation and Drainage—30 August
Hydro Power and Other Water Uses—1 September

Meetings of the Forest Resources Section

Forest Inventories—19 August
Protection of Forests—22 August
Forest Management—23 August
Protective Functions of the Forests—25 August
Administration of Forests—26 August
Logging and Sawmill Techniques—29 August
Preservation and Chemical Utilization of Wood—31 August

Meetings of the Land Resources Section

Methods of Soil Conservation—19 August
Organization and Evaluation of Soil Conservation Programmes—22 August
Soil Surveys and Research in Relation to Soil Conservation—23 August
Aids to Farming—24 August
Improving Soil Productivity—25 August
Plant Breeding—2 September
Protection of Crops and Grasslands—30 August
Storage and Preservation of Agricultural Products—19 August
Livestock Breeding—30 August
Crop Policy and the Feeding of Livestock—31 August
Livestock Diseases and Pests—1 September
Condition of Grazing Lands—2 September
Seeding and Restoration of Natural Grazing Lands—29 August
Opportunities for the More Effective Use of New Agricultural Lands—31 August

Meetings of the Wildlife and Fish Resources Section

Changes in Abundance of Fish Populations—22 August
Developing Fishery Resources—25 August
Fisheries Statistics and Technological Development—2 September
Management and Cultivation of Fresh Water Fish—24 August
Research in the Conservation and Utilization of Marine Resources—1 September
Game and Fur Conservation—26 August
Management of Wildlife Resources—29 August

Films on Resource Subjects Shown at the Conference

These films were selected from a larger group assembled from various sources by the Films and Visual Information Division of the United Nations Department of Public Information. The country of origin is indicated, but official submission by the government is not implied. Further information about most of these films is available in *An International Index of Films on the Conservation and Utilization of Resources* (E/Conf.7/3).

Monday, 22 August—*Conservation and Utilization of Resources*—United Kingdom (Extracts from several documentary films, assembled and edited by United Kingdom officials for this showing)

Tuesday, 23 August—*The House in the Desert*—Israel
The Wizard of Svalof—Sweden

Wednesday, 24 August—*Pond Culture of Fish in India*—India

Thursday, 25 August—*Birth of the Soil*—U.S.A.
Soil Conservation on Wither Hills—New Zealand
Then It Happened—U.S.A.

Friday, 26 August—*In the Woods of the North*—U.S.S.R.
Rising Tide—Canada

Monday, 29 August—*Tube Wells*—India
Operation Tenstripes—Netherlands
Artificial Insemination of Cattle—United Kingdom

Tuesday, 30 August—*Science at Your Service*—Canada

Thursday, 2 September—*The New Earth*—Netherlands lands
Mineurs de France—France

Friday, 3 September—*Gasoline Refinery Process*—United Kingdom
Save Our Land—Colombia

CONFERENCE METHOD

In accordance with the Council resolution authorizing the Conference, in arranging for papers and discussions, the primary concern was with the practical application of science to resource management and use rather than with refinements in research and scientific methodology. The authors and other participants were invited to discuss the economic possibilities and practical opportunities for the further application of their special techniques, and the factors limiting such application as well.

It was recognized that many of the techniques developed thus far had been applied only in certain climates and under certain levels of economic and technical development and the experts were asked to consider how these techniques could be brought into wider use particularly for the benefit of less-developed areas. In this way, while the papers and discussions of the Conference constituted for the most part a body of authoritative technical data produced by specialists, they were oriented in a direction significantly different from those of the customary specialized scientific gatherings.

The detailed planning and procedures for the conduct of each of the meetings were determined by its Presiding Officers, assisted by the Programme Officer and the authors of papers to be presented at the particular meeting.[11]

Under the Conference method, papers for plenary meetings were generally presented in full, and were not circulated in advance.[12] For most of the plenary meetings, the Presiding Officer, Programme Director and Programme Officer met with the authors of contributed papers in advance of the meeting, and some of the discussions, the complete texts of which are printed in the proceedings, reflect the many viewpoints which appeared first in these informal meetings.

In contrast to the plenary meetings, papers for section meetings were never read verbatim, and a maximum of the meeting-time was thus made available for full discussion by the participants. This procedure in the section meetings was made possible by the advance reproduction and distribution of papers. The papers to be mailed to each participant were selected in accordance with information supplied by him as to which of the section meetings he expected to attend. Papers received too late for pre-Conference mailing were furnished to participants at the time of their registration.

As in all conferences, a great deal of the exchange of information and experience took place in informal discussions between participants, notably at Lake Success. These extensive, informal discussions represented an invaluable feature of the Conference itself and the proceedings at the meetings were enriched by them.

[11] Presiding Officers were selected by the Secretary-General and are listed on page xxvi.

[12] Except background papers for Meeting 12 which were circulated several days in advance of the meeting.

HOSPITALITY AND FIELD TRIPS

The resolution authorizing the Conference did not provide any funds for defraying the expenses of participants and these were borne for the most part by governments and organizations and, to some extent, by the participants themselves. Every effort, however, was made by the Secretariat to facilitate travel and living arrangements. A housing questionnaire was mailed to all participants and reservations in Manhattan hotels were made in advance by the Secretariat for those who requested them. Passenger buses provided by the United Nations offered free transportation daily for the Conferees between several convenient points in Manhattan and the Interim Headquarters at Lake Success. The Conference registration room at Lake Success served as a center for general information on travel and living arrangements.

Immediately adjacent to the Conference registration room space was provided for officials of the United

States Government and the American Citizens' Committee for UNSCCUR who offered a number of hospitality and field trip services to the Conference participants. Two exhibits on conservation subjects provided by the United States Department of Agriculture and the United States Department of the Interior were displayed throughout the Conference in the main corridor of the Interim Headquarters.

Several large formal functions as well as numerous receptions and other social activities on a smaller scale contributed a great deal to the formation of that social coherence which is so valuable in international gatherings of this kind.

On Friday evening, 19 August 1949, the United States Delegation to the Conference held a reception in the Ritz-Carlton Hotel for Conference participants from other countries and for the Conference Secretariat. The receiving line was headed by Secretary of the Interior Julius A. Krug and Secretary of Agriculture Charles A. Brannan.

Mr. Thomas J. Watson of the American Citizens' Committee for UNSCCUR was host to the Conferees at a notable luncheon held in the Hotel Pierre on Wednesday, 31 August 1949. Mr. Watson presided and the group was addressed by a number of leading American citizens.

At the close of the Conference on Wednesday, 6 September 1949, Mr. Trygve Lie, Secretary-General of the United Nations, received Conference participants at a farewell gathering in the Delegates' Lounge at Lake Success and proffered to all his thanks and appreciation for their fruitful labours of the preceding three weeks.

American Citizens' Committee for UNSCCUR

The American Citizens' Committee for UNSCCUR which was formed prior to the Conference by a group of private United States citizens contributed a great deal to the pleasure as well as the information gained by the Conferees. The membership of this Committee was as follows:

Clarence Francis, Chairman

H. E. Babcock	Fairfield Osborn
James Douglas	Randolph Pack
Clark Eichelberger	Thorndike Saville
Herbert Hoover	Philip Sporn
Columbus Iselin	John Suman
Kent Leavitt	Fenton Turck
Wheeler McMillan	Thomas J. Watson
W. F. Moehlman	Edward R. Weidlein

C. Williams

Edward Douglas, Co-ordinator for Local Field Trips

W. Howard Chase, Chairman of the Public Relations Steering Committee

The Committee on Field Trips of the American Citizens' Committee, under the leadership of Mr. Thomas J. Watson, assisted by Mr. Edward Douglas, consisted of:

MINERALS	— James Douglas
FUEL	— John Suman
ENERGY	— Philip Sporn
WATER	— Thorndike Saville
FORESTS	— Randolph Pack
LAND	— Kent Leavitt
WILDLIFE AND FISH	— Columbus Iselin

Each of these members, in turn, organized special subcommittees for the field for which he was responsible. Requirements of space prohibit more than the brief listing given here.

MINERALS

Wednesday, 24 August: A visit to the copper smelter and refinery of Phelps Dodge Corporation, Long Island City, N.Y.: a copper smelter and electrolytic refinery, with all necessary auxiliaries, service departments and a copper sulphate plant for processing tank house solutions.

Monday, 29 August: A trip to the MacIntyre mine of the National Lead Company, Tahawus, N.Y.; titanium-iron ore mining and milling operations.

FUELS AND ENERGY

Wednesday, 24 August: A visit to the Seaboard Plant of the Koppers Company, Kearny, N.J.: a merchant coke plant processing 4,400 tons of coal daily.

Friday, 26 August: A visit to the Bradley-Mahoney Company, Bronx, N.Y.: a new and extremely modern retail coal terminal.

Friday, 2 September: A visit to the refinery of the Esso Standard Oil Company and new Esso Laboratories of the Standard Oil Development Company, Bayway, N.J.

Friday, 2 September: Inspection of two outstanding steam-electric generating plants: The Sewaren Generating Station of the Public Service Electric and Gas Company, Perth Amboy, N.J.; and the Waterside Generating Station, Consolidated Edison Company, Manhattan.

WATER

Tuesday, 30 August: An inspection tour of New York Harbor installations aboard the U.S. Seagoing Hopper Dredge Goethals of the Corps of Engineers, U.S. Army.

Friday, 2 September: A trip to Merriman Dam and Neversink Dam and Tunnel, elements of the New York City water supply system which are under construction.

FORESTS

Tuesday, 30 August: A trip to the Charles Lathrop Pack Forests, Warrensburg, N.Y.: 2,250 acres administered by the New York State College of Forestry.

LAND

Saturday, 20 August: An inspection of the Chauncey Stillman Farm, Milbrook, N.Y.: demonstration of a variety of proper land-use practices on pasture, crop and woodland.

WILDLIFE AND FISH

Tuesday and Wednesday, 30-31 August: A two-day visit to Woods Hole Oceanographic Institution, Marine Biological Laboratory and Laboratory of the Fish and Wildlife Service, Woods Hole, Mass.

GENERAL

Saturday, 27 August: An inspection of the New York Zoological Park, Bronx, N.Y., including laboratories and special exhibits.

The Engineers Joint Council held an informal open house for Conferees in the Engineering Societies Building, New York City, on Wednesday, 31 August. The facilities of the Building, which houses the headquarters of five leading engineering societies as well as the Engineering Societies Library, were made available to the Conference participants throughout the period of the Conference.

The International Business Machines Corporation arranged, for the Conferees, several special demonstrations of the Selective Sequence Electronic Calculator at its headquarters in New York City.

Post-Conference Field Trip

Conference participants from other countries were invited to be the guests of the United States Government on an extended field trip through the eastern part of the United States during the six days immediately following the Conference. One hundred and thirty-seven Conferees from thirty-nine countries and four international organizations took advantage of this opportunity.

The Post-Conference Field Trip was planned and co-ordinated by an Interdepartmental Committee of the United States Government consisting of representatives from the Departments of State, Agriculture, Interior, Commerce and the Corps of Engineers, and conducted and financed by the Department of State. The primary purpose of the trip was to enable the engineers, scientists, resource technicians, economists and other experts from abroad, attending the United Nations Scientific Conference on the Conservation and Utilization of Resources, to observe and study industrial and governmental projects and methods of conservation and utilization of resources in the eastern part of the United States.

The field trip participants boarded a special train in New York City on 6 September 1949, the last day of the Conference, and proceeded to Pittsburgh, Pennsylvania, Columbus, Ohio, the Tennessee Valley Area, Washington, D.C., and returned to New York City on the evening of 12 September.

Each of the six days was spent in observing and studying projects illustrative of the main sections of the agenda of the Conference, i.e., Mineral Resources, Fuels and Energy, Land Resources, Water, Forests, and Fish and Wildlife. These projects were located in the vicinity of the above-mentioned cities or areas.

At Pittsburgh, Columbus and Washington, four local trips each covering different phases of the agenda were made available to the participants depending upon their specific interest. In the area of the Tennessee Valley Authority all participants observed the same projects.

At Pittsburgh, Pennsylvania, visits were made to the Irwin Works of U.S. Steel, the Mellon Institute, the Metals Research Laboratory of the Carnegie Institute of Technology, and the Bureau of Mines Central Experiment Station and Experimental Coal Mine at Bruceton, Pennsylvania. Under the auspices of the U.S. Department of Agriculture Club, a farm tour was devoted to a review of conservation and utilization practices employed in the area. The group also visited the H.J. Heinz Company plant and inspected certain U.S. Army Corps of Engineers projects on the Ohio River, covering a comprehensive river basin development.

The second stop of the tour was at Columbus, Ohio, which included a visit to facilities of Ohio State University for those particularly interested in mineral resources, fuels and energy, inspection of the plant of the Jeffrey Manufacturing Company, makers of mining machinery, and an inspection of the Battelle Memorial Institute laboratories where demonstrations and discussions took place. Another tour included visits to Delaware Dam and local flood protection projects of the U.S. Army Corps of Engineers. An inspection tour under the auspices of the U.S. Forest Service, Department of Agriculture, to review methods for reclamation by forestry measures of land strip-mined for coal was provided as a third optional trip. For those interested in land resources, a farm trip through the corn-belt area of Ohio was conducted with demonstrations at several representative farms.

The third area visited was the Tennessee Valley which projects of the Tennessee Valley Authority were inspected. Under the direction of TVA staff members an inspection was made of demonstration farms and areas operated co-operatively by State Extension Services and the TVA at Muscle Shoals, Alabama. In view of eight hours' delay in arrival at Muscle Shoals, on account of a train wreck, plans to visit the Chemical and Fertilizer Plant were cancelled.

The group also made an inspection of TVA mass production forestry measures. At the city of Decatur, Alabama, the scientists saw examples of new industries using the area's raw materials, the development of TVA fisheries programme in impounded waters, malaria control practices and migratory waterfowl conservation experiments. At the city of Guntersville, the guests were shown an example of a community utilizing services of planning agencies to strengthen facilities and resources. Visits to Chickamauga Dam at Chattanooga, Tennessee, and the Norris Dam at Knoxville were also made.

Returning to Washington, D.C., on 12 September, the first tour included an inspection of the Eastern Experiment Station of the Bureau of Mines at College Park, Maryland, and a visit to the laboratories of the National Bureau of Standards in Washington. Another tour included a visit to the 12,000 acre station agriculture research center, U.S. Department of Agriculture, at Beltsville, Maryland. A highlight of the trip was a visit to the Patuxent Wildlife Research Refuge which is under the direction of the Fish and Wildlife Service. The final trip on the agenda included an inspection of the Timber Engineering Company laboratory at Washington where developments in wood processing were demonstrated.

Various hospitality functions were attended by all of the participants at almost every stop along the route of the trip. The most important of these were:

Pittsburgh, Pennsylvania—Reception and dinner by the Pittsburgh Chamber of Commerce and the Mellon Institute.

Columbus, Ohio—Reception at the railroad station by the Honorable Earl J. Lausche, Governor of Ohio, and the Honorable James A. Rhodes, Mayor of Columbus.

Decatur, Alabama—Barbecue dinner by the citizens of Decatur.

Guntersville, Alabama—Picnic lunch by the citizens of Guntersville.

Chattanooga, Tennessee—Dinner and programme at the University of Chattanooga by the citizens of Chattanooga.

In addition to the above, participants in the various local trips were guests at luncheons given by some of the sponsors of these trips.

PUBLICATION OF THE PROCEEDINGS

The principal purpose of the Conference, as determined by the Economic and Social Council, was an international exchange of ideas and experience among experts. The full texts of the papers presented to the plenary and section meetings and the records of discussion are being published so that the work of the Conference will be available to specialists in the fields of conservation and use of resources all over the world who were unable to attend the Conference.

In addition to the proceedings of the plenary meetings published in this volume, it is planned to publish a separate volume for each section and an index volume. These proceedings will be published in the two working languages of the Conference, English and French.

In the preparation of the proceedings a number of procedures, which are summarized below, have been adopted to meet problems arising partly from the fact that the Conference was conducted in several languages and partly because of the wide geographic distribution of authors and other discussants.

Reproduction of Contributed Papers

The full texts of contributed papers as submitted in written form are being published whether they were read in full (as was the case for many of those presented to the plenary meetings), informally presented with extensive deviations from the prepared manuscript (as was done by a number of the speakers in the plenary meetings), briefly summarized (as was the usual case in section meetings), or only circulated (as occurred in a number of instances where authors were not able to attend the Conference). Because of the wide geographic dispersion of Conference authors and the desire to expedite publication of the proceedings, printers' proofs were not furnished to authors for correction.

However, a number of steps have been taken to insure the correctness of the texts of the papers reproduced in the printed proceedings. The steps that were taken varied according to whether the original language of the paper was English or another language.

Of the total of approximately 550 Conference papers about 430 were submitted originally in English, and these, except for less than a dozen papers, were reproduced prior to the Conference, either by the United Nations or by the author, for the use of participants. The authors of these papers have been asked to review and correct the pre-Conference prints and they have done so in all except a few cases; these corrected copies, rather than the original manuscript, have been employed for printer's copy. With respect to these papers, the only editing that has been performed was that required to create a common printing format for abstracts, headings, footnotes and bibliography or to clarify the more difficult passages. Diversity in English usage and spelling of the original texts has usually been allowed to stand.

Of the remaining papers which were originally submitted in a language other than English, approximately 80 were in French, 30 in Spanish, and 10 in German, Italian, Norwegian or Dutch. These have been translated into English by the United Nations Secretariat. Because of the great number and wide variety of technical terms used in the course of the proceedings it was thought desirable to have these translations reviewed, for technical language, by experts in the various specialized fields and this was done with the co-operation of experts in the United Nations Food and Agriculture Organization and in Departments of the United States Government. Authors of these papers were not requested to correct the translations although, frequently, pre-Conference prints of the English language versions were available to the authors and they, in a few instances, submitted suggestions and corrections.

Since French, jointly with English, was a working language of the Conference, papers originally submitted in French were generally reproduced in the original language and were sent to authors for review. All authors' corrections were examined and, where necessary, incorporated into the English translation.

In the case of all papers, bibliographies and other references were generally recast but have not been verified.

Records of Plenary Meeting Discussions

The published proceedings of the plenary meetings include a verbatim record of all discussions in addition to the full text of contributed papers. This record was made either from original spoken English, from the simultaneous interpretation of Spanish into English provided at the time of the meeting or, in the case of participants who spoke in French, by the translation of a verbatim record made in the original language. Where the participants in their discussions spoke from a prepared manuscript and furnished this manuscript to the Secretariat, it was usually substituted for the verbatim record.

At the time of the Conference, the verbatim record was available within one or two days after the meeting and many of the participants had an opportunity to review and correct their remarks while still at Lake Success. Where participants did not have this opportunity, copies of their remarks were mailed to them for correction in most instances. However, where remarks were very brief, these were checked by the Secretariat directly against sound recordings which had been made at the time of the meetings. To facilitate publication, the verbatim records of the sixteenth and seventeenth meetings, which were in the form of symposia, were reviewed by the Discussion Leaders, rather than by the participants.

Records of Section Meeting Discussions

A summary of the discussion at each section meeting, running usually from 4,000 to 6,000 words, is being prepared for inclusion with the section meeting proceedings. These summaries have been initially reviewed by the Programme Officers of the individual meetings, and are being circulated for review by the discussants prior to final publication.

REPORT ON THE CONFERENCE BY THE SECRETARY-GENERAL

(The Secretary-General presented a report, document E/1579, on the Conference on 28 December 1949 to the 10th Session of the Economic and Social Council. The text of this report is given below, except for certain paragraphs the contents of which are fully covered in the preceding introductory material to this volume.)

The summary given below is merely intended to show the scope of the discussions which took place in plenary and in the sections, and some of the highlights of these discussions.

Plenary Meetings

The eighteen plenary meetings fulfilled several important functions for the Conference. It was at these meetings that the common spirit, approach and purpose were developed for the fifty-four section meetings. It was at these meetings also that the participants returned to review together the conclusions of their various specialized discussions and to assess mutually the overall trends and possibilities in resources conservation and development.

The main topics on which papers were read and discussions took place in plenary were: the world resource situation (the legacy of resource depletion, the increasing pressure of resources); a world review of critical shortages (food, forests, minerals, fuels); the interdependence of resources (the complementary nature of European resources, the planning of land use for full production with special reference to European conditions); the use and conservation of resources (soil and forest conservation and the protection of water supplies, techniques for increasing agricultural production, estimates of undiscovered oil and gas reserves, economics of competitive fuels for various purposes and their use to meet future fuel requirements, metals in relation to living standards); the development of new resources by applied technology (fodder yeast and algae, the contribution of chemurgy, wood fibre, food yeast, fat synthesis by micro-organisms and its possible applications in food industry); methods of resource appraisal; the adaptation of resource programmes; assessing resources in relation to industrialization plans; education for conservation; resource techniques for less-developed countries; and the integrated development of river basins.

Plenary discussions and papers at the eighteen plenary meetings were, with few exceptions, non-technical and dealt with summary data, conclusions and fundamental principles. They ranged over many diverse subjects and brought out wide differences in views as well as substantial areas of agreement. A recurring theme throughout the Conference expressed by many of the experts was the wasteful depletion of resources associated with modern war and the elimination of war as a condition of effective long-run conservation.

Early plenary meetings posed the question of the adequacy of resources to meet growing demands. The pressures on resource use had been increasing with the industrial revolution, the earth's population had doubled in the last four generations; this and the growing demands imposed by industrialization had led to heavy withdrawals from the stocks of such non-renewable resources as minerals. Moreover, the capacity of the lands, forest and inland waters of substantial areas to renew their benefits repeatedly had been impaired for years to come by the mistakes in their use made years earlier. Despite this knowledge of their consequences it was pointed out that such malpractices in the use of renewable resources continued in many countries.

With respect to minerals resources it was pointed out that a world-wide rise in *per capita* consumption standards to a level approaching that of the United States or of other industrialized countries would soon exhaust known reserves for some of the most important and basic minerals on the basis of existing populations. In the case of food, the world's needs for an adequate diet for all demanded an increase of as much as 163 per cent in the case of fruits and vegetables, 100 per cent in the case of milk, 46 per cent in the case of meat, 34 per cent in the case of fats and 21 per cent in the case of cereals. *Per capita* consumption of forest products in industrial countries was far above that prevailing in the less-developed areas. The widespread application of improved techniques was essential to correct the potential disparity between world resources and the needs of a world committed to increased standards of living for a population still growing. While history had been marked by the most appalling misuse of resources under certain circumstances, it was also pointed out that it had witnessed, particularly in recent decades, the development of techniques which were constantly expanding productivity and opening up new sources of supply. Some experts held that food and timber production had in many areas been expanded at the expense of the fertility and productivity of the soil, but others pointed to agricultural areas where large increases of agricultural production had been achieved and the fertility and productivity of the land as a whole were as great or greater than they had been several hundred years ago.

In general, expert after expert concluded that it was possible through the less wasteful use of resources, the fuller application of existing techniques and the exploitation of new scientific developments, to support a far greater population than exists today, at a much higher level of living. It was concluded that the techniques discussed at the Conference, if fully applied, would make possible the realization of this goal.

The participating scientists felt that such full application of conservation and development technology depended on solving many problems in the political, social and economic spheres. Indeed, more than one scientist stated that it was the obligation of the experts to participate in the political and economic scene actively in order to ensure that their discoveries and knowledge were put to proper use.

In connexion with the relationship of conservation to use, a number of participants warned against excessive pre-occupation with conservation as an end in itself. They pointed out that the appropriate standard was conservation in human effort in meeting human needs and that there was, for example, little point in conserving fuels to repose underground for use centuries later when in the interim science might open up vast new resources of energy based on atomic and electro-chemical processes or the direct utilization of the energy of the sun. Conservation of non-renewable resources, many held, should be emphasized primarily where there are imminent shortages in terms of current and immediately prospective demands and supplies.

The outstanding possibilities for the development of new resources which were discussed at the Conference included tropical lands and forests and "creatable resources". These were characterized by a common problem, that all of them depended on future scientific research. Soil and forest science as we know it today is primarily applicable to the temperate climates. The exploitation of the tropics requires vast new scientific knowledge. With respect to "creatable resources", science had already shown that food from algae, seaweed, food yeast and fat synthesis by micro-organisms all offered vast possibilities for new food supplies, and represent highly efficient methods for the production of food. It was, for example, pointed out that a bullock weighing 1,000 pounds produced one pound of protein in 24 hours, as compared to an initial stock of *torula* yeast weighing 1,000 pounds which had yielded 4,000 pounds of protein in 24 hours on an experimental basis. The prediction was made that it was not fanciful to expect that in another few decades man's very primitive methods of producing food would be supplemented by new industrialized, scientific methods in much the same way as new alloys and synthetic plastics and fibres had augmented the traditional supplies and production methods in the past few decades. Realization of these possibilities called for continuing and expanding support in the field of research.

While the question of interdependence of resources occupied the entire discussion of one of the early meetings, it too proved to be an ever-recurring theme throughout the Conference. Resource developments were in many respects competitive. Tropical soils could be used for the development of agriculture or of forestry. Land devoted to agriculture in turn had its alternative applications as to type of crops. Water resources could be used primarily for energy purposes or for irrigations, agriculture or recreation. In this way, resources were often competitive and alternative.

At the same time resource developments were very often complementary. Changes in forestation might drastically affect the character of drainage and ultimately, through erosion, adjoining soils. Thus it was often essential to plan simultaneously forestation and soil and water conservation. Water development, particularly as manifested in the comprehensive development of river basins, could be most effectively carried out by simultaneous applications of water for power, agriculture, forests, irrigation and other purposes, although one or the other of these might receive greater emphasis in a given situation, depending on local conditions, means and social approach. Indeed, the Conference devoted much attention to this question of comprehensive development of river basins and, with virtually no dissent, agreed that it was a most important method not only of conservation but of harnessing the vast power and water resources of the world's great rivers.

Techniques for under-developed countries was another question which not only occupied the discussion of several entire meetings but formed a continual focus of discussion throughout the Conference. It is impossible without full presentation of the many viewpoints represented even to list the numerous points and questions which were raised with respect to this subject. However, among the more outstanding were the following: the techniques essential to accelerate the most efficient development of the local processing of raw materials produced in the less-developed countries where this is desirable from an economic standpoint; the mutual contribution of industrialization and improved agricultural techniques to the economic development of the under-developed countries; the adaptation of techniques to the special conditions of the under-developed countries (e.g., the improvement of agricultural storage without excessive capital cost to narrow the gap between the estimated 25 per cent loss in the "village basket" of the under-developed countries and the 1 or 2 per cent loss in the elaborate grain elevators of the highly industrialized countries) ; special conditions essential for the education and training methods both for conservation and development, the important role to be played by local national and regional technical institutes, and extension methods of bringing education directly to the farm; the vast contribution to be made by improved health, not only to better living of populations but to their economic development (for example, it was pointed out that in certain areas, the efficiency in agricultural workers was reduced by as much as 50 to 90 per cent by hookworm disease, a disease which could be controlled and eliminated).

Another recurring topic was that of resource survey and inventories. Examples were given where major projects had been wastefully undertaken in the absence of adequate surveys. Participants pointed to serious deficiencies in data with respect to major resources. Growing improvements in the techniques of surveys and their interpretation were making them cheaper and more universal in application. Many experts thought that the United Nations could make a very important contribution by acting as a central clearing house on surveys and inventories. This was one of the recommendations which, together with the technical assistance programme, many of the individual participants suggested would be a logical development of the initiative taken by the Economic and Social Council in calling the Conference.

Section Meetings

On each of eleven mornings of the fifteen days of the Conference, five section meetings met to consider the techniques of resource conservation and utilization in more detail and with specific reference to particular classes of resources.

Mineral Resources Section

In these meetings particular emphasis was placed on the techniques necessary to make minerals go as far as possible in satisfying man's needs, since, unlike the organic resources, which may be drawn upon repeatedly with proper treatment, the amount of a given mineral in the earth's crust is a fixed quantity. In view of the concern of the Conference with the development of the less-developed countries, minerals were of special importance, since minerals constitute the key raw materials for the machines and structures of an industrial society.

The plan of organization of the mineral section meetings was as follows: First, the extent of mineral supplies was considered in relation to their cost of recovery, including the effect of transportation on costs deriving from the necessity of bringing together minerals with fuels or electrical energy. Next, the outlook for future discovery was considered in relation to the new techniques available for mineral finding. Finally, the techniques necessary to make the limited supply of minerals go as far as possible in meeting man's needs and for the conservation of such supplies were considered under the particular headings of mining and milling, manufacture, utilization and reclamation, corrosion control and substitution. Special attention was given to all these factors together in relation to inorganic fertilizers in view of their importance for the most effective use of the renewable resources of the earth. Treated in this way, mineral resources were the subject of sixty-two papers presented and discussed at eight meetings.

It was held that while there was no immediate prospect of critical shortages, the long-range outlook was one of shortages of a substantial number of minerals, particularly if standards of living, dependent in large measure on mineral supplies, were increased significantly in the less-developed countries. On the other hand, those holding to an optimistic view of the future emphasized the dynamic character of the known extent of mineral reserves which tends to increase with progress in the techniques of discovery, mining, manufacture and use.

For example, new discoveries had been made in recent years even in such areas as the United Kingdom, which had been regarded as being thoroughly surveyed in years past. Since few parts of the earth had developed the use of their mineral resources so intensively as this area, the prospect for future substantial discoveries could be regarded as good. An essential characteristic of such discoveries, however, is the close co-operation particularly between geologists and geophysicists, but also with technicians in the field of mining and utilization. The new techniques, such as the use by geophysicists of the air-borne magnetometer, held promise of reducing the costs of exploration in the great unexplored areas of the world, but these methods were effective only when used in conjunction with other techniques and disciplines.

Aside from new discoveries, the steady reduction in the costs of extraction by means of mechanization and improvements in milling and refining, permitting the economical use of lower grades of ores, had the effect of extending the effective supply at existing operations and of rendering economically usable deposits as yet unexploited. In the manufacture of products from minerals, particular emphasis was placed on development in the use of oxygen as a means of reducing costs in iron and steel manufacture and on the recovery of non-ferrous metals and minerals from the gases of refinery flues.

More economical design as a method of stretching the world's effective supply of minerals was illustrated by a number of concrete examples. Tremendous losses were associated with the corrosion of metals and the economics of the techniques for its control was the subject of a number of papers. In an examination of the methods of scrap recovery, widely varying situations with respect to particular metals were discovered, some metals being almost entirely consumed in irrecoverable form in certain uses, while for others there was sound prospect for increasing the recoverable stock of metals-in-use as their extraction continues.

The light metals, aluminium, magnesium and titanium, present in almost inexhaustible quantities either in the earth's crust or in the waters of the seas, were being exploited through techniques which gave promise of permitting a slow increase in the expanded use of some, such as aluminium and magnesium, and the future use of others such as titanium, not now employed in significant quantities in its metallic form.

Fuels and Energy Section

The Fuels and Energy Section of the Conference comprised ten meetings of which three were devoted to petroleum and natural gas, four to coal, one to space heating, one to the question of the integrated power system, and one to future trends and new developments. In all, sixty-one papers were presented and discussed at these meetings.

In addition, an entire plenary meeting of the Conference was devoted to the broader aspects of fuel and energy resources. Because of the interrelations of major types of resources, fuel and energy questions were also discussed at other sections of the Conference; the Water Section, for example, devoted considerable time to hydro power, its structure, production and relation to water use and comprehensive river basin development.

The discussion of petroleum questions included estimates of reserves, problems of discovery, conservation in production, secondary recovery, oil from shale, and oil chemistry. One of the experts estimated that undiscovered petroleum reserves amount to one and a half trillion barrels, or 500 times the world's present annual consumption and concluded that the problem was not a question of the adequacy of world petroleum sources but of the ability to discover them. Discussion ranged from the comment that these estimates appeared to be an exercise in metaphysics to approval and references to the manner in which estimates of the oil reserves of the Middle East were continually being revised upwards.

In the review of oil and natural gas discovery techniques the view was generally advanced that revolutionary changes in techniques should not be anticipated and that methods had reached such a state of effectiveness that there was reasonable certainty that the world's demand for oil would be met for years to come. Geophysical methods of mapping concealed geology were now dominant although they did not report directly on the existence of oil. Aeromagnetic surveying, with its advantages of speed, low cost and access to otherwise difficult areas was recognized to be, at the minimum, a useful adjunct to other methods. One of the participants, disagreeing with the proposition that no new revolutionary methods of discovery would be forthcoming, pointed out that experiments were now under way to develop a technique for determining chemical composition of underground deposits at a distance, through the union of geology, physics and chemistry.

In the meeting on developments in drilling, production and secondary recovery of petroleum, the role of planned operation of a pool and its contribution to increased recovery, and the proper exploitation of reservoir energy generally and its supplementation by injection of gas and water, were stressed.

The Conference heard reports that the technique of extracting oil from shale, which had been comparatively neglected for over a century owing to its relatively high costs as compared with petroleum, was nearing the range of economic feasibility. It was reported that extraction of oil from Swedish oil shale would require further mechanization and development of by-products to ensure an adequate economic return. Studies in the United States indicated that 200 billion barrels of oil could be recovered and costs for some deposits were estimated at below $2.00 a barrel of oil.

The discussion of coal resources and their use began with a meeting which brought out the great contrast in coal mining techniques throughout the world resulting from different regional characteristics and diverse methods that are being employed to increase production and reduce costs. High productivity at low cost rather than conservation was reported to be the principal emphasis of the coal industries of certain industrial countries; on the other hand at least one government was reported to be placing a great deal of emphasis on conservation, having reduced extraction losses to 5 per cent.

New and improved techniques in coal preparation reported at the Conference were facilitating mine mechanization, permitting the recovery of fines and making possible the improved use of coal, particularly by bringing into the coking coal classification vast reserves of coal heretofore considered non-coking. In connexion with metallurgical coke, one group of papers pointed to a whole series of modifications in iron and steel industry practice which could reduce both the quantity and quality of coke required for iron smelting. Leading experts urged that the time was ripe for new and more exact estimates of coal reserves and for a more universal standard for testing and reporting coal quality.

The Conference received reports on the recent French and the first United States experiments on underground gasification of coal. Widely divergent opinions were expressed on the economic promise and point of suitable application of this technique which is still in the experimental stage.

Conservation in utilization of fuel was the main theme of the papers and discussions of the subject of space heating. In colder countries where space heating was commonly employed it could no longer be considered a luxury and often accounted for as much as 30 per cent to 50 per cent of the total energy consumed in the country. Better design of buildings, including particularly the use of improved insulating materials, and central (or district) heating were two of the major techniques described; the heat-pump and solar energy heating methods which are in the experimental stage were also reviewed. Discussion brought out the fact that many of these conservation techniques required a larger initial capital outlay which was eventually compensated for by reduced energy costs.

The integrated power system was reported as making possible more economical use of fuel, more effective extraction of hydro energy, and definite savings in capital through the reduction in requirements for spare generating capacity. Also it was an important tool for balancing on an extended geographical basis industrial needs and possibilities against diverse sources of energy. Among questions which were examined or raised in dealing with this technique were: the transport of power over extended distances to centres of industry as against the transport of semi-finished products prepared at the sources of power and their transport to the centres of the industry; the desirability of planning larger systems so that they would consist of a group of nearly self-supporting smaller systems; and the applicability of the experience of highly industrialized areas to the development of less industrially advanced areas.

At the meeting dealing with future trends and new developments promising future possibilities for the gas turbine were reported including the possibilities of using coal in a gas turbine. However, wider use at high efficiency depended upon further metallurgical and design improvements. The possibilities of using wind-power were examined and it was reported that installations were both economically and technically feasible under certain limited conditions (isolated or difficult areas with respect to fuel or electricity; also as auxiliaries to other power forms or in combination with them). One of the experts from France reported on the plans which were being developed in his country for harnessing tidal power. It was stated that this plant would produce about 800 million kilowatt-hours per year and that its construction did not raise any difficult or even novel technical problems.

Water Resources Section

No group of section meetings emphasized more the need for close co-operation between various specialists than those dealing with water resources and their control and use. The skills and knowledge of foresters, agricultural scientists, civil engineers, electrical engineers, administrators and economists were all required. In recent years the growth of urban population has brought home the possibility of shortages, and the supply of even such essential needs as drinking water and its availability has been a limited factor in the growth of industry in various places, while its destructive release in large quantities leads to soil erosion and floods.

The plan of these meetings was to examine first the techniques of locating and supplying water, including extensions in the effective supply through measures of pollution control, next examining the methods of controlling its destructive run-off and then methods of its use for navigation, irrigation and energy development. Finally, problems and experience in the combined development of water resources for a variety of uses was considered at a symposium of the section and in two of the plenary meetings. Treated in this way water resources was the subject of eighty-four papers presented at eight section meetings and two plenary meetings.

In the location and appraisal of underground water resources the need for close co-operation between geologists and specialists in other fields was emphasized. The Conference was fortunate also in receiving the most extended reports thus far available on the developments in the study of experimental meteorology which gives promise of yielding methods for the control of the clouds themselves, inducing in some instances the artificial precipitation of moisture and in others the stabilization of clouds. The tentative nature of results in this pioneer field was emphasized, but there was a general feeling among the specialists present that its thorough discussion would accelerate progress in the development and use of this technique.

An essential step in the controlled use of water is the development of accurate methods of forecasting annual and long-time yields in the given drainage basin from snow and rainfall. The wide variety of methods employed in arriving at such forecasts and the important technical differences between them characterized these meetings. There was general agreement, nevertheless, on the need for the collection of the basic data on water yields well in advance of the initiation of water control projects, such as dams, levees and irrigation works. The control of pollution could extend the effective supply of water and involved the co-operation of various specialities. Experts pointed out that the cost of purifying sewage water for use in irrigation, or in industry, could be offset by the recovery of a variety of by-products. Reports were received on the progress in the desalination of brackish and sea water, a technique particularly important for arid regions.

In the control of water to avoid floods and soil erosion and permit its use for navigation, irrigation and energy production, the outstanding conclusion was the need for the closest co-operation between the engineers responsible for the development of such control structures as dams and desilting works and the foresters and grazing land specialists who could prevent the rapid run-off in the headlands of a drainage basin. Without adequate development of the vegetative cover in the headlands of the drainage basin, the production of silt could reduce the life of a reservoir by hundreds of years, and on the other hand, the use of control structures such as check dams was frequently essential to provide the time necessary to gain control over water run-off and permit the regeneration of plant and forest cover.

The problems of assessing the benefits of flood control in terms of prevention of flood losses and improving the utility of property was discussed at some length because of the difficulties involved in this calculation. The value of lands protected against floods increased and building and improvement of such protected areas were encouraged by flood control. But some experts pointed out that if the rate of siltation remained high, flood control structures became ineffectual in a relatively short time and the community was faced with either an almost endless programme of flood control construction or the destruction by floods of the values added to protected property during the period in which flood control had been effective. Closely associated with flood control is the development of inland navigation which was regarded as especially important for the under-developed countries since history had shown that the substantial use of inland water transportation frequently preceded the construction of railways. In discussion of irrigation it was pointed out that co-operation with soil scientists was particularly important to avoid the impairment of certain types of land by irrigation which might necessitate their eventual retirement from cultivation.

The use of water for the generation of hydro-electric power was regarded as particularly important because of its contribution to economic development and because electric power frequently helped pay for the costs of flood control, navigation and irrigation structures. It was necessary, however, to consider the effect of dams for hydro-electric power and flood control on the fisheries of a stream which might be destroyed or seriously impaired unless piscicultures were involved in the planning from the outset. These considerations pointed to the need for the combined development of river basins taking into account the competitive demands for water and arriving at the best possible compromise between these demands. Several participants pointed out, however, that such overall plans should not interfere with the use of water for particular purposes when only such limited development was within reach of the country at the outset, particularly if such limited development could be carried out, so as not to prejudice a rounded comprehensive river basin development at a later stage.

Forests Section

Forest resources are important both from the standpoint of soil conservation and water control, as well as providing directly products which now enter into every field of human activity, including, experimentally, the production of food.

The plan of organization in these meetings was as follows: first, an examination of the techniques of inventorying the forest resources; second, an examination of the techniques, management, methods and administrative measures needed to protect and preserve the forest for the maximum yield of their own products and the most effective protection of other resources; and finally, the techniques for harvesting the forest crop and utilizing its products. Treated in this way, forest resources was the subject of seventy-seven papers presented at seven meetings.

Forest inventories constitute the basis for intelligent, planned utilization. Recent years have witnessed the development of the new tools of aerial photography and mapping to supplement the older methods still favoured by some forest surveyors. Striking developments in photogrammetry have made it possible to estimate the volume of standing timber with reasonable accuracy and to distinguish individual species.

In connexion with policies and administrative measures necessary for the protection of forests, the use of such modern devices as radio communication and the parachuting of fire-fighters in remote sections were discussed, together with the problems of protection against the spread of tree diseases in which international co-operation is especially important.

In discussing forests as a means of protecting other resources, experts emphasized that it was cheaper in many instances to develop and protect the forest cover essential to the storage of water in forest soils than to build expensive down-stream dams and reservoirs for flood control. The proper realization of the protective function of the forest depends upon an accurate classification of forests between commercially productive forests and those maintained for protection of other resources.

In the harvesting of the forest crop major emphasis was placed on the necessity for integration of forest industries in order to increase the extent of utilization.

In the United States, for example, it was estimated that only 50 per cent of the timber cut in the forests reached the consumer in the form of forest products, that about 20 per cent was burned as fuel and the remainder entirely wasted. Integration of forest product industries such as saw mills, pulp mills and waste products plants would aid conservation by reducing this waste. The shift in recent years to new types of more flexible logging equipment such as tractors and trucks was valuable to sustained yield operations if properly applied. Among the most recently developed of the specific techniques discussed was that for facilitating removal of bark from trees to be used for pulping by injecting chemicals in the standing tree.

Chemical developments with respect to forest products were recognized as important aids to conservation. The application of wood preservatives such as creosol and the more recent water-borne and organic-solvent types of preservatives could increase the life of timber in service from three to four times. New methods of utilizing the waste liquor from pulp mills, thereby combating stream pollution, were outlined. Perhaps the most promising developments, many still in the experimental stage, were those involving the chemical utilization of wood waste for the production of sugar, yeast and wallboard.

Most of the discussion of recent technical developments related to forests of the temperate zone, whereas the discussion of the tropical forests consisted mainly of a review of unsolved problems. Many of the tropical forests are characterized by a large number of species intermixed, with only a few of known commercial uses. The large variety of species presents special problems as yet largely unexplored in utilizing the new techniques of aerial survey. The special silvicultural problems of the tropical forests were the subject of a number of papers where authors described the difficulties associated with maintaining the growth of those few species, such as teak and mahogany, of known commercial value in forests dominated by species of no known commercial value. The experts agreed that the central problem was to systemize the identification of additional species of tropical forests, find commercial uses for a larger number of species, adapt logging methods to the unique problems posed and develop integrated production to the maximum extent possible. In this connexion developments in pulping processes were stated to open the possibility of using the immense wood supply in the tropical forests for the preparation of paper pulp.

Land Resources

Soil resources, the crops grown from the soil and the livestock fed upon the products of the soil were the subject of the largest group of section meetings. Several of the opening meetings were devoted to the methods of assessing and protecting the soil. These were followed by meetings devoted to the measures necessary to achieve larger yields from the soil through such methods as mechanization, application of fertilizers, appropriate cropping systems and plant breeding. Two subsequent meetings examined the techniques for the protection of growing things against diseases and pests and their protection during storage after harvest. Five meetings were devoted to the problems of livestock and the protection and restoration of grazing lands. One of the most important meetings in this series was devoted to the opportunities for increased agricultural use of new lands. Organized in this way, there were fourteen section meetings on land resources which had before them a total of 142 papers.

The problem of soil erosion which annually destroys or impairs the fertility of valuable acres is perhaps the most prominent example of the need for conservation. In the discussion of this subject appropriate emphasis was placed on the physical technique for combating soil erosion such as contour farming, maintenance of vegetative cover and such relatively recent developments as stubblemulch farming. However, it was also pointed out that the barriers to the application of the latest techniques were frequently economic in character, including such factors as low farm incomes, small operating units, unstable business conditions and inequitable landlord-tenant relationships.

One meeting discussed the question of whether or not soil conservation measures could pay their own way in a commercial sense. There was no general agreement on the answer to this question, but a majority of the participants felt that some measure of governmental subsidy was necessary. Fundamental to soil conservation programmes is the development of adequate soil surveys and soil research involving the co-operative action of soil scientists, geologists, ecologists, and economists. In view of the special emphasis on the largely unsolved problems of the tropics, the adaptation of aerial survey methods employed so successfully in forest inventory surveys was regarded as a specially important problem for technical study.

Increasing the yield from the soil was looked upon as more than simply the application of fertilizers, but rather as involving co-ordinated action through the use of fertilizers, lime and pesticides, and the practice of crop rotation and drainage as needed. Participants cited examples of increased yields of from 15 to 40 per cent through such measures. With respect to farm mechanization there was general agreement on the need for extended adaptation of farm implements by manufacturers to meet specific problems, including the development of power equipment for use with the lower grades of fuel. The necessity for measures to ensure that mechanization was not accompanied by an increase in soil erosion was pointed out. There was some agreement that the most effective use of mechanized equipment in agriculture might require an increase in the average size of farms. The possibility of improving indigenous, small farm tools was the subject of one meeting, although there was disagreement among the experts on the extent of increased production possible through such measures.

The development of superior plants through genetic methods was regarded as one of the methods of increasing soil productivity in which the cost was small compared to the advances made in crop productivity. Such plant breeding could be directed towards increased yields or to increased resistance to diseases. Plant breeding techniques are especially important for the extension of agricultural production to hitherto less favourable climates. Several participants emphasized that the Food and Agriculture Organization of the United Nations could play a particularly important part in this field in the co-ordination of international effort.

In the protection of plants against diseases and insects, while the participants discussed the substantial advances in the use of chemical sprays, it was felt that too much reliance might have been placed on these methods at the expense of proper attention to improved methods of cultivation, use of fertilizers and the development of strains resistant to disease. Diseases reduced the yield of certain plants by as much as 50 per cent, and in the control of such diseases rapid international action was particularly important; it was suggested that the Food and Agriculture Organization of the United Nations might consider the publication of a bulletin to bring together information on insect damage and plant diseases.

Losses after harvesting were very considerable, one of the participants estimating that losses of food in the United States by damage through rats alone amounted to over 200 million dollars a year. The substantial advances in the methods for the preservation and storage of food were described. However, one expert pointed out that these were limited largely to the industrially advanced countries and that the percentage losses were much larger in the food output of the less-developed countries, most of which did not enter world commerce. These represented an important field for the development of simple methods of silage and storage suitable for immediate application in less-developed countries.

The efficiency of livestock in converting animal feeds to human foods, which was the subject of one meeting, is important as a guide to policy in the planting of crops. The close relation of types of livestock food to the incidence of certain diseases was noted. Modern drugs could almost remove the menace of a number of diseases according to a leading specialist. The control of diseases and parasites required co-ordinated international action to regulate imports and exports of livestock. Livestock breeding to build resistance to diseases and parasites was one of the important means of combating such dangers as well as other dangers resulting from the introduction of stocks to new environments. Several experts described their experiences and the problems connected with the adaptation of livestock to tropical countries.

The factors contributing to the deterioration of grazing lands and the methods for their restoration were the subjects of two meetings. Measures for the control of grazing land condition were particularly important for the low rainfall areas which provided one-third of the total feed for livestock. The prevalence and health of the natural grasses indigenous to such semi-arid grasslands could serve, it was pointed out, as an indicator of whether or not such areas were over-grazed. Prompt steps to correct over-grazing or other mismanagement in response to the evidence of such indicator plants were essential because after erosion had set in it might be either extremely costly or even impossible to prevent further deterioration and creation of additional deserts.

Since the world is faced with the problem of feeding an increasing population at a better standard, the opportunities for opening new lands to agricultural production evoked special interest in a meeting which considered experience gained in a dozen countries. The participants exchanged experience on the methods employed and the barriers to be overcome in reclaiming land by drainage, adapting agricultural techniques, eradicating disease, and other necessary steps.

Wildlife and Fish Section

The meetings dealing with wildlife, fish and other marine resources comprised seven meetings of which five were devoted to fish and marine resources.

The discussion of fish resources opened with a consideration of the factors affecting the changes in abundance of fish populations. This was followed by meetings devoted to: latent fishery resources and means for their development; research on the conservation and utilization of marine resources; technological developments in fisheries, permitting their more effective utilization; and pond culture of fish. Organized in this way, forty-eight papers were presented in the five meetings.

The discussion of changes in the magnitudes of fish populations served to emphasize primarily the need for more extensive research. Several of the experts pointed to situations which illustrated a declining output due to over-fishing, but all stressed the importance of natural factors affecting the fluctuations in fish populations. There was also agreement that large areas of the world were still under-fished and one expert estimated that production could be increased by 22 per cent. As evidence of the fact that little had been done to test exhaustively the possibilities of increased fish production from the waters of the southern hemisphere it was noted that 98 per cent of the fish was caught from the waters of the northern hemisphere. In view of the large areas requiring further exploration to raise fish production, the fisheries experts present produced a map indicating the major fisheries believed to be under-fished in 1949.

The organization of research on fish resources and the operation of such research as presently organized in the highly developed countries were described. Development of such research in the less-developed countries was regarded as particularly important, but the view was expressed that such research would most profitably follow on the development of off-shore fisheries using modern mechanized equipment, since most of the fisheries in such areas had been confined close to shore because of the inadequacy of fishing vessels. In less-developed countries there was need for the immediate study of the factors affecting the storage and distribution of fish with a view to increasing the fisherman's return on his catch before there could be a substantial increase in production. This latter factor affected as well the technological developments in fisheries, in which many of the advances were applicable only in the preservation of fish which commanded a high market price. Other simpler and less expensive methods of preservation were discussed, but it was pointed out that additional work was necessary to develop preservation methods applicable in the less-developed countries, if marine fish production were to be substantially increased in those areas.

From the standpoint of the less-developed countries, special interest attached to the meeting dealing with pond culture, where a series of papers covered the extensive experience in Asian countries with this technique. In the opinion of the experts cultivation of fish as a farm crop through pond culture could be further expanded in Asia and should be introduced on a wide scale in Africa and Latin America. Its expansion would provide a source of protein food supply particularly needed in the countries of those regions. A particular advantage is that ponds may be scattered through rural areas and thus be close to the markets, obviating the necessity for the use of advanced preservation and transport methods. Unlike measures for the development of marine fisheries, substantial capital investments are not always involved and where required are usually domestic in character. Pond culture is closely linked with the promotion of irrigation, since the periodic draining of the ponds, rather than interfering with fish production, may be positively beneficial. Of particular interest to Asia were the descriptions of the use of rice-paddies for simultaneous production of rice and fish.

The Conference likewise discussed the developments in the use of marine algae which in substantial coastal areas occur in large quantities and which can, with suitable treatment, yield many valuable products.

Two meetings were devoted to game and fowl conservation and the management of wildlife resources at which twenty papers were presented. The problem of reconciling wildlife production with the use of land for agricultural and other purposes was the subject of one meeting. With the extension of agriculture to new areas, it has become increasingly important to develop methods for preserving wildlife resources without interfering with the use of lands for crop cultivation and livestock growth. Even in less-inhabited areas the problem of maintaining wildlife is one of balancing human needs against those of predatory and herbivorus animals. It was pointed out that the only certain way to maintain the balance of nature was to set aside natural parks or reserves to be maintained as nearly as possible in their original state.

These two meetings provided a link with the simultaneous meetings of the International Technical Conference on the Protection of Nature, sponsored jointly by UNESCO and the International Union for the Protection of Nature, which held its meetings at Lake Success during a portion of the period UNSCCUR was in session. The Conference for the Protection of Nature arranged its schedule so that its participants could attend certain of the UNSCCUR meetings. It considered in more detail the problems and techniques necessary for the maintenance of bird and wildlife, the scenic and recreational values of nature and the scientific and recreational values of primitive areas. The proceedings of this conference will be published separately from those of UNSCCUR and detailed reports on its proceedings may be obtained from the Natural Science Section of UNESCO.

Conclusions

The terms of reference of the Conference required that it be limited solely to an exchange of ideas and experience on the conservation and utilization of resources among engineers, scientists and experts. Accordingly, this Conference did no more than provide a forum for the presentation of papers and the discussion of these papers by the scientists and experts present. In general, the evidence indicated that this was a fruitful method of approach, and that the Conference was more productive by virtue of this limitation than it would have been had the participants been required to engage in the task of reaching agreements on resolutions and recommendations. However, it was evident that the experts in attendance felt, at times, that there were specific fields where the United Nations might act with the expectation of achieving lasting and immediately beneficial results. Thus, individual participants suggested that the Food and Agriculture Organization should promote the expeditious exchange of information on the occurrence of plant diseases in order to prevent their spread; special importance was attached in the discussion of fuels and energy to the promotion and development of international standards on the quality of fuels, where the United Nations might stimulate action through the International Organization for Standardization; another suggestion which was advanced by a considerable number of the participants was that the United Nations could serve as a central point in bringing together and co-ordinating the results of resources surveys so that all might judge what has been achieved and what might be possible along these lines. The records of the Conference reveal a number of other suggestions. As these random examples suggest it would be wasteful to ignore this positive aspect of the Conference work, while to pursue them would help to promote the fruitful collaboration which the Conference initiated.

The Conference was the first occasion on which the United Nations had brought together a large and representative group of scientists. More significantly, it was the first time that the United Nations had sought to obtain views and opinions of independent experts over so wide a field in the context of Articles 55 and 56 of the Charter. It was to be observed that this direct participation in an activity of the United Nations focused and made evident a real concern among the experts that their interest in, and potential contribution to, the work of the United Nations should be brought to bear on the problems with which the Economic and Social Council is occupied. The participants in UNSCCUR have now had an opportunity to report to their colleagues and exchange views on the results of the Conference not only in specialized fields but in the broader aspects to which the Conference devoted much time.

To continue this collaboration with experts and scientists and to review carefully the practicable suggestions which emerged during the Conference has an added timeliness in view of the expansion proposed for the programme of technical assistance for economic development. This will, it is certain, concentrate attention sharply upon problems of resource utilization and development and on resource conservation. Moreover, it will be especially the economic considerations involved in these problems which the technical assistance programme will raise most sharply. It would be worthwhile then to canalize this interest and take steps to elicit the positive proposals made by Conference participants, screen them and make them available by means of a report to the Council. In this way a wider currency may be given to valuable suggestions which member countries may wish to explore themselves in relation to their domestic circumstances or which the Council may wish to consider as subjects for international action.

The Council may wish to consider the adoption of a resolution on the lines of the following draft as a method of achieving this end:

The Economic and Social Council

Notes the report of the Secretary-General on the United Nations Scientific Conference on the Conservation and Utilization of Resources, and

Recognizing that the purposes sought by the Conference merit a continuing effort to make scientific and technical knowledge widely available,

Recommends that the Secretary-General seek to obtain the proposals and suggestions of participants in the work of this Conference in their fields of competence on problems involved in the conservation of resources, their utilization and development.

Should the Council choose to adopt a resolution along the lines suggested above, the Secretary-General will seek in the first instance the advice of the members of the Preparatory Committee which assisted him in the formulation of the programme of the Conference with regard to the most effective methods to follow in his efforts to elicit proposals from the participants in the Conference.

PREPARATORY COMMITTEE

(Positions shown are those occupied according to information supplied to the Secretariat at the time of appointment to the Preparatory Committee in June 1948.)

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MR. A. J. VAN TASSEL, *Secretary; Department of Economic Affairs, United Nations.*

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SECRETARIAT

The general responsibility for the preparation and organization of the Conference, under the direction of the Secretary-General of the United Nations, was placed within the Division of Economic Stability and Development of the Department of Economic Affairs.

Mr. Antoine Goldet, Principal Director of the Department of Economic Affairs, served as Secretary-General of the Conference; Mr. Carter Goodrich, Chairman of the Preparatory Committee, served as Programme Director of the Conference; Mr. Alfred J. Van Tassel, Secretary of the Preparatory Committee, served as Executive Secretary of the Conference; Mr. Herbert Schimmel, Deputy Secretary of the Preparatory Committee, served as Deputy Executive Secretary of the Conference; members of the Preparatory Committee, together with Mr. J. H. Angus, of the United Nations Economic Commission for Europe, and Mr. George C. Brewer, Jr., of the Conservation Foundation, served as the Conference Programme Officers.

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Note: The list under each country-heading includes any authors or delegates selected by the government in question, as well as authors or participants nominated by organizations or invited directly by the Secretary-General. The listing of a name under a given country does not, however, necessarily imply a particular nationality since, in a few cases, an individual may have been employed in a country other than his own at the time of his invitation or attendance at the Conference.

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Permanent International Bureau of Analytical Chemistry (Paris)
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  B. E. V. Parham
  H. G. MacMillan

World Power Conference[15] (London)
  Sir Harold Hartley

[15]As indicated in the previous section on Preparatory Work, the World Power Conference extended valuable assistance during the preparation of the Conference. Its advice was sought directly in the nomination of authors on certain topics, and in several countries its national committees co-operated with their respective governments in the preparation of other contributions.

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American Federation of Labor (AF of L)
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  Lewis W. Johnson

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Carnegie Endowment for International Peace
  Paul F. Kerr

Commission of the Churches on International Affairs
  Ira W. Moomaw

Inter-American Council of Commerce and Production
  Earl F. Cruickshank

International Alliance of Women—Equal Rights, Equal Responsibilities
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International Chamber of Commerce
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International Federation for Housing and Town Planning
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International Organization of Employers
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International Organization for Standardization
  E. A. Pratt

International Union of Catholic Women's Leagues
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International Union of Producers and Distributors of Electric Power
  Jean Aubert

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  Harold P. Nutter

Pax Romana — International Catholic Movement for Intellectual and Cultural Affairs
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Pax Romana — International Movement of Catholic Students
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  Stephen M. Schwebel

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[16]Organizations having consultative status with the Economic and Social Council.

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[17]Due to the widespread interest in the Conference and the facility with which representatives of learned societies in the United States could attend, a group of learned societies in the United States were invited to send observers, in addition to those societies originally invited to send participants.

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[18] The country listed opposite a name refers only to the List of Contributors and Participants on page xxix and does not necessarily indicate nationality.

[19] In addition to the observers listed as (NGO) and (Soc), a number of participants served also as observers for learned societies or non-governmental organizations. *See:* List of Organizations Nominating Observers on page liii.

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Devadanam, K. J. (P) India
De Vos, A. (P) Canada
De Vries, D. M. (A) Netherlands
De Vries, E. (AP) Netherlands
Dhar, S. K. (P) United Nations
Diamond, R. W. (A) Canada
Díaz Vial, C. (A) Chile
Dickinson, F. E. (P) USA
Dill, R. S. (AP) USA
Din, A. (A) Burma
Dirven, J. G. (A) Netherlands
Dixey, F. (AP) UK
Dixon, J. W. (P) USA
Doak, B. W. (P) New Zealand
Dobson, W. N. (Soc) USA
Dodderidge, H. H. (P) NGO
Domínguez, F. J. (A) Chile
Donnell, J. C. II (P) USA
Doolittle, C. E. (P) USA
Dorfman, A. (P) United Nations
Douglas, E. (P) USA
Doumenc, M. (A) France
Dove, W. E. (P) USA
Drake, G. L. (A) USA
Dreux, R. (P) France
Driessen, M. G. (P) USA
Duckham, A. N. (P) USA
Duley, F. L. (AP) USA
Dumont, R. (A) France
Dunlap, H. A. (A) USA
Dupré Ceniceros, E. (A) Mexico
Durke, R. C. (P) USA
Durrer, R. (A) Switzerland
Duschek, S. (A) Austria
Dutton, W. L. (P) USA
Duvdevani, M. S. (A) Israel
Dworsky, L. B. (P) USA
Dykes, J. C. (AP) USA

Easter, S. S. (P) FAO
Edelman, C. H. (AP) Netherlands
Edelman, J. (P) USA
Edge, Mrs. C. N. (P) USA
Edwards, J. D. (P) USA
Edwards, K. J. (P) USA
Egloff, G. (AP) USA
Eichelberger, C. (P) USA
Eide, E. (A) Norway
Eklund, B. (A) Sweden
El Banna, A. M. (P) Egypt
Elder, J. L. (AP) USA
Eliassen, A. (P) Norway
Ellinger, G. A. (P) USA
Elliott, I. L. (AP) New Zealand
Ellsworth, R. S. (P) USA
El Saby, M. K. (A) Egypt
El Samny, A. El Sayed (P) Egypt
Empey, W. A. (A) Australia
Entrican, A. R. (A) New Zealand
Eoyang, T. T. (P) China
Eren, F. (P) Turkey
Erlanson, C. O. (P) USA
Errera, J. (P) Belgium
Erselcuk, M. (P) USA
Evans, U. R. (A) UK
Eysvoogel, W. F. (AP) Netherlands

Fabregat, E. R. (P) Uruguay
Falkum, E. (P) Norway
Falla, R. A. (A) New Zealand
Faragher, W. F. (P) USA
Farden, R. (A) France
Fathy, A. A. (P) Egypt
Faye, J. (A) France
Fearnley, J. T. (P) UK
Feiss, J. W. (P) USA
Felber, V. (A) Austria
Felicissimo, J., Jr. (P) Brazil
Fell, G. B. (P) USA
Fentress, C. (P) USA
Fernández, Ramona (AP) Cuba
Festenessi, J. J. I. (A) Argentina
Fick, N. C. (P) USA
Fieldner, A. C. (AP) USA
Fies, M. H. (A) USA
Filipovic, J. (A) Yugoslavia
Fink, O. E. (P) USA
Finney, R. J. (P) USA
Fisher, H. D. (P) Canada

Fisher, J. L. (P) USA
Fion, H. (P) France
Fong, C. T. (A) China
Foote, P. D. (P) USA
Fornerod, M. F. (P) Switzerland
Forsling, C. L. (AP) USA
Fortunescu, R. C. (P) FAO
Fosberg, F. R. (P) USA
Foster, A. O. (AP) USA
Fournier, L'Abbé O. (P) Canada
Fracker, S. B. USA
Francis, C. (P) USA
Francke, Mrs. L. J. (Soc) USA
Frankel, O. H. (A) New Zealand
Franz, H. (A) Austria
Fraser, T. (A) USA
Freeman, Mrs. H. G. (NGO)
Freudenthal, A. M. (P) Israel
Frey, C. N. (Soc) USA
Friedrich, W. G. (P) USA
Frigon, R. A. (P) Canada
Friry, P. (P) France
Frolow, V. (A) France
Frost, H. S. (A) India
Frost, S. L. (P) USA
Fuchss, W. F. (P) Switzerland
Furon, R. (A) France

Gabbard, L. P. (P) USA
Gabrielson, I. N. (AP) USA
Galavis S., F. A. (P) Venezuela
Galichon, J. (P) France
Galley, R. A. E. (AP) UK
Galtsoff, P. S. (P) USA
Garbosky, A. J. (A) Argentina
García Quintero, A. (P) Mexico
Garnsey, M. E. (P) USA
Garrett, G. A. (P) USA
Gates, R. M. (P) USA
Gazonnaud, P. (A) France
Geijer, P. (A) Sweden
Georges, M. (A) France
Gerhardsen, G. M. (A) FAO
Gester, C. G. (P) USA
Ghosh, Sir Jnan C. (P) India
Gibboney, C. N. (P) USA
Gibbons, Rev. W. J. (Soc) USA
Gibrat, M. (A) France
Giguet, R. (A) France
Gille, A. (AP) UNESCO
Giroux, C. H. (P) USA
Goldschmidt, A. E. (P) USA
Gondelles A., R. (P) Venezuela
González Molina, M. (P) Venezuela
Goodrich, C. (P) USA
Gorman, W. A. (P) USA
Gorrie, R. M. (A) Pakistan
Gouilly-Frossard, M. (A) France
Gouin, L. (A) France
Goulden, C. H. (AP) Canada
Graham, E. H. (AP) USA
Graham, M. (AP) UK
Grandstaff, J. O. (AP) USA
Grange, L. I. (A) New Zealand
Gray, A. (A) USA
Gray, G. J. (P) USA
Greaves, C. (P) Canada
Green, H. H. (A) UK
Greene, H. (P) FAO
Grimmett, R. E. R. (A) New Zealand
Grizzard, A. L. (Soc) USA
Gross, F. J. (P) Brazil
Grounds, A. (A) UK
Grzywienski, A. (A) Austria
Gualtieri, R. (A) Italy
Guillaume, M. (AP) France
Guillou, R. (A) USA
Gunness, R. C. (P) USA
Gutermuth, C. R. (Soc) USA
Guthrie, Boyd (P) USA
Guy, D. J. (Soc) USA

Hacking, Sir John (A) UK
Haegglund, E. (A) Sweden
Hahman, W. F. (P) USA
Hainsworth, R. O. (P) USA
Hale, J. D. (AP) Canada
Hall, J. A. (AP) USA
Hals, A. O. (AP) Norway
Hamid, Khan B. M. A. (AP) Pakistan
Hamilton, W. J., Jr. (P) USA
Hamlin E. C. (P) USA
Hammond, J. (AP) UK
Hannum, E. C. (P) USA
Hansen, A. K. A. (P) Denmark
Hardy, E. A. (AP) Canada
Hardy, F. (AP) UK
Harkom, J. F. (A) Canada
Harrison, J. D. B. (AP) FAO
Harroy, J. P. (AP) Belgium
Hart, G. H. (AP) USA
Hart, J. L. (A) Canada
Hart, M. L. 't (A) Netherlands
Hartley, Sir Harold (P) UK
Hathaway, G. A. (P) USA
Havinga, B. (A) Netherlands
Hawkins, L. A. (P) USA
Hazzard, A. S. (P) USA
Heacox, C. E. (P) USA
Head, J. L. (P) USA
Heald, K. C. (P) USA
Hebley, H. F. (AP) USA
Hefford, A. E. (A) New Zealand
Heim, R. (P) France
Heisig, C. P. (P) USA
Hellinga, F. (A) Netherlands
Hendrix, J. W. (A) USA
Henry, J. (A) Belgium
Herington, G. N. (A) UK
Heritage, C. C. (AP) USA
Herschman, H. (P) USA
Hess, E. (A) Switzerland
Hewett, D. F. (P) USA
Hey, D. (A) Union of South Africa
Hibben, T. E. (P) USA
Hicks, D. (A) UK
Higazy, R. A. (P) Egypt
Hilbert, G. E. (AP) USA
Hill, G. E. (P) WHO
Hitchcock, C. B. (Soc) USA
Hiyama, G. (A) Japan
Hman, U. (A) Burma
Hockensmith, R. D. (P) USA
Hodgins, S. R. N. (P) Canada
Hoffmaster, P. J. (P) USA
Hofstede, A. E. (A) Indonesia
Hogg, C. C. (P) USA
Holler, H. D. (P) USA
Holman, H. E. (P) USA
Holmgren, J. P. (A) Norway
Holroyd, R. (A) UK
Holzer, W. F. (AP) USA
Homes, M. V. (A) Belgium
Hora, S. L. (AP) India
Horning, W. H. (P) USA
Hos, G. C. D. (A) Netherlands
Hotchkiss, W. O. (P) USA
Howard, L. B. (AP) USA
Howard, R. J. (P) USA
Hubbert, M. K. (P) USA
Huberty, M. R. (AP) USA
Hudson, P. S. (P) FAO
Hukill, W. V. (A) USA
Hunter, L. N. (P) USA
Huntsman, A. G. (A) Canada
Husain, I. (A) Pakistan
Hasanain, S. Z. (A) Pakistan
Hutcheon, N. B. (A) Canada
Hutchins, L. M. (AP) USA

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Institute of Plant Breeding (A) Netherlands
Intermountain Forest and Range Experiment Station (A) USA
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Ion, D. C. (P) UK
Irmay, M. S. (AP) Israel

Jackson, P. (A) UK
Jacob, K. D. (AP) USA
Jacqué, L. (AP) France
Jacquiot, C. (A) France
James, M. C. (P) USA
Jansa, O.V. E. (A) Sweden
Jeffries, Z. (P) USA
Jelacin, I. (AP) Yugoslavia
Jensen, O. (A) Norway
Jensen, P. F. (P) Denmark
Jensen, S. T. (AP) Denmark
Job, T. J. (A) India
Johnson, C. S. (P) USA
Johnson, L. W. (NGO)
Johnson, R. T. (P) USA
Johnson, S. E. (A) USA
Johnson, V. W. (AP) USA
Johnston, S. S. (AP) USA
Johnston, W. D. (P) USA
Jolain, R. (AP) France
Jollès, P. (P) Switzerland
Jolley, H. R. (P) USA
Jones, E. E. (P) UK

Jones, L. A. (AP) USA
Jony, E. (P) USA
Jordan, P. H. (P) USA
Josephson, H. R. (P) USA
Jovovic, N. (A) Yugoslavia
Joyce, T. B. (P) USA
Juda, W. (P) Israel
Jurion, F. (A) Belgium
Jůva, K. (A) Czechoslovakia

Kabraji, K. J. (A) Pakistan
Kalinski, A. (AP) Greece
Kampmeier, R. A. (P) USA
Karpov, A. V. (P) USA
Kask, J. L. (P) FAO
Kastmark, C. F. (A) Sweden
Kathpalia, K. N. (P) India
Keen, B. A. (A) UK
Keenleyside, H. L. (AP) Canada
Kefford, J. F. (A) Australia
Keiling, J. (A) France
Kelkar, D. G. (P) India
Keller, W. (AP) USA
Kelley, R. B. (A) Australia
Kellogg, C. E. (AP) USA
Kelly, F. C., Jr. (Soc) USA
Kelly, S. F. (P) USA
Kemler, E. N. (AP) USA
Kemp, L. C., Jr. (P) USA
Kennedy, F. (A) UK
Kerkham, R. K. (A) UK
Kerr, G. M. (P) USA
Kerr, P. F. (Soc) (NGO)
Khan, M. H. (A) Pakistan
Khosla, A. N. (A) India
King, A. (P) UK
King, C. D. B. (P) Liberia
Knipling, E. F. (AP) USA
Knudsen, A. F. (P) Denmark
Köhler, R. (A) Austria
Korringa, P. (A) Netherlands
Kotok, E. I. (P) USA
Krishna, S. (A) India
Krishnan, M. S. (AP) India
Krueger, M. (AP) USA
Krug, J. A. (P) USA
Krupinski, B. (A) Poland
Ksemsri, M. C. A. (P) Thailand
Kuntschen, M. F. (A) Switzerland
Kyi, U. (P) Burma

Lamoureux, V. B. (P) USA
Landa, S. (A) Czechoslovakia
Lane, E. W. (AP) USA
Langford-Smith, T. (A) Australia
Lant, F. C. (A) UK
La Que, F. L. (AP) USA
Laskowski, T. (A) Poland
Lathrop, E. C. (P) USA
Latorre, E. (P) Colombia
Lawrence, H. M. (Soc) USA
Lawton, F. L. (P) Canada
Leahey, A. (AP) Canada
Leaming, M. P. (P) USA
Lebeau, R. (P) Belgium
LeClerg, E. L. (P) USA
Le Cornec, M. (A) France
Lee, G. W. (AP) UK
Lees, G. M. (A) UK
LeGall, J. J. (A) France
Legendre, A. (A) France
Legget, R. F. (A) Canada
Leggette, R. M. (P) USA
Lehmann, R. G. (P) France
Leitch, Isabella (AP) UK
Leloup, M. (A) FAO
Leopold, A. S. (AP) USA
Lernhardt, Alfred (A) Austria
Le-Roy G., M. J. (P) Cuba
Lester-Smith, W. C. (A) UK
Le Van, J. H. (P) USA
Levèque, L. R. (P) Haiti
Levorsen, A. I. (AP) USA
Levy, E. B. (A) New Zealand
Levy, W. J. (P) USA
Lewis, A. B. (AP) FAO
Lewis, R. D. (A) USA
Lhérisson, Camille (A) Haiti
Libert, O. J. (P) USA
Lietz, W. T. (P) Netherlands
Lin, S. Y. (A) Hong Kong
Lindemann, H. J. (AP) Norway
Lineweaver, G. W. (P) USA
Lincoln, F. C. (P) USA
Littlejohn, L. J. S. (A) UK
Lobell, M. J. (A) Chile
Locke, E. G. (A) USA
Løddesøl, A. (A) Norway
López, C. G. (P) Ecuador
López Videla, J. (P) Bolivia
Louis, P.-F. (A) France
Loveridge, E. W. (AP) USA
Lowry, H. H. (P) USA
Lowson, H. (P) UK
Lozada, F. R. (P) Philippines
Lund, J. T. (P) IBRD
Lundberg, H. T. F. (AP) Canada
Lundin, E. H. (AP) Sweden
Luongo, N. A. (P) USA
Lush, J. L. (A) USA

MacArthur, Kathleen (NGO)
MacDonald, D. L. (P) USA
Macdonald, J. (P) UK
Macfarlane, W. A. (P) UK
MacKenzie, G. L. (P) Canada
Mackley, F. (AP) UK
MacMillan, H. G. (P) SOPACOM
MacStoker, F. J. (Soc) USA
Madrid, C. (P) Colombia
Mahalanobis, P. C. (AP) India
Maitland, V. K. (AP) UK
Malina, F. J. (P) UNESCO
Malmström, T. V. (P) Sweden
Mann, R. H. (AP) USA
Manwaring, H. L. (P) USA
Marchant, L. R. (NGO)
Marsh, R. E. (AP) USA
Marshall, J. H. (P) USA
Martin, G. W. (Soc) USA
Mascia, L. (P) Italy
Massé, P. (A) France
Masson, D. R. (P) Union of South Africa
Maštovský, O. (A) Czechoslovakia
Matern, B. (A) Sweden
Matson, E. E. (A) USA
Matter, J. (A) France
Matthews, A. F. (P) USA
Maynard, L. A. (A) USA
McClellan, L. N. (AP) USA
McCormack, A. V. (AP) USA
McCulloch, W. C. (P) USA
McIntosh, D. C. (A) Canada
McKinney, A. W. (P) USA
McLaughlin, D. H. (AP) USA
McLaughlin, G. E. (P) USA
McLintock, W. F. P. (AP) UK
McMorris, W. L., Jr. (AP) USA
McNally, J. A. (AP) Canada
McPhail, H. F. (P) USA
McPhee, H. C. (P) USA
Meehean, O. L. (AP) USA
Menhinick, H. K. (P) USA
Merrill, C. (AP) USA
Merriman, D. (P) USA
Messines, J. (A) France
Meyer, A. J., Jr. (P) Lebanon
Meyer, H. A. (P) Switzerland
Meyerhoff, H. A. (AP) USA
Meyer-Peter, E. (A) Switzerland
Michaud, H. H. (P) USA
Middleton, A. D. (A) UK
Miège, E. (A) French Union
Migaux, L. (A) France
Miller, A. E. (P) USA
Miller, H. J. (A) UK
Miller, H. M., Jr. (Soc) USA
Miller, O. M. (Soc) USA
Les Mines domaniales de Potasse d'Alsace (A) France
Minett, F. C. (A) Pakistan
Ministerio de Agricultura y Cría (A) Venezuela
Ministry of Agriculture (A) Argentina
Ministerio de Fomento (A) Venezuela
Ministry of National Economy (A) Argentina
Ministry of Water Economics (A) Yugoslavia
Monge M., C. (P) Peru
Monod, Th. (AP) French Union
Monture, G. C. (P) Canada
Moomaw, I. W. (NGO)
Moore, R. E. (P) USA
Moore, W. C. (A) UK
Morales, J. J. (P) Nicaragua
Moreno, A. (AP) Cuba
Morgan, J. D., Jr. (P) USA
Morris, J. S. (P) USA
Morris, R. H. (P) USA
Morris, S. B. (P) USA
Morrison, F. B. (AP) USA

Moursi, A. A. (P) Egypt
Muir, A. (AP) UK
Mukherjee, J. N. (AP) India
Mulcahy, B. P. (P) USA
Munns, E. N. (AP) USA
Murie, O. J. (Soc) USA
Murray, W. J., Jr. (AP) USA
Muskat, M. (AP) USA
Myint, U A. (P) Burma

Nair, K. R. (A) India
Narayanamurti, D. (A) India
Needham, L. W. (A) UK
Nelson, S. B. (P) USA
Nelson, W. R. (P) USA
Newman, L. L. (AP) USA
Nielsen, J. P. (P) USA
Nielson, R. D. (P) USA
Nighman, C. E. (P) USA
Nilsson, G. (A) Sweden
Nilsson-Leissner, G. (A) Sweden
Norberg, C. R. (P) USA
Nordengren, S. (A) Sweden
Notevarp, O. (A) Norway
Nutter, H. P. (NGO)
O'Dwyer, W. (P) USA
Ogg, Sir William G. (AP) UK
Olds, L. (AP) USA
Olivé, R. E. A. (P) Cuba
Olivieri, F. M. (P) Venezuela
Olsen, C. J. (P) USA
Oppedal, M. (P) Norway
Opsomer, J. E. (A) Belgium
Orellano A., Ricardo (AP) Venezuela
Orozco M., M. (AP) Guatemala
Orpen, Mrs. J. H. (P) Union of South Africa
Orpen, J. H. (P) Union of South Africa
Orr, J. L. (AP) Canada
Ortiz Méndez, J. (P) Colombia
Osborn, F. (AP) USA
Osborne, J. G. (AP) USA
Oy, E. (A) Norway

Packard, F. M. (P) USA
Pacheco, R. (P) Bolivia
Padilla G., G. (P) Venezuela
Pagot, J. R. (A) France
Paige, S. (P) USA
Pal, B. P. (A) India
Pandit, Madame V. L. (P) India
Papa Blanco, F. F. (P) Uruguay
Papanicolaou, D. (AP) Greece
Papi Gil, A. (A) Nicaragua
Parham, B. E. V. (P) SOPACOM
Parker, F. W. (P) USA
Parker, J. C. (AP) USA
Parkinson, D. (P) USA
Parks, Mercer (AP) USA
Parsons, A. B. (P) USA
Partain, L. E. (P) USA
Pask, V. A. (P) UK
Paulsen, C. G. (AP) USA
Pavari, A. (A) Italy
Pavlovic, S. (AP) Yugoslavia
Peace, T. R. (A) UK
Peck, R. P. (P) USA
Pehrson, E. W. (AP) USA
Pendleton, R. L. (A) USA
Pérard, J. (A) France
Perlman, S. D. (P) USA
Peter, H. W. (P) USA
Peterson, L. E. (Soc) USA
Pfeffer, A. (A) Czechoslovakia
Phelan, V. C. (AP) ILO
Phillips, P. L. (P) USA
Phillips, R. W. (A) FAO
Picard, F. (AP) France
Picton, W. L. (P) USA
Pinchot, Mrs. G. (P) USA
Pinochet, R. (P) Chile
Pirnia, H. (A) Iran
Pizarro, G. (P) Chile
Pohl, L. L. (P) France
Potter, C. E. (P) USA
Potter, C. J. (P) USA
Pough, F. H. (P) USA
Pough, R. (P) USA
Poulin, J. A. (P) USA
Pourbaix, M. (AP) Belgium
Power, E. A. (AP) USA
Prashad, B. (A) India
Pratt, E. A. (P) USA
Prego, A. J. (A) Argentina
Price, M. P. (P) UK
Price, R. C. (P) USA
Pritchard, A. L. (P) Canada
Pritchard, D. W. (P) USA

Quevedo, C. V. (A) Argentina

Rabanal, H. R. (A) Philippines
Raeside, J. D. (P) New Zealand
Raggatt, H. G. (A) Australia
Rajagopalaswamy, K. (AP) India
Ralston, O. (A) USA
Randall, R. H. (A) USA
Raney, E. C. (Soc) USA
Ranganathan, C. R. (A) India
Ranghel, A. G. (AP) Colombia
Rao, H. S. (A) India
Rasmussen, D. I. (AP) USA
Ratineau, J. (P) France
Raushenbush, S. (AP) USA
Ravanzo, R. R. (P) Philippines
Raver, P. J. (AP) USA
Ray, J. N. (A) India
Raychandhuri, S. P. (A) India
Reay, G. A. (A) UK
Recknagel, A. B. (P) USA
Regan, M. M. (P) USA
Reichelderfer, F. W. (P) USA
Reifenberg, A. (P) Israel
Renner, F. G. (AP) USA
Rennerfelt, E. (A) Sweden
Renou, J. (A) France
Rettaliata, J. T, (P) USA
Revelle, R. R. D. (P) USA
Reyna Drouet, R. (P) Ecuador
Rhoad, A. O. (AP) Costa Rica
Riaz, A. G. (A) Pakistan
Richards, B. D. (A) UK
Richards, S. H. (P) UK
Richardson, N. A. (A) UK
Riches, N. (NGO)
Richter, S. (P) Sweden
Riddell, J. O. (A) New Zealand
Ridgeway, G. L. (NGO)
Ringers, J. A. (P) Netherlands
Ripley, P. O. (A) Canada
Ripley, S. D. (P) USA
Rison, S. (P) UK
Ritchie, A. T. A. (A) UK
Ritchie, F. G. (P) USA
Robb, W. (A) UK
Roberts, G., Jr. (P) USA
Robinson, A. (A) UK
Robinson, J. F. (P) USA
Robinson, Lord (P) UK
Rockwell, F. G. (P) USA
Rodríguez, F. C. (AP) Philippines
Rodríguez Aguilar, M. (P) Mexico
Rodríguez Arias, J. C. (P) Argentina
Rodríguez G., J. N. (P) Colombia
Rodríguez L., A. (A) Mexico
Rodríguez Z., M. (A) Chile
Roelse, H. V. (P) USA
Rogers, H. T. (P) USA
Rollefsen, G. (A) Norway
Romero, S. A. (P) Venezuela
Rose, H. J. (P) USA
Rottensten, K. (A) Denmark
Rounce, N. V. (A) UK
Rousseau, J. (P) Canada
Rousselier, M. (A) France
Rowan, A. H. (P) USA
Rowse, R. H. (A) UK
Roxbee Cox, H. (A) UK
Roy, S. N. (P) India
Ruebhausen, Mrs. Z. P. (NGO)
Rusck, A. (A) Sweden
Russenholt, E. S. (P) Canada

Sabatier, J. (A) France
Sachanen, A. N. (P) USA
Said, R. (P) Egypt
Sain, K. (P) India
Saint-Guilhem, R. (A) France
Salatin, F. (P) Chile
Salim, P. B. A. (A) Pakistan
Salkind, V. (P) Israel
Sallenave, P. (A) France
Salnikov, I. (AP) USA
Salter, R. M. (AP) USA
Sam, Eleen (P) UNESCO
Sampson, A. W. (AP) USA
Samuel, L. (P) Israel
Sanguinetti, R. (P) Uruguay
Santa Cruz, H. (P) Chile
Santa Rosa, J. (A) Brazil
Saraoja, E. K. (A) Finland
Sattar, A. (A) Pakistan
Saucedo Carillo, F. (P) Mexico
Saurino, B. (P) USA

Saville, T. (P) USA
Sawyer, C. (P) USA
Scarseth, G. D. (Soc) USA
Schaefer, Mrs. M. C. (NGO)
Schaefer, V. J. (AP) USA
Schaeffer, L. (A) France
Schang, P. (A) France
Schjanberg, E. (A) Sweden
Schmidt, W. A. (AP) USA
Schneider, J. (P) Chile
Scholle, S. (P) USA
Schoonmaker, W. J. (Soc) USA
Schroeder, W. C. (AP) USA
Schurter, W. (A) Switzerland
Schwebel, S. C (NGO)
Schwendeman, J. R. (NGO)
Scott, G. M. (NGO)
Sears, P. D. (A) New Zealand
Seele, K. C. (P) USA
Seely, H. E. (AP) Canada
Seidenfaden, G. (P) Denmark
Sen, A. T. (A) India
Sequens, J. (A) Czechoslovakia
Sethi, D. R. (A) India
Setinek, Karel (A) Czechoslovakia
Setzer, J. (A) Brazil
Sevian, V. J. (AP) Iraq
Shafei, M. Z. (P) Egypt
Shanklin, J. F. (P) USA
Shannon, R. S. (P) USA
Shaw, A. C. (P) USA
Shaw. C. (NGO)
Sheinerman, S. (P) Israel
Shelton, B. (AP) USA
Shelubsky, M. (A) Israel
Sherman, A. (AP) Liberia
Shewhart, W. A. (AP) USA
Shiah, C. D. (P) China
Shoemaker, J. H. (P) USA
Show, S. B. (AP) FAO
Siddiqi, R. H. (A) Pakistan
Silkett, R. J. (P) USA
Simaika, Y. M. (A) Egypt
Simmons, F. C. (AP) USA
Simonpietri, A. C. (P) USA
Skinner, C. (P) USA
Smetana, J. (A) Czechoslovakia
Smith, F. G. W. (P) USA
Smith, J. T. (AP) USA
Snelgrove, A. K. (P) USA
Snider, R. G. (P) USA
Snyder, R. (P) USA
Society for the Preservation of Windmills in the Netherlands (A) Netherlands
Sömme, S. (A) Norway
Son Sann (P) French Union
Soper, J. D. (A) Canada
Sörensen, E. (AP) Denmark
Souyannayong (P) French Union
Spaic, Ivan (A) Yugoslavia
Speedie, M. G. (A) Australia
Speh, C. F. (P) USA
Spiegler, K. (A) Israel
Sporn, P. (AP) USA
Spurr, S. H. (AP) USA
Stableforth, A. W. (A) UK
Stafford, H. M. (AP) USA
Stage, H. H. (P) USA
Stakman, E. C. (AP) USA
Stamm, A. J. (AP) USA
Stamp, L. D. (AP) UK
Stanley, O. G. (AP) USA
Stead, W. H. (P) USA
Steel, E. W. (A) Venezuela
Steidle, E. (P) USA
Stevenson, L. T. (Soc) USA
Stewarts & Lloyds Ltd. (A) UK
Stigzelius, H. (P) Finland
Stolz, G. (NGO)
Stong, B. J. (Soc) USA
Storie, R. E. (P) USA
Straub, L. G. (AP) USA
Straus, M. W. (AP) USA
Strome, I. R. (P) Canada
Strong, T. H. (A) Australia
Suh, Kwang J. (P) Korea
Sullivan, J. (AP) USA
Suman, J. (P) USA
Sutherland, B. P. (A) Canada
Sutton, H. (AP) UK
Sveistrup, P. P. (P) Denmark
Swanson, C. L. W. (P) USA
Swanson, C. O. (A) Canada
Swanson, G. (AP) USA
Swick, L. J. (P) USA
Sylvain, P. G. (A) Haiti
Szyfres, B. (P) Uruguay

Tabares, R. E. (P) Cuba
Takayama, S. (A) Japan
Tallarico, L. A. (A) Argentina
Tamesis, F. (A) Philippines
Taning, A. V. (A) Denmark
Tannous, A. (P) USA
Tarr, H. L. A. (A) Canada
Tasker, C. (P) USA
Taton, A. (A) Belgium
Taylor, E. L. (A) UK
Taylor, H. F. (P) USA
Technical Agricultural Service (A) Netherlands
Teed, P. L. (A) UK
Telkes, Dr. Maria (AP) USA
Tempany, Sir Harold A. (A) UK
Tester, A. L. (A) USA
Tha, Po (P) Burma
Thaysen, A. C. (A) UK
Theodorides, Ph. (P) Greece
Thiery, R. R. (P) Argentina
Thistle, M. W. (A) Canada
Thomas, P. H. (AP) USA
Thompson, H. (A) Australia
Thomson, A. P. (A) New Zealand
Thorn, J. (P) United Nations
Thornthwaite, C. W. (P) USA
Tigershchiöld, M. (A) Sweden
Timmons, J. F. (P) USA
Tofani, B. J. (P) . USA
Tolly, H. R. (P) FAO
Torrey, P. D. (A) USA
Truitt, R. V. (P) USA
Tukker, J. G. (A) Netherlands
Tunstell, G. (P) Canada
Turk, K. L. (P) USA
Turnbull, R. F. (A) Australia
Turner, A. W. (AP) USA

Uhlig, H. H. (AP) USA
Urbain, A. (A) France
Uren, L. C. (P) USA
Uribe Arango, H. (P) Colombia
Utah Agricultural Experiment Station (A) USA
Utz, E. J. (AP) USA
Uytenbogaart, J. W. H. (AP) Netherlands

Valdeyron, M. (A) Tunisia
Valdez P., J. (P) Bolivia
Van Beukering, J. A. (A) Netherlands
Van Blommestein, W. J. (P) Indonesia
Vance, B. F. (P) USA
Vandeveer, W. W. (P) USA
Van Graan, H. (P) Union of South Africa
Van Rysselberghe, P. (A) Belgium
Van Straelen, V. (A) Belgium
Vargas Vaglio, O. (P) Costa Rica
Varlet, H. (A) France
Vaugh, M. (A) India
Vaughan-Jones, T. G. C. (A) UK
Velander, E. (P) Sweden
Vergara, R. (AP) Chile
Verlot, J. B. (P) France
Vernon, W. H. J. (A) UK
Viaud, M. C. (AP) El Salvador
Virtanen, A. I. (A) Finland
Visentini, M. (A) Italy
Vital, M. N. (A) Switzerland
Vogel, G. H. (P) USA
Vogt, W. (P) USA
Von Bonde, C. (A) Union of South Africa
Voskuil, W. H. (P) USA

Wadia, D. N. (A) India
Wagar, J. V. K. (AP) USA
Wah, Thein (P) Burma
Walford, L. A. (P) USA
Wanaraks, P. A. (A) Thailand
Wangaard, F. F. (P) USA
Ware, T. M. (AP) USA
Warne, W. E. (P) USA
Warren, G. I. (P) USA
Wasson, T. (P) USA
Wästlund, G. (A) Sweden
Water, R. R. (A) UK
Waterer, R. R. (A) UK
Wathen, A. L. (P) USA
Watts, L. F. (P) USA
Weaver, F. L. (P) USA
Weaver, P. (P) USA
Weber, E. W. (P) USA
Weeks, L. G. (P) USA
Wegelius, T. H. P. (P) Finland

Wei, H. R. (P) China
Weissmann, E. (AP) United Nations
Weitzell, E. C. (P) USA
Welch, F. J. (P) USA
Wennström, M. (A) Sweden
Weston, J. C. (A) UK
Westwood, R. W. (Soc) USA
Wetmore, A. (P) USA
Weymark, W. J. (P) Canada
Wheeler, R. A. (P) IBRD
Whipple, C. E. (P) USA
Whitaker, J. R. (P) USA
White, G. F. (AP) USA
White, R. G. (A) UK
Wickard, C. R. (P) USA
Will, R. R. (P) USA
Williams, C. (AP) USA
Williams, F. A. (A) UK
Wilson, H. H. (A) UK
Wilson, M. L. (P) USA
Wilson, R. N. (P) USA
Wing, S. P. (P) USA
Wirth, C. L. (AP) USA
Witteveen, C. J. (A) Netherlands
Wolman, A. (AP) USA
Wood, R. F. (A) UK
Woodford, T. V. D. (AP) USA
Woodward, F. N. (AP) UK
Wooten, H. H. (AP) USA
Wormser, F. E. (P) USA
Worthing, Marion W. (P) USA
Worthington, E. B. (A) UK
Woulbroun, J. (P) Belgium
Wrather, W. E. (AP) USA
Wright, Alice M. (Soc) USA
Wright, S. J. (A) UK
Wylie, N. V. K. (P) Canada

Yancey, H. F. (AP) USA
Yates, F. (A) UK
Yellott, J. I. (A) USA
Young, G. H. (P) USA

Zahniser, H. (P) USA
Zárate B., H. (P) Bolivia
Zavadil, J. (A) Czechoslovakia
Zayed, A. (P) Egypt
Zouain, M. (P) Lebanon
Zuckerman, S. (P) UK

PROCEEDINGS OF THE PLENARY MEETINGS

Introductory And Welcoming Addresses

Wednesday Morning, 17 August 1949

Chairmen:

Trygve LIE, Secretary-General of the United Nations

Antoine GOLDET, Secretary-General of the Conference, Director of the Department of Economic Affairs, United Nations

Addresses:

William O'DWYER, Mayor of the City of New York

Detlev BRONK, Chairman, National Research Council, U. S. A.

Julius A. KRUG, Secretary of the Interior, United States of America

The CHAIRMAN (Mr. Lie): It gives me great pleasure to open the Scientific Conference on the Conservation and Utilization of Resources and to extend a welcome to you.

Lake Success plays daily host to the conferences and meetings of the United Nations. But these are more often meetings of the diplomatic representatives of the Member nations than of expert groups concerned with specialized subjects. Never before have these halls housed the discussions of such a large and diversified assembly of specialists as are gathered here today.

This is the first time the United Nations has called directly on the world of science to come together. On a number of occasions, the specialized agencies of the United Nations have convened meetings of scientists to assist in their important work. But this Conference, which cuts across the fields of interest of several specialized agencies, is necessarily the responsibility of the United Nations. I am happy to say that the specialized agencies have rendered invaluable aid in planning and convening the Conference—especially the Food and Agriculture Organization, which is responsible for the work on such a large part of the Conference agenda.

The United Nations has come a long way since this Conference was first proposed three years ago by the President of the United States. The decision of the Economic and Social Council to call the Conference was made in 1947. At that time, the date of the Conference was tentatively set for two years ahead. I am told that when an official in one of the troubled capitals of the world was informed of this tentative decision, he observed that this was the most optimistic thing he had heard about the United Nations in several months. I think it is a tribute to the functioning of the United Nations since then, that no one today would feel any surprise if we were to announce our intention to hold a conference of any sort in 1951. Despite all difficulties, the United Nations has proved itself an effective force for peace, and is here to stay.

Today the United Nations is embarking on a new phase of its programme to build the foundations for permanent peace. It is calling on science to mobilize technical knowledge in support of one of the high purposes of the Charter—to raise the standards of living. This is one of the keys to peace. For behind most wars stand the spectres of hunger and want—effective warmongers of the past. Solutions to these problems, though not so spectacular as those in the political field, are of vital importance to world peace.

Floods, crop failures and droughts know no frontiers. Their effect cuts across national boundary lines. No country has a monopoly of the techniques in the sound use and conservation of natural resources, and both industrial and non-industrial countries can profit from the techniques developed in different parts of the world. That, in part, is why you have come here.

Together you hold the technical keys which can unlock new wealth from the earth for the benefit of mankind. You know that underlying all economic shortages is the basic problem of how to develop and, in developing, how to conserve the earth's resources. All of you have something to teach, and something to learn, about specific ways and means of solving these resource problems.

Your work here will represent a first step by the United Nations to mobilize all of science in support of a co-ordinated world-wide effort that will contribute to effective action on these questions.

We all remember how many Members of the United Nations achieved miracles of production in the heat of the last war. If we could really put science and technology to fuller use in peace as we did in war, I believe that no one could predict the world population which our resources could support, or the rise in the average standard of living that would be possible.

You are aware of the steps that are being taken by the United Nations and its specialized agencies towards developing a greatly expanded programme of technical assistance to the under-developed areas of the world. The exchange of technical information that will take place here will provide invaluable assistance in planning the implementation of this programme.

Dramatic evidence of the interdependence of resources is given in such integrated developments as that of the Tennessee Valley Authority in the United States. I am happy to learn that the United States Government will give the participants from other countries an opportunity to see the TVA at work following the Conference.

Such programmes can bring beneficial results not only in terms of higher living standards but in their contributions to stability and peace. In my annual report to the General Assembly on the work of the Organization, I have, for these reasons, suggested that high priority in the programme of technical assistance be given to development of the Valleys of the Tigris, the Euphrates and the Jordan, and the further development of the Valley of the Nile, as steps to stability and peaceful economic and social progress for the whole area of the Middle East.

There are many other types of technical projects of a specific nature that do not involve such heavy capital investment as these river-valley projects, but which can contribute greatly to human betterment.

Science and technology promise to open new horizons in the future. Under the greatest co-ordinated attack of scientists yet mustered, the atom has relinquished the secret of the largest potential source of energy yet discovered by man. We know that today, on the frontiers of science, experiments are going forward which might yield equally impressive results. I know that you will have much to tell us.

Scientific progress and economic development are not ends in themselves; they are means to a better and richer life for mankind, in which human rights and fundamental freedoms can more readily be observed and respected everywhere.

If you, from the world of science, can set the sights for humanity high enough, the governments and their peoples will be encouraged in their search for solutions to the difficult problems which they face. I welcome you all to the meetings here at Lake Success.

Our next speaker has on many occasions shown warm friendship for and active interest in the United Nations. As Mayor of the City of New York, he has given invaluable assistance to me and my staff in connexion with the planning of the permanent headquarters of the United Nations in Manhattan, in providing us with facilities for the General Assembly sessions at Flushing, and in dealing with the difficult housing problems of my staff. Before that, he arranged everything in connexion with the use of Hunter College; he helped us to find

Lake Success; I do not know of a single question in connexion with the City of New York and the neighbourhood and the United Nations, on which he has not assisted us and advised us wisely. I cannot over-estimate the value of his collaboration. He is a genuine friend of the United Nations, and it gives me great personal pleasure to introduce the Honourable William O'Dwyer, Mayor of the City of New York.

Mr. O'Dwyer: Mr. Secretary-General, Mr. Secretary Krug and distinguished gathering of this Conference: It is a signal privilege and an honour for me to welcome you to our City for this United Nations Scientific Conference on the Conservation and Utilization of Resources.

I am aware that I am here before the men and women of my generation who are distinguished in the most important sense that a member of mankind may be distinguished. You are that small group of this generation—pitifully small in every age—who see with utter clarity the problem before which all other problems fade away: the problem of man's survival in this universe. You are that handful, untainted by the suicidal follies of our species, who see that nature's plentifulness is a heritage not to be squandered with impunity, that it must be conserved for future generations or its bankruptcy will extinguish us all. You are that handful of practical men and women in a world of ambitious dreamers who see what new horizons of abundance and respite from toil are possible for men, if they but use the intelligence and diligence and resourcefulness of which man is capable.

No one can say that your work is made easy for you. In few places are you the honoured prophets. There are few places in the world today where your counsel and your warning have not cut across some passion or prejudice, some sloth or fear. In such an irrational atmosphere, the conservationist has had to work in obscurity and has had to develop special attributes of tenacity and patience to save men from themselves.

We are all citizens of a planet, and the planet will not endure pillaging forever. Many are the signs pointing to us that the indulgence of Mother Nature is past. The disaster of the last war was a cataclysm of rending force. By the light of that conflagration, we saw the immense strides made in science and technology in the modern world. We also saw the depletion and impoverishment of vast areas and the lowering of living standards. The conquest of space, the discovery of vast new resources of power, the immense ingenuity of our scientists and the sheer massing of all this power for destructiveness have shrunk the size of this planet and have shaken the individual man out of his indifference.

I should like to see inscribed in one of the buildings of the United Nations in our City, in letters of permanent stone, for generations to read, these two sentences from your own programme:

"This store of scientific and practical knowledge is itself one of the world's great resources. It is a resource that grows with use and is enlarged by sharing."

I regard this—and many will regard this—as a full blueprint of a truer civilization.

Today, men are in a mood of grace. For the first time, thinkingly and soberly, they are ready to take up their account with nature. You are the accountants who are preparing the balance sheet. The accounting may prove shocking to some; others may quarrel with the bill; still others may threaten to fight. But in the long run, and in the highest interest of mankind, the account must be squared.

I believe that this old human race—sometimes so stupid and sometimes so inspired, sometimes so vile and yet sometimes so noble—must and will summon up the intelligence and the fortitude and the grace to make an honest accounting and bail itself out of oblivion. Just as figures are universal, so do you, men and women of good will, speak a universal language. You speak the language of every man's heart's desire—for security and for abundance. You speak of the just reward of labour and of labour with a purpose. You speak of a better world for generations to come.

Mr. Secretary-General, Secretary Krug, and all the ladies and gentlemen of this Conference, for the eight million people of New York City, I welcome you and from our hearts we wish you the greatest success in this Conference.

The Chairman (Mr. Lie): Thank you, Mayor O'Dwyer.

The next speaker is here to welcome the participants in this Conference on behalf of American science. He is himself a distinguished scientist who served during the war in the organization which co-ordinated the efforts of the United States scientists in contributing to victory. Today, he is the President of Johns Hopkins University and also serves as Chairman of the National Research Council, which co-ordinates research in natural science under the United States Government.

I take pleasure in introducing Dr. Detlev Bronk.

Mr. Bronk: Mr. Secretary-General, Secretary Krug, Mayor O'Dwyer, and members of this distinguished Conference, I take a special pleasure in bringing greetings to you from your scientific colleagues of the United States, through the agency of the National Research Council of this country.

Our nation was formed by the union of peoples from many nations. Our country was developed by the use of scientific knowledge discovered by the scientists of many other lands. Now, at a time when the only frontiers which remain are the limitless frontiers of knowledge, American scientists recognize a duty and privilege to participate in the development and protection of the natural resources of the world, for the benefit of peoples everywhere. To do so is but to follow the age-old tradition of international co-operation among scientists.

National boundaries are meaningless in the study of natural phenomena. The properties of inorganic matter and living organisms are little affected by the limits of States. Natural phenomena, observed anywhere, must be fitted into a consistent pattern of universal validity. This is the basis for the world-wide unity of science.

To be a nationalist in science is to handicap one's own accomplishments. The course of new discoveries starts from the territory of established knowledge. The genesis of new ideas is catalysed by the work and thoughts of others who are free to speak.

Recognizing this, scientists were among the first to realize the practical dependence of their work upon the efforts of those in distant lands. Together with the traders for rare goods, scientists have sought intellectual products and new discoveries, wherever they were to be found. Expressive of this desire to share in the work of others is that admirable phrase so often used by scientists, "My foreign colleague", with all its wholesome implications. The desire for international co-operation derives from no unique nobility of spirit, but comes rather from the simple realization of the advantages to be gained from the free exchange of ideas. If scientists are better prepared for the acceptance of the principles of world unity, it is because they have longer realized the benefits that come from such co-operation.

There is a further circumstance which shapes the international attitudes of the scientist. When he considers the social usefulness of his accomplishments, he cannot but realize that he is truly a citizen of the world. A new chemical agent for the treatment of disease is of potential benefit to all men. The laws of genetics, discovered by Mendel, have made possible increased food supplies for all countries. The observations of Galileo, Copernicus and Newton have widened the intellectual horizon of no one national group. And so the scientists cannot fail to realize that the furtherance of scientific research in any free country increases the material resources of all nations. To further scientific investigation is a common responsibility and a common advantage.

As a scientist and as an American I like to recall that the first American international statesman was also a scientist who recognized these international values of science. Even under the duress of war between the United States and Great Britain in 1779, Benjamin Franklin had the courage and the wisdom to address this directive to the commanders of all armed ships acting under commission from our Congress. "Gentlemen", he wrote, "a ship has been fitted out from England to make discoveries in unknown seas under the conduct of that most celebrated navigator and discoverer, Captain Cook. This an undertaking truly laudable in itself, because the increase of geographical knowledge facilitates the communication between distant nations and the exchange of useful products and manufactures, extends the arts, and science of other kinds is increased to the benefit of mankind in general. This, then, is to recommend to you that should the said ship fall into your hands, you would not consider her an enemy, nor suffer any plunder to be made of the effects contained in her, nor obstruct her safe return to England." Would that more recognized that the furtherance of science can contribute to the benefit and advantage of mankind everywhere.

Today the traditional freedom for scientific research and intellectual inquiry is threatened by the greed of nations and by fears engendered by international tensions. Accordingly, it is fortunate that scientists should have the assistance of the United Nations in gathering them together to consider the relations of the peoples of the world to the world in which they live. It is a function appropriate to a world organization, for the knowledge of nature and of natural forces which determines those relationships is the proper possession of all people without regard to nationality. Widely separated areas of the world are interrelated by a unity of natural laws and forces more important to the welfare of peoples than the unnatural laws and forces which separate them into nations.

It is appropriate, directly and by analogy, that the world organization devoted to the elimination of conflict between man and man should sponsor this Conference, for the conservation and wise utilization of resources requires the elimination of conflict between man and nature. Both crusades depend upon a reaffirmation of human values. Stimulated by the rapid growth of physical science, we have thought too much of man's supposed conquest of nature, too little of man's place in the pattern of nature. Man's welfare and survival demand appreciation of his biological needs, and better understanding of the means whereby he can be adapted more effectively to the environment of which he is a part.

If we are thus to solve the problems of the present and secure a better future, we must now and without delay give more thought to the role of man among the hosts of plant and animal life which populate the world.

If we are to shape a more satisfying life for men and women, the time has come to create a biotechnic civilization, proclaimed by Lewis Mumford, in which flesh and blood will be no less real than concrete and steel and the material products of science.

I vividly recall an experience during the general conference of the UNESCO in Mexico City two years ago. While sitting in a telegraph office there, surrounded by the marvels of modern scientific communication, I became aware of an old Aztec Indian lady standing in the doorway viewing these instruments of science. As I left I saw the Aztec Indian lady in her tattered clothing standing at the curb looking at a large limousine. Convinced that she was envious of that which others had but she did not possess, I was moved to press alms upon her. To my surprise and pleasure she returned the alms with a warm smile, and, pointing at the UNESCO badge, said in broken English, "Science will give us all we need and all that we desire."

I left with renewed chagrin that fear for the future should characterize our age in which scientific knowledge and undiminished intellectual curiosity should make possible undreamed of progress towards a better life. I could not escape a sense of shame that so few enjoy the benefits of science in a world of unbalanced material cultures. I could not resist determination to preach to fellow-scientists our obligation to consider more the influence of science upon the relations of men to men and of men to nature.

It would be folly not to recognize that the pressures of growing populations and the transformation of the materials of nature into scientifically created products to satisfy the increased wants of man for war and peace are rapidly depleting the world's resources. But we would lack reasonable faith in the powers of science if we did not believe that scientific research and the wise use of scientific knowledge can discover and create new resources for the needs of man and better conserve them for his future use.

If nations seek satisfaction and survival by pillaging nature and sister nations, catastrophe for all the human race lies ahead. But nations can, through science, peacefully gain those material benefits which they have sought in vain to acquire through armed conflict. For this to be achieved there must be a more intimate partnership between scientists and those who deal with the motives and the relationships of peoples.

Knowledge of man and nature is our greatest resource. Science provides the building stones of a better world, but the world will be as men choose to make it.

American scientists gladly share the task of creating onditions throughout the world which will better satisfy ie needs of men.

The Chairman (Mr. Lie): It gives me great pleasre now to introduce Mr. Julius A. Krug, Secretary f the Interior of the United States Government. He ; a distinguished engineer who has worked on projects uch as the Tennessee Valley Authority. During the 'ar, Secretary Krug was Chairman of the War Produc-on Board. He has, therefore, had direct and personal xperience in the productive use of natural resources nd in their administration. As Secretary of the In-erior, Mr. Krug has direct responsibility for admin-istration in many fields of science which will be covered y this Conference. Secretary Krug has played a lead-ig part in the planning of this Conference.

Mr. Krug: On behalf of President Truman and the Inited States delegation, I take great pleasure in wel-oming you to this historic Conference. The good that iis group can do is, in my opinion, practically un-mited. The President looks at this meeting as an rganization of effective forces for progress and for eace. He has asked me to express his appreciation or the fact that the United Nations has accepted his iggestion and called you together for world service. The people of the world will pay close attention to our deliberations here, and I think that they will arn much from you. Two years ago, in suggesting iis Conference, President Truman expressed the hope iat international science could itself become a great iternational resource. There should be freedom of ccess to that resource for all. You are engaged in iaking that hope a reality.

I need hardly say that the world expects much of ou. The men who can save the eroding soil, the dying lants, the disease-ridden cattle and crops, and provide iore food and better food, are clearly among the most seful members of the human race.

You represent far more than the ability and effort of ie human race to cope with the natural and man-made ilamities that impede our growth and progress. Few roblems of resource conservation, as you all know, can e worked out by any one specialist alone. They require ie joint efforts of many for their solution. The "know-ow" you have perfected—including the knowledge of ow to work together—is an essential part of the wis-om we need in building a co-operating world.

More immediately, the peoples of the world want elp in turning their best dreams into reality. There is emand everywhere for a fair chance to share in the pportunities which the world's scientists have opened p. People in the remotest hills and deserts have limpsed the possibility of shifting some of their entury-old back-breaking labour over to the machines. They are formulating the goals of a higher standard of ving, of better education for their children, of a life iat contains some leisure, pleasure and promise.

None of us should underrate the force of this great opular longing. It is one of the major facts of this entury. It crosses national boundaries. It pervades roups in all communities. It is dynamic. It pushes rganizations and governments into action.

This Conference is meeting to deal with concrete facts id new ideas. You are bringing together outstanding pecialists in many resource fields to exchange knowledge and share wisdom in a common cause. That cause is the improvement of man's standard of living, particularly in the under-developed areas of the world, through the protection and wise use of man's common heritage of natural wealth, wherever it may be.

This is no selfish purpose. It is a step along the road of freeing millions of people from the grinding burden of toil and hardship. It is a step in the direction of using the world's resources for the benefit of all its people. It is a great stride towards international teamwork on a high plane of knowledge and skill. I think that you are participating in one of the greatest adventures of the human will and mind in this century.

When President Truman suggested that the Economic and Social Council should hold this meeting in this country he was aiming at the very heart of the problem of world peace. Real conservation can remove economic pressures and fears of scarcity which have always played a large part in bringing on wars. Conservation touches not only the ability of people to live well; it touches their ability to live at all. Conservation and wise development of our resources would help ensure world peace.

The world is interested in everything you do which stimulates the economic progress of large areas that have been by-passed in the world's industrial growth. The President of this country has indicated to you his great hopes in this regard. He intends, when programmes are ready, to obtain substantial help for those areas, both in technology and in investments. They need help, and the entire world will benefit if they receive it.

I am glad that so many scientists are attending this meeting, for they provide the foundation for the work of the administrators. Science must be independent if it is to be fully effective. It must not be controlled by politics. In the field of conservation the administrator's task is to apply the utmost of scientific knowledge as effectively as available human resources permit.

Perhaps the problem can best be summarized in mathematical form. Resources plus technical and scientific skill plus capital investment equal economic development. And it is such development which supports the good living that every child born on this globe is entitled to have.

As the Secretary-General pointed out, most of my experience has been in resource development, first in the Tennessee Valley Authority, then in the War Production Board, and now in the United States Department of the Interior. As an administrator applying current scientific knowledge to the solution of conservation problems, I have encountered certain general guides to sound programmes of resource development and conservation.

First, I think, natural resources are interrelated and must be developed and conserved together for maximum benefit. It is a folly and waste to build flood control dams without at the same time doing the soil and forest conservation to slow up the rainy season runoff and to prevent the reservoirs from filling with silt. It is not conservation or wise utilization to build such flood control dams without also developing the hydro-electric power, the irrigation and the navigation which are possible. In water control developments, frequently the integrated whole shows much greater benefits than the sum of its parts.

Likewise, it is not sound conservation to concentrate research and development on metals and materials in short supply when possibilities exist on every side to find and develop substitute materials which are available in abundance. It is not sound to extract a primary product without giving careful consideration to byproducts which can be derived from the same basic raw materials.

We must not become so specialized that we lose sight of the real objective, which is not the extensive development of any one food or any one material, but rather the development of a great combination of materials of every quality and characteristic to serve as a firm foundation for our future standard of living.

Second, faster economic progress and greater social values are obtained from the combined development of industry and resources during the same period than in the usual pattern where there is no such co-ordinated development.

This is a matter of proper timing. Roads, harbours, power plants and other public improvements will not pay for themselves until industry is ready to utilize them. The opening up of a new area requires demonstration of the new opportunities and advantages to industry and agriculture so that businessmen and farmers will have their projects ready to go as soon as the basic developments are ready. I think that ten dollars of development in one year are frequently worth twenty or thirty scattered over ten years.

Third, in any competitive society the responsibility for careful resource development and use should bear equally on the individual owners of natural resources. Those resources are the basis for the strength, the growth, the very future of every nation and people. The private owners have many rights, of course. But, if free governments are to survive, individual citizens cannot have the right as private owners of essential resources to imperil the future of the nation by short-sighted practices in developing these resources.

No individual has the right to damage his fellow citizens by reckless and wasteful use of these resources. For example, as you all know, overgrazing the range and clear-cutting the forests can dump floods on people down stream, silt up vital reservoirs, pollute the streams and endanger future supplies of food and fibre. Until we come to the place where we recognize the real damage of such acts to the property and lives of others and find a practical way to prevent them, it is useless to talk about full conservation in our competitive society.

Fourth, in regions where economic development is at a standstill or has never even started, it takes a vigorous push, and frequently from the outside, to get any substantial development under way.

The Tennessee Valley in this country, for example, had seen fairly good times for many decades; but the time came when, after years of exporting its coal, lumber and raw materials, its smart young men went elsewhere to find opportunities, and the people of the Valley could not get enough money from further exploitation of their depleted resources to purchase even the essentials of a decent standard of living. On its own, the region could not have raised the hundreds of millions of dollars needed to build dams to check the devastating floods, supply low-cost electric power, or produce fertilizers to revitalize their exhausted soil. The Federal Government had to do that. With this help, however, the people of the region made an all-out effort to re-establish their prosperity, and I am proud to say that the successful results have been the focus of attention of thinking people the world over.

The under-developed regions of the world are not alone to blame for their predicament. Yes, they are poor because they have no industry and only primitive agriculture. And yes, they have perhaps no industry and only primitive agriculture because they are poor. We all know that. But nobody can ask them to lift themselves by their own bootstraps. They need help from outside—understanding, technology and investments. The vicious circle of no capital and no development must and can be broken.

Fifth, there can be no major economic development without an institutional climate that aids it.

That climate, I think, includes many things. It includes people who know how to repair and operate trucks, tractors, pumps and other equipment. There must be technicians like yourselves who can make the learning of the industrial world available. There must also be a trained professional group which can adapt new techniques to local circumstances. There must be men trained in business management. There must also be people trained in public responsibility and able to put the general interest above immediate profit opportunities.

There must, however, also be a general understanding that wealth is created only by increasing production. There must be a similar understanding that no real economic progress can be achieved on a high-cost small-sales basis.

There must be investment and, in most countries, some of it in the form of risk capital. Those who use the capital must understand their responsibility towards the lenders, whether the investment be private or public. There must be an equal acceptance of responsibility on the part of those who lend. They must know that no great economic progress can be started with high interest rates and excessive profits Of course, low-cost credit is essential for all conservation work.

Perhaps most important of all in a favourable institutional climate is a feeling of confidence, which must be shared by most of the people, that the country is on the right track, that progress is being made and that no revolutionary changes which greatly affect the rights and equities of the people are in prospect. All worthwhile resource improvements take time, and no one can be expected to initiate them without a reasonable feeling of security for the future.

Without a favourable economic and political climate there can be little success in resource development. It will be a difficult task to help under-developed nations to create that climate.

Sixth, it is essential to know the extent of our resources, and preliminary inventories must be subject to continuous revaluation to keep them up to date.

I certainly regret that it was necessary to postpone such an inventory of world resources so that none is available for this Conference. We shall have to go ahead for some time more or less blindly, without knowing what materials are available in the world. I hope that the United Nations will give leadership to this project in its member countries, as certainly all of them vill want to know more and more about what is on op of their soil, what is under their soil, and the power otential of their streams and rivers.

Seventh, progress of the under-developed areas will nevitably bring them and all of us far more closely ogether. Interdependence follows industrialization. I hould like to take time to elaborate that point, but I am ure it will come up during this Conference.

With these seven observations on conservation and evelopment, I hope we have an introduction to the ubject of this afternoon's plenary meeting on "The Vorld Resources Situation".

I am sure I express general agreement when I say hat we all have great confidence in our scientists. We hall, in plain truth, have to rely on them heavily if the vorld's resources are to stretch over its increasing opulation.

In this country, we have gone through many decades f waste of our natural wealth through selfish exploi- ation, premised on the old-time formula that a dollar n one's pocket today is worth an infinity of dollars in omeone else's pocket a century from now—or for that natter, I think, even tomorrow.

In recent years, there has been a tremendous move- nent in the direction of real conservation. This move- nent has been led for the most part by men and women who do not possess any particular technical or engineer- ng competence, but who have spoken up courageously o halt the short-sighted policies of the interests which n past decades have had most of our scientists and ngineers in their employ.

This movement has been spearheaded by government eaders since the days of Theodore Roosevelt—and for he most part, I might say, regardless of political llegiance. These efforts, however, have been largely egative in the sense that they have dramatized the vaste and damage which have resulted from exploita- ion, and they have stressed the need for conserving our atural wealth, without putting forth constructive ideas s to how we should find the wherewithal to satisfy our ver-increasing needs for the fuels, energy, materials nd foods which are the basis of a sound standard of ving.

I think it is time that we start a new era in conserva- ion, an era consecrated to the development and wise se of what is available to the people of the world. There is not the slightest question in my mind that cientists and engineers can find and develop food, uels and materials to meet the demands of the world's ncreasing population, with a greatly improved standard f living. I do not side with those who "view with larm" the increasing world population and the decreas- ng reserves of some things which now appear to be ssential to our way of living. But, to meet these very erious problems, we must start in time, and I think this Conference is a great start.

Certainly the greatest problem facing the world today s that of raising the standard of living of the people— ot just maintaining it. This objective cannot be ac- omplished by locking up our natural wealth. It can e accomplished, and steady future progress can be ssured, by the intensive concentration of the world's cientific and engineering "know-how" on the basic roblem of making the most of what we have. You all know dozens of examples of the opportunities for using this "know-how". To mention just a few, I would list:

1. The peace-time application of atomic energy.
2. More effective utilization of solar energy.
3. Development of synthetic fuels, particularly from oil shales.
4. Development of substitute materials for those in short supply. For example, aluminium, magnesium and glass can be produced in almost limitless quantities. With improved technology, they can be substituted for many uses of steel, copper and lead, which many people feel at some future date will be in short supply.
5. Improved agricultural methods, including the development of new plants which will require less water and less nutrition from the soil and will absorb more energy from the sun, and better ways of checking soil erosion and restoring soil productivity.
6. Increased use of sea water for the growth of food fishes and other food materials, for extracting chemicals and minerals, and for conversion to fresh water for irrigation and industrial purposes.
7. Improved utilization of metals and other materials to eliminate the waste presently experienced, particularly in the construction of homes and office buildings and consumers' durable goods, such as automobiles.
8. Development of hydro-electric power to conserve oil, gas and coal.
9. Development of improved uses of foods and feeds for human and animal consumption.
10. Further development of improved space-heating in cold weather and cooling methods in warm weather.

These are just a few of the ideas for raising the world's living standards which deserve the attention of this Conference.

Your work here will begin to tell us what can and should happen in this world. It is possible that the destruction of the last war will be wiped out in the memory of men by scientific progress and service in these peaceful, constructive fields. When the historian of the year 2000 looks back over the twentieth century, he may find that the soil and plant and forest scientists, the fuel, power and mineral experts, and the resource economists made up a team that helped save the world's resource base when it was in great danger. And he may say that these groups crowded two hundred and fifty years of industrial progress into fifty years and raised the living standards of the whole under-developed world beyond anything known in history. He may say that the United Nations gained confidence, unity and power in the process. I hope so. With high ability, good will, good faith and co-operation, it is possible.

The CHAIRMAN (Mr. Lie): I thank you, Secretary Krug, for your fine and instructive speech. I think everyone joins me in asking you to take with you to Washington our best thanks to the Government of the United States for all that it has done for the United Nations—and a special greeting and our warmest thanks to President Truman for his interest, his initiative and his steady support of this Conference which is now taking place at Lake Success.

I wish now to turn the meeting over to Mr. Antoine Goldet, Principal Director of the Department of Economic Affairs, who will serve as Acting Secretary-General of this Conference. I regret to announce that

Mr. David Owen, Assistant Secretary-General in charge of the Department of Economic Affairs is ill and cannot be present during the early days of the Conference. Mr. Goldet will outline the plans for your work.

Mr. Goldet took the Chair.

The CHAIRMAN (Mr. Goldet):[a] I am replacing Mr. David Owen, who has been detained in Europe for health reasons. Before saying a few words on our work, I wish to give you a message which I have just received from Mr. Owen. He wishes me to express to Secretary Krug, Mayor O'Dwyer and Professor Bronk, as well as to all those who are taking part in this Conference, his regrets at not being able to be with us at the opening meeting. He also wishes me to give you his best wishes for the success of your work.

Mr. Bronk has just addressed himself to his scientific colleagues. It is to those colleagues that I wish to speak. I spent perhaps the happiest years of my life doing scientific research and I am very glad to find myself twenty-five years later collaborating, through international economic administration, in a scientific and technical undertaking so full of promise.

Professor Bronk has emphasized the unity and the international character of human effort and heritage. He invites us to even greater human fellowship. It is that great enthusiasm for human fellowship which should inspire us and which is expressed in the United Nations Charter.

By conserving our resources we show fellowship towards the men of the future; in their use we show fellowship towards the less-favoured man of the present day.

I am happy that Secretary Krug emphasized how conscious his government was of that fundamental question.

I know that sceptics have doubts regarding the effectiveness of our work and think that high standards of living cannot be attained because populations are increasing with ever-growing rapidity. I shall reply to those men of little faith that up to the present the results obtained by science and techniques have given rise to the hope that the disciples of Malthus will be put to confusion. Even should our endeavours prove long and arduous, it is by redoubling them, and not by sowing doubt in people's hearts, that we shall be able to overcome our difficulties; certainly after the generous and enthusiastic plans outlined by Secretary Krug, such doubts could hardly take root.

The technical principles by which we were guided in organizing this Conference are set out in the introduction to the programme before you, and I will not, after the speeches you have heard, repeat them. I would like, however, to characterize the Conference in one word. I would call it the preface to that programme of technical assistance which resulted from what is called President Truman's Point Four.

That programme of technical assistance has just been drawn up in Geneva by the Economic and Social Council which completed its work on Monday. It will be submitted for the approval of the General Assembly next month.

The first fellowship holders under the first section of the programme of technical assistance are now with us at Lake Success. They have been invited to follow your work, and that is one more material link between this Conference and the wider programme of technical assistance now being developed.

These men come from different countries and seek to broaden their knowledge here; for, out of the programme of technical assistance already outlined, new questions are already arising. Chief among them is the training of the necessary technicians to carry out the broad programmes which are contemplated. It is to this programme of utilization of human resources, if I dare call it so, that we shall soon have to give priority. Mayor O'Dwyer, as you have heard, very happily reminded you of this essential aspect of the problem.

In conclusion I would say that, although we are studying here the purely material side of human progress, that is not an end in itself for us, and we should not lose sight of the other objectives laid down by the Charter, which proclaimed the dignity and worth of human personality. The increase of material resources is not the essential aim of our work. Here I am only emphasizing what Mr. Trygve Lie said to you at the beginning of this meeting and what other speakers have also pointed out; it is precisely because we wish to reach higher cultural levels in all fields that we are so anxious to raise the material standards of living. Only when we have reached the indispensable minimum standard of living can we hope to develop culture and the things of the spirit, and it is with the conviction that, by our present work, we are contributing to human progress in its fullest sense, that I invite you to begin that work today.

The first plenary meeting will be held this afternoon at 4 p.m. under the chairmanship of Mr. Bhatnagar.

I am at your service with my other colleagues on the Conference Secretariat, Professor Carter Goodrich and Mr. Van Tassel, whose constant efforts were an essential factor in drawing up the programme for this Conference and whom I should now like to thank on behalf of the Secretariat. Together with the members of the Committee who will follow the work of the different sections, I will try to solve any difficulties you may encounter and on which you may request my assistance.

The Hospitality Committee, of which Mr. Francis is Chairman, has made magnificent efforts to help you to profit from your stay in the United States, over and above your meetings here. Provision has been made for a certain number of field trips during and after the Conference. They will enable you to study methods of conserving and utilizing certain resources in practice.

Thanks to the American Citizens' Committee you will be able to visit the principal undertakings in the New York region which have been divided into groups according to the main sections of your programme.

For those of you who can remain another week after the end of the Conference, the United States Government has prepared an extended field trip from 6 to 1[illegible] September. A special train will take you to Pittsburgh (Pennsylvania), Columbus (Ohio), and across the Tennessee Valley with which, as you know, Secretary Krug is identified, and finally to Beltsville (Washington, D.C.), where you will see the greatest centre for agronomic studies in the eastern section of the United States.

[a] Mr. Goldet spoke in French.

On your behalf I should like to thank all the members of the Committee, of which Mr. Francis is Chairman, who have contributed so much to make this Conference, as I hope it will be, still more interesting, instructive and agreeable.

For those of you who have not yet been told, I should like to add in conclusion that we would like you to register in Conference Room 9, if possible before this afternoon's meeting. There will be an office there where delegates will be able to find the documents they need together with their participants' cards and any materials which may facilitate their work here. Thank you, gentlemen, the meeting is adjourned.

[redacted]

QUESTION

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Review of the Rates of

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ent of India, Department

Foundation, New York,

Colin G. CLARK, Director, [illegible], and Under-Secretary of State, Department of Labour and Industry, Brisbane, Queensland, Australia

Discussion:

Messrs. VAN TASSEL, KELLOGG

Programme Director:

Carter GOODRICH

Programme Officer:

Alfred J. VAN TASSEL

The CHAIRMAN: Before we call upon our invited speakers, I want to call on the Executive Secretary of the Conference, Mr. Van Tassel, who will explain to us the facilities for simultaneous interpretation and other arrangements which have been made for the Conference participants.

MR. VAN TASSEL: Before the meeting begins, I wish to explain a number of the technical arrangements for the Conference. The simultaneous interpretation apparatus, as some of you already know, is started by lifting the switch; you can then get the appropriate language by turning to a number on the dial. No. 1 gives you the original voice of the speaker; No. 2 gives you the English language; No. 3 French; and No. 5 Spanish. At plenary meetings there will be a simultaneous interpretation of the remarks of speakers in those languages.

I trust that you have all had a chance to register and I would like to call your attention particularly in the information booklet to the material concerning transportation to and from Lake Success. Buses for participants leave from five points in New York City, which are listed on the first page in the information booklet.

I should also like to call the attention of authors and others who wish to partake in the discussions at meetings to the information on the Conference organization and methods, and particularly the information on programme officers, which will be found further along in the booklet.

I have been asked to give a little more extended announcement concerning the programme of field trips which is being arranged in connexion with the Conference. These trips have been planned primarily in order that participants from abroad may study industrial and governmental projects and methods of conservation and utilization of resources in the eastern region of the United States. The American Citizens Committee which is composed of private citizens of the United States, is sponsoring a series of local field trips during the Conference. These trips will include visits to major industrial firms in the New York City area and cover the six main resource sections of the Conference.

The United States Government is sponsoring a post-Conference field trip which will begin on 6 September, the last day of the Conference and end on 12 September. A special train will take members of this field trip to Pittsburgh (Pennsylvania), Columbus (Ohio), the Tennessee Valley Authority area, Washington, and Beltsville (Maryland), and then return to New York City. Each of the six days will be spent in observing and studying projects located in the vicinity of the above-mentioned cities or areas. Each of you, upon registering for the Conference, has received printed information regarding the local trips and the post-Conference field trip; additional information may be obtained at the Field Trip Registration Desk, which is located in Conference Room 8. It is requested that all persons wishing to attend these trips register as soon as possible in order that appropriate plans may be made for them. Thank you very much Dr. Bhatnagar.

The CHAIRMAN: I am deeply sensible of the honour which the United Nations has conferred on my country by choosing me to preside over this plenary meeting on the very first day of the Conference. I wish to assure you that since the advent of freedom in India, science has made progress in our country. The portfolio of scientific research is now held by the Prime Minister himself; this indicates the desires of the peoples of India that science should get attention in our country.

I do not know whether scientific knowledge is to be classed as a finished product or as a raw material. In any case, it differs from ordinary materials inasmuch as it is never exhausted. The more it is used, the more it grows, and in its proper utilization is hidden the mystery of world's future progress. The United Nations has performed a great scientific work in convening this Conference. The lack of raw materials and poverty are prime causes of war and if they can be eliminated, peace and prosperity are more likely to reign supreme. There is a saying in our national language, that nobody can be good unless he has the goods. These goods may be in the shape of raw material, finished products or scientific knowledge. No scientist worth his name will take the view that raw materials and finished products alone are the things that count. They are not considered by him to be superior to scientific knowledge. A happy combination of the three should really be aimed at.

We have in our midst today Mr. Fairfield Osborn who is a well-known figure in the world of science. He is President of the New York Zoological Society; he is also President of the Conservation Foundation and author of a book entitled *Our Plundered Planet*. It was published only last year but has already been translated into eight languages and very soon we will have a translation of it in Hindustani. He will speak on the "World Resources Situation." I now have great pleasure in requesting Mr. Fairfield Osborn to deliver his address.

Mr. OSBORN *delivered the following paper:*

The World Resources Situation

FAIRFIELD OSBORN

This world meeting on resources is a sign of the evolution of human society. A century ago, even a half century ago, such a meeting would have been impossible. Slowly but surely the shackles of selfish nationalism are dissolving. Nations are commencing to sense, with new and piercing clarity, that their well-being is influenced by conditions in countries on the opposite side of the earth. In this chaotic period of the emergence of human society to new levels of international co-operation, the stubborn barriers of prejudice, of ingrained cultures, even of recently adopted ideologies, give way—though slowly!

Representatives of governments in international meetings are, in too many instances, still clinging to the political manoeuverings of times that should be forgotten. Such approaches to the solution of world problems will inevitably become outmoded as it becomes more and more evident that causes must first be dealt with rather than effects. In the main these causes are tangible and material. At their core lies the question of the adequacy of resources.

With the slow though steady growth of understanding between peoples far distant from one another it is becoming evident that all nations share certain basic problems, and that these problems can best be resolved by co-operative impulse, rather than by the impulse of rivalry. Actually the continuance of any nation's existence, as well as the favourable development of civilization as a whole, depends upon the resolution of these common problems. Admittedly there are several of the highest importance towards the solution of which human society must strive. Among them, for example, are: Better education, including the diminishment of illiteracy; the improvement of methods of communication between peoples of different countries and races in order to create understanding—the well-spring of world peace; the encouragement of a better appreciation of the practical value of ethics on a personal, community or national scale, and others of an intellectual or ethical nature. While having in mind all such goals for international co-operation, no one will deny that the primary need, upon which all human welfare and advancement depend, is adequacy of natural resources, whether organic for the support of life itself, or organic and inorganic for the support of a world economy from which all nations derive benefit. In effect, this conference is undoubtedly dealing with the basic problem that faces our civilization. Every one of the countries represented here will be profoundly affected by the manner in which this problem is attacked and eventually resolved.

It may be remarked here that the earth's resources are unimportant *in themselves.* The question is how they are used, and how they are distributed. While we may be meeting here as *technologists,* we are actually *explorers* for the processes that contribute to human happiness. In other words, resources are merely the agents or media by which human society may reach social and ethical maturity. The political climate of a country, a continent or of our world as a whole, is dependent primarily upon our discovering processes that lead to a balanced relationship between human demands and the earth's productivity. No adequate analysis of history has been made that will allow us to follow or accurately interpret the relationship of resource-use with the advances or recessions of past civilizations. It can only be observed that the decline, even the dissolution of once splendid nations, have frequently been correlated with the exhaustion of the productivity of lands and of other natural resources. It is certainly no exaggeration to say that the future of mankind will depend upon the degree to which natural resources can continue to be available.

Despite the growing evidences of co-operation between nations, it is unlikely that this world meeting would be taking place, even now, were it not for conditions of obvious and increasing seriousness. While it is true that the struggle for food is age-old, and the difficulty of obtaining adequate resources for needs other than subsistence has existed throughout history, the solution has been found in the past principally through exploitation of new regions, even new continents. These exist no longer.

Within the last century startling developments of a worldwide nature have taken place. These changes have been so rapid, in some cases so violent, that adjustments to them, socially as well as materially, have barely kept pace. Unquestionably the greatest factor of change is the explosive upsurge in population in virtually all countries resulting in a doubling of the world population within the last century, or an increase of more than a thousand million people. Further, population increases are continuing, with the prospect, barring some cataclysm, of 3,000 million or more people at the end of the century—only five decades from today. One result has been that the habitable and cultivable regions of the earth are now largely occupied, leaving certain tropical regions and arctic regions as the last remaining frontiers.

This doubling of the earth's population in merely four generations has been accompanied, as we are well aware, by an almost fantastic series of inventions which have brought about what may be described as the *second* industrial revolution. The consequence has been that the drain upon the earth's resources has increased not upon a mathematical scale related to population growth, but upon a geometrical scale related to greater numbers of people demanding a greater variety of products from an infinitely more complex industrial system. This demand is still on the upward spiral, and will continue so as we strive for so-called higher standards of living for greater numbers of people. Well may the resource-technologists ask, "How can we do our part?"

One or two examples of the geometrical increase in resource-use will serve our purpose. For instance, iron production since the middle of the 19th century has increased five times as fast as population. Since the year 1880, the production of zinc has increased more than fivefold, and the production of copper has increased more than tenfold. In view of the fact that petroleum is a relatively new commodity, reference to the extraordinary increase in its use is somewhat illogical. However, it is a striking fact that the world production of petroleum in the single year of 1946 was slightly more than one and a half times the total world production during the first forty-three years of petroleum exploitation. In the United States, for example, the production of motor fuels in the year 1918 approximated 80 million barrels; and in the year 1946 exceeded nine times that amount.

I will not endeavour to measure the ultimate outcome of this rapid upward curve of uses of inorganic resources. As is widely recognized, known reserves of ore, which are now commercially extractable, such as copper, lead and zinc, are only sufficient to permit continuance of the present drain upon them within the lifetime of many of us here. The exhaustion of these resources implies major, even drastic changes in the world's economy. One can and should place considerable reliance upon the probability of the discovery of new reserves of non-replaceable resources. Further, in the mineral field, it is logical to place great reliance on the resourcefulness of technologists in creating substitutes, especially for fuel. In fact, the trend of scientific accomplishment is such that one is inclined to anticipate developments where the Aladdin's lamp of science will prove capable of resolving difficulties which at the moment appear insurmountable. As far as the adequacy and future use of inorganic resources is concerned, the technologist is our brightest, indeed our principal hope.

We are forced, by their very nature, to make a sharp distinction between mineral resources, which are irreplaceable, and those other so vital resources that are derived from the productivity of the earth, and are therefore renewable. In the "best of all possible worlds" there should be no conservation problem today. The productive capacity of the earth is so great that from a theoretical point of view, which assumes intelligent management, the calamitous shortages recorded throughout history should have been unnecessary and avoidable. One can even dare to make a further statement regarding the present situation, namely, that if correct practices were now being generally applied toward forests, agricultural lands and marine resources, coupled with adequate methods of distribution, the present haunting fears regarding adequacy of food supplies and other organic materials would no longer be justified.

Unfortunately, the causes of our apprehension are not easily removed. Against our will, as it were, we are forced to recognize that throughout most of history mankind's record in the handling of renewable resources has been one of failure. In itself this fact might be of no importance as far as the future is concerned were it not for two consequences: first, the damage, much of it of permanent character, that has been inflicted upon once fertile regions; second, the malpractices of the past are still continuing in many countries, perhaps, one must fearfully admit, in most. Another disconcerting fact is that the failures of the past were not necessarily those of ignorance but continued in the face of contemporary knowledge of their consequences. Who can not be moved by Plato's words, and what modern conservationist will not bow to the correctness of his observations?

"At the period, however, with which we are dealing, when Attica was still intact, what are now her mountains were lofty, soil-clad hills; her so-called shingle plains of the present day were full of rich soil; and her mountains were heavily afforested—a fact of which there are still visible traces. There are mountains in Attica which can now keep nothing but bees, but which were clothed, not so very long ago, with fine trees producing timber suitable for roofing the largest buildings; the roofs hewn from this timber are still in existence. There were also many lofty cultivated trees, while the country produced boundless pasture for cattle. The annual supply of rainfall was not lost, as it is at present, through being allowed to flow over the denuded surface into the sea, but was received by the country, in all its abundance, into her bosom where she stored it in her impervious potter's earth and so was able to discharge the drainage of the heights into the hollows in the form of springs and rivers with an abundant volume and a wide territorial distribution. The shrines that survive to the present day on the sites of extinct water-supplies are evidence for the correctness of my present hypothesis." (Plato, *Critias*).

This statement, made more than 2,000 years ago, might have been written by a modern ecologist. Plato recognized that forests, water supply and fertile soils were related so intimately that they were in truth a unity, not independent elements. Can we in the United States even today claim that our resource practices adequately recognize this cardinal principle? We are forced to admit that they do not.

Through the centuries, in many countries, there have been recurrent efforts to establish wise and adequate agricultural practices including the establishment of methods that would protect forests from over-cutting. In many cases these programmes looking towards the proper use of renewable resources were so soundly conceived that they endured for considerable periods of time. The people of northern Europe undoubtedly benefited from their observations of the desolation of lands around the Mediterranean basin that had been caused by deforestation and erosion. There are many examples that are illustrative of the efforts that were made. In France, in the middle of the 17th century, Colbert observed "France will perish for lack of woods," and with an unbiased and incorruptible Commission passed the forest reforms and ordinances of 1669. This final law was considered a "masterpiece" and lasted into the 19th century. The social upheaval resulting from the revolution of 1789 caused disastrous changes by abolishing Colbert's juridical controls. Under Bonaparte some attempts were made to bring back order but they were only partially successful. In the meanwhile, in Germany as well as in the northern European countries such as Sweden and Norway, sound forestry methods were becoming well established. In all these movements one concept emerged, namely, that the owner of a renewable resource such as forests was not free to exercise his legal rights as an individual but in effect was made to conserve his property for the benefit of the people as a whole. It may be remarked that this concept of trusteeship of basic resources is one that is still only partially recognized in a number of countries, including the United States.

It would be misleading to convey the idea that the above relatively recent examples of strivings toward sound conservation practices were either the first of their kind or otherwise unique. Far back in man's history similar examples can be found, even in ancient civilizations in the Near East as well as in the Orient. In China during the Chow Dynasty that commenced in 1100 B.C. and lasted almost 1,000 years, there prevailed practices for the conservation of land and forests that were in many respects comparable to modern methods. In other instances the relationship of the adequacy of subsistence to population was openly recognized. For instance, the Polynesians met the emergent danger of famine by laws that permitted only two children to one couple. In fact, on certain islands but one child was allowed. Who can say that the question of population pressures is not inextricably interwoven with that of the adequacy of renewable resources?

In considering the problem in the light of historical experience, one is forced to the unhappy conclusion that up to the present time no really satisfactory answer has been found. The failures of the past have not been so much those of lack of knowledge as of lack of its sustained application.

It is true, of course, that modern science has made extraordinary advances. In the matter of mineral resources, the potentialities inherent in scientific development will unquestionably result in the provision of substitutes for many of those resources in which shortages are now threatened. Further, it is evident that new and even revolutionary sources of energy are at hand.

The question of renewable resources is an altogether different one and, indeed, one of more immediate urgency. While science can both activate and supplement the processes of nature, we face the fact that man, despite his almost infinite intellectual and technical powers, cannot create life nor should we assume that he ever will be able to do so. In considering the problem of the adequacy of organic or life-supporting resources, we are dealing with the economy of nature which is in truth life itself. Consequently, we need to recognize that forests, water resources, productive soils and animal life are interrelated and dependent one upon the other. Our conservation practices, generally speaking, do not even begin as yet to be adapted to this cardinal truth. It is evident that the solution of the renewable resource problem demands a new and enlightened approach which will result in the co-ordination of many interrelated techniques.

This world meeting may make a great, perhaps even an epochal contribution to the future of civilization. It will inevitably serve as a correlator of existing knowledges, and that result in itself will prove of large value. The exchanges of opinion that will occur here will of themselves lead to new advances in knowledge. However, the lessons of history demonstrate, with compelling force, that knowledge in itself is transitory, even impotent, unless widely applied and permanently integrated into the every-day point of view of people as a whole. What we are seeking is the acceptance of a clear concept regarding man's relationship to his environment.

In the light of experience, and in these terms, conservation becomes a political and administrative problem, an educational, even a social, cultural and ethical problem. Therefore it is not one with which the scientist or technologist can deal single-handed. Further, conservation, in the sense that it implies the wise use and equitable distribution of the earth's resources, offers a point of synthesis for international co-operation for which the world is waiting. It can be said that the road to plenty and the road to peace are one. Yet at this very hour about half the people on the earth are face to face with want. The alleviation of this want and the misery that goes with it is the principal problem that the resource expert is called upon to resolve. He cannot, however, act alone. This is indeed the critical hour when all the forces in our civilization will be called to action.

The CHAIRMAN: The second speaker is Dr. Colin G. Clark, and I have great pleasure in inviting him to deliver his address on "World Resources and World Population."

Dr. Colin Clark needs no introduction from me as he is an economist with a world-wide reputation. I think the secret of his success as an economist lies in the fact that he had his training as a chemist at the great University of Oxford. Nobody can enter into a variety of useful combinations without having something of chemistry in him. He has for some time lectured at Cambridge University. He is now economic adviser to the Government of Queensland. His fame has travelled far and wide as author of the two books *Conditions of Economic Progress* and *Economics of 1960*. He has made notable contributions to scientific papers on problems of economics and population. It is a pleasure to have him in our midst and I now call on him to deliver his address.

Mr. CLARK *delivered the following paper:*

World Resources and World Population

COLIN CLARK

ABSTRACT[1]

While man has proved himself capable of the most appalling misuse of natural resources under certain circumstances, he has also shown himself capable of scientific improvement of agricultural technique capable of raising the product per man-year at the rate of 1½ per cent per annum. Even in some of the crowded areas of Europe and Asia great increases in agricultural production have been achieved. The world's population is increasing at the rate of 1 per cent per annum and our problem is clearly soluble if we go about it the right way. The world shortage of food is not due to lack of land, but to lack of labour. In almost every country industrialization is taking labour away from agriculture. (The shortage is needlessly accentuated by the action of countries like Australia and Argentina in accelerating industrial development when their agricultural resources are still largely unused). World food prices will have to rise about 70 per cent relative to industrial prices in order to attract sufficient labour back to agriculture to meet the world's demands for an increasing standard of living. Even under favourable circumstances this process will take 20 or 30 years to achieve.

The world rate of population growth has accelerated since 1920. This is entirely a consequence of declining mortality, not of increasing reproductivity. Reproductivity is now falling rapidly in Japan, Russia, India and all countries which have established contact with "western civilization;" while in China, mortality is so high that population appears to be stationary or declining in spite of high reproductivity. The claim that in countries where fertility is high it should be artificially reduced is thus groundless economically; its real origin appears to lie in a feeling of race superiority on the part of Europeans and North Americans which the rest of the world bitterly resents.

[1]The author has directed that certain portions of the text, all of a more or less technical nature, should be omitted in reading or circulating the paper to a general audience. Since they are, however, essential to any demographer or economist who wishes critically to examine the paper, they have been placed as appendixes to which appropriate reference will be made in the text.

"The curves of population and the means of survival have long since crossed. Ever more rapidly they are drawing apart. . . . All possible conservation measures are futile unless human breeding is checked. It is obvious that fifty years hence the world cannot support three billion people at any but coolie standards for most of them." (William Vogt, *Road to Survival*).

"Soil erosion is no longer the menace that it was . . . the application to the whole world of the farming standards that now prevail in the most efficient countries could probably produce a doubling of the food supply . . . before very long the normal state of affairs will return and the supply of food in the world market will show a chronic tendency to outrun the effective demand for it." (*The Economist*, London, 14 May 1949).

It is not often that we have the spectacle of two authorities contradicting each other quite so categorically. It is with some diffidence that I contend, in the paper which follows, that both are wrong, and that the real truth is to be found in neither position. Some encouragement can be drawn from the recollection that there have been other occasions where the seeker after truth has found himself beset by a clamour from both sides. Many of the most dangerous errors do not consist of outright falsehoods, but of statements which, while true in themselves, are exaggerated, taken out of their true context, and followed without the necessary qualifications.

The conservation of soil, forests, stream flows and natural biological equilibria is certainly one of the most important and urgent tasks which faces us today. In this respect Mr. Vogt is undoubtedly right. But the available evidence controverts his contention that the world will never be able to feed 3,000 million (or even a larger) population. He has neglected or played down the possibilities of improvements in the technique of agriculture.

The Economist, on the other hand, overrates these possibilities and neglects the time and effort necessary to bring them about. There is another factor which *The Economist* has not mentioned, which in the long run may be almost as important as improvement in agricultural technique, namely, the transfer of agricultural population by migration from overcrowded to fertile but underpopulated lands. But this will be an even slower and more difficult process.

The general conclusion is that the world will be able to support an increasing population for as far ahead as we can foresee. But it will not be on the basis of the cheap food and glutted markets, which *The Economist* regards almost as a law of nature (a piece of wishful thinking perhaps pardonable in a country so extremely dependent on food imports). The feeding of the world's population will necessarily involve a sharp and sustained rise in the price of farm products relative to the price of industrial goods. The agriculturist who, for the last quarter of a century, has been the "poor relation", supported in many countries by assistance from the public Treasury, must and will become a wealthier, more influential and more respected member of society. The industrial population (which in most countries can well afford to do so) will have to hand over a slightly larger proportion of its total product in exchange for the farm products which it consumes.

Making the best summary of available information, it appears that the world's population has been increasing at the rate of about 1 per cent per annum since 1920, and that this rate of increase is likely to continue to 1970 with perhaps a slight acceleration to a rate of about 1.1 per cent per annum between 1960 and 1970. Beyond that date I have not ventured to prophesy.

There does seem to have been a significant increase in the rate round about 1920. For each decade that we go back into the past the data become more uncertain, but so far as they go they seem to indicate that between 1850 and 1914 the world's population was increasing at the rate of only about ¾ per cent per annum. Between 1914 and 1921 there was very little net increase in the world's population. The military losses in the First World War were estimated at between 9 million[2] and 13 million[3]—less than one year's normal rate of increase of the world's natural rate of increase of population at that time. The "deficit of births" has been estimated by Professors Lorimer and Notestein at 10 million for Russia and 12½ million for Western Europe. But the principal elements in the slowing down of the growth of world population were the influenza epidemic of 1918 which killed 10 million people in India alone, also to the typhus and other epidemics in Eastern Europe, and to the revolution and famine in Russia in 1917-21, which led to a further loss of some 10 million. The true cause of the influenza epidemic is still unknown—the typhus epidemic appears to have been an indirect consequence of the war. In any case, whatever its causes, this temporary slowing down in the rate of growth of world population may have played an important part in bringing about the relative surplus of farm produce in the subsequent two decades.

In the Second World War the deaths of combatants numbered again some 13 million[4] to which must be added non-combatant deaths directly due to the war which have been tentatively estimated by M. Vincent at as high as 18 million (of which 10 million were in Russia, 4.6 million in Poland, and 1.4 million in Jugoslavia). Apparently this war has not been followed by epidemics and famines in the same manner as its predecessor and, even if we accept M. Vincent's figure in full, we get total war losses amounting to 1.3 per cent of the world's population, or only a little over one year's natural increase.

Birth deficits seem to have been on a very much smaller scale than in the First World War, even in Russia and Japan. This war seems to have led to a *postponement*[5] rather than to a permanent deficit of births. This has occurred because throughout the world so many married couples now have decided in advance how many

[2]Professor Landry, *Traité de Démographie.*

[3]Professor Willcox, *Journal of the American Statistical Association,* 1928. The principal difference between the two estimates is for Russia's losses which Professor Willcox based at 5 million and Professor Landry at only 1.7 million. *The Metropolitan Life Insurance Company Bulletin* of January 1946, reviewing these figures, is closer to Professor Landry's figure than to Professor Willcox's.

[4]Generally similar figures are quoted in the League of Nations *Monthly Bulletin of Statistics,* May 1946: *Metropolitan Life Insurance Bulletin,* January 1946: M. Vincent, *Population,* January-March 1947. The principal components were Russia 5.7 million, Germany 3.3 million, Japan 1.5 million, U.S. and Britain 0.3 million each.

[5]In many countries the war led to an acceleration of marriages which normally would not have occurred till later; so even this postponement of births was to a considerable extent counteracted.

children they want, and war postpones rather than prevents their conception: whereas under conditions of 1914, when children were conceived more nearly to the limit of natural capacity, a birth lost during the war could generally not be made up afterwards.

The change in trend which came after 1920 was of course due to increases in the extra-European population. Europe's population, in spite of heavy emigration, was increasing at about 1 per cent *per annum* between 1870 and 1914 (though this average obscures a rather higher rate of increase in Eastern Europe and a rather lower rate of increase in Western Europe). After 1920 the rate of increase slowed down in Europe just as it began to accelerate in Asia, Africa and Latin America.

Nowhere has there been any evidence of increased reproductivity. All the evidence which we have throughout the period shows that reproductivity is either high and stationary, as in comparatively primitive societies, or in the old-established Asiatic civilizations; or else declining with greater or less rapidity in the countries influenced by "western civilization". The whole change in trend after 1920 was due to the diffusion throughout the world of at least the first rudiments of medical science, in countries where mortality had hitherto been extremely high. In some countries of erstwhile high mortality such as Japan and the more-developed areas of Latin America, the reduction of mortality had begun before the 1920's but was accelerated at that time.

Fertility is measured by the factor generally known as "total fertility", i.e., the average size of family when the average is taken over all women, including those who do not marry or who are childless, but excluding those who died before the age of 45.[6] Throughout a great part of the world this figure still stands at the level at which it appears to have stood throughout past ages, namely, somewhere between 6 and 7. This rate still prevails among communities as diverse as the primitive inhabitants of West Africa, the ancient civilizations of China and Arabia, and the dwellers in newly settled areas of Brazil. So far as evidence is available, it appears to be the general rate of reproduction among primitive people everywhere, and in our own not very distant past. It prevailed as recently as the beginning of the present century in Russia and Japan. It is a phenomenon so widespread that we might indeed be entitled to call it the natural rate of reproduction. (I hope the fact that I have a family of seven myself does not prejudice my judgment in this matter).

It should be remembered that in primitive societies, and also in the oriental civilization, virtually all the women are married. The hardships of life (together with a certain amount of deliberate infanticide) ensure that the male population is always in excess of the female. This alone makes a difference of some 20 per cent in reproductivity, as compared with Western countries. (At the same time the prohibition on the re-marriage of widows in the Hindu religion reduces India's reproductivity). In general, the rate of mortality in primitive societies is such that this rate of reproduction provides for little if any net increase of population.

Prior to the nineteenth century the population of Africa and South America appears to have been stationary or declining over long periods; the population of Japan rose by less than 10 per cent between 1650 and 1850; the population of China appears to have been virtually stationary for a century. Since 1850 (the period of the Taiping Rebellion, which is believed to have cost millions of lives) China has suffered ever-increasing military anarchy and social chaos, leading in many Provinces even to a breakdown of the irrigation works on which the life of the people depends. Under these circumstances deaths from famine, epidemic, war and flood have been on such a frightful scale that even the high reproductivity of the Chinese is unable to provide for any net increase of population.

(See Appendix A for critical discussion of data)

Upon these primitive societies or stagnant civilizations comes the impact of western civilization, or, if we wish to be more precise, of an urban and commercial society, in violent contrast to the old traditional civilization and the dependence upon agriculture, fishing and hunting. The impact affects every aspect of life both spiritual and material. In the demographic field it first results in a decline in mortality. For a period this declining mortality is still associated with an unchanged high reproductivity and a rapid net increase of population ensues. Then a time comes when urban and commercial life begins to affect reproductivity, which falls fast and far.

In Western Europe and North America these changes came about slowly. Mortality began to decline in the 18th century. The decline in reproductivity[7] was also slow. At the beginning of the nineteenth century, when a certain amount of urban development had already taken place, fertility throughout Western Europe and the United States appears to have been in the neighbourhood of 5. Except in France, where reproductivity declined gradually throughout the nineteenth century, a general decline began about 1880. In Italy and Spain the decline started later, but has been more rapid: In Eastern Europe the beginning of the decline did not come till the First World War, but its rate has been more rapid still.

(See Appendix B for critical discussion of data)

In the rest of the world the demographic impact of western civilization, being delayed, has been much more violent. In some cases mortality rates appear to be falling about three times as fast as they did in nineteenth century Europe. This is not after all surprising, when we reflect that many discoveries of drugs and preventive medicine, which were unknown in nineteenth century Europe, are available throughout most of the world today. Thus in a mere 12 years, from 1923 to 1935, the Japanese expectation of life rose from 42.6 years to 48.3 years. It took Great Britain over thirty years approximately from 1870 to 1903, to cover the same range.

Likewise the decline in fertility in these countries is also very rapid. In Japan the decline appears to have started about 1910, almost exactly forty years after the "westernization" of 1868. By 1925 Japanese total fertility had been reduced to 5.34, and by 1940 to 4.30. It is surprising to find that in Russia and India, in spite of their very different circumstances, the decline in re-

[6]The other measure generally used, namely, *gross reproduction rate,* is obtained by approximately halving total fertility; strictly speaking by multiplying it by a factor 0.487, to allow for the fact that female births are slightly less than half of total births.

[7]Pierre Depoid, *Reproduction Nette en Europe depuis l'Origine des Statistiques de l'État Civil,* Statistique Générale de la France, 1941.

productivity began at about the same date and proceeded at about the same rate as in Japan. For Latin America it appears that the decline in reproductivity began in the 1930's. It will perhaps begin in Africa and South-East Asia about 1960 and will come last in China.

But, meanwhile, in many parts of the world, we shall find declining mortalities still associated with high reproductivity. Detailed calculations based on the assumptions given above lead to the estimates quoted in the table. Some estimate of migration is also necessary for these calculations. Migration from the totalitarian countries of Eastern Europe is at present prohibited; were it not, there would be a great outflow from them. For the next two decades it is assumed that the only countries with a substantial outflow of migrants will be Italy, Germany and Great Britain. It is assumed that 100,000 migrants a year will be received in the United States, 275,000 in Latin America, and 100,000 in Australia and New Zealand.

(See Appendix C for critical discussion of data)

We are faced, therefore, with the prospect of world population increasing at the rate of 1 per cent per annum. At what rate can the supply of farm products be increased? Data from a number of countries show that the real quantity of farm products produced per man-hour of labour can increase at the rate of 1½ per cent a year.

On the face of it, then, we have the problem beaten. A rate of growth of 1½ per cent a year exceeds the rate of population growth of 1 per cent a year. But there are four most important qualifications which will be mentioned in ascending order of importance:

1. The demand for food *per head* is not constant, but increases with increasing real income and standards of living.

2. The 1½ per cent per year rate of improvement would not hold if an increased agricultural population were densely crowded on to a limited area.

3. Farmers and farm workers in future will expect to work shorter hours and take longer holidays after the manner of the urban population; thereby reducing production.

4. The whole comparison rests on the assumption that the farm population remains constant, whereas, as a matter of fact, throughout a large part of the world it is in rapid decline.

The increasing demand for food with rising real income can be fairly closely measured and allowed for in the calculations. It is, of course, most marked at the lower income levels. A 50 per cent increase in real income per head in China, other things being equal, would cause food consumption per head to rise by as much as 35 per cent. But even at American income levels a 50 per cent rise in real income per head would increase demand for food per head by 25 per cent (taking in this case the form of replacement of coarser foods by more meat, fruit and dairy products).

Evidence of increasing real product, over a long period, per unit of labour engaged, comes from the United States, Britain, Ireland, Germany, Sweden, France, India, Japan, Australia and New Zealand. This evidence is sometimes criticized on the grounds that, while it may show increasing product per unit of labour, it does not show increasing product per unit of area. But the four last named countries show large increases per unit of area.

(See Appendix D for critical discussion of data)

But the most important qualification is regarding the rural labour force. The maintenance of this labour force is the condition which is not being fulfilled. In nearly every country a "flight from the land" has been taking place and shows every sign of continuing, and, indeed, accelerating. As might be expected, the diminution of agricultural population is most rapid in economically advanced countries where numerous other economic opportunities are offering, while in some of the Asian countries the agricultural population is still increasing. Within the United States it is found that the loss of agricultural labour is most rapid in the now industrialized middle-western States, where productivity per head in agriculture is also high; there is a less rapid loss of labour in the less productive southern States.

There are many factors making for an increase in the rate of loss of rural population. The motor bus, the radio, universal education, military service, political movements and a host of other social and incidental factors are bringing the countryman into ever closer association with town life, and giving him opportunities to obtain urban employment. Within the memory of older men still living in Western Europe, and up to the present day in Eastern Europe and Asia, the countryman has been separated from the towns not only by difficulties of transport but also by wide divergencies of custom and even of dialect. All these barriers are rapidly disappearing and in the near future we may expect them to disappear in other parts of the world also.

It is not, therefore, the law of diminishing returns or the lack of agricultural areas for cultivation which has caused the world food shortage, and which may cause a worse shortage in the future; it is the lack of labour. It might be a fairer way of putting it to say that up to now we have been fed by the underpaid labour of peasants and agricultural labourers throughout the world; that the older generation expected this state of affairs but that a new generation of countrymen is now growing up throughout the world who are not prepared to remain at their work unless they see in it economic opportunities comparable to those of the urban population. Better means of communication, laws and customs favouring social mobility, and, above all, the maintenance of full employment in industry, will all accelerate this tendency.

In effect, therefore, the countryman says to the urban world—"What are you going to do about it?" We may, and doubtless will, intensify our search for technical improvements and may succeed in raising the rate at which they can be applied. But this alone will not provide for an improvement or even a maintenance of standards of living for an increasing world population, when the supply of agricultural labour continues to fall. In the course of years, however, we may be able to make very substantial improvements in production, even in face of a declining total labour force if the labour is redistributed, i. e., if the conditions of the world's economy are such as to admit a rapid growth of rural population in the most productive and hitherto least exploited parts of the world, and a diminution of rural population in the most overcrowded areas.

Except in so far as we can solve our problem by such redistribution, the only course remaining open to us is to allow the prices of agricultural produce to rise relative to the prices of manufactured goods and services to a point where they can offer to the agriculturist throughout the world an income sufficient to induce him and his children to remain on the land. As has already been stated the relative rise in the price of farm products throughout the world will have to be substantial.

The improvement which might be obtained in the world's food supplies through geographical redistribution of the world's rural population is, in the long run, very great, but it is bound to be slow. There appear to be limits to the rate at which rural population can be reduced in overcrowded areas, or expanded in hitherto unsettled areas.

Economic history shows that where rurally overpopulated countries have developed alternative employment to relieve pressure on the land, the rate at which male rural employment has been decreased has not generally exceeded 1½ per cent per annum. (The rate at which the male rural population of the USSR was decreased in the decade 1928-1938 was 3¼ per cent per annum, but this entailed much hardship. In the United States during recent years the numbers working in agriculture have been declining at a rate as rapid as 2 per cent per annum; but this may have been due to the peculiar conditions of the time and place and is not taken as a standard applicable elsewhere.) On the other hand, the limit of growth in the rural populations of developing or efficient countries is put at about 2.9 per cent per annum. (The United States, for instance, maintained a growth of rural population of 33 per cent per decade for three decades from 1820, and only slightly lower rates for the 1850's and 1870's.)

Unless, therefore, we are contemplating population transfers on the scale attempted in the USSR (and it is very probable that they are just as economically inefficient as they are inhumane), we must content ourselves with these limits.

The world's principal reserves of unused cultivable land lie in Africa and South America. The relative abundance or otherwise of farm products during the next few decades will depend on the rapidity and success with which these areas are developed. This in turn will depend on the availability both of capital and the technical skill to build roads, harbours, schools, and all other innovations necessary to convert sparsely populated and primitive areas into productive agricultural land.

Any exceptional development of these continents will call for the outlay of enormous quantities of capital, and the indications are that the world is going to be pretty short of capital for a number of years to come. In the United States, the standards of consumption, not to mention taxation, are rapidly advancing and the amount saved by a person at any *given real income* shows a strong downward trend as time goes on. And although probably the savings of the United States will constitute as much as a quarter of the whole world's savings, the indications are that the expansion of United States industry will be on such a scale as to absorb nearly the whole of this vast sum and leave comparatively little for lending to the rest of the world.

In the tables which follow, therefore, no exceptional development of Africa or South America is hypothecated. Development there, as in other countries, will proceed, it is assumed, at about the same pace as it has shown in the past. The expected 1960 levels of real income are shown in the table and we can rest assured that it is going to take all the world's available capital resources to catch up the war-time arrears and destruction and to reach the indicated levels by 1960.

Besides the capital which the United States has to spare for the world market, the principal sources of international capital investment will come from countries which have already attained a fairly high level of real income and where the rate of population increase is slowing down or has disappeared—principally Britain, France and Germany, their smaller counterparts, Belgium, Sweden and Switzerland, and probably some newcomers to this field such as Canada, Argentina, Denmark, Australia and South Africa. Another unexpected newcomer to this field may be Japan. Although her productivity is still fairly low and her population still increasing fairly rapidly, yet the rate of saving is extraordinarily high among all classes of the Japanese population and we may before long see Japan as a capital exporter on a large scale.

Of the capital-importing countries, by far the largest demand will come from India, which country is now at such a stage of development that she may take as much as all the other capital-importing countries taken together. Demands for capital will come from all the Asian countries except Japan, from Africa and from Latin America. Western Europe will probably all be capital-exporting except for Italy and Portugal. Russia and Eastern Europe, if their economies were free, would be entering the world market in a big way as capital borrowers: alternatively, they will have to impose severe reductions in the standard of living of their peoples if economic progress is to be maintained.

Assessing, then, the probable general course of world economic development, and using the methods of *The Economics of 1960* (published in 1942) I come again to similar conclusions, even though this later calculation incorporates a good deal more recent information. The world price of farm products in 1960, relative to the price of manufactured goods and services, is expected to be about 70 per cent higher than in the base period 1925-1934.[8] Between 1960 and 1970 a further slight rise in the relative price of farm products is to be expected. This substantial change in the terms of trade will, of course, enrich some countries and impoverish others. The principal gainers will be countries with large food exports (if they are willing to take advantage of the situation by leaving their labour in agriculture and do not attempt an uneconomic development of industry). The countries which will feel the adverse effects most severely are those which are dependent upon imports for the biggest part of their food and raw material supplies, namely, Great Britain and Japan. Even in their case, a rise in standards of living will not be prevented; but it will be slower than it might otherwise have been. The expected development of world supplies of farm products is as follows:

[8]In 1937 agricultural and manufactured goods again stood at approximately the same relative prices as they did in the base decade 1925-1934.

	Population (Millions)		Supply of farm products (1,000 million of International Units)		Supply of farm products per head (International Units)	
	1935	1960	1935	1960	1935	1960
Russia, Eastern Europe Eastern Germany, China...........	652	715	13.2	14.6	20.2	20.4
Rest of the World..................	1,330	1,794	36.5	49.1	27.4	27.4

Output will almost exactly keep pace with increasing population. But with increasing real incomes,[9] people will *expect* to consume more or better qualities of food and in their inability to obtain them will bid the price up. The general price elasticity of the demand for food is in the neighbourhood of .5, i. e., it takes a 2 per cent rise in prices to cause a 1 per cent fall in demand. The elasticity of supply, during the next two decades, will be very low. In many countries the discrepancy between urban and industrial incomes is so great that the number of rural workers is declining at the maximum rate of 15 per cent per decade, and will continue to do so even if there is a substantial increase in food prices. Once these extreme discrepancies have been overcome, then the numbers of farm population will become somewhat more responsive to the incentives of a higher price, and the elasticity of supply of food will increase somewhat.

There are three factors now operating in the world which are making the loss of labour from agriculture considerably more rapid, and consequently the world shortage of farm products more marked than it would otherwise be. The first policy, which is from any point of view justifiable, is that of certain densely populated and under-developed countries in artificially accelerating the growth of their industries (as in India, Russia, or Egypt). With excessive density of settlement their agriculture is uneconomic and becomes increasingly so as population rises. Under the laws of increasing returns their industry will not become remunerative until it has reached a certain scale; it can generally only be launched, therefore, as a result of deliberate governmental intervention.

But the other policies pursued by Argentina, Australia and some other food-exporting countries, are unjustified either from the point of view of the country concerned, or of the world as a whole. These are the policies of accelerating industrialization, though there is no pressure of population on the land to justify it, but rather the reverse; and at the same time taking steps by artificial means to provide that their own consumers obtain food at substantially below world prices. These policies have the effect of discouraging agriculture by both taking away its labour and reducing its returns; and reducing supplies on the world market by encouraging their own people to consume more heartily than the world price would justify, while in turn these countries obtain a number of industries which are generally grossly uneconomic and quite unable to compete with the rest of the world.

The analysis made hitherto confines itself to farm products as a whole. Time and circumstances clearly do not permit an attempt to analyze the probable demand of prices for individual farm products, or for fishery, forest or mineral products. But it is hoped that the data given in the attached tables will facilitate analysis of future demand by those interested. If we plot past consumption per head of any commodity in different countries against the current levels of real income, we can get some idea of the shape of the demand function, and with due qualifications we can project this into the future, i.e., the amount demanded per head at any given level of real income. The principal qualification, of course, is that demand depends upon price as well as upon income. Perhaps the most interesting example of this is to be found in the demand for timber. Timber consumption per head in most European and Asian countries is a fairly close function of income, rising rapidly at first and then more slowly. Consumption of sawn timber per head in the United States at its peak in 1904 was over 40 cubic feet as against some 15 cubic feet only, expected from the demand-function curve. Timber was extremely abundant and cheap at that time. By 1940, although real income per head had doubled since 1904, timber consumption had been brought down by higher prices to 19 cubic feet per head, almost exactly the amount predicted from the demand-function relationship. Many natural products can be with greater or less readiness replaced by substitutes, which indeed is one of the principal factors determining the elasticity of demand when prices rise.

APPENDIX A

It will be noticed in the attached table that the figure given for the population of China is very much lower than that commonly quoted, and no increase is shown since 1850. These are the conclusions advanced by Professor Wilcox,[10] who has advanced good reasons for believing them to be true. He estimates that between 1650 and 1850 Chinese population rose from 100 million to 350 million (an average rate of increase, it may be noted, of just under ¾ per cent per annum).

Sir Alexander Carr-Saunders[11] accepts the conventional figure of 450 million for the present day but agrees that there has been virtually no net growth since 1850. He puts the population in 1650 at 150 million as

[9]A point worth mentioning is that while increasing world population may evoke diminishing returns (as we have defined it in Appendix D) in some parts of the world in agriculture, mining and other extractive industries yet at the same time most industrial processes are subject to *increasing returns*, and a substantial rise in world population will have the effect of considerably increasing the net product per head in industry above the level which it would have held if world population had remained stationary.

A necessary part of the mechanism by which increasing returns operate in industry is by an ever-increasing sub-division and specialization of industrial processes. This can only be enjoyed on an international scale when the industries of different countries are able to trade and compete with one another freely.

[10]*Revue de l'Institut Internationale de Statistique,* April 1937.

[11]*World Population—Past Growth and Present Trends.*

against Professor Willcox's 100 million.[12] Professor Warren Thompson[13] estimates the 1940 population at 400 million, and believes that it will remain virtually stationary till 1960. Professor Ta Chen[14] considers the population rose to a maximum of 400 million about 1930, having been only 60 million in 1600. He believes that under the Han Dynasty, at the beginning of the Christian era, the population was also about 60 million and that during the intervening period it passed through three complete cycles of decline and growth, associated with political anarchy and political stability, respectively.

APPENDIX B

The statistical techniques for the analysis of reproductivity have greatly improved during recent years. The very low figures of reproductivity first calculated for the 1930's (on which were based a number of prognostications of further falls) proved on further analysis to be largely transitory effects of the postponement of marriages due to economic depression. The war had the effect of accelerating marriage, but led to the postponement of many births, which reappeared in a violent but temporary increase in the number of births in the first post-war years. More careful analysis, in which age at marriage and the number of marriages of different duration are taken into account, has been applied in England, France and Sweden, and in each case leads to practically the same conclusions—namely, that marriages are now generally earlier than they were, and the total fertility has stopped falling and stabilized at about 2.2 —a rate slightly below that required to maintain the population, even under the most favourable conditions of mortality.

On the other hand, the Netherlands is an example of a country where marriages are later but fertility appears to have settled down at a higher level of about 2.7. Netherlands figures are also used in projecting the population of Italy, Portugal, Spain, Eire and Finland, and of Australia and New Zealand; for the rest of Western Europe the lower figure is used.

APPENDIX C

Apart from China, there is general agreement about the population of the world for the present and the recent past. In the tables estimates are made for 1960 and 1970 on assumptions which will now be described.

For Europe and Soviet Russia estimates up to 1970 were prepared by Professor Notestein and others.[15] Three adjustments are necessary in that these data:

1. Take no account of war losses.
2. Make no allowance for migration.
3. Assume a continuing downward trend of reproductivity at a rapidity which does not in fact appear to be borne out.

The following assumptions were made about migration over the period 1950 to 1970:

Average Net Migration Per Annum

	Net emigration		*Net immigration*
Italy	240,000	United States	100,000
Germany	200,000	Argentina	100,000
Great Britain and Northern Ireland	100,000	Rest of Latin America	175,000
Eire	15,000	Australia	80,000
Netherlands	15,000	South Africa	25,000
		Canada	20,000
		New Zealand	20,000
		France	40,000
		Belgium	10,000
	570,000		570,000

War losses were obtained from the sources quoted in footnotes 2, 3, and 4 of the main text. The military losses were arbitrarily distributed among the younger male age groups, and the civil losses over the whole population.

Reproductivity was assumed to be stabilized at levels given in the text above, except for Eastern Europe, where Professor Notestein's assumed declining fertilities were retained.

For Germany, in default of up-to-date demographic information, a stable population was assumed.

For countries outside Europe and North America, the demographic data are scanty. For these countries mortality projections were based on Professor Notestein's data. On pages 186-187 of this work are given scales of the highest mortality experience known in European records ("beginning of first segment"), and rates per annum at which such mortalities are expected to decrease.

For non-European countries with high mortality it is assumed:

1. That mortality stood at a stable maximum level until a decline began at the following dates: Latin America (except Argentina and Uruguay) 1895, India 1900, rest of Asia (except Japan and China) and Africa (except South Africa) 1920, China 1950.
2. That mortality shows European rates of decrease[16] once the "first segment" is reached, but before that the rate of decrease was *three times* the European "first segment" rates.
3. That the maximum rates of mortality mentioned in (1) above exceeded the beginning of the "first segment" by amounts corresponding to 35 years on the accelerated scale of reduction hypothecated in (2) (or succeeded the European maximum by 105 years measured at 19th century European rates of decline of mortality).

In Japan the structure of the mortality curve is peculiar. Mortality is remarkably high between the ages of 15 and 29 (said to be due to tuberculosis), low elsewhere. For ages 15-29 the "first segment" is assumed to be reached in 1950, for other ages in 1920. War deaths appear to have been just about counterbalanced by returning emigrants, garrisons, colonial settlers etc.

[12] One might mention a contemporary estimate of Gregory King who put the 17th century Chinese population at 230 million. King's other work is so remarkable that this estimate should at any rate receive some consideration.

[13] *Annals of the American Academy of Political Science,* January 1945.

[14] *American Journal of Sociology,* July 1946.

[15] *The Future Population of Europe and the Soviet Union,* League of Nations, 1944.

[16] For convenience in calculation, after applying these rates of decrease for the first ten years, we apply the mortality rates shown for Yugoslavia from 1940 onwards (*op. cit.* pages 310-311), i.e., it is assumed that Yugoslavia (the country with the highest mortality in Europe passed the "first segment" in 1930. This involves only a slight modification of previous assumptions.

For the USSR, Professor Notestein's mortality projections were used apart from an allowance for abnormal war losses. M. Vincent's estimated civilian war deaths of 10 million are approximately allowed for by doubling the estimated mortality rates between 1940 and 1945. For military casualties an estimate of 6 million is adopted apportioned as follows:

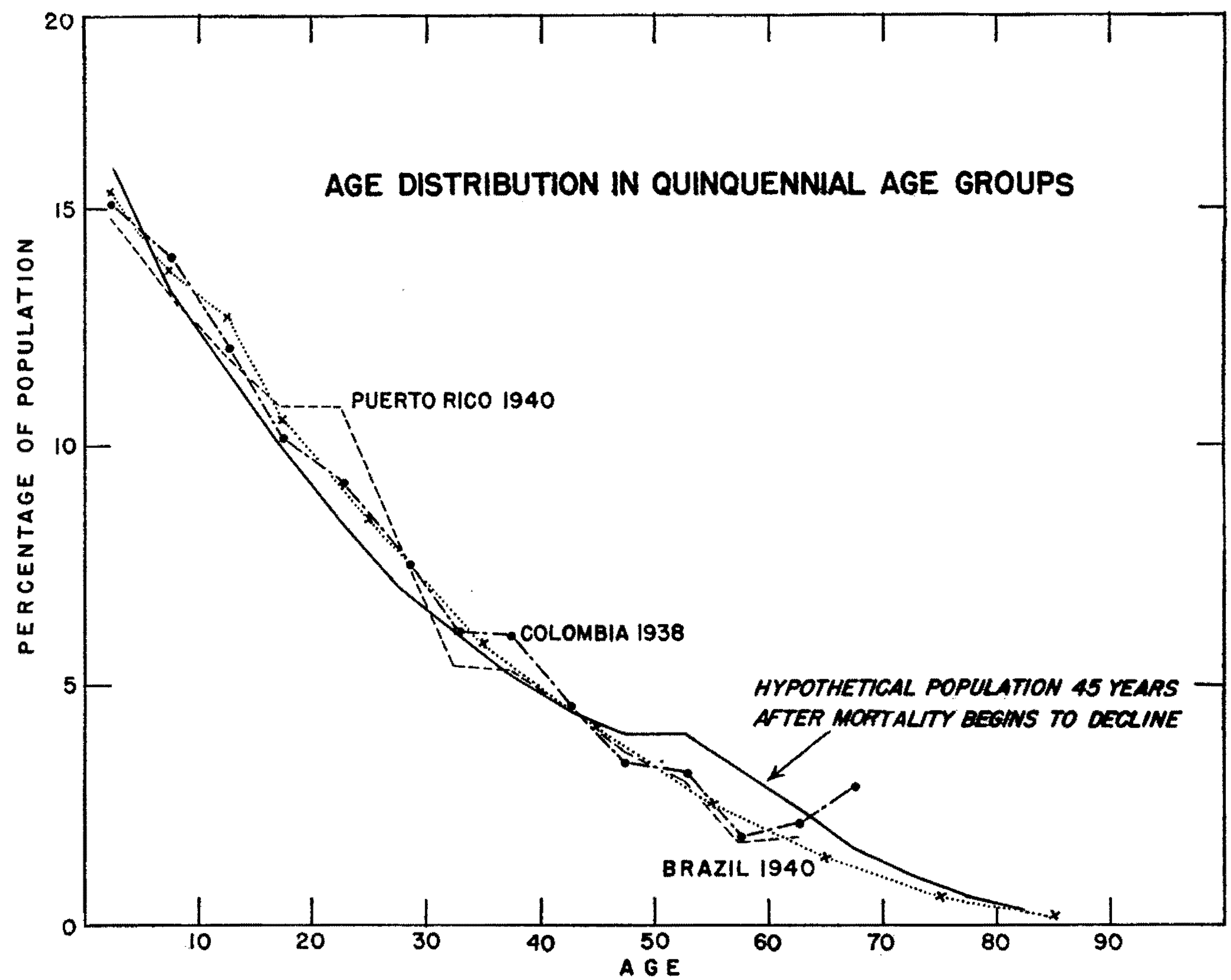
Age in 1945	15-19	20-24	25-29	30-34
Numbers (in millions)	0.5	2.0	2.5	1.0

Outside Europe and the English-speaking non-European countries, there are no satisfactory age-tables except for Japan. The age-tables published for India, for some Latin-American countries, Egypt and Turkey, are obviously full of defects. (A great many of the world's inhabitants honestly do not know their own ages).

The procedure adopted, therefore, was to take the published Indian age-table of 1901 (with its more obvious defects arbitrarily adjusted) as indicative of the age structure of a population in which both mortality and fertility have been at their maximum for a long period. To this are applied mortality rates declining in accordance with Assumption (2) above, and fertility rates beginning to decline 40 years later than mortality rates. The errors unavoidably included in the basic figures thus get largely "washed out" in the course of a few decades.

It was assumed for Latin America that mortality began to decline in 1895. A hypothetical age-table constructed by the above procedure run on for forty-five years fits fairly well to the recorded 1940 age distribution of Brazil, Colombia and Puerto Rico, which appear to have been the most accurate of the available censuses (see attached diagram). The considerable irregularities remaining in their figures indicate that it is still preferable to use the hypothetical age distribution, until more accurate census data are available. (The hypothetical curve itself shows a kink at age 50 as a result of discontinuity with the original assumed age distribution).

For the USSR, Professor Notestein's estimated age table was used as a base and projected to 1950 on the birth and mortality assumptions given above. To allow for newly incorporated territories, whose age composition is expected to have been generally similar to that of the USSR, an addition of 15.8 per cent is then made to all age groups except 0-5 (the effect of the incorporated territories is separately allowed for in this group, see below). Among the men 15-35, the base for this calculation is taken *before* deducting the estimated 6 million war deaths. It is a coincidence that these transformations bring the estimated 1950 population of the USSR back to Professor Notestein's original figure of 203 million.



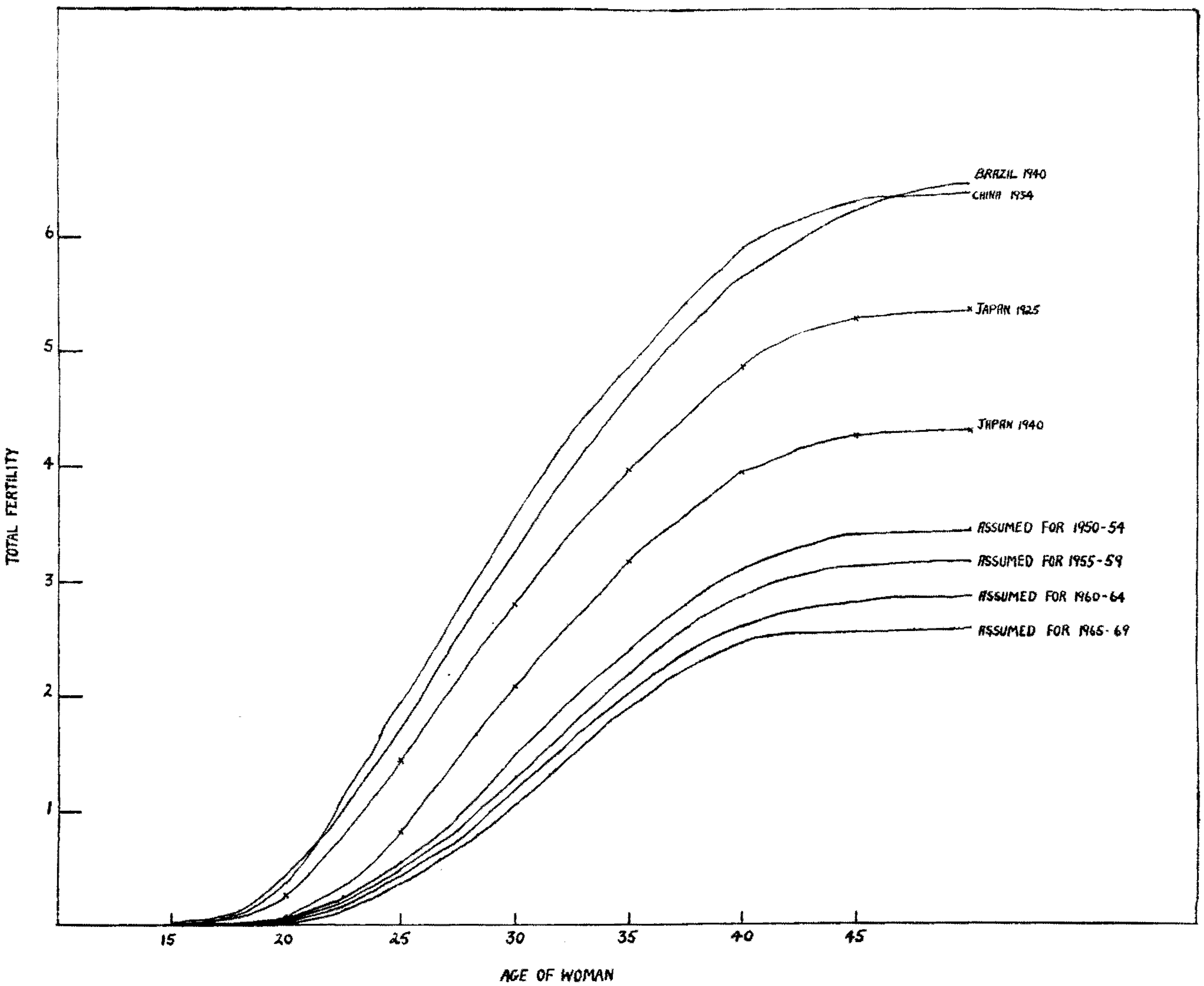
In the parts of the world mentioned above, fertility is also assumed to have been stable at a maximum level for a long period, and various dates are assumed at which fertility begins to decline at a given rate.

The maximum fertility, for women of various ages, is taken as that found by Mortara for Brazil (*Revista Brasileira de Estatistica,* April-September 1947). Though the Brazilian census may have been defective in some respects, this fertility table shows evidence of careful construction. Brazilian fertility may have begun to decline slightly by 1940, but this table is based on the total number of children *ever born* (excluding still births) to Brazilian women in 1940, and thus reflects predominantly the fertility of earlier periods.

This indicates a total fertility of 6.45 or gross reproduction rate of 3.15. A very similar fertility is shown (see diagram) by some Chinese data. (*An Experiment in the Registration of Vital Statistics in China,* Scripps Foundation, 1934). Compare also the fertility of 3.11 for Egypt in 1937 (Kiser and Whelpton, *Annals of the American Academy of Political and Social Science,* January 1945, page 114), and of 3.29 for Russia in 1897 (Lorimer, *The Population of the Soviet Union,* League of Nations). It is true that higher gross reproduction rates have been computed, i.e., 3.4 approximately for Japan in 1868 (Taeuber and Notestein, *Population Studies,* June 1947), nearly 3.5 for Korea between 1920 and 1940 (Taeuber, *Milbank Quarterly,* January 1947), 3.3 for Formosa (*Population Index,* July 1944), and 3.33 for the Palestine Arabs in 1931 (Rita Hinden, *Sociological Review,* January-April 1942), while the world's record appears to be the figure of 5.0 reached by French-Canadian women in the 17th century (Georges Sebagh, *American Journal of Sociology,* vol. 47, no. 5, pages 680-689).

On the other hand, a special study in Indo China (*Population Index,* April 1945) showed a total fertility of only 5.2 (gross reproduction rate 2.54). A study of the Taliensi tribe in West Africa, (Fortes, *Sociological Review,* July-October 1943), showed a gross reproduction rate of 3.1 (and net rate of 1.7).

The decline in fertility is assumed to follow the course of Japan (Taeuber and Notestein, "The Changing Fertility of the Japanese", *Population Studies,* June 1947). The reduction is most rapid in the younger age-groups and is apparently due to later marriage in a more industrialized society. It is assumed that fertility, after it has begun to fall, takes 15 years to fall from the Brazilian



to the Japanese 1925 level, another 15 years to fall to the Japanese 1940 level, and after that its course is extrapolated (see diagram and table below).

Total Fertility Measured as Births Per Woman Per Quinquennium

	15-19	20-24	25-29	30-34	35-39	40-44	45-49	Total
Brazil	0.42	1.29	1.54	1.35	1.03	0.63	0.19	6.45
Japan, 1925	0.25	1.20	1.34	1.19	0.91	0.39	0.06	5.34
Japan, 1940	0.07	0.77	1.24	1.08	0.76	0.33	0.05	4.30
Assumed for Japan, etc.:								
1950–54 .	0.05	0.52	0.88	0.95	0.70	0.30	0.04	3.44
1955–59 .	0.04	0.45	0.80	0.90	0.65	0.27	0.03	3.14
1960–64 .	0.03	0.40	0.75	0.84	0.59	0.21	0.03	2.85
1965–69 .	0.02	0.34	0.70	0.80	0.54	0.16	0.02	2.58

It is assumed that fertility begins to show a decline after 1910 in India and Japan; after 1935 in Latin America, after 1960 in Africa (other than South Africa) and in the rest of Asia, except in China, where it is assumed that there will have been no decline in fertility up to 1970.

Total fertility in the USSR (Lorimer, *loc. cit.*) stood at 5.41 in 1926 and at 4.49 in 1938. These figures are very close to the trend line for Japan given above and it is assumed that the Soviet Union follows the Japanese trend after 1940—with this exception, namely, that the losses of males in the war were so heavy that the effective number of women available for reproduction in any age group is taken as limited by the number of males in the age group five years older.

In this manner the population of 1945 was used to estimate the births for the whole decade 1940-50[17], giving a result of 43.5 million. This was then raised by 5 per cent to allow for territorial acquisition since 1945, and the result apportioned 37½ per cent to the first quinquennium of the decade and 62½ per cent to the second.

For India this procedure is unsatisfactory because of the catastrophic mortality from the influenza epidemic of 1918, which wiped out virtually a whole decade's population increase. As our starting point, therefore, we take the recorded age distribution of 1921 (by which date it may be hoped that accuracy had improved a little over 1901) subject to the following arbitrary corrections:

1. Two million males assumed unrecorded in the 0-4 group.

2. Two million males transferred from the 10-14 to the 15-19 group.

3. One million females transferred from the 25-29 and 0.5 million from the 30-34 to the 15-19 group.

4. Persons over 60 (shown as a single group) apportioned to 5-year groups.

Recorded births are used for the period 1921-40 plus allowance for under-registration of 10 per cent in 1921-30 and 5 per cent in 1931-40[18]. (The heavy decline in registered births since 1940 seems to be due to some extent to decreasing completeness of recording). These refer only to the Provinces and not to the States, i.e., about three quarters of the population. It is assumed that similar birth rates prevailed in the States.

These assumptions fit the observed data so far:

India (excluding Burma): Population (Millions)

	Actual	*Computed*
1921	307.7	
1931	335.1	335.2
1941	389.0	388.4

The computed population shows a growth of 11 per cent between 1941 and 1951. The Indian Census Bureau estimates a growth of only 5½ per cent between 1941 and 1948. However, it must be remembered that:

1. These estimates are based on birth registrations which may prove to have been incomplete;

2. They exclude Pakistan, which is less urbanized than India, and where the rate of growth may have been higher;

3. They were affected by the Bengal famine of 1943, an event largely brought about by transport difficulties and other wartime circumstances, and which may, therefore, we hope, be regarded as non-recurring.

For the United States were used the Bureau of Census "Forecasts of the Population of the United States 1945-75" on the assumptions of medium mortality and fertility and 500,000 per quinquennium net immigration (data on page 81, "adjusted for Census under-enumeration of children"). The actual population at the beginning of 1950 will be some 149.7 million and the discrepancy of 3 million is assumed all to be in the 0-4 group (due to unexpectedly high births 1945-49). This discrepancy is carried on into the appropriate age groups in later years.

APPENDIX D

To meet this criticism we must first exclude the United States, Australia and New Zealand, because in these countries new areas have been brought under cultivation. In Great Britain and Ireland it is true that the last century shows a more or less constant volume of output produced by a declining labour force. But there is some evidence to show that improved agricultural techniques in England, introduced in the 18th and early 19th centuries, nearly doubled the volume of output from a given area; and there is much of the world which has not yet even acquired the agricultural technique of early 19th century England. Likewise on a limited area in France, it appears that the volume of production doubled or trebled between 1815 and 1870 (with a 20 per cent fall in the agricultural labour force). For Sweden where more precise data are available, the real volume of agricultural production increased 2.2-fold between 1870 and 1930. Another outstanding case is that of Japan, where the combined output of agriculture and fishery approximately doubled between 1897 and 1934. In India the volume of agricultural production appears to have increased nearly 25 per cent between

[17] i.e., assuming that, in all marriages where the husband survived the war, births postponed during the war years were made up in the first post-war quinquennium.

[18] These assumptions are consistent with an assumption of some 20 per cent under-registration in 1901–10; during which period the recorded crude birth rate was 38.6, while that deduced from applying Brazilian fertility rates to the estimate age-table was 48.2.

1931 and 1944; and nearly threefold between 1870 and 1930.

It is of course true that agricultural production is generally carried on under conditions of "diminishing returns". This phrase is part of the economists' technical jargon and is widely misunderstood outside. It certainly does not mean, as many people appear to think, that the yield of agriculture diminishes as time goes on. What it does mean is that if we have two pieces of land of similar area, climate and fertility, farmed by men of similar skill and technical knowledge, then the area more densely settled will yield less *per head* (but more *in the aggregate*) than the less-densely settled area.

As a matter of fact, the precise formulation of the law of diminishing returns in agriculture appears to give something like a square-root law. That is to say, a fourfold increase in the density of settlement in an agricultural area would about halve the output per man and about double the aggregate output. Or, stating the matter in a more realistic manner, the agricultural population of an area would have to be increasing at the rate of some 3 per cent per annum (which again is almost inconceivable) in order to neutralize the 1½ per cent per annum of technical improvement which is found to prevail over most of the world. Furthermore, the law of diminishing returns does not apply in the more sparsely settled areas such as Australia and Brazil; it is only after we reach densities of settlement corresponding to those of, say, the western States of the United States, that the law even begins to apply. It does not apply also in some of the most highly mechanized forms of agriculture like sugar-cane growing, where indeed increasing returns are sometimes found to prevail. But the law of diminishing returns does in general provide an explanation of why agricultural output per man in Egypt should be only half of what it is in Italy, in Italy half of what it is in Spain, in Spain half of what it is in Canada, in Canada less than half of what it is in Australia.

Let it be added also that there are many results which the law of diminishing returns does not explain; that is to say, results which show how the effects of population pressure can be overcome by better agricultural science and practice. Per square kilometer of land climatically suitable for agriculture, the density of population in India is as high as in China, and India shows about twice the product. Undeveloped though her agricultural technique is, India differs from China in having a substantial livestock population and a system of roads and railways; these are only possible because India has enjoyed and expects to continue to enjoy firm and just government rather than the anarchy which has prevailed in China.

Similar densities also prevail in Italy and Finland, which show returns greatly above the Indian. In the Netherlands, a country whose farmers have been trained by education and experience to make the best possible use of the soil, the density of settlement is almost exactly the same as in Poland, with a product in the Netherlands three times as high. Denmark has the highest productivity in Europe with a high density of settlement. New Zealand, with a higher density than Australia, has a product per head 50 per cent higher. These examples could be multiplied.

Notes to table

Frontiers:

Except where otherwise stated, each country is recorded within the frontiers of the time and in judging the population trend in any one country account must be taken of frontier changes. The following outstanding changes may be noted—

Alsace Lorraine—Included in France in 1850 (1.5 million) and in Germany in 1913 (1.9 million).

Germany—The 1919-1937 territory had a population of 60.4 million in 1913. The post-1945 territory had a population of 59.9 million in 1939.

Austro-Hungarian Empire—For 1913, shown as the Succession States in their post-1919 boundaries. Population in contemporary boundaries was Austria 29.2 million, Hungary 21.4 million.

Czechoslovakia—1950 figure excludes approximately 1.0 million in territory ceded to Russia.

Poland—The 1939 population of post-1945 Polish territory was 32.3 million, and of the Polish territories ceded to Russia in 1945 11.8 million.

Balkan States and Greece—The figure shown for 1850 represents the whole of "Turkey in Europe". In 1913 and subsequently all Turkey is included with Asia (1913 population of Turkey in Europe 1.9 million). In 1950 excludes 3.8 million population of Roumanian territory ceded to Russia.

Russia—1850 and 1913, excluding Finland but including Baltic States. Including Baltic States from 1950 (1940 population 5.5 million). 1913 population of post-1921 USSR territory, 139.7 million. 1913 total for Eastern Europe adjusted to exclude duplication of territory included in both the Russian and Polish totals.

International unit:

A measure of real wealth, not of money: defined as the quantity of goods and services exchangeable for $1 over the period 1925-34.

"Standard farm land":

Areas of land deemed to be *climatically* suitable for agriculture (no account taken of soil or topography). On Professor Thornthwaite's classification (*Geographical Review,* July 1933) an area of tropical land with regular rainfall is taken as 2 units of standard farm land (on the grounds that it can probably produce two crops per year). Wet or humid, sub-tropical and temperate climates, together with tropical areas of irregular rainfall, are regarded as "standard farm lands". A sub-humid area is converted to standard farm land by a co-efficient of five-sixths, two-thirds or one-half, according to whether its rainfall is distributed through the seasons, is deficient in one season, or is deficient in all seasons. Semi-arid lands, suitable for sparse pasture only, are converted by a co-efficient of one-hundredth. Irrigated land in hot climates is counted as two units.

	Population in millions.						Population aged 15–64 millions.		Level of real income international units per man-hour worked.				Standard farm land '000 sq. kms.	Males engaged in agriculture per sq. km. standard farm land 1940	Real product in agriculture I.U. per man-hour worked. 1940	Expected for 1960— Farm products	
	1850	1913	1920	1950	1960	1970	1950	1970	1913	1929	1939	1960				Production.	Consumption.
																Billions of I.U.	
U.S.A.	23.2	97.2	105.7	149.7	158.5	166.7	97.4	114.7	.55	.78	1.00	1.47	4,580	1.9	.28	7.41	9.70
Canada	2.8	8.0	8.9	13.7	14.5	15.2	8.9	10.6	.51	.61	.75	.96	1,309	1.0	.21	0.59	0.77
Argentina	1.1	7.3	8.6	17.5	21.5	25.9	11.0	17.8			.39	.53	567	1.9	.43	1.03	0.84
Rest of Latin America	31.9	73.7	83.9	143.9	180.0	219.1	81.3	131.7			.10	.15	17,191	1.6	.06	4.80	3.32
Australia	0.4	4.6	5.4	8.0	9.9	11.9	5.0	8.1	.49	.65	.66	.98	1,480	0.4	.68	1.40	0.47
New Zealand	—	1.1	1.2	1.9	2.4	2.9	1.2	2.0		.65	.86	1.17	268	0.6	1.05	0.63	0.12
South Africa	0.3	6.2	6.8	12.1	13.6	14.8	7.3	9.9	.10	.15	.19	.21	316	6.5	.13	0.95	0.39
AMERICA AND DOMINIONS	59.7	198.1	220.5	346.8	400.3	456.5										16.81	15.61
Great Britain and Northern Ireland	22.1	42.5	43.3	49.0	49.0	48.5	33.2	31.9	.37	.52	.58	.69	229	6.3	.21	0.79	2.25
Eire	5.1	3.1	3.1	3.1	3.1	3.2	1.9	2.0	.18	.31	.32	.49	69	8.9	.11	0.17	0.12
Spain	14.2	20.3	20.8	28.2	30.4	32.7	18.8	21.4	.27	.37	.27	.58	265	13.8	.12	1.09	1.27
Portugal	3.9	6.0	6.0	8.5	9.4	10.3	5.5	6.8	.11		.15	.22	64	21.4	.07	0.35	0.24
France	35.8	39.8	39.0	41.9	42.7	43.1	28.8	28.5	.21	.32	.38	.48	511	8.4	.17	2.24	1.80
Belgium and Luxembourg	4.5	7.9	7.7	8.8	9.0	9.1	6.0	6.0	.22	.33	.35	.49	28	18.6	.20	0.32	0.37
Netherlands	3.1	6.1	6.8	10.0	10.7	11.6	6.3	7.7	.29	.43	.45	.60	31	18.6	.21	0.34	0.45
Germany	33.8	67.0	62.2	72.6	(72.6)	(72.6)	(49.0)	(49.0)	.31	.32	.49	.56	425	10.6	.17	2.17	3.40
Switzerland	2.4	3.9	3.9	4.6	4.8	4.9	3.2	3.3	.23	.36	.37	.54	20	19.5	.19	0.24	0.20
Italy	24.0	35.6	36.6	46.6	48.0	49.1	30.7	31.3	.13	.16	.20	.30	246	25.6	.06	1.03	1.50
Austria	18.0	6.8	6.5	7.0	6.9	6.9	4.7	4.6	.23	.21	.25	.30	65	11.5	.13	0.31	0.26
Norway	1.3	2.4	2.6	3.2	3.4	3.5	2.2	2.3	.21	.28	.38	.48	94	4.7	.09	0.10	0.15
Sweden	3.5	5.6	5.9	7.0	7.2	7.3	4.7	4.9	.23	.32	.41	.53	155	4.9	.14	0.31	0.31
Denmark	1.4	2.9	3.2	4.2	4.4	4.6	2.8	3.1	.30	.37	.40	.55	39	14.6	.25	0.43	0.27
Finland	1.6	3.2	3.3	4.1	4.3	4.6	2.6	3.0	.19	.24	.33	.43	20	34.8	.07	0.12	0.16
WESTERN EUROPE AND SCANDINAVIA	174.8	275.5	250.9	299.0	305.9	312.0										10.01	12.75
Czechoslovakia		13.6	13.6	12.6	13.1	13.3	8.6	9.0	.18	.28	.28	.36	126	12.0	.11	0.51	0.50
Poland		30.0	26.7	25.0	27.3	29.2	16.6	20.3	.20	.16	.19	.32	354	17.3	.07	1.26	0.88
Hungary	13.2	7.8	7.9	9.5	9.5	9.3	6.6	6.6	.14	.16	.17	.20	79	20.1	.09	0.50	0.29
Greece	1.1	4.8	5.5	8.0	8.5	8.8	5.2	6.1	.11	.15	.16	.26	112	9.4	.06	0.23	0.26
Balkan States	12.9	17.9	33.1	40.3	43.6	45.5	26.5	31.6	.16	.16	.16	.20	556	15.2	.05	1.53	1.16
Baltic States			4.7						.11	.15	.20		152	7.5	.09		
Russia	83.4	172.8	130.9	203.0	222.1	236.9	135.0	164.4	.17	.15	.17	.23	3,203	11.0	.04	4.95	6.64
EASTERN EUROPE AND ASIATIC RUSSIA	109.6	216.9	222.4	298.4	324.1	343.0										8.98	9.73
China	350.0	350.0	350.0	350.0	363.5	399.5	195.5	234.4	.03	.03	.03	.04	2,752	26.9	.02	4.71	4.46
Japan	27.2	53.4	56.0	82.9	92.9	100.8	49.6	67.6	.05	.13	.19	.20	418	20.9	.05	1.46	2.78
India and Pakistan	205.0	325.2	317.7	426.0	458.8	490.0	265.1	329.6	.06	.08	.09	.15	2,883	27.1	.04	11.25	10.36
Africa (excluding Egypt and Sth. Africa)	90.0	110.8	112.0	146.7	179.8	222.4	84.0	123.7			.05	.06	15,043	2.2	.02	3.62	2.28
South West Asia and Egypt	(	49.6	51.0	84.2	103.2	127.8	48.2	70.9			.10	.15	490	37.6	.02	1.22	2.22
South East Asia and Oceania	76.5 (	128.0	134.8	228.5	280.2	346.5	130.9	192.7			.05	.06	7,723	6.7	.02	5.62	3.57
AFRICA, ASIA AND OCEANIA	748.7	1017.0	1021.5	1326.2	1478.4	1687.0										27.88	25.67
WORLD	1093	1707	1715	2270	2509	2798										63.7	63.7

Notes to table — see page 25.

Real product per man-hour in agriculture:

This figure, in accordance with past experience, is assumed to rise at the rate of 1½ per cent per year.

The only exception is the United States where, between 1940 and 1946, real product per man-hour in agriculture showed a rise of 56 per cent as against the 9½ per cent expected. This gain appears to have been permanently retained, while since 1946 the upward trend of 1½ per cent per year has been resumed.

Farm products:

Net value in international units, excluding the value of industrial goods and services (fertilizers, transport, etc.,) incorporated therein.

The CHAIRMAN: These addresses are now open for discussion. Anyone who wishes to ask questions of the speakers can send a note to me or speak from his seat.

I am sure I am voicing the feeling of all of you when I propose a very hearty vote of thanks to the two speakers of the meeting, whose exposition was so masterly. Of course, one may not entirely agree with their general observations made with respect to the prices of farm products. In India, for example, it is well known that the prices of farm products have increased fourfold and this has affected health, and the middle-class population has been completely wiped out as a result of this process. A better equilibrium certainly must be reached before we can say that things are going satisfactorily. I do not think that prices of farm products can be increased in India any more; what we need is greater production so that food may be available to the population as a whole.

Any differences that exist between Mr. Osborn and Dr. Clark may perhaps be fought out here, in this meeting, and I therefore invite Mr. Osborn to comment on the observations made by Dr. Clark. These are put so nicely that it appears that there are no differences between the two principal speakers. Knowing more intimately their viewpoints, I think it will be a good point of departure for our discussion today to hear from Mr. Osborn as to what he thinks of the solutions suggested by Dr. Clark.

Mr. OSBORN: Dr. Clark, you used a phrase and made a statement regarding the rate of growth of productivity and you were referring, as I understand it, to the productivity with respect to the products of land. May I ask Dr. Clark whether he should not have used instead of the word "productivity" the term "rate of production", in the case of land. I think that you were talking about the rate of growth of quantity production. I would like to point out that there are a good many people who, recognizing the extraordinary amount of volume production which it has been possible to generate by new processes of forcing growth, are concerned that the quality of productivity is being sacrificed. Do you agree with this latter observation?

Mr. CLARK: Yes, for your country and for mine, I think we both have bad records. On the other hand, France, Sweden and Japan have records which show that the quantity of products per unit of area has greatly increased, and as far as we can ascertain the fertility of the soil has been maintained or even improved.

Mr. OSBORN: Without pressing the point unduly, you do then recognize that while production may be stepped up, negative factors (relating to proper land use) may appear?

Mr. CLARK: I am well aware of that, and of the fearful damage which can be done in a short time.

Just one other point I would like to mention. I have endeavoured to make a crude ascertainment of the areas of land potentially available for agriculture throughout the world. I have proceeded on a climatic basis only; I am in no position to classify soils even if the data were available. I count as double the high rainfall tropical soils which are capable of growing two crops a year and allow various deductions for the poorer climates. The order of magnitude is interesting in terms of square kilometres of standard farm land. The United States has 4.5 million; Canada has a little over 1.5 million; Australia has 1.5 million; Latin America has 17.5 million; Africa 15 million. Compare these figures with 2.75 million for the whole Chinese population; India and Pakistan have only a slightly larger area of climatically suitable soil; and Russia has only 3.25 million. You can allow a very large margin of error, even a 100 per cent error factor, and the enormous areas of unused land in Africa and South America still stand out. That does forcibly bring to our minds the urgent scientific problem of the tropical soils. We know something about temperate soils; we know extraordinarily little about tropical soils. The message I want to leave before this Conference is, that on the solution of the problem of tropical soils, the world's future well-being will largely depend. The misuse of the tropical soils, a terrifyingly easy possibility, may leave the world permanently hungered and impoverished, to a degree which we scarcely care to contemplate.

The CHAIRMAN: There are only a few minutes left and I would like to call on Dr. Kellogg of the United States Department of Agriculture.

Dr. KELLOGG: I shall only comment on the last paper, I am particularly gratified by the last remark made by Dr. Clark. I too have made some calculations, quite different ones, and I find that there is a large amount of land available and the greatest part of that is in the tropics. That land can be efficiently managed, even though a great deal of it is not well managed at present. There are places that are well managed and where production is very high.

I would, perhaps, take issue with the prediction about agricultural labour. I do not believe that we will need anything like the present ratio of agricultural labour to industrial labour in the future. And that is particularly true as we cultivate the tropics. The cultivation of the tropics only goes forward now, where areas have available to them all the modern products of industry—machinery, electric power, fertilizers, hormones, insecticides, etc. If there is a key to this problem, that key is somehow to get people off the crowded areas, where they have no job, so that those that remain can have a job, and the others can start making products of industry that farmers need to do their job. We need more people in industry producing fertilizers and such things than perhaps are provided in the figures that you used as your basis for calculation. I am not sure of that—I think that.

I am accused of being an optimist and I am an optimist as far as the physical resources are concerned. We have the physical resources and we have the skills to give every person in the world abundant food for a far larger population than now exists. I am not, however, optimistic when I look around the world and see the political, social and economic handicaps in getting that skill applied to those acres by an alert and healthy agricultural population, for it is only an alert and healthy agricultural population that will use these skills we are talking about. When we are talking about feeding the world, we are talking about feeding farmers. Farmers that are illiterate, have too few acres, and are diseased, are not going to read the proceedings of this Conference or even your reports about it.

The CHAIRMAN: Dr. Kellogg's remarks are particularly appreciated by me, and I am sure they are well appreciated by the audience. Gentlemen, we have reached the limit of our time. The meeting will now adjourn.

A/54/763

...lish Academy of Engineering

...eneral, Food and Agriculture

Marcel LELOUP, Director, Forestry and Forest Products Division, Food and Agriculture Organization of the United Nations

Critical Mineral Shortages

H. L. KEENLEYSIDE, Deputy Minister, Department of Mines and Resources, Canada

Critical Shortages: Fuels and Energy

John C. PARKER, Vice President, Consolidated Edison Company of New York, N.Y., U. S. A. (Nominee of the World Power Conference)

Programme Director:

Carter GOODRICH

Programme Officer:

Alfred J. VAN TASSEL

Mr. Leloup's paper was delivered by Mr. R. C. Fortunescu, Chief of Secretariat, Division of Forestry and Forest Products, Food and Agriculture Organization of the United Nations.

The CHAIRMAN: I shall not spend too much of your time in telling you how much of an honour and a pleasure it is to be selected as your Chairman today; that is, that Sweden has been selected to provide a Chairman. Sweden, in this connexion, has one merit: economy is a natural thing for us. We have never been a land of abundance. One of our popular songs says: "Our land is poor and shall remain, but still we like to live and work and die there." So the subject of conservation and careful utilization is not new to us.

Yesterday we had an outline of the subjects to be treated. Knowledge is paramount in dealing with the tremendous problems facing us. The Secretary-General told us that scientists, through their knowledge, have the keys to open resources for the welfare of mankind. Mayor O'Dwyer underlined this; he told us that knowledge is our greatest resource. The subject of this Conference, as you know, is to compile, exchange, and discuss the facts on resources. But it is not easy even to discern the facts; I think that was one of the conclusions of yesterday's proceedings. We are all humans, subject to human limitations, and many of us are seasoned specialists in certain fields. We are accustomed to analysing possibilities for competing with other adjoining fields of activity or other regions of the globe. We must now try to see the wider aspects. In one of our old Scandinavian songs, it is said: "Better burden bore no man but much knowledge." But we must examine every item of information carefully, because we do not want to carry in that burden anything that is not true. Professor Bronk said yesterday that national borders are unnatural when studying natural phenomena. But there are other borders we must erase. Borders that grow sometimes into Chinese walls between fields of speciality.

One of Sweden's scientists some years ago said that even when dealing with fundamental facts of nature, each man carries a pair of goggles, ground by his training and experience, tinted by the philosophies and policies of the contemporary world surrounding him. We must put these intricately ground goggles away for the time. In the sectional meetings there will be opportunities for the specialists to measure their wits, but here, in the plenary meeting, we must try to put the specialist's goggles away. Even if our vision gets more blurred, we may get a better over-all view of the broad field before us.

We have the privilege, this afternoon, to listen to four eminent speakers of wide experience, dealing with four major classes of resources: food, forests, minerals, and fuels and energy. They all have access to great stores of knowledge. Never before have all nations given so freely of information about their own affairs as they do now to the United Nations and its agencies. That burden of knowledge is borne by a few men and it is, indeed, also a great burden of responsibility.

I have the great pleasure to introduce first Sir Herbert Broadley, who is the author of the paper "Critical Shortages of Food". Sir Herbert has a wide experience; he has been in the Civil Service in India; he has been on the Board of Trade; in the Imperial Customs Conference; he has dealt with the German Repatriation Act Committee, the Imperial and Economic Committee; he has been in the advertising business with one of the big London firms; he has been in Berlin on their account; he is a member of the Council of Institutes of Incorporated Practitioners in Advertising and would therefore also have a great understanding of the psychological facts underlying our problems. Now he is serving as Deputy Director-General of the Food and Agriculture Organization of the United Nations. I have the pleasure to ask Sir Herbert to deliver his address.

SIR HERBERT BROADLEY *delivered the following paper:*

Critical Shortages of Food

SIR HERBERT BROADLEY, K.B.E.

It would be true to say that, at the present time, there is no country in the world where everybody is adequately fed: it would be also true to say that in most countries of the world some people are actually hungry—and in many of them these hungry people number thousands and millions. People are still dying of famine and starvation—often, alas, because of humanity's own follies. It is the very fact of famine and starvation, the existence of hungry people, which is partly the cause of those follies—unhappiness and ill health, envy, political disturbances and even war, all of which mean the production of much less food than a peaceful, energetic world could provide.

Add to this situation the rapid increase in population which has marked the post-war years—20 million new mouths to be fed every year—and the relatively slow rate of agricultural recovery in a war-ravaged world, and one may well be tempted to despair of achieving a happy, well-fed, peaceful planet. It is because there are grounds for hope as well as for despair that the United Nations has called this Conference. In fact, if the problem were really insoluble, then the Food and Agriculture Organization might as well close its doors, for those high ideals conceived at Hot Springs at the height of the war would be only dreams and delusions. But President Roosevelt who called that Conference and all the practical experts in nutrition, agriculture, fisheries and forestry who attended it, took a very different view. They believed that a world free from want was possible. FAO still holds that to be a cardinal article of practical faith.

But let us look first at the immensity of the problem. I do not intend to venture into the technical fields of irrigation, soil science, agriculture or the expansion of new systems of plant and animal breeding, the elimination of disease, the reduction of waste and deterioration of foodstuffs. These are the subjects with which subsequent papers at this Conference will deal. All I will attempt to do is to measure the size of the problem and to give my reasons for believing that its solution is not beyond possibility.

It is true that the hungry—as well as the poor—we have always had with us. In the middle ages, England recorded seven major famines, in the centuries between 1200 and 1600. In India and China through their long histories, famine, disease and pestilence have been endemic. Even during the nineteenth century and at the beginning of the twentieth, Europe was three times at the end of her apparent resources, faced with the bleak outlook of insufficient food for the growing population. But each time the immediate pressure was mitigated by new developments, even though thousands and indeed millions continued to go hungry or suffer more or less acute malnutrition.

The first of these three food crises in Europe occurred during and at the end of the Napoleonic wars—partly the result of two decades of fighting and devastation. It was remedied by the development of more intensive agriculture and a restoration of transportation in the early 1820's. The second occurred about the middle of the century when the rapidly increasing populations of Europe, stimulated by the industrial revolution, were outgrowing their local resources. This crisis was solved by bringing onto the world's markets vast new food supplies from the American west. The third period started about the end of the nineteenth century and was not really solved until after the First World War, when large scale farming in Australia, Argentina and Western Canada again brought a new supply of food to the industrial countries of Europe.

Each time, new developments or new resources produced increased supplies of food. Each time, events overtook the relief obtained and increasing populations again pressed hard on available supplies. But although each time the production of additional food averted widespread disaster it was never sufficient to provide the whole of the people of Europe with a satisfactory standard of nutrition.

Just before the outbreak of the Second World War, food standards, in spite of great progress in many countries, fell far short of desirable figures. Less than one-third of the world's population were in areas where the available food supplies represented an average calorie content in excess of what is regarded as a reasonable minimum figure—that is, 2,750 calories per head a day. And not all of these supplies were actually consumed; some were lost in the retail shop, in storage, and in food preparation in the home. This third of the world's population, having access to an average reasonable calorie diet, comprised mainly North America, Oceania and much of Europe. Most of Asia, parts of the Middle East, much of Latin America and Africa fell into a much lower category, with an available calorie supply well behind a standard which nutritionists regard as essential to full health and an active useful life. But much as the world fell short of a minimum calorie diet before the war, it fell still further short of minimum requirements of proteins, vitamins and minerals, largely obtained from the protective foods. Two surveys carried out in England in the 1930's, admittedly on partial and restricted scales, indicated that over half of the population of that then relatively well-fed country fell short in one or other essential nutritional ingredient of a diet necessary to health.

But all attempts to measure the degree with which pre-war world food supplies fell short of world needs were fragmentary estimates based upon a limited volume of information. This was partly due to inadequate appreciation of the importance of nutrition. All we knew for certain was that millions of people everywhere had insufficient total food to ensure the healthy happy lives they had the right to claim, and that notwithstanding some improvements and developments in food production no solution was in sight. In fact, the world had not realized the measure of the problem, and therefore had no conception of the herculean efforts necessary to solve it.

The establishment of FAO in 1945 provided the first attempt to determine how far the world's food supplies fell short of minimum needs. Early in 1946, FAO convened a small group of nutrition experts to consider the question of nutritional targets. They set up nutritional standards based on quantitative principles (a minimum energy-value in calories per person per day) and on qualitative principles (certain minimum quantities of high quality protein and vitamin and mineral-bearing foodstuffs). The targets were adjusted to take account of regional differences in consumption habits and production possibilities.

An estimate was then made of the quantity of the food required to provide mankind with the diet necessary to supply these requirements. It vastly exceeded the total amount of food which the world was consuming before the war and consequently still more than that which was being currently consumed in those immediate post-war years. Even such relatively well-fed countries as the United States and the United Kingdom needed additional supplies of nearly every foodstuff. On the basis of estimated populations for 1950 (four years ahead of the date the calculation was made), the United States required, as compared with pre-war, 55 per cent more milk, 48 per cent more fruit and vegetables and 17 per cent more meat, fish and eggs. For other foodstuffs, small increases would have sufficed. The United Kingdom, on the other hand, needed 70 per cent more fruit and vegetables, 57 per cent more milk, a little more meat than the pre-war diet had provided, and some additional quantities of other foodstuffs.

In other regions, estimates based upon 1960 population expectations for the notoriously malnourished countries of Asia, South-eastern Europe and Latin America showed that they needed phenomenal increases in most foodstuffs. China needed an increase of over 5,000 per cent in milk, over 300 per cent in fruit and vegetables; India over 300 per cent in meat, fish and eggs, and the same increase in milk.

Rounding off the figures and taking the world as a whole, the world's needs for an adequate diet for all, by 1960, demanded increases over pre-war supplies of the following amounts:

	Per cent
Cereals	21
Roots and tubers	27
Sugar	12
Fats	34
Pulses	80
Fruits and vegetables	163
Meat	46
Milk	100

This means a need of over 60 million more tons of cereals as compared with pre-war supplies, another 30 million tons of meat, 250 million additional tons of fruit and vegetables and no less than 35,000 million gallons more milk. That and more is what the world would need to provide its teeming millions in 1960 with a reasonably satisfactory diet for everybody. A vast undertaking indeed!

These figures have often been quoted and are now well known. But it is necessary to repeat them to measure the task ahead. What are the prospects of producing all this extra food, and still more the quantities needed for the increasing generations after 1960? What progress are we making toward its achievement?

Since the war, progress has been all too slow. Some progress indeed there has been. The position might have been worse than it is: but it is nothing like as good as we might reasonably have expected; and it falls far, far short of what we so desperately require.

For 1948-49, the world supply of foodstuffs is estimated to be about 5 per cent above the average output of pre-war and at least 10 per cent above that of 1947-48. But with the increase in population which has occurred in the last ten years (no less than 200 million people), the average consumption per head is still below the prewar figures. Furthermore, there is now a greater disparity between the different countries of the world than ever before, in that much of the increase in consumption that has taken place since the beginning of the war has been amongst those countries in which consumption was high in the pre-war years.

While such slow and uncertain progress marks the world's efforts to rebuild its food production after the devastating years of war, other factors are making the advance we look for difficult of achievement. During the past decades and indeed centuries, the productive resources of the world have been damaged by nature and wasted by man. This thin layer of topsoil which clothes parts of this planet just as a thin piece of tissue paper covers an orange—and indeed, because of the holes representing mountains and seas, covers only part of the orange—is all that stands between life and death of the world's inhabitants. Thin and incomplete as this tissue-paper wrapping is, it has nevertheless been still further reduced by disastrous exploitations of forests, ill-conceived methods of cultivation, short cuts to wealth.

How therefore can we expect to meet these food targets which FAO has set before the world in face of an increasing population, our mishandled resources, our tardy recovery from a devastating war? Fortunately, these are not the only factors in the situation. There is another side to the picture; otherwise, FAO would be supporting a lost cause and this United Nations Conference would be wasting its time. We believe that the books of food supplies and food needs can be balanced, by increasing the supply assets, not by reducing the needs liabilities.

And why do we believe that? Because there are so many encouraging factors. Nevertheless they are factors which do not operate of their own accord. They are factors which we must bend to our ends, with no little sweat, blood and tears. There is land still uncultivated which can be brought into production; there are lost areas (wasted by nature and plundered by man) which can be restored to cultivation; there are ways of greatly increasing the output of our present fertile acres to bring forth food more abundantly. Later speakers during this Conference will describe *how* this can be done. It will be for delegates on their return to their own countries to see that governments are brought to a realization of their responsibilities and the necessary measures adopted.

Look, for instance, how a single field can play its part. From the fall of Rome to the French Revolution, grain yields in Europe remained at an average of 10 bushels or less an acre. By 1850, they had risen to 14 bushels in France, to 16 bushels in Germany and to over 20 bushels in England. By 1906, they had gone to 20 bushels in France, 30 bushels in Germany and to over 30 in England. Now in Denmark and the Netherlands, the average figure is close to 45 bushels an acre, with much higher yields on particular farms—and the end is not yet. New strains, more fertilizers, new production techniques and modern appliances are all playing their part. On land at present under cultivation it is entirely practicable to increase production on most items by an average of at least 20 per cent.

Not only can each field play a greater part in this campaign for more foods, but we can bring back into production fields which have ceased to yield—fields which are no longer fields but barren tracts or waste desert. We are now only too well aware of the dangers of soil erosion. During recent years, measures have been devised and applied to prevent its extension and to restore lost acres. Soil conservation is now an established branch of agriculture and forestry. The "dust bowl" area of the United States is now producing larger quantities of grain that it did before the "dust bowl" conditions of the middle 1930's appeared. Forestry practices and schemes of planned reafforestation will not only provide the world with the timber and other forest products it needs; they will also protect agricultural land from erosion, gradually restore lost fertility and be the means of bringing water supplies to dry and thirsty lands. More trees ultimately mean more food.

Nor must we be satisfied only with the restoration of lost fields to production: we can convert into productive fields land which has hitherto never contributed to our food supplies. It is reasonable to assume that about half of the world's land surface is unsuitable for cultivation. This includes the mountains, the snow-covered areas of the Arctic and Antarctic and some of the sandy desert regions. But of the half which is potentially cultivatable, only about one-fifth is now being farmed. The greatest areas of undeveloped farm land lie in northern Canada, the Soviet Union, in Africa, Central and South America and in parts of South-east Asia and some of the tropical islands. If only 10 per cent of the potential farm lands of northern Canada and the Soviet Union were used for dairying and cold weather vegetables, on the pattern of Scandinavia, there would be added 300 million acres of new farm land to our resources. The United States itself could provide another 70 million acres.

The really great areas of undeveloped soils in the world are in the tropic regions—Africa, South and Central America. Beginnings of projects for increased food production in these areas are already taking shape in British East Africa, the Belgian Congo and West Africa. But they are all in the initial stages. Dr. Salter has calculated that if only 20 per cent of the unused tropical soils were brought into cultivation, we should be harnessing for the better feeding of mankind at least another 1,000 million acres. Such lands might well prove as prolific in production as the tropical soil of Java and Hawaii. If so, the additional food supplies would be tremendous.

And do not let us forget that part of the earth which is not land at all. The seas—the origin of life—may contribute much to its preservation—in large quantities of food, in mineral salts invaluable as fertilizers, in power. Man has not yet attempted to till the waters of the earth as he has tilled the land. In fishing we are still at the nomadic hunting stage of obtaining our food supplies. The time will come when we shall cast our bread upon the waters and see it multiplied manyfold.

Leaving aside the seas, rivers, lakes and ponds for the moment, let us see what the land alone can contribute to solving our problems. Dr. Kellogg of the U.S. Department of Agriculture has estimated that if the farming of existing crop land was raised to those reasonable standards of efficiency which have been demonstrated in many places, if an extra 1,000 million acres were developed in tropical areas (only a fraction of the potential territory) and if an extra 300 million acres were brought into production outside the tropics (again only a part of the present uncultivated soil), then those extra 60 million tons of cereals, 30 million tons of meat, 350 million tons of fruit and vegetables and those 35,000 million gallons of milk would be much more than forthcoming.

There is therefore no cause for despair: but there is cause for serious reflection and real determination. It is easy to produce figures: it is much less easy to produce food. The improvement of present production methods, the recovery of lost lands and the protection of threatened acres and, above all, the cultivation of new territories call for research, technical assistance, training, capital investment on a large scale. President Truman visualized the possibilities in the famous Point Four of his inaugural address last January. The United Nations and the specialized agencies have developed that vision into broad programmes of action. It still remains to convert those broad conceptions of what is possible into the practical achievements of what is needed.

The cultivation of new territories is a very different proposition from the improvement of production methods in areas already under cultivation. Greatly increased output from the farms in the backward countries is possible without vast expensive projects of mechanization. Better yielding seeds can be introduced at small cost. Fertilizers are becoming available in increasing quantities. FAO is already assisting several of its member countries in such matters; much can be done by supplying trained experts to train other people to adopt simple technical processes.

On the other hand, the opening up of new lands—whether in the tropical areas or in those unproductive regions outside the tropics—calls for a wider approach. The areas must be surveyed, soil studied and maps prepared, settlement schemes must be planned, experts must be trained in local conditions, steps must be taken to measure the extent of soil erosion and prevent its further development. All this will cost money. But it will be money invested in the production of a happier, healthier mankind. The ultimate savings will be immense, in better health, harder work, avoidance of war, and in all the vast cost of what we spend on armaments and other measures to prepare for war and prevent it.

If funds for an expanded programme of technical assistance for economic development are provided by the Member countries of the United Nations, this will supply a means of undertaking this vast task of charting the world's potential food resources and planning for their better utilization. In any case, it might well be urged that this is so vital a matter to humanity that the nations of the world might establish a "World Food Fund" for the very purposes I have described, possibly as the spearhead of the comprehensive programme of technical assistance for economic development. It would not be a fund to provide the capital investment ultimately required, nor would it be used for commercial transactions in the commodity field—those must be financed from elsewhere—but it would provide the resources for accurately measuring the possibilities, organizing the necessary research, planning the strategy of the international food campaign and training those upon whom will fall the responsibility of directing the tactical operations of that campaign. So far, we have only just begun to realize the dangers of a world population hungry, underfed, ill and discontented; we have only glimpsed the possibilities of increased food production on a vast scale. But we have not yet taken either very seriously. The feeling of responsibility is growing: we need the sinews of war. A "World Food Fund" would enable us to marshall the forces needed to win this terrific battle on which so much depends. If we succeed, it may well be that the twentieth century will be the century of the agricultural revolution, just as the nineteenth century was the century of the industrial revolution.

But it is not enough merely to produce more food. That is a vital first step. Food must be there before hunger can be assuaged. But we no longer sit beneath the flapdoodle tree where the food ripens over our heads and falls into our mouths; where our own backyards provide us with all we need. Industrialization has created vast urban areas, huge concentrations of population far from the fields and orchards and farms of the world. One of our greatest problems of today is to achieve a satisfactory system of exchange between these two worlds. At the present time, the world is patently failing to solve this problem. Farmers in some countries are even now afraid that they may be producing more than they can sell, with all the consequences of over-production: surpluses, slumps, bankruptcy. And at the same time, millions are hungry in other countries for lack of the very food that may soon be piling up in unsold dumps elsewhere. So critical has this issue already become that the recent meeting of the FAO Council in Paris charged the Director-General and his staff to make this one of their major preoccupations and prepare a report, with the best technical advice they can obtain, for the next conference, on all the implications of the present position; with practical proposals for ensuring that the available supplies of food flow from those who create it to those who need it, and that farmers do not arbitrarily have to restrict production while millions of people are still hungry and underfed.

This is a long-term as well as an immediate problem.

In developing increased food production, we must make sure that we are not just piling up supplies in particular places, without having made sure that these supplies will reach those who need them. In other words, the development of increased food production is part of the orderly development of economic activity in all its aspects throughout the world, so that the results of human effort in every field are interchangeable to the benefit of all. A world economy which does not provide agricultural and industrial producers with a fair basis for exchanging the products of their labours will frustrate the best endeavours to increase the supply of food which the world so much needs.

The development of increased food production within the wider economic conception is not planning in the discredited bureaucratic sense, with its form filling, permits, controls and so on. It is the co-ordination of national policies, rather than the regimentation of national programmes; it is projection of long-term objectives into an interrelated whole, so that efforts of the different countries of the world are co-ordinated on broad lines to achieve complementary rather than duplicated or conflicting activities. That is the field in which FAO is endeavouring to help its member nations.

That is our task, if we are effectively to banish the grim forebodings of those who peer dimly down the "road to survival" and fear that it may end in a precipice. It need end in no precipice: it can broaden out over rich, fertile, sunlit plains. Great efforts, much toil, vast imagination are needed. To ensure that these themselves are productive, financial resources to be used as a "World Food Fund" are required—for surveying possibilities, for developing the necessary plans for production, for working out the bases of exchange and distribution. Other papers during this Conference will detail many of the fields in which work is already going on and indicate how much more is capable of achievement. These are the themes of other speakers. I have tried merely to indicate the size of the problem and the reasons for confidence in its solution. At this stage in our deliberations, I want mainly to express our faith in the future. We are not assembled here with our backs to the wall determined to make a last grim bloody stand in a hopeless cause. We are preparing for a new day, a new "D" day, confident in the assurance that victory is possible—nay, sure—if we have courage, plan intelligently and use all the resources of this world aright.

The CHAIRMAN: Sir Herbert Broadley, we all wish to thank you very cordially for this splendid exposé of the world food position. I think we can place as a motto for this speech the quotation: "A world free from want is possible, that is an article of faith: free from want not by reducing the needs, the liabilities, but by increasing the supply of assets". But there are also shadows creeping into the picture. When critical situations have arisen, Sir Herbert has told us, new regions have been admitted in the world's affairs—North America's "Golden West", Australia, and Argentina. Soon these regions, through rising home consumption, will be out of the international market. Even now only 10 per cent of the world's food goes through the international market. FAO is planning to create new farm land in tropical and semitropical regions.

One of the most remarkable facts pointed out by Sir Herbert is that the great increases in consumption of food have taken place in the best-fed countries and even in those countries, he told us, millions of people are inadequately fed. Behind these facts lie economic laws that may be more difficult to handle than the application of scientific research. But nature, too, is a hard master; cultivation according to present techniques often leads to erosion, dust storms, increased attacks by insects and pests. As Mr. Colin Clark said yesterday, we do not know much about tropical farming; on the other hand, in Scandinavia, living close to the Arctic, we are not so optimistic as to the possibility of increasing yield per acre. Mr. Clark also pointed out that new acreage for farming means new investments in roads, dwellings, schools, fertilizer and tractor factories, etc. It means more men and more mouths to feed. And all this is slow work. FAO has taken up the transportation and distribution problem, as Sir Herbert just told us, and there also they will meet increasing costs, costs which hit the needy. However, we are grateful to Sir Herbert for giving us this sweeping picture of the food resources field, and we are happy that he is so strong in his optimism and in his faith.

I regret that the author of the next paper, Mr. Leloup, is not able to attend the Conference as his duties have required him to be away in Europe. I should like, nevertheless, to present in the ordinary way, Mr. Marcel Leloup of France who is the author of the next paper on Forests. Mr. Leloup is an engineer from the *Ecole Polytechnique* in Paris, but he has also studied at the *Ecole des Eaux et Forêts* in Nancy. He is now Director of the Division of Forestry and Forest Products of the FAO.

We are, however, fortunate to have present with us Mr. Fortunescu, who will present Mr. Leloup's paper and who is one of his closest collaborators in the FAO.

Mr. FORTUNESCU *delivered the following paper:*

Critical Shortages: Forests[1]

MARCEL LELOUP

INTRODUCTION

Man has produced within a few centuries a change in the face of the earth so profound as to be comparable with the variations brought about by the preceding geological ages. Barely one thousand years ago, when the earth's population was very small, forests occupied the largest part of the earth's surface, with the possible

[1]Original text: French.

exception of Asia and the Mediterranean seaboard. They no longer do so today.

In primitive times the forest was at once the enemy and the friend of man. It provided him with an easy source of shelter, food, and sometimes even clothing; but as time went on he had to work hard to cut down trees, dig out the stumps, transform forest soil into agricultural soil, and sometimes struggle to prevent tree growth from re-invading land brought under cultivation.

Today the picture is a very different one. In most countries the man in the street has only a very vague idea of the role of the forest. He does not easily see a connexion between the wood he uses every day in many different forms and the forest which produces it, at the price of constant care, the need for which he barely realizes, and vigilant protection, which is sometimes required precisely to counteract his own negligence. But in considering the shortage of forest products one must go right back to their source in order to realize the difficulty of obtaining from the existing exploited forests the material required to meet human needs.

Let us look briefly at the present situation from this point of view.[2]

WORLD BALANCE IN RESOURCES

The following is a balance sheet based on present known facts. It cannot be mathematically exact, as our information is taken from estimates which vary in exactitude with the different regions. It is, notwithstanding, a more or less faithful picture of the present situation, and the resulting conclusions are based on facts which can easily be verified.

RESOURCES

For a population of 2,300 millions the world has a total forest area of 4,000 million hectares (27 per cent of the total continental area), 2,600 million hectares of which are estimated to be productive and 1,400 million exploited.

It is difficult to estimate the annual production of the world forest area. From the statistical point of view the unexploited forests, commonly called virgin, have a nil increment, as they do not become a positive source of production until exploited. Hence it is only for the exploited and properly managed forests that a possible annual yield can be estimated and the annual extraction judged to be higher or lower than that yield or equivalent to it.

REQUIREMENTS

The same is true of requirements. At present they are not precisely known and to form the first estimate would require lengthy and laborious research. It is very difficult even to reach a definition of the term "requirement", not only because requirements differ with climatic conditions, but also because they vary considerably with the degree of civilization and the available resources in substitute products and materials, notably for heating and building. Hence the only data we possess relate to consumption, which is certainly much below requirements, as we shall shortly indicate.

CONSUMPTION

The Statistical Yearbook of Forest Products estimates the 1947 timber consumption as 1,453 million cubic metres (1,000 million tons of roundwood), or 0.6 cubic metres or 430 kilogrammes per inhabitant, made up as follows:

	Millions of cubic metres	*Per cent*
Fuel wood	825	57
Saw timber	360	25
Pulp	119	8
Industrial wood	149	10
	1,453	100

Wood consumption varies enormously from one region to another. In some it is 7 cubic metres per inhabitant and in others only 0.02 cubic metres; some use very little firewood while in others it is the main fuel.

If we exclude fuel wood, we find that high wood consumption regularly accompanies a high standard of living. For these reasons it seems we shall obtain a more exact picture of the situation by considering the balance of resources by regions; it is proposed to adopt that method in the present paper and to give a systematized outline of the characteristics of each region.

It must not be forgotten, however, that statistics can only show what may be called "controlled" production. Outside of that, in most countries there are no data of the extent (often much too large, unfortunately) of the annual loss of forest resources caused by abuses such as fire, destructive grazing and unplanned nomad agriculture. To forest production proper must be added the production from hedges, rural trees and roadside or canalside plantations, which are of considerable importance in some countries.

Europe

For a population of 385 millions, the forest area is estimated to be 126 million hectares (26 per cent of the total area—0.3 hectare per inhabitant), 3 million hectares of which are inaccessible. Before the war there was a more or less equal balance between growth and cut. But during the war and post-war years the cut has been appreciably greater than the growth.

Saw timber consumption is estimated at 10 million standards or 0.21 cubic metres per inhabitant.

The European Forestry and Forest Products Commission estimates that reconstruction needs require an additional cut of 50 million cubic metres, at least 20 per cent more than the present growth rate.

USSR

Situated partly in Europe but mainly in Asia, the USSR possesses one-quarter of the world's productive forests. The 1950 production estimate is 280 million cubic metres, of which 37 million cubic metres are saw timber. Present consumption is estimated at 1½ cubic metres per inhabitant.

The possibilities for the future development of forest exploitation and forest industries are considerable, owing to the existence of forests as yet unexploited in the north-western part of the country, and a production of 1 million cubic metres, or three times the 1950 figure, may be possible in future.

Near East and North Africa

There is a sparsely-wooded region with a population of 120 millions. There are only 31 million hectares of

[2]The present paper is concerned only with the shortage of materials, omitting all questions relating to the other uses of the forest, which are to be dealt with separately at other meetings of the Conference.

productive forest, one-half of which is classed as inaccessible.

Local *per capita* consumption is only 0.01 cubic metre and this area may be said to obtain its supplies from the European market, thereby contributing to the deficit in Europe.

The present critical situation is the fatal consequence of a forest devastation which appears to date back 4,000 years.

North America

For a population of 153 millions there are 456 million hectares of productive forest of which 158 million hectares are classed as inaccessible, giving a *per capita* figure of 2 hectares of accessible forest.

The *per capita* consumption of wood in North America is the highest in the world, 20 per cent higher than in Europe, and it is accompanied by a high standard of living.

The *per capita* consumption of saw timber is 1 cubic metre, five times greater than in Europe. The region uses 65 per cent of the total world consumption of pulp, although the population is only 8 per cent of that of the world.

The annual cut of saw timber is much higher than the growth of productive wood (50 per cent more), and the situation cannot fail to deteriorate if no steps are taken to remedy it.

South America

This region presents a dual paradox:

(*a*) It contains the largest reserve of unexploited forests, yet its wood consumption is low;

(*b*) In spite of the large forests, almost all the countries of this vast region have soil-conservation and reafforestation problems.

The population of the region is 151 millions and there are 715 million hectares of forest, or 4.7 hectares per inhabitant.

Estimated consumption is 176 million cubic metres, mainly fuel wood; saw timber consumption is estimated at only 9 million cubic metres, or one-seventeenth of that of North America, only slightly exceeding consumption in Australia and New Zealand, which have a total population of 10 millions.

Economic development of the region should result in a rapid rise in the standard of living with a consequent great increase in wood consumption, and it seems unlikely that this region will export large quantities of timber in the future.

Africa (Excluding North Africa)

Africa contains 747 million hectares of forest, 298 of which are productive but only one-half of these are exploited.

The continent has a population of 143 millions and the *per capita* wood consumption is estimated to be 0.4 cubic metre.

Before the war, although it exported a limited quantity of high-quality timber, Africa was in the main considered to be an importer of timber. It would be unwise to consider this region as capable of exporting large quantities: for the same reasons as in Latin America, the development of the region will be accompanied by a considerable increase in local wood consumption, and if strict precautions are not taken there is more likely to be a tendency towards destruction of the forests followed by deterioration in the soil fertility of the region.

Far East

This region contains one-half of the world's population—1,152 millions—and its productive forest amounts to only 0.3 hectare per person, the same proportion as in Europe, but only one-half of it is accessible. Moreover, the forests are very unequally distributed.

There is a shortage of saw timber almost everywhere, and in certain large areas a shortage of fuel wood also. In some countries the shortage is very severe and the problem requires quite special attention.

The shortage of pulp and paper is a matter of common knowledge.

The *per capita* consumption is only one-fifth of that of North America.

Oceania

In a total area of 855 million hectares with a population of 12 millions, there are 50 million hectares of natural forests and a number of fairly large artificial plantations.

The region affords an excellent illustration of the importance of wood in modern standards of living: including the necessary imported wood, the consumption of timber and pulp per head is higher than in Europe.

The area's resources make it fairly capable of meeting its own needs.

CRITICAL SURVEY OF THE SITUATION

The following conclusions may be drawn from this somewhat cursory survey:

(*a*) Three regions—Europe, the Near East and North America—require more saw timber than their forests are at present capable of producing on a sustained-yield basis.

(*b*) One-third of the human race, living in Europe, North America, the USSR and Oceania, absorbs 83 per cent of the total world consumption of saw timber and 95 per cent of that of wood-pulp.

If we accept the idea that saw timber and wood-pulp are elements essential to modern high standards of living, in order to provide reasonable housing and education, our purpose will be to meet the needs of the 1,500 million inhabitants at present under-supplied and thenceforward to make available to them a quantity of wood products much greater than they at present consume.

Particularly in the countries advanced in forestry, where people are conscious of the value of forests, know their possibilities and try to keep the annual cut down to a quantity compatible with good conservation, the conclusion generally maintained has been that, although there is a shortage in certain continents, it could easily be remedied by imports supplied by exploitation in regions where a surplus is held to exist. The situation as we have shown it to be indicates that in the long run this conclusion is most certainly mistaken.

Must we immediately conclude that the forests of the world are incapable of meeting man's present and future requirements?

Our answer to the question put in that way is a categorical "No."

PROPOSED REMEDIES

Modern research and technique, both in silviculture and in the use of forest products, would suggest that there are practical solutions to the problem, which may be classified under the following three headings:

(1) *Better utilization of forest products:* by which is meant a better output, both at the exploiting and at the saving stage, eliminating all waste, combined with a rational and more economical industrial use of the products.

(2) *Better forest management.* At the present time the output from managed forests almost everywhere could be increased and virgin forests could be transformed, by exploitation and appropriate silvicultural methods, from what is at present entirely unproductive capital into productive capital.

(3) *Conservation of existing forest capital and re-afforestation.* In many countries, however, the first need, before planning, is to ensure adequate protection of the forest against abuse by man and beast, an essential step in transforming the forest into a productive resource. In addition, there are millions of hectares where agriculture has been abandoned, which could be transformed into productive surfaces by reafforestation.

Certain areas also need reafforestation to prevent soil destruction and ensure a regular water supply, the most essential of mankind's resources.

For those who may not be convinced of the efficacy of the proposed remedies I should like to quote a few figures:

(1) It is estimated that at the present time the wood supplied to consumers in the form of various products represents only 40 per cent of the cut. Technicians have demonstrated that better mechanical utilization could increase this percentage to 60; technical processes for the utilization of waste wood also now exist. By methods now well known it is possible to utilize almost the whole of the cut.

There is no doubt, therefore, that by applying these methods it might be possible in the not very distant future almost to double the volume of useful products obtained from the same quantity of raw forest material.

(2) Let us consider the 2,600 million hectares of productive forests in the world. Each hectare could produce 3 cubic metres of wood annually, which would place at the disposal of the world as a whole 7,800 million cubic metres per year, or more than five times its present apparent consumption.

There is another point which I should like to emphasize, however, for it is of supreme importance in connexion with the solutions contemplated. It is essential that forestry experts and timber experts should work together on the various proposed solutions.

The timber supplied to industry should, of course, be of the quality it requires for optimum efficiency, but the demands of industry must also be compatible with the rules the silviculturist must apply in order to achieve an optimum output from his forests.

Forests and forest industries should be considered as a whole. This would lead to the idea of forestry combines, which could take varying forms to suit different regional or even local conditions.

GENERAL CONCLUSIONS

In conclusion, I should like to draw your attention to the importance of the problem before us.

The gravity of the present situation must not be ignored, and although certain countries may be ready to take the necessary measures, this is perhaps not true of all regions.

It is characteristic of the problems of forestry and forest production that the methods applied only bear fruit after a long time. If the exploitation of inaccessible forests is excluded, it may be said that the results of measures taken today are often only visible in twenty-five or thirty years.

There is no doubt whatsoever that urgent measures need to be taken.

If we fail to act now, future generations will have to bear the consequences of our blindness, and our responsibility for failing, with full knowledge of the facts, to take the necessary measures will be heavy in their sight.

On the other hand, if we all work in the direction indicated we may have entire confidence in the future.

In spite of their diversity, in spite of the difficulties which prevent the transport of some of their products for great distances, the forests of the world are one, because they are everywhere an element essential to human welfare, and it is upon the human welfare of each country that the harmony and progress of humanity as a whole depend. If the plan I have tried to outline is put into effect everywhere without delay, we can rest assured that this great collective wealth of the globe will be capable of meeting the needs of its inhabitants.

The CHAIRMAN: We thank you, Mr. Fortunescu, for your clear exposition of Mr. Leloup's paper, and we ask you to convey to him our gratitude for the fine paper which he has prepared. We are especially glad to note that he has not limited himself to average figures but has examined the forestry situation in each major region of the world. He has pointed out quite frankly that the situation is difficult. One might perhaps add that roads and other means of transportation, as well as structures, are also necessary in the forests, and that all of these cost money. Replanting is also necessary, and even that is a considerable item of cost. Further, even where forests already exist, we may have to consider the necessity of replacing the minerals and other substances—of using forest fertilizers. Again, Mr. Fortunescu, please convey our most sincere thanks to Mr. Leloup.

I have now the honour to introduce Dr. Hugh Keenleyside, the author of the next paper on "Critical Mineral Shortages". Dr. Keenleyside is a man of great scientific training. He is Doctor of Philosophy and also a Doctor of Laws. He is Deputy Minister of the Department of Mines and Resources in Canada and thus has had experience in administration. He is founder and member of a number of organizations for the study of Arctic and Canadian geographic conditions.

Mr. KEENLEYSIDE *delivered the following paper:*

Critical Mineral Shortages

H. L. KEENLEYSIDE

I

I am deeply sensible of both the honour and responsibility which I accepted in agreeing to prepare a statement on critical mineral shortages for a plenary session of this Conference.

It would be difficult to exaggerate the importance of the subject. The significance of minerals in providing the material basis for the economic life and social organization of humanity has long been recognized. Indeed, historians and archaeologists commonly designate the major divisions of human history by reference to the mineral products which were most characteristic of the successive eras. Thus we have the Paleolithic and Neolithic Periods and the Copper, Bronze and Iron Ages.

Contemporary civilization, beyond all preceding experience, depends for its continuance on the minerals which permit and sustain its existence. The growth and concentrations of population, the frequency and speed of movement and transport, the extent and quality of human control over the forces of nature are all directly dependent upon the discovery and utilization of mineral resources. It is, therefore, of prime importance that we should have as accurate information as can be obtained about the extent of the available reserves in this field.

It will be obvious to all those who have given thought to the subject that a single paper can do no more than outline in general terms the facts of so vast and complicated a subject. However, even generalizations are difficult because our information is so inadequate. Both scientists and economists have boldly adventured in this field and many volumes have been written on particular aspects of its problems—especially within the last ten years. But in most cases the result has been simply to underline the conclusion that our knowledge of the facts is so meagre as to make any precise estimate or detailed and dogmatic forecast either impossible or else of most dubious validity.

Estimates of the general position have varied all the way from a strong conviction that new sources of supply and new techniques of exploitation will always keep ahead of human demand, to the contrary view that the standard of life now enjoyed by the more industrialized nations is in danger of early collapse through the exhaustion of essential resources.

Optimistic observers point out that there is today no serious or general shortage of any essential metallic or non-metallic mineral product. They recall the way in which discovery has kept abreast of increasing demand in the past, and argue that new discoveries, combined with increased efficiency in methods of processing and utilization, will be adequate to meet any foreseeable future needs.

Those who take the more pessimistic view rightly emphasize that mineral resources, as contrasted with those of the animal and vegetable kingdoms, are wasting assets; they are not replaceable. Nature has supplied a certain amount of metal and mineral content in the crust of the earth and when the utilizable portions of this are exhausted, either by waste or by beneficial use, it cannot be restored. The current rates of consumption present an altogether new problem for which past experience gives no assurance of a solution.

Scientists and industrialists agree on the necessity of maintaining an ample supply of minerals and metals if contemporary forms of civilization are to be maintained or if further progress is to be achieved along lines already defined. Iron, copper, lead, zinc, nickel, aluminium, magnesium and other base metals are by definition fundamental to our way of life. Almost equally important are such alloying metals as manganese, chromium, molybdenum and tungsten, which are essential to the steel industry. The industrial minerals—limestone, sulphur, salt and fluorspar—supply the raw materials for much of the world's chemical industry, while the mineral fertilizers, phosphate rock and potash, are of growing importance in agriculture. Without these, or effective substitutes, large segments of the prospective population of the earth will be condemned to lives of misery and degradation.

The implications of these facts raise a problem so vast and of such universal incidence that in a sane world they would be made the immediate subject of common study and co-operative planning. Unfortunately, the society in which we live is, as yet, very far from having reached that degree of sanity. It is true that some measure of co-operative activity does exist among scientists and that this could readily be expanded if international political and social conditions would permit. Unfortunately, the current trend would seem to be in the opposite direction. Of this the clearest example is to be found in the difficulties that are being experienced in adapting atomic energy to beneficial rather than to destructive uses. *In the race between education and catastrophe, education is falling farther and farther behind.*

Unhappy as the situation is, we can derive some meagre satisfaction from such gatherings as that upon which we are presently engaged. Whatever the ultimate results of this Conference, we shall at least know that here a co-operative international effort has been made to look at the whole problem of world resources in terms of the general welfare. *This Conference may not represent a long step forward but at least it is not an illustration of the contemporary international practice of walking backwards.*

II

Before commencing a more detailed examination of the problem with which we are faced it would, I think be well to spend a moment in defining terms. For the purpose of this discussion it is assumed that a "critical shortage" means a shortage of such proportions that the essential needs of the world cannot be met and that the material progress of humanity must, in consequence, be slowed down or directed towards new objectives. I do not include among the "essential needs" the requirements of war. *If humanity finds it impossible to avoid war, we may as well assume that we shall be interested in surviva* *rather than in progress.* Nor do essential needs include an obstinate adherence to custom or convenience. If a plastic will take the place of a metal in any particular function, the use of metal in that function is not an essential need.

Consideration should not be given to temporary shortages which, like temporary surpluses, may result from changes in the business cycle. It is only by studying the long-term requirements that significant conclusions can be reached.

Nor should problems of national self-sufficiency be allowed to intrude. In scattering its beneficence, nature has not taken note of national boundaries, and it is to be hoped that eventually our economic and political systems can be so adjusted as to ensure an equitable international distribution of mineral and of other resources.

Examined in these terms it is quite clear that there are in the world today no critical mineral shortages. But this temporary condition should not be allowed to induce a false optimism as to the future. The warning signals are flying. *In a matter of this importance we cannot afford to do too little; we must not postpone our studies until too late.*

III

As has already been indicated, and as must be constantly recalled, we are hampered in our consideration of this subject by the fact that there are no reliable and complete statistics covering either the extent of our mineral resources or even the rate at which they are being currently consumed. This is true nationally and even more true internationally. Consumption fluctuates from year to year in accordance with the industrial activity prevailing in the individual countries and in many of these the statistical information available has only a nominal or shadowy relationship to the material facts. Our difficulties are increased by the particular consideration that there are no recent figures available, except in isolated instances, in regard to either reserves or consumption in the USSR. Any attempt, therefore, to estimate the world position must be critically viewed in the light of these gaps in our knowledge. Yet in this case ignorance is dangerous.

We do know, with reasonable accuracy, what proportionate amounts of aluminium, iron, magnesium, titanium and other metals are to be found in the crust of the earth. We know, for example, that for every 100 units of lead there are:

200 units of zinc
400 units of uranium
480 units of copper
1,000 units of nickel
1,800 units of chromium
32,000 units of titanium
248,000 units of iron
400,000 units of aluminium.

The "Big-Four" of the metal world—nickel, copper, zinc and lead—are relatively scarce. But this, however interesting, is of little real significance. What is important is the extent to which the various metals are to be found in economically, or even in technically, workable concentrations. For example, lead, zinc and tin are rarer constituents of the earth's crust than uranium, although usable deposits of the latter are of much less frequent occurrence than are those of the other three metals. It is not the quantity, it is the concentration that matters.

Among the reasons for our meagre knowledge of our mineral heritage is the fact that in only a few countries has there been any systematic and detailed geological and mineralogical study of the national domain. Even in the United States of America, where more attention has been given to this matter than in any other country, estimates of available resources are recognized as being little better than intelligent guesses. For example, in 1914 the taxable iron ore reserves of the famous Mesabi range were estimated at 1,386 million tons. In 1947 the reserves were still in excess of 900 million tons, although in the meantime many hundreds of millions had been withdrawn. Similarly a competent authority in 1945 estimated the proven oil reserves of the United States at a figure more than four times as great as the accepted estimate made in 1915 in spite of the tremendous withdrawals during the generation that had intervened. Since that time the great oil fields of the Middle East have been discovered, and promising fields in other areas have been opened. Thus any attempt to estimate the real extent of world reserves of oil becomes an exercise of dubious value. Yet we cannot escape the fact that this resource is being consumed at a rate never before approached in history, and that the rate of consumption is steadily and rapidly rising.

Since the beginning of this century the depletion of our mineral resources has been proceeding at an unexampled rate. Indeed, *the quantity of mineral products consumed between 1900 and 1949 far exceeds that of the whole preceding period of man's existence on earth.* It is a grim commentary on human intelligence that a great proportion of the minerals used during the last five decades has been criminally wasted in the waging of the most destructive wars in history.

The increases in consumption since 1900 have covered all the more important metals and minerals. During that time production of pig iron, lead and tin has more than doubled; zinc and copper have quadrupled; aluminium, nickel, tungsten and others have shown still greater ratios of increase.[1] A similar expansion has occurred in the use of industrial minerals, while the use of certain metals used in alloys has risen to astronomical heights.

The rate of consumption of any mineral resource is, of course, subject to a variety of influences. Under conditions of free enterprise mineral deposits are normally exploited only when the margin between the costs of production and the price the consumer will pay will yield a profit to the operator. Obviously, therefore, any improvements in mining, milling or refining techniques that result in lower production costs or in an increase in the percentage of the metal recovered, will correspondingly increase the total of our commercially available resources. The more efficient we become in the utilization of low-grade ores, the more satisfactory our supply position. The same result can also be obtained in the free market when the consumer is willing or able to pay increased prices. It is only in times of emergency, and unfortunately this usually means in times of war,

[1]Under present conditions something over 100 million tons of pig iron, about 3 million tons of copper, 2 million tons of aluminium and 1¼ million tons each of lead and zinc are annually required. (This does not include the large and growing consumption of scrap metals.)

that the influence of prices becomes insignificant. In such circumstances scientific or technical considerations rather than market influences decide the availability of essential commodities. Finally, the supply position is affected by the accessibility of deposits, the availability of labour and power, and such political factors as taxation and royalties.

Significant as these economic factors are, however, they do not affect the over-all position of the extent and variety of our mineral resources—except as they may advance or retard the current rates of consumption.

It is significant that in the cases of agriculture, forestry, fisheries and certain other fields of resources development some progress has been made in the direction of conservation. All these are renewable resources. Yet in the case of minerals, which are not renewable, there has been practically no effort, except in time of war, to interfere with the free play of a market that is interested primarily in profits. This anomaly cannot continue indefinitely.

IV

If we cannot give an adequate estimate of our present resources we may find some significance in an examination of the certain trend of future demands. If these should, in any instances, expand beyond all likelihood of any comparable new discoveries, that fact will be immediately pertinent to our inquiry.

There are certain basic factors which are clearly distinguishable. *The first of these is the rapidity with which the number of human beings on the earth is increasing.* Success in the battle against famine and disease is contributing directly to this result. Not only is the population increasing, it is increasing at an accelerating rate. At the present tempo the population of the world will double in less than ninety years. The current increase is approximately 20 million persons per annum or about 60,000 every day. Even in the length of time occupied in the presentation of this paper over 1,500 more human beings are being born than have died. In military terms, two new battalions are added to the population of the world every hour of every day.

A second fundamental factor is the almost universal demand for a higher standard of living. This will mean, inevitably, an expansion of the demand for mineral products.

As an indication of how this might affect the world's mineral resources, a distinguished American scientist recently prepared a study of the consumption of pig iron in the United States as compared with that in the rest of the world. In 1945 the utilization in the United States was 790 pounds *per capita*; for the whole world, including the United States, it was 97 pounds; for the world, not including the United States, it was 47 pounds. He then went on to say that these figures deserve careful thought by those who envisage supplies for the whole world even remotely approaching those of the present highly industrialized countries. (8)[2]

Consider what would happen if the rate of consumption of iron were to rise throughout the rest of the world to *one-half* the present rate in the United States. The total demand—on the basis of the present world population—would be in the neighborhood of 450 million metric tons per annum. Applying the United States experience on the same basis to other metals it is possible to envisage a prospective world demand for:

10.9 million metric tons of copper
8.7 million metric tons of aluminium
8.3 million metric tons of lead
6.8 million metric tons of zinc
2,480.0 million metric tons of oil.

But the population of the world will not remain static and there is no reason to believe that the people of other nations will be satisfied indefinitely with a rate of consumption only one-half that of the United States today. *Yet if demand in these proportions should develop, it would, so far as we now can estimate, be greatly beyond the capacity of any known or probable supply.*

Increasing scientific knowledge combined with humanity's desire for a decent standard of living, have resulted in the development of many new uses, not only for the common metals, but for those less known and more rare. Among the latter, attention is now being centred on uranium as a source of atomic energy but there are also cadmium, calcium, columbium, magnesium, molybdenum, tantalum and titanium. The last of these is still in its experimental stage of production but it possesses such inherent physical qualities as to capture the imagination of metallurgist and manufacturer alike, being as strong as steel with half the weight and with great resistance to corrosion.

Many of the new advances in man's mastery over nature place additional burdens on our metal resources. Air and automotive transportation, electrical refrigeration, air conditioning, radio, television and rural electrification are all developments which have greatly expanded the demand for metals. The utilization of atomic energy will require vast increases in the production of steel, copper, lead and the rarer metals.

Within the last two decades the metallurgist has sought to improve the quality of metals for manufacturing purposes by the addition of alloying elements to obtain greater strength and other desirable properties. Today these alloys are virtually made to the order of the manufacturer and designing engineer. As the research metallurgist gains more and more knowledge of the properties of metals, new combinations of properties will be provided by alloys of the future, each one serving some particular need of industry. As this science proceeds the demands for the rarer metals will correspondingly increase. It is here that critical shortages may first appear. For example, in the development of metal alloys to withstand the high temperatures of the jet engine, columbium and cobalt are regarded as essential. Yet these metals are not only rare in the composition of the earth's crust but economic concentrations are exceptionally difficult to find.

Thus it is quite clear that the combination of an increasing population and rising standards of living will place a strain on our metal resources which will almost certainly in the end prove beyond the capacity of man and nature to supply. It remains to be considered what steps can and should be taken in an effort to prepare for this development.

V

Our hopes for the future should be directed first towards the discovery of new ore bodies.

[2]Numbers within parentheses refer to items in the bibliography.

It has been said with a great deal of truth that the easy mineral finds have now been made. A review of the discoveries made within the last two decades, particularly in the base metals, reveals only a few of major importance. With minor exceptions the metals are today coming from areas that were discovered many years ago. Only the intensive work of the geologist and mining engineer in determining the structure and extension of the known ore bodies has lengthened the active life of these mining areas. Other ore bodies, buried beneath glacial or other overburden, undoubtedly exist but their discovery can seldom be accomplished by surface prospecting. *The lonely prospector with hammer or pan is today a romantic rather than a significant figure. In his place the contribution of the scientist must be brought to the rescue of the mining industry.*

Already much has been done by the physicist and geologist in the use of geophysical methods of prospecting for oil concentrations. The use of the magnetometer, the dip needle and other similar devices is beginning to reveal mineral deposits hidden beneath the overburden, although their results must still be checked by physical means such as diamond drilling.

Probably the outstanding development in geophysical prospecting in recent years has been the air-borne magnetometer. By this means a continuous record can be made of the magnetic intensity along the path flown by the plane. This record enables the geologist to determine areas of high intensity such as are usually associated with metallic ore bodies. The results obtained are generally as accurate as those obtained on the ground and the flying magnetometer has the advantage of speed since 150 miles or more of magnetic profile can be secured in an hour of flying time.

Other scientific aids in prospecting for certain ores include ultra-violet light, and recently in the search for radio-active materials the Geiger counter has become indispensable.

The greatest hope for fresh supplies of ore depends upon the discovery of new ore bodies in those areas as yet undeveloped. The map of the world shows vast areas of South America, Africa, northern Canada, Asia and Australia, which have not yet been geologically mapped or intensively prospected. New deposits will certainly be difficult to find but with our constantly growing knowledge of the geological and allied sciences it may reasonably be expected that many discoveries will yet be made.

VI

The second step to be taken in our effort to postpone the inevitable date when mineral shortages will develop is the improvement of our techniques of extraction and processing. New and more efficient methods of mining are constantly being sought. In addition, we must continue to broaden the field of research in our metallurgical practices. The record of discovery in this field offers good evidence that further research will result in further refinements. The development of the cyanide process made it possible to recover gold from ores previously regarded as worthless and thus added immeasurably to the world's reserves of this metal. The change from gravity methods of concentration to froth flotation produced comparable results in the treatment of sulphide ores. The electrolytic refining of metals has not only increased the purity of the product but has been responsible for the recovery of many new and rare metals as by-products. Cobalt and metals of the platinum group are recovered from the copper-nickel ores of the Sudbury area, while cadmium, bismuth, indium, thallium and other rare metals have been recovered from lead-zinc refineries. The introduction of dust precipitators and baghouses into the smoke stacks of smelters and roasters has resulted in the reclaiming of large quantities of metals that have been volatilized or vapourized. The development of processes for the manufacture of sulphuric acid from the smelter gases resulting from the treatment of sulphide ores is now established practice. A large part of the world's requirements of magnesium and magnesia are now extracted from sea-water, a procedure that was considered fantastic when it was first proposed less than fifty years ago.

These are merely examples of past achievement in a field in which further progress can be confidently anticipated. In the future, as higher grades of ore are depleted, more attention must be given to the treatment of complex and low-grade ore bodies by leaching or other chemical methods. Further study must also be given to the possibility of obtaining minerals from sea-water.

In addition to the search for new ore bodies and the improvement of our processes of extraction and treatment, greater study must be given to the possibilities of conservation and substitution.

Under the heading of *conservation* there are two steps of obvious importance. The first is the re-use of metal scrap. Among the more highly industrialized countries scrap today plays a role of real and increasing importance. The chief sources of supply are the obsolescence of manufactured metal products and the waste that results from machining and other steps in fabrication. In the latter case careful segregation and handling of the waste permits its direct return to the melting furnaces. Waiting for metal products to become obsolete is a slower process but in those countries that have long been industrialized the supplies of obsolescent or obsolete material are playing a more and more important part as a continuing source of metal reserves. In typical recent years scrap provided 49 per cent of the iron, 42 per cent of the lead, 34 per cent of the copper, and 13 per cent of the zinc used in the United States.

The second step in conservation is the prevention of corrosion by the use of preventive coatings of some other metal or of one of the resin compounds, or by the creation of new alloys that resist the corrosive influence of the elements. Much work has already been done in this field but much more remains to be achieved.

Closely related to conservation is *substitution,* and substitution is being achieved in a rapidly increasing variety of forms and instances. Technical developments in manufacturing often permit the substitution of metals that are in plentiful supply for others that are relatively scarce. The use of aluminium and magnesium in transportation and other fields as a substitute for steel is an example of this process. These metals and their alloys have also been applied to many structural and building uses in which strength is not of paramount importance. The use of aluminium as a substitute for copper in electrical transmission lines has effected a tremendous saving of the scarcer metal. Where lightness is a factor in design, both aluminium and magnesium are being used with marked success in the castings industry. The knowledge and skill of the metallurgist are now being devoted to the introduction of new alloys of these metals that will further widen their use. The supplies of both are relatively abundant.

The short supply of tin and its comparatively high price during and since the war have led to reductions in its use and in some cases to substitution in alloys, babbits and solders.

Perhaps the most important developments in the field of substitution are those provided by the industrial chemists who have produced synthetic products that can be used in place of metals in an increasing range of manufactured products. So extensive and successful have these developments been that an increasing number of chemists are prepared to argue that prospective shortages in the field of metals can be disregarded. They cite the case of the nitrate fertilizer industry and the plastics industry as examples of the alchemy of the future.

In a book written by the Chief of the Forest Products Branch of the Food and Agriculture Organization of the United Nations, and significantly entitled "The Coming Age of Wood",(11) the author argues that the material salvation of the world is to be found in a properly-managed forest policy. *According to his argument wood can supply not only hamburg steaks and fur coats but, suitably treated, can also take the place of metal for almost every purpose in which the latter is now used.*

Without accepting all of the claims of the chemical fraternity, it is undoubtedly true that over a very wide range of use synthetics can be employed to relieve the pressure on our mineral resources. It must, however, be recognized that chemicals, which in turn are based on inorganic materials, are employed in the manufacture of these synthetic products. Thus, indirectly, the drain on the mineral resources of the world will continue even though it may be reduced by the use of synthetics. Moreover, it is probable that there will always be certain cases in which the requirement of high resistance to shock and other similar specifications will demand the continued use of metal products. Given the type of civilization that humanity has developed and that is likely to characterize the future of the race, the demand for metals to be used in circumstances of this kind will certainly continue. *Consequently, the use of plastics and other similar synthetic products should now be regarded as an important conservation measure; we can only hope that it will eventually develop into a final substitute.*

In this connexion, however, it should be recognized that considerable progress has been made in the devising of synthetic mineral products. Prior to the First World War Chile was virtually the only source of nitrate for fertilizers and explosives. The development of a process for the manufacture of synthetic sodium nitrate and ammonium nitrate has reduced the world's dependence upon the natural product, although it is significant that the production of natural nitrate has not appreciably declined. Artificial crystals, artificial mica and artificial graphite have all been successfully produced and for some uses are even considered to be superior to the natural product. Perhaps the outstanding development in this field has been the manufacture of the artificial abrasives, silicon carbide and carborundum. These have largely replaced the natural abrasives, corundum and emery, economic deposits of which are relatively rare. Fortunately, the mineral basis of these artificial substitutes, silica, alumina and coke, are in abundant supply. A further example of this kind of substitution is to be found in the development of an artificial cryolite from the use of fluorspar thus reducing the importance of the natural cryolite upon which the aluminium-refining industry depended, and which is known to exist only at Ivigtut in Greenland.

VII

In conclusion we must revert to the theme that has been fundamental to this whole discussion and repeat again that our knowledge of the world's supply of mineral products is so meagre and so unreliable as to make it impossible to forecast with any assurance even an approximate date at which we will be faced with a critical shortage of any specific item. *It is clear,* as I have already stated, *that there is no serious and immediate over-all and irreplaceable shortage of any essential mineral. But it is equally clear that the demand for mineral products is increasing at such a rate that unless there is a fundamental change in the economic fabric of human society we will ultimately be faced with the exhaustion of many of our mineral reserves.* In some cases, particularly lead, cobalt and copper, and possibly also iron and oil, the supply will be exhausted more rapidly than in others. New discoveries, improved methods of extraction and processing, and careful conservation will postpone the advent of critical mineral shortages. Substitution may provide alternate solutions. When shortages do develop they may not be critical because alternatives may be available. *But this is a hope, not a promise.* In the meantime the practices which have used or squandered our mineral resources in the past still continue and consumption is rising at a rate that can only be described as alarming.

The situation that is thus developing will make heavy demands on human intelligence and good will. Since no one nation has been endowed with all its mineral requirements, the problem crosses every national boundary. The discovery of solutions is of universal concern.

The experience of the two world wars has shown the folly of wasting our irreplaceable mineral supplies in barren struggles that, apart entirely from the moral and social degradation which they produce, end only in general impoverishment and the permanent depletion of our resources. Further conflicts of this kind will hasten the day when real shortages in our reserves will develop. *They may leave us too little time.*

Because the problem is a world problem, the search for solutions should be on a world basis. That search can be made infinitely more productive if it is based on an increased appreciation of the necessity for scientific research in this field. There must be co-operation in the exchange of technical and industrial knowledge. Above all, there must be peace. *Given these conditions we can refuse to admit that any material problem is beyond the ultimate competence of mankind.*

If, on the contrary, we hold firm to our ideological, national and racial rivalries and hatreds, if we place on our scientists the bitter burden of the prostitution of their services in war, if we fail to realize the danger as well as the immorality of the irresponsible behaviour that has marked the past conduct of international affairs, humanity will suffer the fate that it has long invited.

The world has entered a new era. Humanity has at last achieved the power of self-destruction. Our record gives no assurance that it will not be used.

Surely the time has come to abandon the perversity of war; to devote our talents and our wills to the immensely harder tasks of peace.

If we in this generation are to make our contribution to the solution of the real problems facing mankind, we must be prepared to abandon many customary ways. Our link in the growing chain that binds nature to man's needs must be truly welded if those that follow are to meet the problems of their day. It was never more true than it is today that:

> "New times demand new measures and new men,
> The World advances, and in time outgrows
> The laws that in our fathers' day were best;
> And doubtless, after us some better scheme
> Will be shaped out by wiser men than we,
> Made wiser by the steady growth of truth".

Table 1. Abundance of Metals

In the upper 10 miles of the earth's crust (with aluminium designated 100 instead of 8.13 per cent)

341	Silicon	0.61	Barium	0.06	Tungsten	10^{-3}	Tin, Arsenic, Molybdenum, Rubidium
100	Aluminium	0.45	Chromium	0.05	Zinc	10^{-4}	Mercury, Cadmium, Antimony, Calcium
62	Iron	0.32	Zirconium	0.05	Lithium	10^{-5}	Silver, Bismuth, Selenium
45	Calcium	0.25	Nickel	.04	Hafnium	10^{-6}	Gold, Platinum, Tellurium
35	Sodium	0.23	Strontium	0.04	Tantalum Columbium	10^{-7}	Osmium, Iridium, Thallium
32	Potassium	0.21	Vanadium	.025	Lead	10^{-8}	Indium, Palladium, Germanium, Gallium, Ruthenium, Rhenium
26	Magnesium	0.18	Rare Earths	.025	Thorium		
8	Titanium	0.12	Copper	.012	Beryllium	10^{-9}	Radium
1.25	Manganese	0.10	Uranium	.012	Cobalt		

Sources: F. W. Clarke and H. S. Washington, "The Composition of the Earth Crust", *U.S. Geological Survey*, Prof. Paper 127, Washington, D.C., 1924.
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Table 2. World Production of Basic Metals

(Primary metals in thousands of metric tons)

	1910	*1922*	*1929*	*1938*	*1943*	*1946*	*1948* estimate
Copper	877	904	1,950	2,018	2,757	1,833	2,358
Aluminium	37.9	92.3	281	572	1,941	748	1,542
Zinc	825	719	1,496	1,565	1,828	1,406	1,724
Lead	1,193	1,070	1,474	1,678	1,574	1,161	1,724
Magnesium	—	—	3	24	240	14	18
Nickel	22.5	11.7	56	114	172	127	145
Tin	116.4	122.6	195	161	118	90	136
TOTAL NON-FERROUS	3,071.8	2,919.6	5,455	6,132	8,630	5,379	7,647
Pig iron	66,300	55,640	98,249	82,750	110,768	79,833	108,862
Ratio Ferrous and Non-ferrous	20.9	19	18	13.5	12.8	14.8	14.2

Source: Mineral Year Book and *Mineral Industry*, 1941.

Table 3. World Metal Production—New Metal Only

(Thousands of metric tons—yearly averages over 10-year periods)

	1 *1901-10*	*2* *1911-20*	*3* *1921-30*	*4* *1931-40*	*5* *1947*	*6* *Peak year*	*Ratio of increase Col. 1 to Col. 6*
Aluminium	18	95	183	383	1,073	1,953 (1943)	1:108
Bauxite ore	207	599	1,378	2,544	4,200*	14,137 (1943)	1: 68
Asbestos	74	140	306	380	800*	800 est. 1947	1: 10.8
Copper	690	1,106	1,368	1,790	2,154	2,718 (1942)	1: 3.9
Fluorspar	102	200	260	319	660	1,050 (1944)	1: 10.3
Pig iron	50,060	66,600	65,400	76,770	109,600	137,000 (1943)	1: 2.7
Lead	996	1,107	1,438	1,499	1,167	1,850 (1941)	1: 1.86
Manganese ore	2,211	1,860	2,642	3,928	3,700	5,491 (1941)	1: 2.48
Mercury	3,674	3,741	3,947	4,077	4,825	9,480 (1941)	1: 2.58
Molybdenum	128	294	832	8,860	10,000*	31,300 (1943)	1:244
Nickel	16	35	36	80	138	167 (1943)	1: 10.4
Nitrates (Natural sodium nitrate)	1,769	2,510	2,169	1,193	1,400	3,240 (1929)	1: 1.83
Phosphate rock	4,076	5,373	8,830	9,767	12,000*	12,000 est. 1947	1: 2.94
Potash (K_2O equivalent)	441	972	1,693	2,286	3,000	3,660 (1943)	1: 8.30
Sulphur	744	1,155	2,232	2,500	4,300	4,300 est. 1947	1: 5.8
Tin	103	127	152	158	116	237	1: 2.3
Tungsten (60% WO_3 con.)	3,432	15,335	10,510	25,280	26,000	61,200 (1943)	1: 17.8
Zinc	667	881	1,117	1,349	1,540	1,760 (1942)	1: 2.64
Salt	15,060	20,630	25,440	31,394	36,000*	38,577 (1942)	1: 2.56
Mica	4,490	12,003	15,514	23,313	60,000*	6,200 (1946)	1: 14.3

*Estimate.

Note: These statistics are intended to indicate trends other than absolute figures. They are as accurate as available information permits, but as in many cases, especially in recent years, production figures are not available for all producing countries they cannot be considered to be exact.

World Mineral Production 1946

(Output of principal nations expressed in percentages of world production)

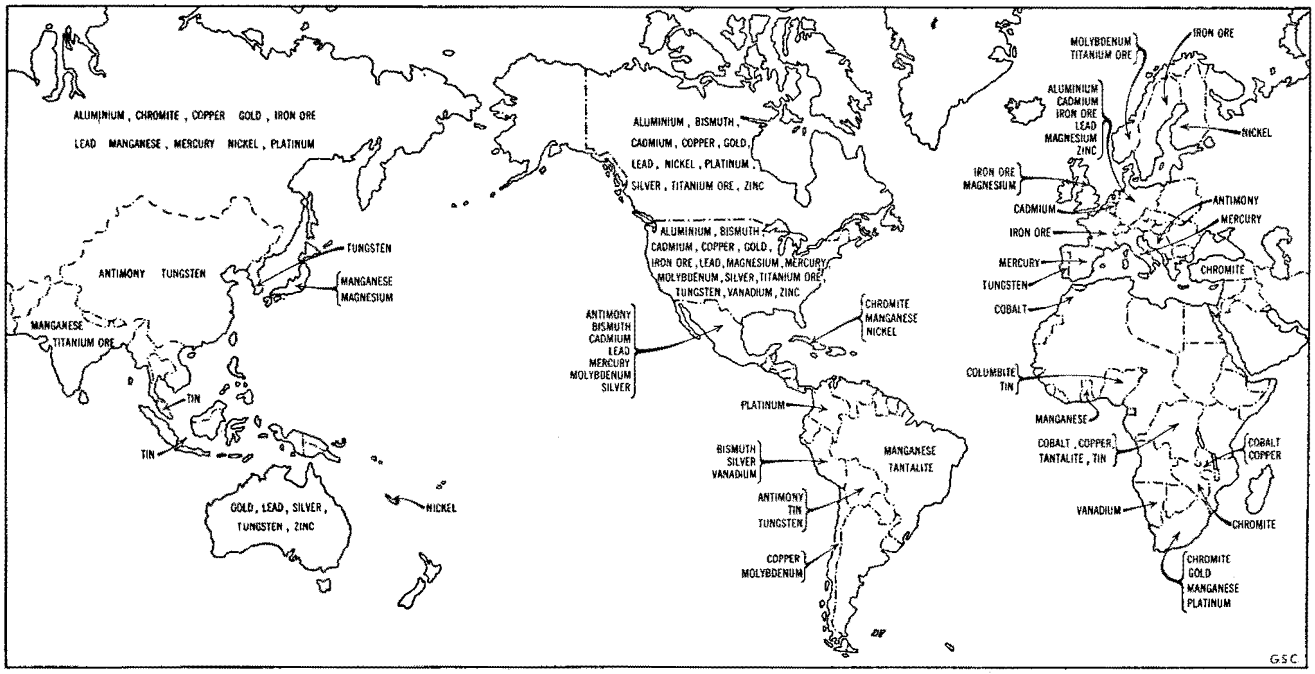
	1946 (metric tons)	*Country and percentage*
Aluminium	750,000	USA 49, Canada 23, USSR 12 (est.)
Antimony	24,900	Bolivia 25, Mexico 24, Union of South Africa 10, Hungary, Yugoslavia, China
Asbestos	720,000	Canada 70, USSR 14, S. Rhodesia 7, Swaziland 4
Barite	1,100,000 est.	USA 60, Canada 10, UK 10, Germany, USSR
Bauxite	4,000,000	British Guiana 29, USA 27, Surinam 14, France 12, USSR
Bismuth	940	Peru 30, Canada 11, USA
Cadmium	4,049	USA 57, Mexico 18, Canada 8.5, Australia 5.5
Chromite	1,110,000	Union of S. Africa 17, Cuba 15, Southern Rhodesia 13, Turkey 10, USSR 35 (?)
Cobalt	2,860	Belgian Congo 75, N. Rhodesia 17, French Morocco 6.5
Columbite	1,680	Nigeria 99
Copper	1,860,000	USA 34, Chile 19, N. Rhodesia 10, Canada 10, Belgian Congo 7.7, USSR
Corundum	3,372	Union of South Africa 55, Canada 31, Nyasaland 11
Cryolite		Greenland
Diamonds (metric carats)	10,313,000	Belgian Congo 58, Union of South Africa 12, Gold Coast 8, Angola 7.7, Brazil 3.1
Fluorspar	567,000	USA 44, UK 8.2, Canada 5.4, USSR, Germany
Gold	27,777	Union of South Africa 42, USSR 2, Canada 10, USA 5
Graphite	145,000	Chosen 60 (?), Mexico 15, Japan 8, Madagascar 6
Gypsum	10,319,000	USA 50, UK 16, Canada 16, France 4.3
Iron ore	146,000,000	USA 49, France 11, UK 8.5, USSR, Germany
Lead	1,166,000	USA 38, Australia 13, Canada 13, Mexico 12, USSR 8.7
Magnesium	11,977	USA 40, USSR 25, Italy 11, UK 10
Manganese ore	3,650,000	USSR 47, Gold Coast 16, India 10
Mercury	4,800	Italy 35, Spain 29, USA 18, Mexico 8.4
Mica	64,200	USA 77, India
Molybdenum	10,000	USA 82, Mexico 8.2
Nickel	127,000	Canada 68, USSR 11, Cuba 10
Petroleum (1,000 bbls.)	2,750,190	USA 63, Venezuela 14, USSR 6, Iran 5.3
Phosphate	11,885,000	USA 59, French Morocco 22, Tunisia 11, Algeria 4.9
Platinum metals (troy ounces)	576,000	Canada 42, USSR 30, Union of South Africa 13
Potash (K_2O)	2,240,000	USA 38, France 23, Germany
Salt	35,545,000	USA 38, USSR 14, UK 9, China 6.4, India 6
Silver (fine oz.)	129,000,000	Mexico 33, USA 16, Canada 10, Peru 10
Sulphur	4,250,000	USA 91
Talc	770,000	USA 54, France 8.6, China, Chosen, Italy
Tantalite	200	Belgian Congo 60, Brazil 22
Tin	90,500	Bolivia 42, Belgian Congo 15, Nigeria 11, Malaya 10, Netherlands E. Indies 7.3
Titanium concentrates	500,000	USA 52, Norway 13, India 20
Tungsten (60 per cent WO_3)	19,000	USA 25, China 14, Bolivia 11, Brazil 8.5
Vanadium	1,069	USA 54, Peru 30, S.W. Africa 10
Zinc	1,406,500	USA 47, Canada 12, Belgium 6.1, Australia 5.6

Note: The foregoing table does not list all producing countries, but is designed more to show the relative importance of producing areas, the erratic geographical distribution of the commercial deposits, and the consequent interdependence of the nations of the world for essential mineral requirements.

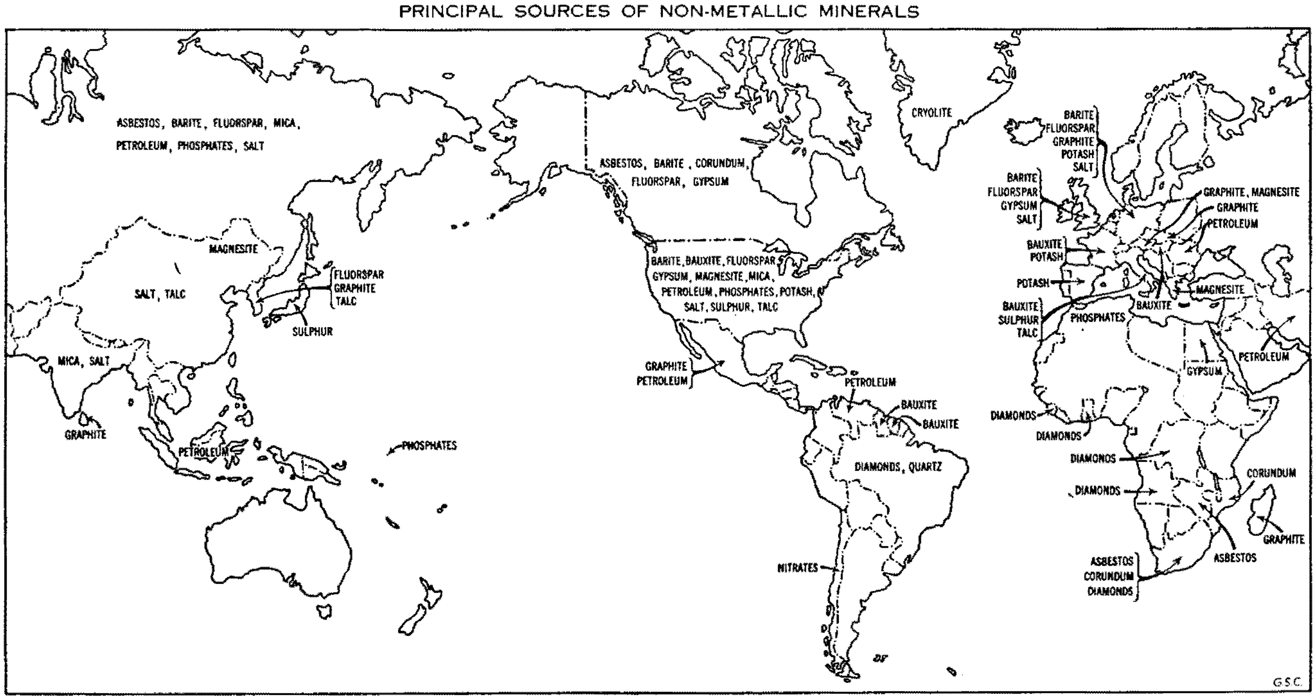
The year 1946 has been chosen since it represents the post-war year for which most complete data are available. It is realized that it does not represent the norm since rehabilitation was far from complete in the war-torn areas. This is particularly true of the tin-producing areas. As of 1949 rehabilitation of mines and smelters in Malaya and Indonesia was proceeding at a satisfactory rate. At the last meeting of the Tin Study group in London it was estimated that tin production would exceed the potential demand for commercial uses by the end of 1949.

Sources: Department of the Interior, Bureau of Mines, *Mineral Yearbook 1946*. Preprints from the Bureau of Mines, *Minerals Yearbook 1947*.

PRINCIPAL SOURCES OF METALLIC MINERALS



PRINCIPAL SOURCES OF NON-METALLIC MINERALS



Note to accompany maps

These maps indicate only the countries which normally produce 10 per cent or more of the world's requirements of a selected list of metals and minerals. They are intended not to show all known sources but rather to illustrate the distribution of those mineral areas most actively developed under present conditions.

The picture presented can by no means be considered final. The vast areas of Asia, Africa, Australia, Northern Canada and South America which have not been prospected or mapped in detail are all potentially rich in minerals, and new discoveries may at any time upset the balance as we know it today. Present-day production is no true indication of the world distribution of mineral deposits. Each continent has large areas of Precambrian rocks, and igneous intrusive rocks of Tertiary age whose chief economic attraction is as a source of minerals. No large unit of these rocks has thus far failed, when adequately prospected, to be the source of essential minerals.

The difference in productivity of these areas is due more to the ingenuity and efficiency of the inhabitants of the region in discovering and using the mineral wealth than to a lack of this wealth in the underlying rocks. As the more remote areas are mapped with the assistance of aircraft and modern prospecting methods, great new deposits will be opened up to play their part in the world supply of minerals.

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The Mineral Industry Statistical Summary, London, Imperial Institute, covering years to 1944.

Metal Statistics, Metallgesellschaft Aktiengesellschaft, Frankfort-on-Main.

M. Meisner, *Weltmonatstatistik,* Preussischen Geologischen Landesanstalt, Stuttgart, Ferdinand Enke.

The CHAIRMAN: Dr. Keenleyside, in expressing the appreciation and thanks of the audience, I wish to emphasize particularly the many excellent references contained in your paper. It deals not only with detailed figures on deposits, but you have also pointed out how incomplete is our knowledge about the minerals contained in the crust of the earth. You have given us insight into the psychological effects of temporary and local shortages. You have pointed out the importance of minerals that are consumed in very small quantities, but still form essential pivots in the world's machinery. You have pointed out that one metal can often be replaced by another and that metals can be replaced by plastics and wood. Indeed, if the distribution of minerals in the crust of the earth had been a quite different one from now, it may be suggested that man would perhaps have been able to build up a high, but somewhat different civilization on whatever minerals happened to be available.

You have suggested that there are no really critical shortages now and that the future depends entirely on our own actions. You have pointed out very clearly that we cannot afford to increase world consumption to the level of the United States today and that gives us all food for thought. You have discussed the question of scrap metal; it is an old saying that no mine is better than a good scrap heap. You have mentioned the fight against corrosion. You say that shortages may not become critical for a long time. Even if this is a hope, not a promise, we thank you for these bright spots in a picture where light and shadows form an intricate pattern.

And now I have the honour to introduce the fourth and last speaker of this morning, Dr. J. C. Parker, Vice-President of the Consolidated Edison Co. of New York, who speaks about "Critical Shortages—Fuels and Energy." Dr. Parker is an engineer with a scientific education specializing in power—steam, electric and hydro-electric power. He is a fellow of numerous scientific and engineering societies and has just retired as Vice-President of the Consolidated Edison Co. of New York. Dr. Parker, will you please present your paper.

Mr. PARKER: I was at much pains to indicate that this paper was presented because of the perhaps somewhat indiscreet nomination of myself by the World Power Conference to present the paper. Let me emphasize, that I do not speak for the World Power Conference, that anything that I have said in the paper is my own, and that in the Conference there doubtless will be many strenuous objections to some of the philosophies set forth here.

Mr. PARKER *then delivered the following paper:*

Critical Shortages—Fuels and Energy

JOHN C. PARKER

ABSTRACT

This paper seeks to review the current reserves of fuels and the supplies of energy.

It differentiates the enormous reserves of solid fuels from the more limited production. It indicates substantial improvements in the production of fuels and energy in 1948 above the status ten years earlier, concludes that statistical data as now available are intrinsically unreliable and fragmentary and, moreover, but little probative of economic fact.

It attempts to relate the conservation of fuel and energy to the conservation of effort in production rather than to the conservation of resources and attempts, further, to indicate that appraisal of the adequacy of the supply of fuels and energy through the processes of production is relative to the general economy of the area under consideration rather than being a matter measurable in terms of absolutes.

It is almost trite to say that a world survey of shortages of such things as fuel and energy must start with local shortages and that ameliorative operations also will have in a measure to be local in character. At the same time this runs into a bit of a paradox since it will be recognized that the locality which experiences a shortage may be part of a larger natural locality, and that what is done in one minor locality may profoundly affect a natural region which perhaps should be considered as a whole for the optimum development of resources.

An attempt at a statistical study of the supplies of fuels and of energy starting with localities defined by the political boundaries of the various countries of the world discloses discrepancies of trend and status from country to country of such a character as to a large degree to nullify the value of any global statistics and, indeed, to emphasize the significance of local and particular considerations. Moreover, a recital of merely statistical data of the entire congeries of nations would be wearisome and uninformative. It is deemed essential, therefore, that an analysis be made of the functional significance of such data, for instance, as appear in the *Fourth Statistical Year Book of the World Power Conference,* which gives data on resources and annual statistics for 1936-1946.

A highly superficial scanning of the data in the Year Book discloses, for instance, that as to every principal coal-producing country of the world there is a virtually indefinitely large reserve of coals—either proven or probable. As to each of these countries and as to all varieties of solid fuels the reserves are adequate to the present rate of use for centuries or even for millennia. There is then no problem of the adequacy of the stock in place in the earth.

Superficially there would seem, as to many countries, to be an entirely different situation as to the trends of production. These in the decennium reported were highly regressive in many countries.

Even as to the nature of progress or regression in production there will of necessity be a variety of interpretations which means that the significance of the data may not be the same for various localities. There are some countries, for instance, in which production has materially expanded. The data show that this has in part been induced by an enhanced domestic use and in part by export. Some of the export activity in its turn is due to definite shortages of production elsewhere, either responsively to international policy or to economic motivation. Some of the shortages of production are obviously due to the devastation of equipment and workings brought about by military action; some by more deliberate, subsequent political action and in other places by internal social and economic readjustments.

While probably of minor significance, it is an unavoidable inference that some of the lessened production is due to a reduced need consequent on a lowered level of industrial activity, and some to a reduced financial ability to buy solid fuels and their product in the form of gas or electrical energy.

There is likewise a suspicion that in some places, at least, a lessened coal production may be due to the working out of the more easily mined seams.

To the extent that lessened production has to do with the mining itself—that is to say, as a consequence of social and economic readjustments or of the necessity to work more difficult seams—remedies may be found in a fuller mechanization of mining operations or possibly in the distillation of coal in place for the extraction of gas where such extraction is adaptable to the requirements of utilization.

As to mines the output of which has been reduced by the flooding of workings or the disablement or removal of machinery, the remedy is obvious.

As to those areas in which a reduced production is a consequence of a lowered industrial economy or of narrower economic resources of a local population, there is neither a direct remedy nor a need for such a specific remedy. The problem is broader and more profound.

Solid fuel production in a given area is important for only two possible reasons—comparatively local utilization or export. If the barriers of transportation or embargoes or customs duties prevent or impede export, there remains approximately local utilization. The production of coal in and of itself is not a desideratum. An economy that effectively can utilize coal, industrially or for the comfort or convenience of the people, is at once intrinsically important and a necessary precedent to the production of fuels which in any event are only a means to a social and economic end.

It would be beyond the scope of this paper and indeed an impropriety to discuss what are the best means by which general political and economic ameliorative conditions can be brought about. This much, however, seems certain—that if the human benefits to be accomplished by technologic improvements of the processes of extraction fall short of balancing the human effort that must be expended in those technological developments the latter should not be undertaken.

By way of parenthesis, it might be asked why an over-all global figure of production should not be stated. There are two obvious answers to this question. One is that such a figure, though it showed an improved production status for the world as a whole, would be illusory as to those localities which, none the less, suffer an acute shortage from their needful usage. Beyond that, however, is the unfortunate fact that data are not at hand as to important fuel-producing regions so that precise survey becomes impossible.

For what it may signify, however, a reference is made to a United Nations publication No. 1949, *Major Economic Changes in 1948,* which says:

"World production (excluding the USSR) of fuel and energy—coal lignite, crude petroleum, hydro-electric energy and natural gas—during the first nine months of 1948 reached 125 per cent of pre-war levels. The relative contributions of coal, petroleum and electricity to this increase may be gauged from the following indices (based on monthly averages):

Year	*Fuel and energy*	*Electricity*	*Crude petroleum*	*Coal*
1937	100	100	100	100
1947	120	170	152	102
1948 (Jan.-Sept.)	125	183	171	104

"The output of electric power and crude petroleum continued to climb steeply in contrast with the slow but steady increase in coal production. The long-term trend towards the substitution of other sources of fuel and energy for coal appears to have been accelerated considerably during the post-war years."

And again:

"By the autumn of 1948, world production of coal had reached near-record levels, thereby considerably alleviating the critical shortage of this commodity, which has characterized the post-war period, particularly in Europe. World production of coal during the year ended 30 September 1948 is estimated at more than 1,520 million metric tons—about 10 per cent above the 1937 level, and about 3 per cent above that of 1947. The largest part of the increase was due to the recovery of coal production in Europe, where 1948 output (excluding the USSR) reached 88 per cent of the pre-war level and represented a gain of 8 per cent over the preceding year.

"The outstanding developments in Europe were the increase of production in practically all coal-producing countries, substantial increases in amounts available for export from European sources and, as a consequence, marked increases in supplies in most countries and a substantial decline in imports from outside Europe, particularly from the United States."

The problem posed by the solid fuels would seem at first blush to be not one of conservation in the face of the virtually unlimited reserves, proven and probable, and with the as yet unknown reserves in less-developed areas of the earth's surface. There is obviously little point in conserving solid fuels to repose underground for use centuries hence when in the interim energy may come to be developed directly from the sun's heat or through the processes of nuclear fission. In many cases the conservation of coals will be accomplished only by the expenditure of human effort in producing the materials for, and in constructing and operating, devices which may at some far distant date be found not to have saved anything worth the saving.

This may be stated another way. Coal lying underground is of negligible value, while coal as extracted and delivered to the point of utilization has a cost measured mainly by the human expenditure involved. This expenditure of human effort is currently measurable and may be vastly worth conserving. The techniques necessary to conserve it will themselves involve an expenditure of effort. The problem then is that of striking a balance. Will the sum total of effort wrapped up in devices for mechanizing our mining be less, all things considered, than the extra effort necessary with unmechanized production, remembering that the activity engaged in mechanizing the mines will of necessity be activity deflected from other use by society. Will the aggregate of labour expended in the production of cement and steel and electrical machinery and turbines for a hydro-electric project be less than the aggregate of human effort involved in fuel plants and in the mining and transportation of fuel by the optimum method during the presumptive life of the alternative hydro-electric plant?

There is here posed a problem in conservation, not of resources in a state of nature but of the current and subsequent human resources necessary to bring them into the service of men.

To these questions there can be no general answer though protagonists of one enthusiasm or another have sought to generalize. A difficult hydro-electric development remote from the location at which people care to use its product may, in the face of an ample supply of easily extracted and delivered fuel, constitute anything but a conservation project. On the other hand, areas blessed with easily developed water powers reasonably close to a need for their energy and distant from an economically adequate fuel supply might develop these water powers as a real measure in conservation.

Similarly, those things which may be warranted in improving the efficiency of utilization of fuels are almost of necessity insusceptible of a generalized appraisal. In an area in which it is difficult to procure a sufficient supply of suitable fuels, the part of real conservation may be to develop metallurgical processes and power-generating equipment which, through higher efficiency, will minimize the effort of extraction and transportation of fuels. If, however, these refinements can be accomplished only by the long-term expenditure—with emphasis on the length of the term—of scarce human skill of a sufficiently high order, it easily may prove the part of conservation to direct that human skill into activities for which there is more pressing need. Whether this can best be accomplished by over-all planning or by processes of *laissez faire* is beside the point. The end result must be a sound balance of expenditure—not of monetary units as such but of the human effort of which those monetary units may be a significant symbol.

Enough has been said here to indicate somewhat the status and the trend in solid fuel production, the status of the reserves and the intensely local character of the problem. Highly similar conditions obtain with reference to some aspects of the world's energy supply, though here there are notable differences.

In the first place—granted enduring reserves of fuels —there is no such thing as a more than transitory world energy shortage. There may be a shortage of the means of converting energy from one form to another—commonly described as plant capacity. It is obvious that a real shortage in this respect is very simply, and yet not quite so simply, to be relieved by building power plants. Of course, there may be a naturally imposed limit to the supply of hydro-electric energy dependent as it is on the volume of stream flow. This, however, is a question of the nature of the source rather than of overall limitation. There may, too, be a limitation in the fuel supplies that can be made available in any given area, either because of artificially created barriers against transportation or because of the inherent economic difficulties of the transportation itself or even of extraction.

If these latter inherent difficulties prove insurmountable, the situation is that the area of such an unavoidable limitation simply cannot have an economy which demands great amounts of energy. The situation in this respect is not essentially different from the fact that areas of the earth's surface adapted to the growing of bananas will be incapable of producing hard winter wheat and vice versa.

To refrain from developing the type of economy to which an area may be adapted simply because it cannot precisely duplicate the economy of some other area would obviously be an absurdity. This, of course, is not to say that diligent inquiry and thoughtful courage should not be employed even in the face of some natural handicaps if the prospect of return in the way of a better balanced economy is sufficiently bright.

Not only is there no such thing as an intrinsic energy shortage but for any given area there is no limit to the amount of energy which can be produced with sufficient expenditure of human effort—in simple monetary terms, at a price. It is true, of course, that the price may be way out of proportion to the importance of the energy supply but it must very clearly be recognized that the importance of the energy supply lies in the plan for utilization rather than being intrinsic in the energy itself.

It is almost self-evident that for "heavy" processes in which the use of energy is large relatively to the amount of labour and raw materials involved in industrial production, the supply of large quantities of energy at a very low price may be a *sine qua non* of competition in world markets. Deep mining operations for low value materials are one case in point. Electro-chemical operations and electro-metallurgical enterprises well may be another.

On the other hand, for the more "refined" types of industry, the matter of energy cost may be less than two or even one per cent of the cost of industrial operation. If there are adequate economic reasons for the establishment of industries of such a type in any given area, though that area may be devoid of water powers and far distant from the sources of fuel supply, the economic effort to build fuel-consuming power plants may be well-nigh negligible against the importance of the development of the economy of the region. It is in this sense that it may be said that there is no intrinsic limit to the amount of energy potentially available for such an area.

When one comes, then, to appraising the adequacy of the energy supply of a specific area, it is necessary first to determine for what purpose energy might be used in that area.

This is definitely a local problem to be approached with the utmost of objectivity and not merely from the viewpoint of assuming that an economy which is sound for one area will express itself in the same type of production in another area.

Many things enter into determination of the reasonable pattern of economic development. Proximity to raw materials is one. Has the area a plentiful supply of hard woods or are its timberlands rich in conifers? What are the products of its mines? Or of its fisheries? What can be the products of its mines or of its fisheries? To what types of agriculture are its soil and climate adapted? And are its natural resources in such combination as clearly to point to industrial elaboration within the area?

Depending on the weight and bulk and aggregate quantity of its raw or industrial products, has it the natural facilities for transportation or can it provide itself with man-created facilities to get its products to a market?

Above all else, what can become the economic genius of its population?

The answers to such questions in extremely complex combination will determine whether an area can become an industrial area or not and, if it is to be an industrial area, whether the industry will be of the heavy or of the refined type.

With these rather fundamental facts in mind, it becomes easily apparent that there can be no statistical criterion by which to gauge whether an area is power-rich or power-poor or, at least, that the criterion does not consist in comparing the power development of one area against the power development of another.

Even for a specific area, a study of the growth or the decline of its power facilities or of its energy production over the course of the years has little or no meaning until the data are thrown up against the general economic history of the area, and again until it is determined whether the growth or lack of growth with respect to power and energy are a result of the changing character of the general economy or a cause of it.

It is conceivable, for instance, that the full pre-emption of the economical hydro-electric resources of an area which has few industrial activities other than electrochemical might be the cause of economic industrial stagnation of that country and force its further development largely into an extractive economy.

On the other hand, an industrial depression occurring in a highly industrialized country would be the cause rather than the effect of power and energy stagnation.

For example, the *Statistical Year Book of the World Power Conference* shows that the installed capacity of electricity supply undertakings of North America increased from an index of 100 in 1933 to only 113 in 1939. That was a period of a well-known economic depression. In the years from 1939 to 1946, however, the installed capacities increased from 113 to 147, largely under the stimulus of wartime production and post-war readjustment. The record with respect to energy production is of the same character but in a highly magnified degree. There is here a clear presumption that both plant capacity and energy output served as measures of, rather than causes of, industrial growth.

On this subject, the Year Book says:

"Continental and World Totals: Because of gaps and discontinuities in the data, it is impossible to compute series of continental totals of electricity production and distribution. It has, however, been possible to calculate series of indices (using the method of link relatives when necessary), which represent approximately the development of electricity production by Electricity Supply Undertakings in two of the continental areas, Europe and North America. It is emphasized that these indices are intended to give a general description of the course of electrical development and not an accurate measurement of changes; and they take no account of electrical development in Germany, Hungary, Italy and the U.S.S.R., which are important producers of electricity but for which sufficient data are not available . . ."

"In North America, the indices for which are dominated by electrical development in the U.S.A., installed capacities increased continually after 1935, and production of electricity increased continually from 1933 to 1944, except for a decrease in 1938, a year of economic recession; in 1945 there was a decrease, and in 1946 an increase too small to affect the index . . ."

Despite this caveat by the World Power Conference with reference even to continental figures, it is noteworthy that the energy production of certain countries in Europe increased from an index of 100 in 1933 to only 178 in 1939 and then, despite the ravages of war and the exceedingly great difficulty of plant restoration, to 266 in 1946.

For North America, the increase up to 1939 was from 100 to 158 with an attained output in 1946 identical with that of the reported countries of Europe, namely, 266.

It is interesting to note that in both continental areas, the increase in utilization of plant accounted for an energy increase much greater than the increase in plant capacity, the index of energy production in 1946 being almost twice the index of plant capacity for each continental area.

These data, so far as their fragmentary character permits of any conclusions, would seem to indicate that the adaptation of energy supply to economic development and the adaptation of economic development to certain limitations of energy supply prevent any very direct appraisal, from simple statistical data, of the existence of an energy shortage. They do as well give support to the conclusion of the United Nations Department of Economic Affairs, as shown in its analysis of major economic changes in 1948.

"The output of electric power continued to climb steeply . . .; for the first nine months of 1948 it was about 83 per cent above pre-war production for the world as a whole (excluding the USSR)."

The data concerning liquid fuels are too fragmentary to permit as general conclusions as may be drawn with reference to solid fuels and energy, at least so far as concerns world production of crude petroleum and the production in many of the significant areas (exclusive of the USSR). The Department of Economic Affairs in the publication above referred to shows a vigorous increase in production above that of 1937 and a wide distribution of that increase.

It may be concluded that there is no world shortage present or imminent with reference to the resources discussed in this paper; that production has shown a vigorous increase in the ten years just concluded but that there are problems of artificial restraint in the interchange of facilities. These problems, of course, are of a character foreign to the scientific or technologic approach, though they may be of vastly more compelling character than are the elements of technology.

In the utilization of our fuels and more particularly in the utilization of energy, it is important to avoid a common misconception or, at least, to bring it into a proper relationship. It is often assumed that the improvement of under-developed areas may depend primarily on a plentiful supply of energy and that the furnishing of such a supply will put such areas on an approximate parity with other regions. It does not take much consideration to realize that neither fuel nor energy as such can be applied to the development of an economy—that no one can merely take in hand a number of kilowatt hours and make direct use of them. Fuel and energy find their proper place in economic development through the instrumentalities of utilization and these in turn depend on the materials for production, skill in the organization of enterprise and the development of markets for the things produced.

By and large, the instrumentalities of utilization require the outlay of materially greater human effort than does, for instance, the associated power equipment; both must go forward in step each with the other and both of them in harmony with the genius of a people and the inherent economic possibilities of their area. There is not, of course, an indefinitely large amount of human effort available for such development, and so the tempo must adjust itself to what can be done. The process of patient realistic development of resources and their utilization for the service of mankind will be the more rapid and the more effective if there is a nice balance between the creation of the instruments of utilization and the instruments of production of fuel and energy.

The machine age has, of course, been characterized by tremendously expanded uses of energy in its various forms. It must always be borne in mind, however, that the sequence has in the main been the development of machines which could do better or in greater quantity things formerly done "by hand"; that when the machine for such purpose had been developed, it then became an absolute essential that there be a supply of power to drive it, the power requirements being greater or less, depending on the character of the thing to be produced. Not always have the human and economic benefits to society been greater in those fields of production making the greater demand for mechanical power. Not always, on the other hand, have they been less because of a putative refinement of the product.

The essential fact obviously is that whatever the train of causation, a supply of energy—greater or less as the case may be—is a *sine qua non* of both local and world progress.

The CHAIRMAN: Dr. Parker, we all wish to thank you very much for this exposé on one of the most important basic industries, the supply of fuel and power to humanity.

I shall not detain you with extensive remarks trying to integrate, as it were, the proceedings of this morning. I just want to make two or three very brief remarks. One of the most striking features about this discussion, I think, is this: We have been accustomed to worrying about exhaustible resources, about fossil fuel running short, about mineral deposits being exhausted. Now, the papers of this morning seem to turn the table entirely. It is in the creatable resources of food and wood that we may expect shortages, in the resources which are created by the biochemical synthesis going on, under the influence of the sun, on farms and fields and in forests. If shortages occur it is because of another biological factor: the creation of new members of the human family. The fundamental problem is whether we can keep a balance between these two biological factors. I shall not go into this now in detail but wish to mention two productive factors which have not so far been dealt with: biosynthesis in the lakes and seas, and the possibility of industrially organized production of food by cultivation of microbiological life. Both of these will be discussed later on.

Finally, as an engineer, I should like to draw your attention to another aspect in regard to the possibility of reaching a balance between consumption and production. In consumption, there is the law of decreasing value increments, which causes the added satisfaction, from one additional unit of consumption, to decrease. The urge to increase consumption, therefore, decreases as consumption grows. On the production side, there is the law of increasing cost increments. The cost of producing one additional unit rises. We all know the lowering of cost with mass production; I refer to something else. If new lands are cultivated, the cost per unit cost will be higher. Thus value decreases; cost fuel deposits or water power sites are developed, the unit cost will be higher. Thus value decreases, cost increases. The two curves bend in different directions, and the balance struck at their crossing point is reached much sooner than expected. We will see many examples of this, I am sure, as the Conference proceeds.

I think we can all be satisfied with our work this morning. It has shown that we have much to do in coming sessions before we will arrive at anything like a balanced opinion on the great problems before us. The meeting will now adjourn.

The Interdependence of Resources

Thursday Afternoon, 18 August 1949

Chairman:

J. A. KRUG, Secretary of the Interior, United States of America

Contributed Papers:

The Interdependence of Resources

Emmanuel DE MARTONNE, Member of the *Académie des Sciences de l'Institut de France,* Honorary President of the International Union, Paris, France

The Complementary Nature of European Resources—A Basis for Developing Regional Economic Co-operation

Ernest WEISSMANN, Director, Industry and Materials Division, United Nations Economic Commission for Europe

The Planning of Land-Use for Full Production with Special Reference to European Conditions and the National Planning Undertaken in the United Kingdom

L. Dudley STAMP, C.B.E., Chief Adviser on Rural Land Use, Ministry of Agriculture, London, England

Discussion:

Messrs. GOLDSCHMIDT, GOODRICH

Programme Director:

Carter GOODRICH

Programme Officer:

Alfred J. VAN TASSEL

The CHAIRMAN: It is my honour and pleasure to be your Chairman for the meeting this afternoon and I am very pleased that it encompasses a subject that I referred to briefly in my talk yesterday. I am also pleased to see that today we have some real experts to elaborate on the general points included in the various talks which were made yesterday on the question of the interrelationship and the interdependence of resources. This afternoon we will have the pleasure of listening to three of the outstanding experts on this subject who present the general picture as a background for the specialized discussions in Section meetings that will come in the days ahead of us.

Before we begin the technical matter under discussion today, I would like to tell the participants, and particularly those from abroad, that the entire American delegation feels that the field trips, arranged for you by Government groups and by various private industrial groups in this country, are an exceedingly important part of the entire Conference. Frankly, I think many of you will gain as much, if not more, from one or more of the field trips, than you will from the excellent discussions that will occur during individual meetings. In order to plan those trips effectively we will have to know at an early date just who is going and on what trips. I realize that many of you have hardly had time to get your feet on the ground, but I would like to have the sequence of trips explained so that those of you who plan to go will let us know promptly. Frankly, I think two or three of these trips alone are each worth the trouble and time that the delegates from outside the country have spent in coming to New York and I hope that you will avail yourselves of the opportunity to see conservation at work in the United States. The best feature is that it has been possible to arrange these trips so that they will be practically without any cost to participants from abroad. It used to be an old slogan, that if you had a twenty-dollar bill and tried to sell it for one dollar on the corner of 42nd Street and Broadway, just about twenty miles from here, you could not get any takers. I hope the same attitude will not prevail at Lake Success. But I do want all of you who have an interest in these trips to look into them immediately and inform the Hospitality Committee making the arrangements for your trip. If I may I would like to have Mr. Goldschmidt, a member of the Preparatory Committee and an assistant to me, say just a word about the trips, so that you will know the dates that are involved, and the time you will have left to make a definite decision on your trips.

Mr. GOLDSCHMIDT: There are two general sets of field trips. First, there are those that will originate during the course of the next three weeks from here at Lake Success. These trips will be in the general New York area. They have been arranged primarily through the good offices of the American Citizens Committee and are related specifically to the major subjects on the agenda: fuels and energy, minerals, land, etc. Secondly, there is the post-Conference field trip on which it is desired to get your reservations as early as possible. I will not attempt to describe the full field-trip programme; you can get that by inquiring in Conference Room 8, which is the office of the Committee and where you can find and choose those trips that will interest you. Incidentally, the Committee has kept its plans quite flexible, and if any of the experts would like to see something that is not on the field-trip programme, the Committee will seek to put it on the programme for the benefit of the visiting experts. There is, however, one very important trip this coming Saturday which I want to mention now, on which we can take sixty of the Conference participants. This trip will be of particular interest to the participants in the land section meetings. The trip will be through the Hudson Valley to Dutchess County where you will see examples of soil conservation work. Since the trip comes the day after tomorrow, it is very important in making arrangements for the trip, which incidentally, will be cost-free, to know all who are coming so that they can be provided with lunch and transportation.

The CHAIRMAN: I would just like to supplement Mr. Goldschmidt's remarks by saying that the trip arranged at the conclusion of these meetings is perhaps one of the most unusual attractions ever made available in this country to foreign visitors. It includes a visit to the great Pittsburgh industrial area, a visit to the soil conservation and agricultural experimental work areas in the state of Ohio and then several days in the Tennessee Valley area. I might say that people have come from all over the world just for the purpose of seeing one of those three attractions alone.

Our first paper of the afternoon is on the "Interdependence of Resources". We have the pleasure of hearing from one of the world's most distinguished scientists; he is a member of the *Académie des Sciences* and Honorary President of the International Geographical Union at Paris, and he has written and edited so many books that I could spend all afternoon just reading the names of them. He is widely known in international geographical circles. I have the honour and pleasure of presenting Dr. de Martonne.

Mr. DE MARTONNE *delivered the following paper:*

The Interdependence of Resources[1]

EMMANUEL DE MARTONNE

ABSTRACT

The purpose of the present report is to draw the attention of specialists to the interdependence of resources.

Resources are divided into four groups: the Atmosphere (air); the Lithosphere (minerals and soils); the Hydrosphere (water); and the Biosphere (plants and animals).

The power-producing minerals (coal and mineral oils), though threatened with exhaustion, still compete with hydro-power plants. The metallurgical industry (particularly the iron industry) strives to counteract the diminution of its raw material by prospecting for new deposits, perfecting alloys, and using formerly neglected metals.

The soil, which is of both mineral and biotic origin, is all too often threatened by the disruption of its rhythmic cycle of reactions through man's intervention. Repeated fires in tropical regions and the non-use or misuse of fertilizers in the temperate zone need to be watched. Soil cartography should be developed. Gullying by erosion destroys the soil where essential forest growth has been destroyed.

The soil, however, requires a certain quantity of water, the supply of which can be assured by dams. These in turn, apart from enabling irrigation, can be a source of electric power and even make a stream navigable. Three examples of varieties of interconnected use of natural resources are provided by enterprises which have been more or less successful according to the natural or social conditions: the Tennessee Valley Authority, the Mondragon Dam on the Rhone, and the Niger Office.

Finally, there is a short reference to the vast reserve of power and life contained in the great oceans, the exploitation of which is beginning to be organized by international scientific bodies.

INTRODUCTION

The purpose of the present paper is to draw attention to the connexions among various phenomena which need to be considered by specialists attending a conference of this kind.

The organizers of the Conference recognized this need when they included among the subjects for the plenary meetings "The interdependence of resources" and their "integrated development". They have referred to it several times in the detailed plan for the sectional meetings, recognizing that in order fully to understand a given phenomenon it is often necessary to consider another under a different heading.

They might also have mentioned the usefulness of considering most of these relationships from the geographical point of view.

In an attempt, within the limits of a very brief survey, to classify the cases most worthy of attention, we may divide resources into those of the Atmosphere, the Lithosphere (useful minerals and soils), the Hydrosphere (oceans, lakes, rivers and ground water), and the Biosphere (vegetation and animals).

It is evident at once that these four fields are not separable.

THE ATMOSPHERE

The atmosphere enveloping our whole planet is indispensable to all life—plant, animal and human. The average temporal and spatial variations in its elements are sufficiently known to enable "climates" to be defined.

In spite of its extreme mobility, the atmosphere has a general stability of condition which leads us to believe that (within the span of history) there is no danger of its exhaustion when industry begins to draw upon it.

When known sources of power were still scarce, the wind provided the motive power for transport, which was confined to the seas, lakes and great rivers.

The silhouette of the windmill has not yet disappeared from the landscape of our plains where it is still used to work against gravity for pumping and drawing off water. The wind turbine as a generator of electricity is not excluded.

Although the movement of the atmosphere is used less and less, its harmful effects, still a current problem, have to be resisted along seacoasts, where the inroads of the dunes, engulfing crops and dwellings, are countered by planting in sufficiently damp climates, but proceed unchecked when the necessary precautions are neglected.

THE LITHOSPHERE

The term lithosphere means primarily the surface masses of the earth which contain the industrial substances, namely:

Solid fuel (coal) or liquid fuel (oil and gas);

Minerals, which form the raw material for all types of manufacture, from the roughest quality to the finest.

SOLID AND LIQUID FUELS

These elements, limited in quantity, are becoming more and more in demand, to the point where the exhaustion of their deposits is foreseeable. Every technical means is brought into play to postpone this disastrous end, and this Conference has the particular aim of making such means known and suggesting new ones.

In countries like France, where the coal is mainly soft and dusty, washing is particularly useful and coking in the mine makes it possible to deliver a more homogenous substance to the blast furnaces; but these practices are costly and their net advantage should be carefully weighed.

Other possibilities are to be found, however, in mineral oils, which compete with coal as sources of power and as the beginning of a chain of chemical transformations of a variety undreamt of a century ago. Finally, there is electrical power, produced by the steam-driven generating plant or by the water-driven turbine.

[1]Original text: French.

The conflict seems increasingly to be between coal and water power. Its scene is laid in the railways, where electrification is gaining ground in almost all countries. With the choice lying between an element in danger of becoming exhausted (coal) and a constantly-renewable force (electricity produced by running water), it seems logical to choose the latter, for transport. The former would do better service if confined to the infinitely variable transformation possible in the chemical industry.

These considerations serve to show the extent to which natural resources are interdependent.

MINERALS

The metallurgical industry provides another example. It seems that one can measure degrees of civilization, either in the history of mankind or in a present-day comparison of countries, according to the degree of development of their metal industries. Copper preceded iron in Europe. In Central and South America, the Europeans found gold serving the purpose which iron now serves. Today we use alloys and processes which after a time may be looked upon as obsolete.

The metallurgy of iron, at any rate as practised today, appears to fulfil all needs but itself creates some. The elimination of wood in the construction of dwellings, vehicles and ships for peace or war, continues and creates a demand for prodigious quantities of iron ore. But iron ore is rarely found in large quantities in a relatively pure state, as in Mount Kiruna in North Sweden, the peak of Itabira in Brazil, or the iron pockets in the Lake Superior area. Here again, all efforts should combine to mitigate the danger of exhaustion of the natural reserves, both of iron itself and of the metal alloys which give to steel its varying degrees of flexibility, elasticity and durability. Laboratory work is the handmaid of work in the field.

This work, which is directed towards discovering new deposits, should be conducted in the spirit of the naturalist or the geographer, with the help of topographical and geological maps. Although chance still plays its part in the finding, exploitation of the discovery requires a methodical survey. This may be guided by general ideas based on known facts, for instance, the greater chances for mineral deposits in the "old platforms", such as the Canadian shield and the Brazilian Massif in the New World.

Aviation seems destined to play an increasingly important part by providing general or detailed views of contours or structure. Geophysical methods and study of anomalies of magnetism and gravity are already producing results, but there is no certainty that the discovery of new deposits will keep abreast of the present rate of consumption.

A policy of economy by the use of new elements must therefore be contemplated. Neglected metals are already taking their place in the range of alloys which may be suitable for filling certain special needs, such as that for aluminium. Equivalents are being sought such as tungsten replacing platinum in electric lamps.

THE SOIL

The soil may be considered as the most superficial and mobile part of the lithosphere, formed by the decomposition of rocks and the relatively extensive spreading of the products, either by movements of the atmosphere or by the action of running water, a fact which links the study of the lithosphere to that of the hydrosphere. But outside the glacial and desert regions, that is to say over more than half the area of the continents, the soil is the medium from which vegetation draws the components of its constantly self-renewing structure. In that sense the study of the soil is linked to that of the biosphere.

The life of the soil normally takes the form of a cycle of transformations which have the advantage of permitting spontaneous renewal, unknown in minerals. A certain balance may be attained, but is too often upset either by a change of climate or by the intervention of man, demanding too much of nature.

In the temperate zone, the rainwater, filtering through the soil, dissolves the most unstable chemical substances, which are often the most necessary to vegetation, leaching them out of the upper layers into which the trees send their roots. The Russian name *podzol* has been adopted to describe soil impoverished in this way.

In the hot humid zone, a similar process takes place but, penetrating more deeply, causes a more serious exhaustion of the soil, allowing only silica and alumina to subsist. The alternation between humid and dry seasons restores the solutions rich in iron and leads to the formation of a crust hostile to tree growth, known as laterite. Plant and soil impoverishment go hand in hand.

In hilly regions the disappearance of the protective forest covering accelerates the ruin of the soil by exposing it to erosion caused by the runoff of the heavy rainfall or landslides of saturated soil.

Man's intervention precipitates these processes. It is quite probable that the bareness of the Mediterranean limestone massifs and of the wide expanses known as *garrigues* are largely due to deforestation. At any rate the danger of the inroads caused by soil erosion into crop-growing areas has been recognized and in the United States an official federal organization exists to prevent it.

Nevertheless the inroads into forest resources continue, both in Europe and America, in the effort to supply the increasingly pressing demand for wood used for the manufacture of paper. Replacement by less valuable substances (straw or reeds) has already been contemplated.

To prevent fire in tropical countries, where bush fires wreak havoc with the vegetal cover, seems a more difficult problem. The flames and smoke-columns of such fires are a spectacle never absent from the panoramas of the African savannah or the Brazilian *campo*. The evergreen equatorial forest may grow again as a secondary forest, but deciduous tropical forests cannot resist centuries of repeated burnings, which leave the soil ruined, sterilized by the closeness to the surface of the laterite layer.

THE HYDROSPHERE AND THE BIOSPHERE

The foregoing brief indications show how important it is to consider the problems of conserving natural resources as a synthesis, emphasizing the relationships which must be taken into account if disastrous developments are to be arrested.

The soil is an element belonging equally to the hydrosphere, biosphere and lithosphere. As the distribution of precipitations in time and space determines the aspect of vegetation, so the study of soil chemistry determines that of plants and may serve as a guide for crop-growing methods.

Alongside practices leading straight to destruction of the earth's vegetal covering, there is another with less rapid harmful effects but none the less to be condemned. That is the exclusive planting of conifers, which encourages podzolization.

Digging the soil too deep, as in vine-growing in the Mediterranean countries, may have serious disadvantages. The relationship between the use of chemical fertilizers and the deterioration of the soil should be studied. After several good harvests they may exhaust the soil. No doubt an agronomist could make an analysis and recommend the best remedy. A quicker and more certain diagnosis, however, would be possible if the great crop-growing countries all possessed detailed soil maps. One of the recommendations which the present Conference might make is that serious consideration be given to hastening the production of such maps.

One of the simplest arrangements for retaining the soil on fairly steep and denuded slopes is the formation of artificial terraces for strip cultivation, a system which has permitted a denser population of the mountain areas of the Mediterranean. This terraced method of cultivation, by means of which even irrigated rice may be grown, is also found in the monsoon countries. Contour ploughing is generally practised in Europe and America and should be used everywhere.

Energetic efforts should be made to protect humid countries against deterioration of their soil and vegetation, in order to meet the needs of populations which are increasing century by century. Equal attention should be given to the sub-arid countries bordering on the deserts, which cover more than 10 per cent of the area of the continents, particularly as traces of lost populations are often found there, as for instance in Central Asia, the northwestern part of the Argentine Republic, and so forth. The disappearance of crops in these areas, attributed to changes of climate, may most often be due to periods of war and insecurity which have caused the people to neglect the structure which retains or brings back to the surface the mountain waters or ground water.

IRRIGATION

The resumption or introduction of irrigation with the aid of improved techniques could provide nourishment for population masses as dense as those in the industrial regions.

Since the coming of the French to North Africa, the native population has tripled. The artesian wells in the Rhir Wadi have extended the chain of oases to the heart of the Sahara. In the western United States the immense dams have enabled many and varied crop-growing centres to be established.

Thus water is everywhere associated with the soil, bringing life to the very heart of the deserts; and its use still presents neglected possibilities. It is in examining these possibilities that the most remarkable combinations in the use of natural resources have been found.

The dam, impounding fresh mountain water and providing a head of several hundred meters, or the wide river in the plain arrested artificially and yielding a vast water supply, afford a source of power equal to that of the largest fuel deposits: a relatively large volume of water skilfully diverted may serve to irrigate a plain; a canal with a limited slope graduated by locks offers possibilities for shipping. It is obvious that the structures required to put these possibilities into effect are likely to produce important geographical and social changes.

The mountain village does not lightly accept the fate of submersion in the waters of the artificial lake, in spite of the attendant advantages. A dam in the plain may enhance the value of the soil and attract population.

The results obtained by the Tennessee Valley Authority, endowed with dictatorial powers, the skilfully combined use of which has served to renew the entire life of a region covering the whole upper part of the basin of this great tributary of the Mississippi, are well known.

A similar project conceived several decades ago for the Rhone basin seemed to have everything in its favour: a water supply vast in relation to the size of the basin, fed during the dry season by the Alpine tributaries and during the cold season by those from the Jura and the central Massif; a gradient in the lower course of the river steep enough to be of use both for power production and, by means of a system of diversions, to extend rich cultivations in an already densely-populated area, not to mention the provision of a watercourse along one of Europe's main trade routes. Long deferred by technical and even political discussions, this project is now being put into effect at Donzère and Mondragon.

The Middle Niger Basin project, with its less favourable prospects, must also be mentioned. It is situated in a part of tropical Africa subject to floods and short periods of violent rain, on the edge of the Sahara desert, where backward peoples must be attracted and settled. One of the proposed dams is, however, already in operation.

Still less near completion is the Rio San Francisco project in the *campos* of Brazil.

As most of the main tropical watercourses are interspersed with numerous very large waterfalls it is possible that something in this field may be done in the economically less developed regions.

MARINE LIFE

It is probably in its combinations with the lithosphere and biosphere that the hydrosphere offers the greatest possibilities as a natural resource. But the immense mass of sea water in itself is not to be neglected. It covers three-quarters of the earth's surface, and its volume is over ten times as great as that of the land above sea level. Millions of tons of organized living matter are contained within it, either unknown or exploited without system or regard for the husbanding of resources.

The shore at low tide was the place where man first learned to look for food, raiding the haunts of the shellfish, the stones covered with molluscs, and for a different purpose, the vast beds of seaweed, which he used as fertilizer, as in Brittany, where the wheatfields have been extended by encroaching into the scrubland as far as the carts laden with seaweed could penetrate.

Deep-sea fishing soon led frail boats out to the fishing grounds of the Atlantic. But the appearance or disappearance of well-known species, in fact due to migrations depending on the temperature and the variations in the supply of *plankton,* were a mystery. Gradually systematic research was organized on ships equipped for physical oceanography, and later at scientific institutes created by the countries chiefly interested. Research is now co-ordinated by an International Council for the Exploration of the Sea, with headquarters at Copenhagen.

The consumption of fresh or preserved fish also raises a great variety of practical problems—rapid transport, canning, use of waste matter—which are examples of the interdependence of economic and scientific factors. The fish is not only a source of food for man but provides meal for fattening cattle; and raw fish serves as an agricultural fertilizer, its oils providing fats in general and certain vitamins and nitrogenous products which were long unknown. The proportion of loss is still too high.

Until recently the North Atlantic was the only great ocean methodically studied, and research is only now beginning to extend to the lower latitudes, in the form of work off the coast of French West Africa.

There is a tendency to systematize whale-fishing, which had become confined to the southern hemisphere as the result of exhaustion of stocks. The whaling companies now follow the advice of the biologist.

The great oceans are still the least rationally exploited of all the spheres.

The CHAIRMAN: Thank you very much, Dr. de Martonne, for a very stimulating paper. I am sure that many of the ideas that you have expressed will be the source of lively discussion in the meetings which lie ahead of us. There was just one point you made—perhaps it is trivial from your point of view, but quite important from mine—with which I must disagree, where you say that the Tennessee Valley Authority is endowed with dictatorial powers. I want to assure you that if you make the post-Conference field trip to the TVA you will find that they have been able to do that masterful job within a democratic pattern and that there is nothing more democratic than the TVA in this country.

We have the pleasure of hearing next from Mr. Ernest Weissmann, who is Director of the Industry and Materials Division of the United Nations Economic Commission for Europe. Mr. Weissmann will deliver a paper on the "Complementary Nature of European Resources" and discuss the basis for developing regional economic co-operation. Mr. Weissmann is an outstanding architect, town-planner and industrial engineer and he has had experience in very many countries. He was formerly active in the industrial rehabilitation programme of UNRRA and now he is doing important work with United Nations.

Mr. WEISSMANN *delivered the following paper:*

The Complementary Nature of European Resources—a Basis for Developing Regional Co-operation

ERNEST WEISSMANN

INTRODUCTION

The subject which we are about to discuss concerns the complementary nature of resources—natural, technological, human and capital—and the problems related to their development and utilization. There are, in the world, insufficiently used resources—untapped natural and human resources in the less industrialized areas, and idle technological and capital resources in the highly developed countries. These resources are complementary in nature. More intensive co-operation between the more developed and the less industrialized countries is, therefore, essential to quicken the pace of economic development throughout the world and to raise the standard of living all around.

It is the purpose of this discussion to show that co-operation is not only necessary, but also possible through expanded trade; and that this trade could be mutually advantageous and of an increasingly stable character. It will also be seen that a vital element in such co-operation are credits to the less developed areas.

It may be more convenient to concentrate, in this discussion, on one area, for instance Europe, and then to show how that area could contribute more fully to the development of resources in other areas. In this connection, I propose to deal briefly with some of the specific activities of the Economic Commission for Europe. This organ of the United Nations is mainly concerned with European problems, but co-operation among the regional Commissions and the specialized agencies of the United Nations is beginning to take definite form.

FACTORS INFLUENCING THE DEVELOPMENT OF NATURAL RESOURCES

Before discussing Europe as an example of possibilities for mutually advantageous co-operation in economic development, it seems useful to consider, in a general way, the major factors influencing the development of resources and their utilization.

The world's known natural resources are limited and unevenly distributed, not only among the continents, but also within continents.[1] Technological resources, the counterpart of natural resources, have grown into an even more unbalanced pattern. As a consequence of this uneven distribution of resources, the gap between the living standards of the more developed and the less de-

[1]Europe is by no means poor in resources, but it is perhaps less favoured by nature than some other areas. The United States of America and the Union of Soviet Socialist Republics are the only countries possessing, within their State boundaries, nearly all natural resources permitting a continuous economic development and, consequently, a steady increase in the standard of living.

veloped areas in the world is widening.[2] Illustrations of this phenomenon are that only one-fifth of the earth's population lives in highly industrialized countries; that agriculture tends to be less highly developed in the so-called agricultural regions of the world; and that, within the relatively small areas of the world which are industrialized, great differences exist in the degree of development in industry and agriculture.

The uneven distribution of Europe's natural and technological resources provides a striking example of the importance of economic co-operation. Expanded co-operation would permit a fuller utilization of plant capacity and skills, at present idle in the more developed countries, and it would speed up the development of natural resources in the less industrialized areas. As a result, industrialized countries could reduce the cost of their manufactures and the less developed countries could increase production, also at less cost, of the goods desired by industrialized countries. These primary commodities could be used to pay for needed manufactures. A portion of the credits required to set in motion such mutually advantageous trade already exists in the form of idle plant capacity and unused natural resources. Suitable solutions for financing the remaining margin of credits can certainly be found.

Apart from trade, natural resources, such as water power, can be developed jointly by two or more nations. Some schemes for harnessing Europe's water power of course transcend national boundaries, as the source of power is sometimes contiguous with or crosses frontiers and the power produced can serve more than one country. Another example of economic co-operation is the recent agreement between Czechoslovakia and Poland for the joint development of the industrial border region of Teszin-Gieszyn, and of the harbour of Szcezcin.

The specifically political aspects of the development of resources are outside the scope of this discussion. Nevertheless, the conclusions derived from an economic and technical analysis, and the concrete possibilities that I shall outline, are, in fact, drawn up against a background of political realities. For example, the geographic distribution of resources and State boundaries do not always correspond. A familiar instance is the Benelux, German and French coal and steel complex. Any significant advance in the development of this area would have to be based not only on technological and economic factors, but also on agreement among several sovereign States. Another example is the fact that one-third of the world's population is now committed to developing its own resources through the medium of national economic plans, while most of the more industrialized countries continue under the system of free enterprise.

The main factors with which we are concerned in this discussion are then technological and economic. Let us review these factors briefly.

TECHNOLOGICAL FACTORS

The development of natural resources can be accelerated by applying more capital equipment and modern techniques. That is why the resources of under-developed areas can be brought into use more fully and more quickly by means of trade with more industrialized countries. This trading relationship expresses in principle the complementarity of natural and technological resources. To be successful, such trade would have to benefit both the more developed and the less industrialized country.

East and Southeast Europe possess important resources of raw materials, agricultural land and manpower. Their development and utilization require equipment for mining and smelting, for timber cutting and sawing; and they require better means of transportation, more tractors, farm machinery and fertilizers. All these technological counterparts of Europe's natural resources can be found in the more industrialized countries of Western Europe.

Leaving aside for the moment the major economic problems involved, there are some important technical problems in this seemingly simple relationship. For example, there is the problem of how far non-ferrous metals should be exported in the form of ore, primary metal or semi-finished product. It is not necessarily sensible either to restrict production solely to ore mining or, alternatively, to manufacturing finished goods entirely at the source of raw materials. What is best in one case may not be good enough in another. The general trend towards industrialization, the progress of science and modern technology, and the change in the traditional pattern of world commerce must be taken into account. The whole relationship between location of resources and the corresponding processing capacity may now need to be re-examined.

An example of interaction between technology and natural resources is the wider use of by-products. Natural resources are by no means inexhaustible, and it is essential to avoid waste. In the field of heavy industry, for instance, a closer linking of chemical and steel production could lower the cost of housing, because many building materials can be made from the waste of these industries. An important by-product of the steel industry is basic slag, a valuable fertilizer. The combined development of resources is the best method of avoiding waste of valuable matter in any field of production.

With the aid of modern technology and science there is ample scope for economy in the use of all materials. Economy is particularly important in the case of irreplaceable materials, like petroleum and coal, or timber, which takes a long time to grow.[3] Attention has been focused, in many parts of Europe, since the war, on the necessity of saving scarce materials. This is now possible through substitution and less waste.[4]

In addition to the development of untapped deposits and more care in the use of essential materials, the known resources can be multiplied through better techniques of processing leaner ores, for instance, and the creation of equivalent synthetic materials through micro-biology and chemistry. The problem of economic cost is clearly of particular importance here, but recent progress seems to be rapidly overcoming this obstacle.

[2] "Consumption standards are significantly higher than before the war in a relatively small number of countries but are barely at, or still below, pre-war levels in most of the world; they have even deteriorated from seriously inadequate pre-war levels in several under-developed countries." (Source: *World Economic Report*, 1948, Department of Economic Affairs, United Nations.)

[3] Of the original mineral reserves in the United States, there are now left 98 per cent of coal, 69 per cent of iron ores, 42 per cent of petroleum, 40 per cent of copper, 34 per cent of zinc, 30 per cent of tungsten and 15 per cent of lead. (Source: *Chemical and Engineering News of the American Chemical Society*, 23 May 1949, "Chemistry Tomorrow", by E. G. Rochow).

[4] See *Economics in Timber Consumption* (E/ECE/TIM/13 and HOU/WP.1/6, January 1949).

The full use of scientific and technically trained personnel and the further training of personnel are necessary conditions for the wise utilization of natural resources. Co-operation among nations may help to spread more widely technical "know-how" and the skilled personnel available. Technical "know-how" is in itself a marketable asset, as is clear from the whole body of national and international legislation relating to patents. Patents and "know-how" have already entered into trade agreements between countries, and there are many attempts to widen international arrangements for the carrying out of scientific research and the dissemination of its results.[5]

ECONOMIC FACTORS

We have discussed some examples of the complementary relation between technological and natural resources. Let us now examine the economic factors involved. Let us, at the same time, confine our discussion to the relationship between governments in the form of international trade. This is by no means the only type of co-operation necessary to foster economic development, but it is of the greatest importance at present.

Co-operation among countries based on the complementarity of their resources and their economies by means of international trade is an established practice. The purpose of international trade is to reap the advantages of division of labour and specialization. This means, however, has not always permitted effective use of resources for the benefit of the less developed areas. The dependent territories of the world have too often been regarded merely as suppliers of cheaper food and raw materials to the more industrialized countries. The terms of trade between the two areas have generally favoured the wealthier area, and they have tended to move against the poorer area.[6]

In Europe, the relationship between West and East has been of a somewhat similar character.[7] It is not sound economy to confine large areas of the globe solely to supplying food and raw materials. Lowering standards of living in such areas will be the result. Western exports to East Europe (or, for that matter, exports from Europe to less industrialized regions) should not be restricted to the export of mining and agricultural equipment and consumer goods only. Countries in East and Southeast Europe are now committed to developing, in a balanced way, industry and agriculture. They therefore wish to import capital equipment of all kinds. A similar change in the pattern of trade may well take place before long in other parts of the world.

This need not be disadvantageous to the highly industrialized countries. On the contrary, manufactures of all kinds would find wider sales; and, as the examples of Australia, North America, the USSR and Sweden show, more industrialization is not necessarily reducing exports of food or raw materials. It should also be remembered that a substantial proportion of international trade takes place between the highly industrialized areas of the world on the basis of diversified production and the diversified markets which are associated with a high standard of living.[8]

The industrialized countries of Western Europe need export markets for their goods and especially for capital equipment. In addition, they need alternative sources of food and raw materials so that they can reduce their spending of hard currency. In the current changing economic situation this problem is tending to grow more acute. This is still another way of saying that it would be normal for industrialized countries to get their food and raw materials where they can sell their manufactures. The less industrialized countries need additional capital equipment, but they also need credits, if they are to increase investment above their present plans. They can hardly pay for additional imports out of current production. In some countries consumption is now kept at a relatively low level in order to pay for a high rate of investment and imports. However, suitable credit arrangements could result in a balanced trade with the more developed areas.

The mutual interest of the more developed and the less industrialized areas is clear. The conditions required to give effect to this mutual interest in the form of expanded trade are more difficult to satisfy. But the problems are by no means insuperable. Indeed, certain of the economic conditions under which they can be solved are now beginning to appear. There are two important conditions for expanded trade between the less and the more developed areas.

The first is that it must be planned over a fairly long time, if it is to be effective. Appropriate arrangements should cover at least the period necessary to produce both the equipment needed and the commodities desired in payment for such equipment. The need for trade planned over a longer period arises primarily from technical reasons. It may be as important in a free enterprise economy as in a planned economy. Expanding markets of a more stable character may mean the difference between curtailment of production and steady development of industry in Western Europe; and a change in the pattern of international trade may require adjustments of European plans, since the resources of some countries are assigned to specific purposes for a number of years. Other facets of the same problem include the importance of reasonably firm delivery of capital equipment, and a reasonable certainty that additional goods, produced as a result of trade agreements, will actually be taken at a certain time by the importing country.

The second important condition is that the less industrialized areas require short and medium term credits. It might well have been to the long term economic interest of Western countries to grant such credits even in the inflationary period immediately after the war. Now, this interest is much clearer and, at the same time, its

[5]In this connexion, see also *Technical Assistance for Economic Development*, pp. 70-72, United Nations, New York, May 1949.

[6]It was estimated from published data that on a world basis, "over the two generations preceding World War II the quantum of manufactured goods obtainable for a quantum of primary commodities declined by more than 40 per cent." (Source: H. W. Singer, *Economic Progress in Under-Developed Countries*, Social Research, New York, March 1949.)

[7]In this connexion, a comparison of pre-war and post-war trade in Europe is significant. "Thus it would appear that trade with the Soviet Union tends to assist the industrialization of the region, while the German trade had the effect of retarding it." (*Survey of the Economic Situation and Prospects of Europe*, p. 144, ECE, Geneva, 1948).

[8]In 1937, the United States, the United Kingdom and Germany accounted for almost a third of the world's exports. In addition, "... there is generally a fairly marked tendency for those (countries) with the highest income per head to be also the ones most dependent on international trade ..." (Source: A. J. Brown, *Applied Economics*, London, 1949.)

realization more possible. In a number of countries idle resources are appearing in the form of unused engineering capacity and unemployed labour as a result of deflationary trends. It would probably be to the benefit of these countries to put their idle resources to work for economic development elsewhere. At present, it would seem that some proportion of the credits required by the less developed countries could be found in Western Europe. This may make it easier for international financing organizations to provide the credit margins which are still required.

EUROPEAN RESOURCES

Let us now turn to Europe's resources and to the way in which some of European economic problems could be resolved through intra-European co-operation and through co-operation with regions outside of Europe.

Before the war, Europe as a whole imported many food stuffs, animal feeds and some of the principal raw materials, liquid fuel and metals. However, Europe was a substantial net exporter of such key materials as coal, steel and timber, and of nearly every kind of machinery. Basically, food and raw materials came from dependent territories, or from areas with which special relations existed. A good example is provided by the United Kingdom.

This pattern has changed since the war. Food and raw materials can no longer be obtained in the same quantities or on the same terms from dependent areas. Imports of these commodities from North America have therefore greatly increased. The underlying factors, however, remain the same: Europe has to import food stuffs and certain basic materials. In addition, a substantial volume of machinery and equipment is now also being imported.

How does the pattern of production and trade compare with Europe's actual resources? The truth is that Europe possesses most of the natural and technological resources necessary for a rapid increase in economic development. There is ample coal, iron ore and timber. Raw materials are plentiful and a developed chemical industry could economically produce many synthetic materials, oil and other essentials. Even in the case of nonferrous metals there are important unused deposits, especially of light metal ores. To grow food, Europe has fertile land, an adequate climate and ample man-power. With modern techniques and equipment, Europe could ultimately produce nearly all the food required. A large and well-developed engineering industry is able to produce all types of equipment needed on the fields, in the mines and in the factories; but Europe's greatest asset of all is a long experience in agriculture and industry, and a large and highly skilled labour force.

The patently insufficient development and use of Europe's resources are evident from its relatively low consumption of basic materials and energy. The European consumes on the average one-third of the steel, one-fourth of the electric power and only one-fifth of the coal that an American uses.[9] Consumption of steel and energy, the key to the level of economic development, is relatively low in Europe as a whole, but it is shockingly low in the less industrialized countries. Thus, a Bulgarian has, on the average, only 16 kilograms of steel annually, a Turk 31 kilowatt-hours of electric power, and a Greek less than 50 kilograms of coal. An Englishman uses 30 times more electric power, 60 times more steel and 80 times more coal.

Certain European countries are desperately short of implements for modern farming. About half the world's nitrogenous fertilizers and soluble phosphates and two-thirds of the world's potash are produced and consumed in Europe. The bulk of the consumption, however, takes place in highly industrialized areas, while Europe's "bread basket" uses little. Hungary, Romania and Yugoslavia consume less than one kilogram of nitrogenous fertilizers for every hectare of arable land. Belgium uses 82 kilograms and the Netherlands 90 kilograms.

The use of agricultural equipment is also concentrated on the farms in industrialized countries. There was on European farms in 1948, on the average, one tractor for every 225 hectares. Switzerland had one tractor for every 23 hectares, the United Kingdom one for every 30, while Hungary, Romania and Yugoslavia had only one tractor for every thousand hectares of their arable land.

Application of modern technology is insufficient in most European countries and modern means of production are unevenly spread. They are particularly scarce in areas which still possess untapped and easily accessible natural resources. As a result productivity varies extremely between countries. It is on the whole much lower than in the United States.

In coal, physical output per worker in the United States was more than two and one-half times that of the United Kingdom; in blast furnace products, it was nearly four times higher; and in cotton weaving, one-third. The physical output per head in manufacturing and mining in America was, before the war, more than twice that of the United Kingdom.[10] The physical output in the less developed countries of Europe was, no doubt, generally lower than in the United Kingdom.

Lower productivity is usually associated with a lower level of income. A low level of income, in turn, limits the capacity of European markets. In 1948 the European earned one-quarter of an average American's income; but the income per head in Greece was only one-seventh of that in Switzerland.[11]

Our review of the technological and economic factors of development shows that qualitative inadequacy of natural resources can be compensated by more intensive application of modern technology; but uneven distribution of resources can be overcome only through co-operation among the nations and the regions of the world. The complementary nature of resources, particularly the technological resources of the more industrialized countries and the natural resources of the others, may facilitate such a course in Europe.

THE WORK OF THE ECONOMIC COMMISSION FOR EUROPE

I now turn to some concrete possibilities of increasing European production and trade immediately. The Eco-

[9] The USSR is not included in these figures. The average European used, in 1948, about 110 kilograms of steel, 482 kilowatt-hours of electric power, and 1.5 tons of coal.

[10] L. Rostas estimated (in the *Economic Journal*, London, April 1943) physical output per head in a wide range of manufacturing industries and mining in the United Kingdom (1935), Germany (1936) and the United States (1937), based on census of production data.

[11] Source: *Economic Survey of Europe for 1948*, Geneva, 1947, E.235/ECE.

nomic Commission for Europe is playing a part in these efforts.

One early result of extended economic co-operation in Europe could be more exports of engineering equipment in the West-East direction. An important effect of this trade would be an ultimate saving of hard currency at present spent for basic materials and food. More trade in engineering equipment with areas outside Europe would probably have a similar effect.[12]

Increased intra-European trade in tractors, farm machinery and fertilizers could open to Western European countries new markets, and it would, at the same time, greatly increase the amount of food for export from Southern and Eastern Europe.

The present drop in "effective demand" is a danger signal in this field. There is, now, an apparent balance, for Europe as a whole, between supply and demand of nitrogenous fertilizers, and a "surplus" of soluble phosphates. Such "surpluses" are expected to go on growing, while a great many tractors and farm machines can no longer be disposed of within existing trade arrangements. We have seen that in the midst of this abundance certain food-producing areas desperately need these implements of modern farming.

An examination of past trends clearly indicates that after the sellers' market a scramble for markets and fluctuations in price and output follow. However, what Europe needs most, in order to retain production at a high level, are new and expanding markets and more "non-dollar" food.

European countries are already intensifying agricultural development in order to raise their own nutrition standards and to increase food exports. They could more easily realize these objectives if they could apply more fertilizers to the land and use more equipment on their farms. Some of these requirements they will meet from their own production, but they are likely to be buyers of large quantities for some years to come, if suitable arrangements can be made.

Let us now examine, by way of illustration, how increased deliveries of equipment from the more industrialized countries could help to raise the output of non-ferrous metals or pyrites in countries with workable ore deposits. In concrete deals, of course, exchanges need not be limited to only one material and the equipment required to produce it. The number of countries participating in such arrangements is also not necessarily limited.

Europe is at present importing about 600,000 tons of sulphur from the United States at a cost of some 20 million dollars annually. This sulphur is mainly used to produce sulphuric acid, an essential factor in many modern industrial processes. Planned increases of production will require another ¾ million tons of sulphur. Even if European importers could bear the additional dollar expenditure, the quantities of sulphur available for export from America are declared to be limited.

An additional quantity of 1½ million tons of pyrites annually must, therefore, be found. A substantial tonnage of pyrites could be obtained from existing and new mines in Europe. Equipment, including transport equipment, is now available in Western European countries. These countries are also important users of sulphur and pyrites. Arrangements, mutually advantageous to West and East, should therefore be possible.

Continued exports of pyrites in the East-West direction would provide the necessary means of payment for the imported equipment needed to establish indigenous production of sulphuric acid in less developed countries. The myth of "creating competitive industries" cannot be raised in this case. It is expensive and dangerous to transport sulphuric acid over long distances.

A similar pattern of possible international action applies also in the case of non-ferrous metals. It has been estimated that Europe may have to import over 2 million tons of lead, zinc, copper and aluminium at an annual cost of some 730 million dollars. Some of these dollars could be saved and hard currency could ultimately be earned by fuller utilization of European non-ferrous ore deposits.

In the Industry and Materials Committee of the Economic Commission for Europe, several governments have expressed their interest in considering concrete projects designed to expand production and trade in non-ferrous metals and sulphur-containing materials. They have asked the Executive Secretary of the Commission to proceed, in consultation with experts of the interested governments, with investigations on costs, on equipment needs and on financing possibilities.

In the case of timber, a production and trade agreement is in the course of negotiation. Several European governments have joined in a scheme which would result in increased exports of timber from a number of producing countries by an amount initially estimated at 110 million dollars within three years. This scheme originated in the Timber Committee. Under this plan, equipment would be provided from Europe and America to producing countries on credit, in European currencies and in dollars. These credits would have the backing of the International Bank for Reconstruction and Development. The loan would be paid for by additional exports of timber.

A primary task of the Commission has been to restore the level of production of coal and steel as rapidly as possible. These industries are now faced with the problem of stimulating domestic consumption and finding new uses and new markets in order to maintain a high level of production. These are the present tasks of the Steel Committee and the Coal Committee. We have seen that certain shortages continue, but that they could be relieved by means of more trade in equipment in the West-East direction. A fuller utilization of engineering capacity would no doubt increase European demand for steel and coal.

Let me add here that the Electric Power Committee and the Inland Transport Committee of the ECE are engaged in activities basic to a rational development of European resources. The Committee on Agriculture is trying to increase Europe's food supply through international action and the Committee on the Development of Trade is tackling the knotty problem of improving trading conditions within Europe and those within overseas areas.

[12]Unused capacity in Western European countries, was roughly estimated at an annual value of output of some 1¼ billion dollars. The total output, in 1947, amounted to some 6 billion dollars. (Source: *Engineering Industry in Europe,* Geneva, 1948, E/ECE/IM/38.)

BREAKING THE VICIOUS CIRCLE

Three main conclusions emerge from our review. The first is that the technological resources of Western Europe and the natural resources of Eastern Europe are complementary. The second is that there are sizeable untapped natural resources both in the less industrialized areas of Europe and elsewhere. Largely because such complementary relationships are not fully utilized to intensify economic co-operation, Europe's technological resources now remain partially idle. The third conclusion is that economic relations between Europe's West and East, and those with the under-developed areas outside, are at present too limited in scope; and that an expansion of economic relations would be mutually beneficial. Prosperity and higher standards of living in the participating countries would be the ultimate result of such co-operation.

European production and intra-European trade seem to be moving at present in a vicious circle. The same is true of Europe in relation to under-developed areas elsewhere. As a consequence, idle capacity and unemployment are growing in the more industrialized countries of Western Europe. Yet urgent needs remain unsatisfied in the less developed countries which are prepared to produce goods desired as a counterpart for imported equipment.

The problem then is how to break the vicious circle. The key to the situation is a decision by the nations concerned to engage in trading relations on an increasing scale and over a definite and extended period of time. The willingness of the highly industrialized countries to grant suitable credits to the less industrialized countries is a prerequisite. They could be joined in this effort by appropriate financing agencies such as the International Bank for Reconstruction and Development.

There have been many indications in recent months that Western and Eastern countries equally feel that an improvement in the degree of economic collaboration is needed. We have seen that co-operation between Europe and other areas is equally important. The regional commissions and the specialized agencies of the United Nations may be called upon to play an increasingly important role as a "clearing house" for information on the countries' needs and the goods they can produce, and as an "honest broker" for the nations who desire to expand economic relations through international co-operation.

The CHAIRMAN: Thank you, Mr. Weissmann. If time permitted, I would like to indulge my prerogative as Chairman to elaborate further on some of these considerations because they are so vitally important in the ultimate success of the Marshall Plan.

Our next speaker, a very distinguished scientist from the United Kingdom, is Professor of Social Geography at the London School of Economics, Director of the Land Utilization Survey of Britain and Chief Adviser on World Land Use for the British Ministry of Agriculture. It gives me great pleasure to introduce at this time Professor L. Dudley Stamp.

Mr. STAMP *delivered the following paper:*

The Planning of Land-Use for Full Production with Special Reference to European Conditions and the National Planning Undertaken in the United Kingdom

L. DUDLEY STAMP

ABSTRACT

The separate Ministry of Town and Country Planning for England and Wales was set up in 1943 and charged with the task of co-ordinating land use. Under the Town and Country Planning Act of 1947 every county must prepare an outline plan for submission to the Ministry within three years. Advice is given on all matters affecting rural or undeveloped land by the Agricultural Land Service of the Ministry of Agriculture. In Scotland similar functions are performed by the Scottish Departments of Health (Planning) and Agriculture. In event of disagreement the decision would be taken by the Cabinet.

Britain's special problems are (*a*) small area and large population—in England and Wales 0.85 acre per head of all types of land; (*b*) great variation in quality of land from barren or uninhabited mountain moorland to extremely rich market-garden land intensively cultivated. Many Departments are demanding land in increasing amounts for industry, housing, schools, recreation, airfields, motor roads etc. and pressure is greatest on farmland which is usually level and well drained but which totals only 0.5 acres *per capita*.

A simple classification of land into ten types has been drawn up. Types 1 to 4 inclusive are the good agricultural lands, and industrial and other development is directed as far as possible onto other types.

THE PROBLEM IN THE OLD WORLD

Most of the countries of Europe and many other parts of the Old World have the same basic problem, a problem which it is difficult for people living in the vast lands of the New World to realize. The emphasis in the present paper is on the more intensive use of existing resources and the elimination of waste. In some respects there is here a difference in emphasis from that expressed by Mr. Secretary Krug at the opening meeting of this Conference when he referred particularly to new lands, new resources and new techniques.

The Old World problem is how to use very small areas of land to the best advantage of very large populations. In some cases the countries are approximately self-supporting in the matter of food—as in France and India; in other cases even with the maximum application of science to agricultural production they must import foodstuffs to live—as in Great Britain. But in each case the basic problem of the present day is how to allocate land for agricultural, industrial and other purposes so as to secure maximum production at maximum efficiency. The problem is complicated by the fact that the lands concerned have been settled and developed for hundreds, often thousands, of years and so have already a highly complex pattern of land-use which it may be extremely difficult to alter.

The paper which follows will deal with Britain—England, Wales and Scotland—as an example, but the conditions are closely comparable in many other countries. India, for instance, faces many of the same problems.

THE BRITISH PROBLEM

The keynote to the British problem of land-use is the small total area of land and the large population. England, Wales and Scotland comprise approximately 56 million acres; the population approaches 50 million. Taking England and Wales alone the land area is 37 million acres, the population 43.5 million, representing approximately 0.85 acres per head. At the same time the land of Britain is extremely varied. It ranges from almost uninhabited mountain moorland, where in the remoter parts there are not even sheep, to land which by virtue of its soil can be ranked amongst the finest in the whole world. It is also important to recall that over large parts of the lowland the climate of Britain is in many respects almost ideal in the absence of extremes of temperature so that farm work can proceed throughout the year and in the evenly distributed rainfall, which means that droughts, wind erosion and gulley erosion are virtually absent.

This geographical environment is, broadly, unalterable.

In British statistics the terms "improved land" and "cultivated land" are used interchangeably to indicate the ordinary farmland which is enclosed in fields, whether ploughed or managed as grassland. In England and Wales the total area of improved farmland is 24.3 million acres, so that the amount of this productive land is only a little over 0.5 acres per head of population. These figures are for England and Wales. The figures for Scotland are usually separately calculated and published. The great difference there is that two-thirds of the country is occupied by the sub-marginal mountain moorland.

MANY USERS OF LAND

In Britain, as in other densely populated countries of Europe, there is a great pressure on existing land resources. Land is required for the purposes set forth below.

Industry: In many places industry must take priority as, for example, in the extractive industries—coal mining, iron ore mining. And because Britain is a country whose prosperity depends on the economic efficiency of its varied industries, it is axiomatic that industrial location must be such that the industries function with the maximum efficiency. This is part of the policy of industrial location now operated by the Board of Trade.

Housing: It is recognized that the housing standards in many of the British towns, especially those which grew up in the great Victorian industrial expansion, are incompatible with modern standards. British people as a whole greatly prefer the individual dwelling, with an enclosed garden, both back and front, laid out for enjoyment especially by the children, and sometimes producing small quantities of vegetables or fruit. As a whole, the British people do not like flats or apartments and the general result of polls which have been taken is to suggest that not more than 10 per cent of the people would choose to dwell in blocks of flats or apartments. Thus Britain requires not only to rebuild the blitzed towns on a more open pattern and to replace at a lower density obsolete and obsolescent housing, but also to allow for the increase in numbers of families and the numerous refugees from Europe who have found asylum in the country. Thus the demands for housing purposes involves hundreds of thousands of acres of what is at present open land.

Food and raw materials: In the inter-war years Britain produced a little over one-third of the food which was consumed in the country. Tremendous efforts were made during the years of the Second World War to increase home production, with the result that the production of many foodstuffs was doubled. Subject to the satisfaction of other demands and operation on economically sound lines, the need for maintaining increased home output of food remains and will remain. There are large tracts of poorer land in the country which may better produce timber, or pit-props, as a raw material than food. Thus the tendency is to think in terms of agro-forestal use and planning of open land.

Recreation: Land is required for purposes of recreation at all levels, from the playing fields attached to schools, the sports grounds of towns, and parks and public squares for air and exercise of town dwellers, to the open tracts of country where younger people can find exercise and pleasure in walking, camping and the study of nature, or to the extensive tracts devoted to such sports as shooting of grouse and the hunting of deer. Attention is now being paid to the creation of national parks, approximating to the American concept, to the demarcation of some of the wilder areas as nature conservation areas, and to the preservation from further development of the very attractive coasts of Britain.

Transport: Although Britain has a very close road and rail network and the existing railway systems are not likely to be extended, the road network is the modern legacy of an ancient layout beginning in Roman times and taking shape through Anglo-Saxon and later periods. The result is an absence of main highways suitable for fast commercial and private road traffic. Britain needs and is planning to build a small number of main motor highways. This necessitates a change in the law, as these motorways will be restricted to certain types of traffic, but they will absorb considerable areas of what is at present farm land. Also the development of air transport has necessitated the development of airfields and a number of major airports. It is particularly difficult to find suitable land sufficiently near the large centres to be served—a difficulty common to all parts of the world.

Defence: It is obviously important that sufficient land should be allocated to the Army, the Navy and the Air Force as training and experimental grounds, and the increasing size of mechanical vehicles and of airplanes is reflected in the increasing demands for larger areas of land.

It will be clear that the main aim of national land planning in Britain is to satisfy these numerous demands upon the small land area, to balance up rival claims and to reach decisions which will be in the best national interest rather than in the interests of any one section of the community. It will be noticed that all these demands on land resources have been increasing and hence land planning on a national scale is a matter of immediate moment. The pressure is especially great on the better qualities of land. A tract which is flat or gently undulating and well drained is almost certain to be excellent and highly productive farmland. It is at the same time the type of land on which the large modern factory, with a horizontal layout, can best be sited. It is also the type of land most easily developed for housing, though not necessarily with the most attractive results. It is also the type of land suitable for laying out as playing fields, or for the construction of an airport. Britain's difficulty is thus to keep the best food-producing land actually in food production.

THE INTER-WAR YEARS

In the years between the First and Second World Wars farming in Britain was a depressed industry and one which did not receive important consideration from the Government. Britain at that time enjoyed the advantages of her accumulated overseas investments. Britain had a large proportion of the world's carrying trade as well as of the world's finance and insurance business. As a result there was an automatic flow into the country of foodstuffs and raw materials which represented the payment of interest or payment for services rendered. It seemed, therefore, as if home production was unimportant and in any case it was difficult for the British farmer with a high standard of living to compete with the cheap food sent from abroad, often below cost and at the expense of the "mining" of soil which was then very widespread in the great agricultural countries of the world.

As a result of the position then occupied by the farming industry and in the absence of any system of land planning, the use of land was determined by the highest bidder, irrespective of quality. It was found that farmland was being lost to various forms of constructional development at the net rate of over 60,000 acres a year (1927-38). In some of the English counties, e.g., Middlesex, the expansion of industry and housing was taking place at a such a rate that it was easy to see a near future when no farmland at all would be left within the county area. The loss, for reasons already stated, was in the main of good quality farmland.

SCIENTIFIC APPROACH TO THE PROBLEM OF LAND-USE

THE LAND UTILIZATION SURVEY OF BRITAIN

This voluntary organization, under the auspices of the London School of Economics of the University of London, was set up in 1930 with the writer of this paper as Director. Its immediate aim was to record the then existing use of every acre in England, Wales and Scotland, the results to be recorded in manuscript on very detailed maps of the British Ordnance Survey on the scale of 1:10,560, or six miles to one inch. The whole country was covered mainly by volunteers between 1931 and 1933. Only small sections remained to be completed in later years, and the whole of the field work was entirely completed before the outbreak of the Second World War. The Land Utilization Survey then set to work to study the results, to publish for general use fully coloured maps of land-use on the scale of one inch to one mile (these have been published to cover the whole of England and Wales and the populous parts of Scotland), and to analyse the extremely complex pattern which was found to exist by attempting to determine the influence of the varied factors, physical or geographical, historical and economic, which had determined that land-use pattern, and which were continuing to exercise their influence at the time. It must be remembered that any future planning of land-use must start from the present position, that there can be no planning of the country as if it were a blank sheet of paper; and that where the existing land-use has been determined, as it has in Britain, over many hundreds of years by the interaction of numerous different factors, very good reasons must be sought before demanding radical changes of a pattern which has thus grown up naturally. When a country, as Britain, has been settled for many hundreds of years the pattern of land-use has a meaning which is much greater than in any of the newer countries of the world where initial mistakes of the pioneers are only now being discovered. The corresponding pioneers in Britain, the Roman conquerors of 2,000 years ago, made similar mistakes. At the present day the existing land pattern in Britain corresponds very closely to that which would be dictated by the free interplay of physical factors of relief, climate and soil. It is determined by physical or geographical rather than economic conditions.

At a later stage the Land Utilization Survey was asked to attempt a classification of land into types. Ten *types* of land were distinguished and mapped: the classification is based on inherent characteristics; it is thus objective and not subjective.

Major category I—Good quality land

Land in this category has a site which is not too elevated, level or gently sloping or undulating, and a favourable aspect, together with soils which are deep, with favourable water conditions, actual or potential, and a soil texture embracing mostly loams but including some peats, sands, silts and clays.

1. *First-class land:* This land is capable of intensive cultivation, especially of foodstuffs for human consumption; has soils which are deep and in texture are mainly loams; the drainage is free but not excessive; soils are not excessively stony and can be worked freely at all seasons.

2. *Good general purpose farm land:* This land is similar to the first, but has a restricted range of usefulness due to:

(*a*) Less depth of soil,

(*b*) Presence of stones,

(*c*) Occasional liability to drought or wetness,

(*d*) Some limitation of seasons when the soil works easily.

It is possible to distinguish (A) suitable for ploughing, (AG) suitable for crops or permanent grass, as when associated with high rainfall.

3. *First-class land* but with restricted use owing to a high permanent water table or liability to winter or

occasional flooding or somewhat heavier soils. Such land is usually unsuitable or less suitable to arable cultivation, though it may frequently be converted to Category 1 by drainage operations.

4. *Good but heavy land:* Although such land has soil of a good depth and the natural fertility is often high, the soils are heavy loams, with the result that both the period of working and the range of possible crops are restricted.

Major category II—Medium quality land

This is land of only medium productivity even when under good management, the productivity being limited by reason of the unfavourable operation of one or more of the factors of site or soil character. These unfavourable factors include:

(*a*) High elevation,
(*b*) Steepness of slope,
(*c*) Unfavourable aspect,
(*d*) Shallowness of soil,
(*e*) Defective water conditions.

5. *Medium-quality light land:* This is land defective by reason of lightness and usually shallowness of soil. Some such land can be ploughed (usually shallow ploughing) but in other cases, particularly on limestones, the occurrence of rock near the surface or of rocky out-crops renders it unsuitable for ploughing, though affording excellent permanent grass.

6. *Medium-quality general purpose farmland:* This is land defective primarily by reason of relief. It is land broken up by steep slopes with patches of considerable elevation with varied aspect and varied water conditions. In consequence the soils are varied, often deficient by reason of stoniness, heaviness or in other ways. When a tract of country of this general character is studied in detail it is usually possible to resolve it into a mosaic of small tracts or patches—it may be only a part of a field in size—of land varying from Categories 1 to 10.

Major category III—Poor quality land

This is land of low productivity by reason of the extreme operations of one or more factors of site and soil.

7. *Poor-quality heavy land:* This is land suffering from extreme heaviness or wetness of soil, and includes the more intractable clay lands and low-lying areas needing extensive drainage works before they can be rendered agriculturally useful.

8. *Poor-quality mountain and moorland:* This is land rendered poor by extreme elevation or ruggedness of relief, usually combined with shallowness of soil, or occurrence of peat.

9. *Poor-quality light land:* This is land rendered poor by extreme lightness of soil, with attendant over-drainage resulting in drought and poverty in nutrient materials and is the land described by the farmer as "hungry". It usually coincides with the out-crop of coarse sands or porous gravels.

10. *Poorest land:* This is land where several factors combine to render the land agriculturally useless or almost so. It may be very diverse, including shingle beaches, moving sand dunes and salt marshes, but in some cases reclamation is possible.

It is found that No. 1 land, the finest of all, occupies in Britain only 2.4 million acres, or roughly 4.2 per cent of the surface. Even taking together all the good agricultural lands (including heavy clay lands which are productive though difficult to manage) only 38.7 per cent of the surface comes into this category.

THE BARLOW COMMISSION

Shortly before the outbreak of the Second World War the British Government appointed a Royal Commission on the Geographical Location of the Industrial Population, presided over by Sir Montague Barlow, and hence usually called "The Barlow Commission". This Commission found reasons to believe that the general tendency for British industry to become concentrated in Greater London, Greater Birmingham and other towns of the heart of the country, was an unhealthy trend, and was accompanied by growing or continued unemployment and decay in the older industrial areas, such as the Midlands of Scotland, the North-Eastern Coalfield and South Wales. The Commission recommended a policy of planned location of industry to secure that a large proportion of the new industrial plants should be established either in the older industrial areas or in parts of the country away from the central belt where the growth, especially of London, was creating almost insuperable difficulties of transport and communications.

THE SCOTT COMMITTEE

It was a natural result of the Barlow proposals that the government should set up a Committee on Land Utilization in Rural Areas, presided over by Lord Justice Scott. The Scott Report deals only with England and Wales but it examines the conditions under which industrial development should be allowed in rural areas and much of the legislation of subsequent years is based upon the blueprint presented by the Scott Report.

In particular the Scott Report brought out the very real danger not only to food production but also to the effect on the amenities of the British countryside which continued expansion of construction without any co-ordinating plan was likely to have.

THE ADMINISTRATIVE APPROACH TO THE PROBLEM

THE EARLY DEVELOPMENT OF TOWN PLANNING

Some aspects of town planning were introduced incidentally in certain housing legislation, but it was not until 1932 that town planning as such was the subject of an Act of Parliament—the Town and Country Planning Act. Under this Act local authorities were encouraged, but not compelled, to prepare town-planning schemes, or to combine and present regional schemes. If local authorities did not choose to submit schemes the government had no power to initiate them. The schemes submitted under this Act nearly all made excessive allowances for urban expansion. Agricultural land was not considered as such, though in some cases it was "zoned" as open land on amenity grounds. Under this Act, therefore, there was little or no attempt to co-ordinate the different uses of land. At the same time good planning was rendered almost impossible because of the fear which local authorities had of having to pay compensation for any restriction of land-use.

In the years preceding the outbreak of the Second World War the government became alarmed at the rapidity with which good agricultural land was being lost. This led to a declaration in both Houses of Parliament that the government would seek to avoid the use of good agricultural land for housing development where other and less valuable land could be appropriately used. Such a government declaration necessitated administrative machinery for its execution. Consequently successive steps were taken for this purpose. It should be noted that these were dictated by the urgency of the problem, and were taken by successive governments, independently of political colour.

THE ESTABLISHMENT OF THE CENTRAL PLANNING BRANCH BY THE MINISTRY OF AGRICULTURE

In the summer of 1942 the Ministry of Agriculture set up a special branch designed to give advice from the agricultural point of view where the planning of rural land was involved. The organization of the Branch was a unique one in British Government annals. A Chief Adviser in Rural Land Use was appointed, whose function was to advise the government on the one hand and on the other hand to convey the government point of view to local authorities and so to guide their activities—in fact, to conserve as far as possible the good agricultural land of the country in food production by persuasion rather than by regulation. At that time, in the war years, production of food was obviously of the highest importance, and this approach proved very successful. The Chief Adviser was represented by ten Rural Land Utilization Officers, one in each of the ten Civil Defence Regions into which England and Wales at that time were divided. These officers, like their chief, were advisers, and in each case were men of standing, well known in their regions. This team was assisted by a small staff of civil servants both at headquarters and in the regions.

Long before the end of the war, local authorities were asked to formulate their post-war housing plans in order that things might go straight ahead when hostilities ceased, and there is no doubt that the Central Planning Branch did an important work in directing the local authorities to the importance of filling in gaps in existing development, and then on to the poorer lands surrounding the towns. A great deal of valuable food-producing land was saved in this way. In due course when the war came to an end, these planning functions were absorbed early in 1948 by the reorganized Agricultural Land Service of the Ministry of Agriculture; and this remains the present position.

THE MINISTRY OF TOWN AND COUNTRY PLANNING

The administration of town planning under the 1932 Act was one of the functions of the Ministry of Health, which is the authority in England and Wales for housing. As the importance of land planning came to be realized the government set up for a short time a Ministry of Works and Planning, and then early in 1943, after the Scott Committee had reported, came the establishment of a separate Ministry—of Town and Country Planning. The Minister was charged essentially with the work of co-ordinating the use of land and of the development programmes of the various Ministries. The Minister is regarded as a "Senior Minister" but does not have a seat in the Cabinet. The difficulties facing the Ministry are many and the fact that the Minister is one amongst others who are concerned with land-use renders his task of co-ordination difficult. It may be said that there are in Britain many land-spending Ministries, but only one land-saving Ministry—the latter being the Ministry of Agriculture. The land-spending Ministries include the Board of Trade (responsible for the location of industry), the Ministry of Health (responsible for housing), the Ministry of Transport (responsible for main roads, including the new motorways), the Ministry of Education (responsible for new schools, with playing fields), the Ministry of Civil Aviation (responsible for civil airports), the Army, Navy and Air Force (responsible for training grounds), and others whose interest in land is of a minor character.

The Ministry of Town and Country Planning, with both a central and a regional organization, is not only responsible for co-ordination but it makes great demands itself on land resources in its function of proposing sites for new towns.

It should be noted that these Ministries, including Town and Country Planning and Agriculture, do not cover Scotland, where the separate Departments, under the Secretary of State for Scotland, perform functions comparable with the Ministries of England and Wales.

THE 1947 ACTS

The year 1947 was marked by the passing of two extremely important Acts: the Agriculture Act and the Town and Country Planning Act. The comprehensive Agriculture Act of 1947 establishes the twin policies for the farmer's security by offering him firstly, guaranteed prices for his produce, fixed in advance and subject to periodical revision after consultation, and secondly, a guaranteed market for the bulk of his output.

In the inter-war years the system was widely followed of encouraging specific types of farming production by subsidies and marketing schemes. The Agriculture Act substitutes for this the general guarantee of security to the farmer, leaving it then to the farmer's initiative to treat the land properly, in fact to practise good husbandry. Under the Act certain powers are retained where farmers do not practise good husbandry, and the Act also sets up the scheme of extending small-holdings designed to assist the landless land worker in due course to become, in suitable cases, a farmer.

The Town and Country Planning Act of 1947 extends compulsory land planning to the whole of Britain. Broadly speaking, each county is constituted the Local Planning Authority, each county is charged with the task of drawing up outline plans covering the whole area—town and country alike—for future development, and the initial outline plans are to be completed within three years.

Thus Britain has embarked upon a nation-wide scheme of land planning very different from the former permissive system. At the same time the old difficulty of compensation has been solved in that the State has become the outright owner of all development value in land; and the landowner now owns the land in its present form of use. Thus if under a town-planning scheme a landowner is prevented from developing his land, he may claim compensation, and a sum of £300 million has been set aside as a Central Fund from which such claims can be paid. The administration of this Fund is in the hands of a new Board, the Central Land Board, which has been set up.

If, on the other hand, the owner of land wishes to carry out some development, he has to pay to the Central

Land Board a development charge, and it is planned that the receipts in development charges should balance or perhaps more than balance the payments of compensation. How this scheme will work out still remains to be seen. A large number of owners of property do not yet realize the change, nor that the State now owns their development values. Some exceptions to the general ruling have already had to be made. Thus the owner of the individual plot who wishes to build a house for his own occupation is not required to pay a development charge. The owner of property can add to his existing development to the extent of 10 per cent, again without charge.

It will be seen that the co-ordination of land-use becomes extremely important in the preparation of these outline plans for the counties. The issue is being complicated to some extent by the proposed establishment of national parks and of nature conservation areas; the opportunity is also being taken to demarcate tracts of wilder land outside the parks where the public can be given a right of access, and for the first time a survey is being made of footpaths, along which the general public are allowed to pass.

THREE PRINCIPLES TO BE OBSERVED

In the schemes for the co-ordination of land-use it is important to determine in every case and for every piece of land its *optimum use* in the national interest. It is easy to use such a phrase, far more difficult to interpret it in practice. At the same time the principle of *multiple use* is almost equally important. In such a small country as Britain many tracts of land can serve more than one purpose. Hill land, for example, can serve as grazing for sheep, as a gathering ground for water supply, as well as access land for public enjoyment. In the third place comes the elimination of waste land. No land should be allowed to lie idle and hence a restoration of land after mineral working—coal, iron ore, gravel, sand and clay—is a problem of equal importance to that of re-using derelict industrial areas.

THE POSITION OF FARMING IN THE LAND-USE PROGRAMME

Wartime progress: Remarkable progress was made in British farming during the war years. When war broke out the machinery was all ready for the setting up of County War Agricultural Executive Committees (C.W.A.E.C.) in each county, consisting mainly of farmers, landowners and land agents acting as a Committee in a voluntary capacity and given extensive powers to control the farmers and farming of their counties. All farmers were classified according to their efficiency as A (good), B (average), C (poor) farmers. The C farmers were assisted with materials, men and money to improve their standards. If they failed to do so the County Committees could dispossess them and either farm the land themselves or put in more efficient farmers. At first there was naturally resentment in this interference with the highly individualistic life of the farmer, but very soon the farmers came to appreciate the advantages of expert advice and of material assistance and before long were approaching the government for the continuance of the system after the war. It has accordingly been reorganized, with a more democratic form of selection of Committee members, and the County Agricultural Committees continue the good work of their predecessors. Amongst the achievements of the Committees during the war was not only the vast increase in output, but the reclamation and ploughing up of half a million acres, mostly of poor quality land in parks and commons. Some of this land must be restored to its old uses, but this did offset the very extensive losses of agricultural land for such purposes as airfields and training camps.

Mechanization: During the war years British farming became the most highly mechanized farming in the world. The machines are mainly of British manufacture, adapted to the farming conditions of the old world and thus differing from those developed for the extensive agriculture of the new lands. Broadly speaking, every full-time farmer now has his own tractor and is steadily adding to his stock of farm implements, as well as being able to draw from the county pools. The number of horses on farms has decreased correspondingly.

Balanced mixed farming: The British farm is essentially a unit where mixed farming is the rule. The Farm Survey, carried out in 1941-42, distinguished for the first time full-time holdings and revealed that the average full-time holding in England and Wales is a little under 100 acres of improved land, that is to say ploughed land or improved and managed grassland. The majority of farms are managed on a system of rotation of crops, especially popular being the four-course rotation in the drier eastern part of the country, the six-course rotation in Scotland, and the longer rotation of seven years or more in the wetter west with grass pastures. Under this system the land is kept in "good heart". No farmer worthy of the name would allow his land to deteriorate. The produce from a mixed farm is correspondingly varied, but the emphasis has been steadily increasing on milk, whilst grain crops, more easily imported and stored, were of temporary wartime importance rather than permanent.

High yields: A characteristic of British farming is the uniformly high yields—for example an average of 35 to 40 bushels of wheat—combined with conservation of soil fertility, and over most of the country a virtually complete absence of soil erosion. No system of farming would be allowed by the County Committees which resulted in impoverishing the land. In this work an enormously important part is played by the management of grass and the control of grazing in small-field units. The small fields of Britain are often misunderstood by visitors. They play an extremely important part in this control of grazing and there is a growing belief in the 10-acre field as ideal. Incidentally, it may be noted that if the output of the newer agricultural lands of the world, including the United States and Canada, were on the same intensive scale, there would on a global basis be no food problem.

Possibilities of improvement: Whilst it would be difficult to improve in many areas upon the maintenance of soil fertility by the existing systems of rotation, combined with the use of both animal and artificial manures, there is room for improvement in many directions—for example, in the average milk yields of the dairy herds.

The landlord-tenant-worker system: Very deeply ingrained in the British scheme is the threefold division of those interested in the land into landlord, tenant-farmer and farm-worker. The majority of farmers are still tenants, sometimes holding their land from large landowners, sometimes, now, from the State, and although owneroccupiers have increased in numbers they are still in the minority and, what is extremely important, the better farmers are usually the tenants. It is they who have the capital available to put into the running of their farm, whereas the owner-occupier is often impoverished and farms badly because of the lack of capital. This aspect of British farming is extremely important, and so often misunderstood.

As farming has become more efficient there has been comparatively little change in the size of farm units, or the number of farmers (some 300,000 in England and Wales). There has, however, been a big drop in the number of farm-workers. The decrease of farm-workers in the past eighty years has been 50 per cent, so that the number of farm-workers is now only slightly larger than the number of farmers. Actually in the west of the country the small family farm is usually run without hired labour. The average 100-acre farm in the heart of the country would perhaps employ one hired man. The larger arable farms in the east are those where two, three or more hired men are to be found on each farm. This, of course, does not take account of specialized types, such as small-holdings and intensive market gardens or fruit farms.

Summarizing, it will be seen that Britain has embarked upon a nation-wide scheme of land-use planning under the general direction of the Ministry of Town and Country Planning (Town Planning Section of the Department of Health in Scotland) but where the interests of all open land are watched and helped by the Ministry of Agriculture (Department of Agriculture in Scotland).

The CHAIRMAN: Thank you, Professor Stamp, for your very excellent paper. At least, in so far as the United States is concerned, we can learn a lot from you on land planning and land utilization for greater productivity. I hope that this Conference can develop, shall I say, the persuasiveness of foresight to bring us all to your point of perfection rather than, as usually seems to be the case, leaving us to depend on the force of necessity sooner or later catching us up. Your excellent experience should be of value to all of us. This concludes our technical papers for today.

Before we adjourn, I would like to have Professor Goodrich, who is Chairman of the Preparatory Committee and Programme Director, tell you a little bit about what will come tomorrow and next week. You can see from reading the programme that starting tomorrow morning all of us are supposed to go to work in the Section meetings.

MR. GOODRICH: Mr. Chairman, as you have just said, this is a turning point in the procedure and method of the Conference. Up to now we have sat together, whatever our special interests, as members of one gathering. Tomorrow morning we break up and become five separate meetings, tomorrow afternoon we come back together and become one meeting. I should like, on behalf of the Preparatory Committee, to state very briefly what seemed to us the logic behind this organization of the Conference. The early papers have set out the problem; they have called attention to the wastes of resources and the tremendous past and present expenditures of resources. They have pointed out the increasing demand on resources, coming from increasing population and accompanying also rising standards ol living. The speakers this morning searched the great areas of production to point out the more dangerous, the more critical shortages. You have noticed that the speakers have differed a good deal, at least in emphasis, on the prospects of mankind in the race of science against depletion. They have all agreed there is much to be done. This afternoon's meeting has stated an approach to the solution and started the examination of what can be done. It is significant of the planning of this Conference that it began with an emphasis on the interdependence of resource problems. But that cannot be the whole story, and the Chairman at the morning meeting, Professor Velander, gave a very good statement of the necessity and the reason why we need to break up tomorrow into the smaller meetings. So tomorrow morning there will be meetings on Fuels and Energy, Water, Forests and two Land meetings. In later mornings there will be Section meetings on Minerals, and Fish and Wildlife topics. It is in these Section meetings, as the Chairman has said, that you must go to work. Certainly it is the place where there will be opportunity for more discussion and for the more detailed sharing of technical "know-how". On the other hand, we do not propose that you should stay for the remainder of the Conference in these separate groups. And again Professor Velander had a word for it. He said that one of the functions of this Conference was to break down the Chinese walls between specialists. So we shall come together tomorrow afternoon and in the other afternoon sessions to look again at the common aspects of the resource problems. From this point forward, Mr. Chairman, it is proposed that the Conference should go forward on this dual basis.

The CHAIRMAN: Thank you, Dr. Goodrich. The meeting is now adjourned.

Soils and Forests

Friday Afternoon, 19 August 1949

Chairman:

Charles F. BRANNAN, Secretary of Agriculture, United States of America

Contributed Papers:

Soil and Water Conservation
Hugh H. BENNETT, Chief, Soil Conservation Service, United States Department of Agriculture

Soil and Forest Conservation and Protection of Water Supplies
A.B. LEWIS, Agriculture Division, and
J. D. B. HARRISON, Forestry and Forest Products Division, Food and Agriculture Organization of the United Nations

Techniques for Increasing Agricultural Production
Robert M. SALTER, Chief, Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture

Discussion:

Messrs. VAN TASSEL, C. H. EDELMAN, GUILLAUME, CLAY

Programme Director:

Carter GOODRICH

Programme Officer:

Alfred J. VAN TASSEL

The CHAIRMAN: I would like to open this meeting this afternoon with at least one announcement which I am sure is of interest to all here. I would like to ask Mr. Van Tassel, the Executive Secretary of this Conference, to make that statement to us.

Mr. VAN TASSEL: The trip to the Stillman farm which has been arranged by the American Citizens Committee for tomorrow, is now fully planned. We have registered ninety people for that trip and there will, unfortunately, be no facilities available for any additional persons. Since there have been a number of inquiries from additional people who would like to attend the trip, it is therefore urged that all those who registered and now feel that they may not be able to attend the trip, so notify the Committee so that their places may be made available to others who wish to attend. Secondly, I would like to announce that some of the buses tonight will go directly to the Ritz Carlton Hotel to accommodate those attending the reception being arranged for all conferees by the United States participants in the Conference.

The CHAIRMAN: May I extend to you or reiterate the extension of greetings and welcome which my colleague, Secretary Krug, extended on the opening of this Conference, and join him in all that he has said. It is not my place nor intention to make an address or any extended remarks today. I have in mind first of all thanking the Secretary-General for permitting me to preside over this plenary session. It is an honour and distinction in which I take a great deal of pride and deep gratification.

It was a number of years ago that a session and an international congress of this kind was first conceived. It was, if I understand correctly, probably suggested first by a great American conservationist, the Honourable Gifford Pinchot, former Governor of the State of Pennsylvania, and one of the great leaders in this country in the conservation movement. It was Gifford Pinchot who first brought to the American people's attention the importance of our forest resources, and who began to direct and guide the thinking of some others, a very few people in the first instance, towards the relationship between the maintenance of a strong economy and society in this country or in any country and the effective use of its soil and other natural resources. So, I would like to take this occasion to pay my respects to a great conservationist, who has unfortunately left us behind with this task.

If there has been any re-expression of these principles, in striking form, of any more importance than the statement of the President of the United States, when he made his now famous Point Four declaration to the Congress, I am not aware of it. It seems to me that in the sessions which we have launched upon, we are at least laying a foundation, beginning to accumulate the knowledge, beginning to implement the thinking at an international level, upon the basis of which "Point Four" can become a reality throughout the world. "Point Four" may become known by other names before you and I see the end of this great task and I am sure none of us will, because it is a long and arduous task. Certainly it will never be well started until we all have, in all parts of the world, an understanding of the resource potentials of every continent on the face of the earth in terms of its capacity to feed man better, to make man more comfortable and to promote the causes of human welfare everywhere. It is in that spirit that we are beginning a task here which has significance, not only in the technical aspects of the problem, but also in terms of the movement for international peace, for international understanding and for the wellbeing of men everywhere. It is in that spirit and in that thought that I take a great deal of pride, a great deal of pleasure in participating in this meeting and throughout the balance of the meetings, which I shall have the opportunity to attend.

Our subject for today is "Using and Conserving Resources," with particular relationship to the soils and the forests. We are particularly fortunate in having three distinguished men in this field to address us in the persons of Dr. Bennett, Dr. Lewis and Dr. Salter.

Dr. Hugh H. Bennett is known to everyone in this room. I suspect many of you know him in person, but certainly all know him by reputation. To me he is of course a fellow employee in the Department of Agriculture, one about whom I had heard a great deal before I had the opportunity to come to Washington and get acquainted with him personally. I look upon Dr. Bennett, and I say this most sincerely, as perhaps one of the greatest evangelists of all times in the cause of soil conservation. It is by the sheer force of Dr. Bennett's belief and enthusiasm for this cause and his untiring energy, in travelling about this United States of ours and all over the world, that we have made many important advances in understanding our soil resources and what must be done about them if we are to remain capable of taking care of the world's population. Dr. Bennett has contributed, perhaps, most of all people in that field as far as this country is concerned. He has given of his energies and of his abilities, almost untiringly, ever since when as a rather young man he started work in this field. Those of us in the Department deeply respect Dr. Bennett's views and thoughts on this subject. There are those who differ with him perhaps in some technical aspects, but certainly no one in all of our wide acquaintance, both here and abroad, questions Dr. Bennett's great desire and great devotion to the cause of soil conservation. It is, therefore, with a great deal of pleasure that I take the privilege of introducing my colleague in the Department of Agriculture, and my revered friend, Dr. Hugh N. Bennett.

Mr. BENNETT *delivered the following paper:*

Soil and Water Conservation

HUGH HAMMOND BENNETT

ABSTRACT

The present state of world affairs is evidence that scientists must hereafter become advocates and teachers of their knowledge, if such knowledge is to be widely used for the benefit of mankind. In the field of natural resources, it is particularly important that the world's statesmen be encouraged and helped to understand the facts and probabilities with respect to these resources. This is a necessary prelude to greater action in conservation.

The basic technology of soil and water conservation is known and its value in practical application is being carried forward effectively in several countries. National and world leaders should understand that in addition to being physically helpful to everybody, soil and water conservation is also politically, economically and socially advantageous.

The area of productive land is limited and the productive quality variable. Productive land is neither permanent nor renewable, but modern soil conservation measures, scientifically applied to the land, can keep that which is left in a productive condition, for the benefit of all. Productive soil cannot be rebuilt in time short of centuries, although sub-soil in some instances can be improved with fertilizers, crop rotations and good management.

The state of world affairs today affords evidence, as I see it, that a great many scientists hereafter must become more than scientists. They must become, also, effective advocates and teachers. I think it must be apparent to everyone here that too much of the knowledge acquired through research—knowledge of great potential benefit to mankind—is not yet being adequately used. Certainly it is not being used widely enough. Nor is the demonstrated ability of science to acquire new knowledge and to help solve current problems being employed as fully as it might be.

The principal reason is apparent. Our leaders frequently do not understand our scientific language. Too generally we have, somehow, failed to communicate to them facts of the greatest importance. Those we have chosen to direct the affairs of our nations—our leaders—are rarely scientists. More often they are lawyers, soldiers, or leaders in public affairs—business, politics, labor. If they do not understand the facts about natural resources and how best to use them, the responsibility is more likely to lie at our own door, as scientists, than at theirs.

One of the great jobs, then, ahead of scientists, particularly those working in the field of natural resources, is to find ways to get their knowledge understood by our leaders and statesmen, and put to wider use.

This conference in itself is a useful step in the right direction. Much was done, over considerable time, to bring it about. In the process leading up to this assemblage, leaders were asked to listen to scientists, to understand the facts about our natural resources. This meeting would not have been possible without the authorization and approval of many of the world's leaders. Here is proof that much can be done if we will only set our minds and hearts to the task.

In the field of soil and water conservation, I believe the next immediate steps to be taken, beyond continuation and development of national action programs for the application of modern soil and water conservation measures to the land, are in the fields of economics, politics, sociology, and, as I mentioned at the outset, in effective advocacy and teaching. The basic technology of soil and water conservation is rapidly coming to be known. Its value in practical application is being demonstrated in the United States and several other countries. And I am proud to remark, incidentally, that the Soil Conservation Service has pioneered in this work. The need now is for greater action over wider and wider areas in more and more nations. This will require decisions—decisions by the leaders of nations. For right decisions they must be properly informed. Somehow, our leaders must be helped to understand that soil and water conservation invariably is economically, socially, and politically advantageous.

SUPPLY OF PRODUCTIVE LAND LIMITED

In agriculture, soil and water must be considered together. Soil without water is desert and water without soil is worthless. Even where water is available, all soil is not productive. It may be waterlogged, or too saline, or too steep, too shallow, and so on. Thus, the area of productive land is limited; it is not known precisely how limited. It is unfortunate that after thousands of years of using the land for the essentials of life, we still have only general information about the world's supply of productive land. The best estimates indicate that in the world as a whole, there is left only about 4 billion acres of immediately arable land (based on our field observations and on published data, country by country). That is all that is available now, so far as I know, for meeting the needs for food, fibers, tobacco, etc. for the world's two and a quarter billion people—with population increasing faster than ever. And not all of this 4 billion acres is good land; much of it is of only mediocre productiveness.

CONSERVATION ESSENTIAL TO FUTURE PRODUCTION

Although it is not known exactly how much of the world's unused land can be developed from now on for production purposes, indications are that there is not nearly enough to feed the increasing population of the world indefinitely, as man has been using the land—or misusing it—even when the remaining virgin areas are added to the land now in use. We cannot say now what the future holds in the way of scientific achievement; so, we can't afford to ignore the facts of today. We can't take the mathematics of land and people and advancing medical science out of the situation.

Our greatest hope lies in changing the way we use and treat the land. The scientific application of modern soil conservation measures holds the only real promise of adequate production in the future that I can see from here.

Any nation which does not have enough productive land within its own borders to produce adequate amounts of food, fiber, and wood for its own population must import these commodities from other nations having a surplus. They can pay for their imports, in most instances, only with other natural resources, such as oil, coal, diamonds, gold, iron, and copper. Every year, everywhere, the drain on natural resources goes on. Everywhere it rains hard enough for water to run downhill. The runoff from unprotected cultivated slopes is colored with soil. This is true for every acre of cultivated land on earth.

PRODUCTIVE LAND IS NOT PERMANENT

Unfortunately, unprotected productive land is not a permanent resource. It would help if everyone understood the full significance of this. Under various conditions of use and treatment, land is extremely unstable—insecure—impermanent. When wind or water moves across bare earth, some soil is picked up and carried away. It may be moved hundreds of miles or only short distances. The amount moved at one time may be small, but eventually large amounts are stripped off the land, unless it is tied down with effective soil-conserving measures.

Soil thus removed by erosion, together with the accompanying waste of water as runoff, leaves the land poorer than it was; often unplowable, useless for further practical crop production. If the soil removal process is allowed to continue long enough, the land is finally unable to support even grass or trees. As long as it is not stripped down to bedrock or subsoil of sterile sand or raw, stubborn clay, however, a certain limited amount of production of useful plants and animals is possible. Some—but not all—erosion-stripped land (subsoil) can be made to produce fair to good crops if enough fertilizer is applied, if soil-improving rotations are used, and if the producer is willing to take unusual care in the management of the land and crops. These efforts, however, must be paid for in one form or another. No person and no nation can discount soil erosion for very long by relying solely on fertilizer or machinery or soil-improving rotations, although they are all important. The point of diminishing returns arrives too soon and leads too quickly to insufficiency, especially where erosion is foolishly permitted to continue and rainfall allowed to run to waste.

In very recent years I have seen soil listed as a "renewable" resource. The implication, I suppose, is that eroded land can be "renewed" and restored in a practical way to its former productive condition. This succeeds only in deluding people who should not be misguided. Deeply eroded land cannot be "renewed" or restored to anything like its original productive condition within a few years. At excessive cost and under laboratory or research plot conditions it is possible, of course, to add fertilizers or manure and grow soil-improving plants in such a way as to stimulate growth and increase yield. This does not mean, however, that the soil is being renewed—and, moreover, man has not found it practical to bring back to his fields and pastures rich soil scattered over the floor of the oceans through the process of erosion.

Recently, the Department of Agriculture published the results of corn produced at the Northwest Appalachian Conservation Experiment Station at Zanesville, Ohio, on a plot which started out with topsoil and wound up at the end of ten years with erosion-exposed subsoil.[1] The range in yield of corn produced over the ten-year period 1933 to 1942, inclusive, was, without fertilizer, approximately 60 bushels the first year on topsoil, with a rainfall of 42.7 inches, to less than 2 bushels per acre the last year, on erosion-exposed subsoil, with a rainfall of 38.6 inches. The treatment was the same over the whole period; no fertilizer was used at any stage. The significant point in this instance is that by 1942, after only ten years of cultivation—wasteful cultivation, to be sure—erosion had removed approximately 6 inches of productive topsoil, down to the level of exceedingly poor subsoil.

The Ohio Agricultural Experiment Station initiated an experiment in 1936 near Wooster to determine the relative crop production of topsoil and subsoil.[2] Measurements were made of the yields of corn, oats, wheat, and hay on virgin topsoil and on subsoil under different systems of cropping and management. Results from the first 9 years (1937-1945) show the average per-acre yield for corn in a rotation of two years of corn followed by one year each of wheat and hay, for virgin topsoil without treatment, was 59.1 bushels per acre, as compared with an average yield of only 19.7 bushels per acre for similarly used subsoil.

Thus we see that on this exposed subsoil, which had a favorable structure but was lacking in organic matter and other available essentials for best crop growth, the yields of corn, oats, wheat, and hay remained substantially lower, irrespective of treatment. I think this is sufficient evidence to show that topsoil is one thing and subsoil another.

Soil that has lost some of its fertility as a result of prolonged or intensive cropping, or as a result of leaching, is renewable in the sense that its fertility levels can be restored by applications of fertilizers and manure and the use of crop rotations but its texture remains unchanged.

Land eroded down to unfavorable subsoil, however, is not renewable in any practical way, except over periods of a great many years, even centuries.

Some who are here today know just how *un*renewable soil can be where man-induced erosion (not the slow geologic type of erosion) has been active for a long time. If soil were in truth a renewable resource I am sure there are areas in many parts of the world where governments would have been busy long since with programs of "renewing" the land for production.

It is not in any sense helpful to delude people with myths of soil "renewability" and assertions about vast, new untouched areas of productive land in the tropics and polar regions which will free the world from want. I have no doubt that mankind now has the scientific

[1]Investigations in Erosion Control and the Reclamation of Eroded Land at the Northwest Appalachian Conservation Experiment Station, In Cooperation with the Ohio Agricultural Experiment Station, Zanesville, Ohio, 1934-42. U. S. Dept. of Agr. Tech. Bull. No. 888. May, 1945.

[2]Ohio Agricultural Experiment Station, Wooster, Ohio. Expt. No. 58.

ability to produce food continuously in the Arctic, the Antarctic, the Amazon Basin, and on both sides of the Andes, the Alps, the Rockies, and the Urals. We can, as a matter of fact, produce food in glass enclosures, copper tanks, in raw subsoil, and even in ground glass, if we set ourselves to the job. But where will the plant nutrients come from? And who will pay the bill in labor, time and money? Would the production be economical? Would the money come from shipments of oil, iron, copper, or what? Remember: You can't pay with topsoil because it cannot be stockpiled and shipped around like metals and minerals even where there is topsoil to spare.

And would the food thus produced contain proper nutrients for healthful growth?

NO EXCUSE FOR COMPLACENCY

I have talked with farmers in Alabama, Venezuela, and the Union of South Africa who are trying to make a living on severely eroded land. I am sure they would have little patience with men who want to de-emphasize the dangers of erosion and who blandly refer to the future bounty of the Amazon and Alaska.

For my part, I see no room for complacency about the land and no excuse for minimizing the threat of erosion to our welfare. I can think of no scientific development of the future which will abolish our dependence on productive land. Meanwhile, I believe we may all hope and even expect that there will be scientific advances in the field of food production. No one can deny that we may sometime have food produced on a purely synthetic basis from materials that do not have their origin in the soil; there have been thus far no clearly decipherable shadows from any such "coming events," that I know of.

From the past record and the present evidence, mankind is going to need more and more food from its limited supply of productive land which is still diminishing as the result of continuing erosion.

With respect to the land-population relationship, I can think of no development short of a world-wide plague or some similar unprecedented disaster that would minimize our dependence on the land. And whether the net population of the world levels off or continues to increase steadily, we shall all have everything to gain and nothing to lose by saving as much as we can of our remaining area of productive land.

Almost all the food we eat, most of our clothing, and all of our wood comes from the land. It is on this productive land that nations depend for life, for strength, for maintenance of their industrial superstructure, and for their cultural and political survival.

MODERN SOIL CONSERVATION

Fortunately, we now have at our disposal a great deal of the basic scientific knowledge necessary to keep our land and keep it in productive use. Good land use and husbandry are pretty close synonyms of soil conservation. Modern soil conservation is based on sound land use and the treatment of land with all the proven appropriate measures that are needed to keep it permanently productive while in use.[3] It means terracing land that needs terracing; it means contouring, strip cropping, and stubble-mulching the land as needed, along with supporting practices of crop rotations, cover crops, etc., wherever needed. It means gully control, stabilizing water outlets, building farm ponds, locating farm roads and fences on the contour, and planting steep, erodible lands to grass or trees. Where land is too wet, modern soil conservation calls for drainage; if it is too dry, it calls for irrigation; if it is subject to wind erosion, it calls for stubble-mulch farming, wind-stripping, and windbreaks. If plant nutrients have been depleted, it calls for fertilization; if water-soluble salts have accumulated in toxic quantities, it calls for leaching out the salts by flooding. And modern soil conservation calls also for the use of the best of the most adaptable varieties of crops as well as the most efficient tools available to farmers.

Each measure is applied to meet a specific need, as determined by actual physical analysis of the land through soil conservation surveys, wherein each individual parcel of land is classified according to kind, condition, and need. Combinations of mutually supporting measures are very often used to safeguard the more hazardous types of land, and what is done in one place is adjusted to the needs of, or effects on, adjacent land.

There is no other way to carry out a successful job of lasting soil conservation: the kind that can be maintained on the land permanently. This is a condition imposed by nature, not by man, although man's treatment of the land frequently has altered the natural conditions in ways that necessitate special treatment. There is no substitute for this painstaking, scientific procedure, and certainly there is no panacea for soil erosion. Trying to get the job done on a permanent basis in any other way will surely yield futile results. And what is to be gained from temporary soil conservation, beyond some momentary advantage?

The Soil Conservation Service does the job co-operatively with farmers out on the ground. We do not invite farmers into a comfortable room and tell them what to do. Our technicians go out with the farmers into their fields, pastures, woodlots, and idle lands, and together they make a plan for the proper use and adequate protection of each acre. The plan, of course, must be fitted to suit the farmer's need and economic ability.

SOIL CONSERVATION DOES MORE THAN SAFEGUARD LAND

Modern soil conservation is not directed merely toward maintenance of the status quo. It is dynamic and progressive; it leads to increased and lasting productivity of the land and thereby promotes the common welfare wherever it is practiced. Probably all regions of the world can be improved, in some degree, and some currently poverty-stricken areas possibly can be advanced to a state of relative prosperity by safeguarding and increasing their agricultural productive capacity through soil and water conservation including land use.

Soil conservation does much more than safeguard land. It directly or indirectly results in a wide variety of fundamental benefits. It both increases the yields per acre and lowers the cost of production on most farm land, which, in turn, starts a whole chain of benefits, such as increased farmer income, increased taxes for support of government, increased trade for both rural and urban communities, and increased employment for professional, skilled, and unskilled workers.

[3]Bennett, H. H. Annual Report of the Chief of the Soil Conservation Service, 1948. U. S. Dept. of Agriculture.

It results in large savings, such as reduced siltation of streams, ditches, harbors, culverts, and costly reservoirs; lessened damage to fills and cuts of highways and railroads; and decreased damage to oyster beds and breeding and feeding grounds of fish, crabs, and other valuable aquatic life. Still other savings result from reduced flood crests on both major and minor streams which thereby lessen damage to farms, homes, manufacturing plants, livestock, highways, railroads, and other property.

Soil conservation, moreover, helps to alleviate drought damage to crops, pastures, and meadows. It encourages a more flexible and diversified type of agriculture. It helps to create a greater pride and satisfaction in farming, along with the greater material returns. It encourages the sons and daughters of farmers to stay on the farm. And, apparently, it helps to improve the nutritional quality of food.

SOIL CONSERVATION, THE MAIN HOPE OF CIVILIZATION

Soil conservation, scientifically applied to the land according to modern standards, is the great need and the main hope of our civilization. To a large degree, people everywhere depend for their well-being on the well-being of their agriculture. Even though there have been phenomenal advancements in invention, manufacturing, mining, transportation, and other industrial activities in recent years, the people of the world are still basically dependent on agriculture. Agricultural production, in turn, depends on the supply of productive land, its proper use and protection. Without this solid foundation, there can be no real hope for a continuously successful agriculture anywhere. Furthermore, without this foundation there can be no assurance of economic stability or social progress. And, as I see it, there can be no assurance of adequate nutrition, prosperity, happiness, or peace anywhere.

So long as people have enough good land and an adequate supply of water to make the land productive, they have the means to overcome, if they will, such handicaps as poverty, malnutrition, inadequate education, and lack of opportunity. Without such resources, scientifically managed, real and lasting progress is impossible.

Soil conservation, then, is mandatory everywhere over the world if our civilization is to avoid a tragic decline, economically and culturally.

PRODUCTIVE LAND A MAJOR FACTOR IN FUTURE INTERNATIONAL RELATIONS

As the population of the world continues to grow and the supply of productive soil diminishes, the maintenance and improvement of the world's limited area of arable land is likely to become a major factor in our national and international deliberations. This seems to me a proper and inevitable result of the present situation. This conference, I believe, is an early indication of a future trend.

A year ago, there was a similar indication. Then, the Inter-American Conference on Conservation of Renewable Natural Resources, attended by official delegations from twenty-one American nations, adopted a *Declaration of Principles* which contained, among other declarations, these adjurations:

"Everywhere in the world natural resources have been depleted by ignorant and reckless exploitation that has ignored the inexorable natural laws which maintain them, and this depletion was disastrously accelerated by the recent world war. Throughout the world steadily increasing populations have put an ever-increasing strain on the dwindling resources. These two forces, each of which reinforces the other, have now brought mankind to an almost critical point. The challenge of our time is that we must arrest and reverse them or face the fact that the very existence of civilization will be brought in peril.

". . . The end in view is that people everywhere will understand that their dependence on the earth lays on them the obligation of respecting the earth and protecting it in order that they may enjoy its fullness. Toward this end it is the duty of governments and their agencies, of religious institutions, of public and private foundations, of universities and colleges and schools, the press, radio and motion pictures to provide instruction that will make clear the penalties of violating the physical laws of nature and the reward of living in accord with them."

There is no question about the truth and wisdom of these declarations. I subscribe to them completely. They are more valid in 1949 than in 1948, because another year of rains and winds have beat on our land and in the same year the world's population has increased by approximately another 20 million.

To get the job done on time, we must all work together. In the first place, that will make us better acquainted and better friends. And, secondly, we must do this vital job, whether we want to or not.

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The CHAIRMAN: Thank you Dr. Bennett. I am sure that those of you who had any hesitancy about accepting my identification of Dr. Bennett as an evangelist in this field, will have no hesitation any longer. It seems to me that Dr. Bennett has said again to us that an ounce of prevention is worth a pound of cure in dealing with the problems of soil conservation. His paper will be subject to some discussion later on in the Conference. But I would like to move on to the other papers before we go into a discussion of the entire subject.

It seems to me, that, perhaps, a story might be appropriate at this time. It occurred to me about the first time I ever heard Dr. Bennett talking about soil conservation. It was probably he, or some other person, who was travelling in an area in our country in which soil conservation had not yet become thoroughly understood and in which our forefathers had done a pretty effective job of ignoring most of the basic principles of soil conservation. This person was driving along a country road—we will call him a visitor—and noticed that the crops out in the fields were pretty bad, the road was bad, etc. He came along to a bend in the road, and there sat a native of the country on the fence, just kind of whittling, and not doing too much. So he engaged him in conversation. The visitor said "It's a pretty sorry country you are living in here, isn't it?" The native allowed that it was a pretty sorry country. The visitor said "I've been noticing the corn and the corn is pretty bad". The fellow said "Yes, corn is pretty bad". The visitor said: "I went by a schoolhouse down there and there wasn't any kids in school". Said the native "We haven't had money enough for sending kids to school for a long time". The visitor remarked about the bad roads and a few other things, and the native agreed with him. He could not start much of a conversation, so he thought he would just terminate it and he said "You know, I don't see how you fellows really produce the essentials of life around this part of the country". The native thought a minute and he said "Well you know, we don't do very well at producing the essentials of life and sometimes when we produces them, they ain't worth drinking". I do not know, Dr. Bennett, whether that really happened to you or not.

I am going to be a little embarrassed here after I get through with my introductions, because in each case I shall have to call your attention to the fact that our speakers have come at one time or another from the United States Department of Agriculture. I want to assure the conferees from outside the United States that we do not believe that we have all the knowledge and all the "know-how" in this important field. I am sure that Dr. Bennett, in his travels over the world, and many other people, like Charles Kellogg and Dr. Salter, who have both made invaluable contributions to this all-important subject, have gained a great deal of information and knowledge in the countries of the world to which they have travelled. We, of the United States, are therefore not in the position of a professor or a teacher here today; we are here as participants in a larger group exchanging and co-operating in the over-all task of solving a world-wide problem, a problem with which many countries were confronted long before we were in this country, and towards which they have made marked advances in improvement in soil work long before we really began to be impressed with the importance of it. So I hope that those of you who are visitors in this country at this time, will realize as we speak here today that we do not consider ourselves the fountain of all information. We recognize that in your countries there have been great and important advances made along this line and this conference, therefore, is an opportunity for exchange of views rather than anything else.

As I introduce the next two speakers, I do want to say this: They came out of the Department of Agriculture, yes, but they also came out of the great Land Grant College system of this country. They got their education not in the Department but brought to the Department information, knowledge, background and enthusiasm for their work. And that is true of Dr. A. B. Lewis. He was, as I said, in the Department of Agriculture a long time, before that he was in the Land Grant College system of this country. For a number of years, he has been in the international field as a member of the FAO staff which has been built up these past few years through the co-operative undertaking of many nations. Dr. Lewis has been the author of a number of books on various aspects of soil science and forestry, and much of his work is well known to you. His paper today is on "Soil and Forest Conservation and Protection of Water Supplies". He advises me that it was prepared in collaboration with Dr. J. D. B. Harrison, also of FAO. And so I take great pleasure now in introducing Dr. Lewis.

Mr. LEWIS *delivered the following paper:*

Soil and Forest Conservation and Protection of Water Supplies

A. B. LEWIS

J. D. B. HARRISON

Man's most powerful interest in the land and water resources of the earth is that they shall yield abundantly the food, fibres, timber and other products that he needs. Land is not used for its own sake but for man's sake, and land is not conserved merely for the future, but for the future of man.

As an influence on the present and future welfare of man, nothing, in fact, is of a greater consequence than the land. Land, including its water supply as one of its principal characteristics, varies greatly in ways that determine how it may best be used and how much it would then produce.

Man has discovered how different kinds of land should be used, and what level of living can be supported on different kinds of land, almost entirely by the process of trial and error. This has been extremely expensive in terms of energy, courage and life. Since more food can be produced by cultivation than in any other way, man, since learning agriculture, has nearly always tried to cultivate the land he settled. Man has spread almost at random over the earth's surface, much as the seed was scattered by the sower in the Parable. Where the land was excellent the settlers have prospered exceedingly and increased in number, and the surplus food produced by them has given rise to the great urban civilizations of the world. Where the land was fairly good, settlers have established themselves and earned a modest livelihood; but where settlers have fallen, so to speak, on land that is poor they may have struck root briefly when conditions were favourable, only to be stricken with poverty or even starvation when the true character of their land, including its climate and water supply, was revealed.

Errors of agricultural settlement not only have injured the settlers themselves but have often damaged the land and made it less productive for purposes besides cultivation. Unwise clearing of land in the upper parts of river basins, furthermore, has disrupted water supplies for power, irrigation, manufacturing, and other uses in downstream areas, and has sometimes resulted in the burying of good valley soils under sterile outwash material and the filling of reservoirs and stream channels. Errors of settlement, in other words, may have irreparable consequences, and, even at best, the correction of such errors is generally a long drawn-out and expensive process.

Settlement of new lands is still going on in many parts of the world. Is it necessary that settlement proceed on the usual hit-or-miss, sink-or-swim basis? That the familiar mistakes and their familiar consequences be repeated in new regions? Must the effects of old mistakes continue to blight the fortunes of countless people on certain lands and gradually destroy the land itself? It is, indeed, not necessary that this be so. Much has been learned about the characteristics of land that make it desirable for various uses. Ways of correcting the misuse of land and its results have been put into practice in some places, and could readily be applied elsewhere.

Knowledge and skills already available can gradually correct old mistakes in settlement and largely prevent new errors. It is the purpose of this paper to outline policies which, we believe, if put into effect, would protect and develop the land and water resources of a country.

Errors in land utilization are of two principal kinds. The first and greatest error is to try to use the land for a purpose to which it is not adapted. The second type of error is to use improper methods of farming, grazing, forestry or other utilization, even though the land is suited to that use.

The first kind of error has occurred on a grand scale, for example, in North-west China. In periods of greater-than-usual rainfall plow-farmers have gradually extended their settlement out upon the semi-arid grazing grounds of the nomads. When the inevitable droughts have come, often lasting several years, these farmers have starved by the thousands, and other thousands have deserted their villages and migrated to the south and east in search of food. During the dry years the wind has blown away the top-soil. When the droughts have ended, torrential summer showers, also characteristic of that semi-arid region, have fallen upon the deserted and barren cultivated fields, washing away the soil and ruining the land even for the grazing of livestock, its original best use. Travellers may now see the ruined villages and scarred landscape that result from this basic error in land use, an error that is sure to be repeated in each period of better-than-usual rainfall.

In the semi-arid regions of the Great Plains of the Western United States, similar errors have been made. Vast areas best adapted by nature for livestock ranges have been settled by plow-farmers. In time of greater-than-usual rainfall this settlement spreads. When the dry years come, the people themselves do not starve—the efficiency of the national economy prevents this—but some of the livestock starves and there is much migration by both people and livestock. The ruin created by wind and water on the idle, cultivated soils is the same as in China. In this region one may see hundreds of square miles inhabited by plow-farmers making a most precarious living, and after several generations still occupying dwellings little better than those of the first settlers. If there were more livestock and fewer people on this land, the wide fluctuation in rainfall from one period to another could generally be met by selling part of or increasing the herds, and would give rise to much less human privation and migration. It would surely be better in many ways if each 10,000 acres of this land supported one prosperous livestock rancher instead of the ten or more poor, struggling farmers it now supports.

In regions where water is scarce, costly errors have been made in irrigating lands where the soil was unsuitable for farming or where drainage could not be or was not provided. Some new lands have also been irrigated in such a way as to deprive previously irrigated downstream areas of their water supply, causing old settlements to revert to desert.

In humid regions, conspicuous errors have been made in clearing the forests and trying to establish farms on lands too poor to support agriculture. One result of such errors is that rural communities of sub-standard income are established, where people are not able to afford the education, health services, roads, and other facilities they need, and either do without these or must be subsidized. Agricultural settlement in parts of the cut-over areas of the Great Lakes States and in the Appalachian Plateau region furnish examples of this condition.

In the south-eastern United States, where many of the forest soils are highly erodible as well as unsuited to farming, a further result is severe erosion, sometimes with gullies so deep as to damage the land even for forests. A still further consequence, especially in hilly regions where forests have been damaged by grazing or cleared to make way for agriculture on unsuitable land, is that the hazards of seasonal flood in down-stream areas are greatly increased. At the same time, the flow of water in the dry seasons is reduced, adversely affecting users of water for irrigation, power, navigation and other purposes.

Another obvious result of attempting to establish farms on unsuitable types of forest land is that the forests, the source of valuable timber and other products, are destroyed, and the development of wood-using industries is prevented. This result can also occur, of course, through the improper exploitation of forests even where farming is not the object.

In the humid tropics the removal of the forest has been found to be particularly dangerous to the soil. Here the major part of the accessible supply of minerals and organic matter is normally embodied in the trees and plants of the forest itself. When these are removed, the high temperatures, strong sunlight, and heavy rainfall quickly cause the oxidation of the organic matter in the soil and the leaching out of the soluble minerals. It may then be impossible to raise crops and even the natural vegetation may fail to reoccupy the land. Severe erosion may follow. In the tropics, therefore, lack of care in selecting land for non-forest uses threatens to produce particularly calamitous results. Tropical agriculture can, however, be productive and permanent where the soil and other conditions are favourable.

Not all errors in land use can be ascribed to the attempt to produce food by farming the wrong kind of land. Seekers for gold, coal, and other minerals have been allowed to ruin valuable land through hydraulic and strip mining, without consideration of the relative value of the minerals produced and the potential agricultural production which was destroyed. Areas so damaged have been small but they have sometimes been of importance locally. Cities, industrial plants, airports and similar non-agricultural establishments have encroached upon other productive farm lands, even where lands less valuable for food production could have been selected.

CLASSIFICATION OF LAND

The essential first step in preventing the improper use of land or in correcting misuses that are already established is to classify the land according to its best use. This classification must recognize first of all that man's first interest in the land is to get a living from it, and must recognize the requirements of the enterprises which man organizes for that purpose.

If, for example, 200 hectares of land are required for the economical administration of a government-owned forest, no smaller contiguous area than this should be classified as suitable for purchase and reforestation by a public agency. Small areas of land suited to forestry probably would be classed in with the farm lands, on the assumption that they would be used for farm woodlots. On grazing lands of such a type that 10,000 hectares are needed to support a family herd of livestock, no smaller area should be classified as suitable for the establishment of enterprises of this kind. Smaller separate areas of grazing land would usually be classified as part of the farm lands, if they were suitable for farm pastures. Similarly, it would not be appropriate to classify as suitable for plow-farming a single piece of good soil in a poor soil district if the area of such soil were less than that required to support a farm family in accord with the standards of the country. One must go still further, and recognize the necessity of furnishing schools, roads and other public services to the users of land. Even where farm-sized areas of suitable agricultural soil are available, such areas usually should not be classified as desirable for independent plow farms if they are scattered widely over a large area adapted mainly to forests, because of the high cost of providing public services.

In classifying land for recommended use, we are not concerned with designating the particular crops which should or should not be raised on a particular field. The question is, instead, is this area generally suitable for the establishment of farms or should it be reserved for forests, livestock ranges, or other uses? If the area is adapted to agriculture, how intensive a type of agriculture will the land support?

In some regions the suitability of land for certain mixed or rotated uses should be considered. The practice of shifting cultivation, whereby land in forests is temporarily cleared for cultivation and then allowed to revert to forest, is an example. While this practice, when uncontrolled, has often damaged the forests and caused the soil to erode, it may prove to be an economic and conservative type of land use when scientifically managed on the right kind of land, as in parts of the Belgian Congo. The clearings may present an opportunity to replant the forest lands to desirable species of trees, as in parts of Burma and the Philippines. Similarly, the use of forests for grazing is generally regarded as undesirable from the standpoint of preserving the forests and safeguarding their beneficial effects in stabilizing water supplies and protecting soils from erosion and floods. Nevertheless, forested areas differ widely in their susceptibility to damage from such use. Combined grazing and forestry may be both safe and profitable, under scientific management, on certain lands.

The classification of land for recommended uses depends fundamentally on an appreciation of human experience. It is easiest to classify for recommended use land which has already been occupied or subject to occupation for some years, since the experience of the farmers and other land users has then only to be observed and related to the basic facts of soil and climate. Farming is such a complex business, and so competitive, that experience is the only reliable guide to land utilization. Where undeveloped lands are to be classified, the classification should depend on an appreciation of the experience of farmers and other land users in utilizing similar land under similar conditions.

Land classification must also, of course, depend on the measurement and mapping of basic characteristics of the land and its present use. A land survey map is essential as a foundation for the work. Aerial photography may be used, along with ground surveys, in making such maps where they do not exist. Land survey maps show the true position of political boundaries, roads, streams and other features, both natural and man-made. A topographic map is essential to show the configuration and elevation of land surfaces, so important in influencing land use. A map of the soil types, more or less detailed depending on frequency of soil variations and the intensity of present or potential agricultural use, is needed. A map of present land uses is highly desirable. Aerial photography may be used in expediting the making of both soil and land-use maps. In areas where the water supply is a limiting factor in crop production and irrigation is needed, measurements and maps of water-supply factors are necessary for land classification. Where the land is already settled for agriculture, a map showing the relative amount and condition of the visible capital accumulated by the farmers on the land has proven very useful in classification, since the net capital accumulation reflects the income-producing capacity of the land over a considerable period of years. Finally, wherever some of the land is being or may be used for farming, the land classifier must have knowledge of the farm management factors which do or would affect the income produced on farms under the local conditions. This knowledge can only be acquired by the systematic study of farms already in existence on the land or of similar farms on similar land. In some countries, most of the land survey, topographic, soil, land-use, water supply, and farm operations surveys and maps have already been made. In many countries, however, this foundation work has not been completed, but will have to be undertaken if the efficient use and conservation of land and water resources is to be achieved.

The task of land classification is that of appraising the land with the aid of all the necessary basic information and coming to conclusions regarding the relative suitability of land areas for various broad purposes. This is not difficult to do in practice. Land classification for recommended use has been done, for example, in several states of the United States, in Canada and in China. In many cases these studies have served as the basis for plans of developing each class of land for its highest possible sustained production. Quite as important is the fact that the land classification maps have enabled us to learn a good deal that was not previously well known concerning the relation between land productivity and many other factors, including farming returns, farm capital, farm-family living standards, agricultural credit, fire insurance, elementary education, the value of roads and electric power, and soil conservation.

The classification of land for recommended uses provides a plan for co-ordinating the utilization and preservation of all land and water resources in the area classified. Because of the importance of water for tree and crop growth, livestock use, human consumption, manufacturing, power, navigation and sanitation, and equally because of its destructive power in floods and as an agent of erosion, a river basin is generally the most logical unit for land classification and development. In humid areas the choice of a river basin as a classification and development unit helps in determining and showing the value of forests on the headwaters lands as a means of absorbing water and regulating streamflow so as to reduce the danger of floods and erosion. Where streams flow from humid uplands into arid or semi-arid valleys, upland forests may be highly beneficial in storing water for irrigation, prolonging the period of flow, and protecting reservoirs and channels from siltation. In view of the fact that the most productive agricultural lands are usually in the valleys, plains and deltas rather than in the uplands, it is conceivable that the total agricultural production of a valley could be increased by sacrificing some of the agricultural land near the headwaters to the forests, thus improving the supply of water for the better lands downstream or better protecting such lands from floods. Considerations such as these logically influence the classification of lands in a river basin for recommended use. It is not so easy to measure and demonstrate such relationships where political units are chosen for classification, as has most often been done.

In dryer regions or in semi-arid portions of a river basin, rainfall may be insufficient for forests but sufficient to support grasses and other herbage suitable for grazing. In these climatic conditions, the grasslands perform a function similar to that of forests where rainfall is greater, in absorbing, storing, and utilizing water and reducing the risk of floods and erosion. Because rainfall is often concentrated in torrential summer showers, the dangers of flood and water erosion in semi-arid regions may be as great as those of drought and wind erosion. It is not unusual to find river basins of which the highest areas should mainly be in forests, the next lower slopes in livestock ranges, and the main valley in intensive agricultural use under irrigation.

LAND DEVELOPMENT

When the land has been classified according to the uses to which it is best adapted, the next problem is to provide that the land shall actually be used for those purposes for which it is adapted. In this connexion it is important to observe that food is the primary necessity of mankind, and that cultivation has generally been found to be the means whereby the most food can be derived from a given area. The first instinct of peoples who have advanced so far as to learn agriculture appears to be to try to cultivate any piece of land coming into their possession if the physical obstacles to cultivation are not obvious and decisive. If the land can be ploughed and there is moisture enough in the soil to sprout the seed, farms will generally be established.

Practical studies have shown that there is a pronounced tendency for the income from land to be divided between the maintenance of buildings, machines, herds, lands and other assets and the reimbursement of labour in such a way that each shares in the higher returns earned on the more productive land, and each participates in the disadvantages of occupying poorer land. Some land occupied by farmers is so poor that it provides the farm operator with a very poor return for his labour and also yields returns that are too low to provide for the upkeep of the necessary farm buildings, fences, ditches, terraces, livestock and other assets that are required for the continued operation of the farm. Nevertheless, farms on land of this character have continued in operation over a long period of years. When one farmer has exhausted his capital and has been forced to sell and leave the farm, another farmer, hopeful of doing better than his predecessor, has generally been ready to invest new capital and try his hand at the venture. In these circumstances, while farmers come and go, a particular sub-marginal farm may continue in use for decades.

Another means whereby sub-marginal farms continue in use is that where poor land is situated in the same political unit as better land, the inhabitants of the better areas subsidize those of the poorer areas by paying, in taxes, more than their share of the cost of public services, such as schools, roads, relief of the poor, police protection, and many others. Private institutions, such as credit agencies and insurance companies, as well as firms selling farm machinery and supplies, unknowingly subsidize the sub-marginal farming areas because they incur a disproportionate share of their costs and losses from serving the poor land, and these high costs and losses are made up out of the returns received in serving the better land.

For these various reasons, land which can be ploughed must be so poor in comparison to other land available in the vicinity as to bring about a very rapid depletion of any capital investment before it will remain out of agricultural use for purely economic reasons. In fact, the competition of farmers bidding for land that ought to remain in livestock ranges or in forests in order to protect the capital and the courage of prospective settlers, will keep the price of such land above that which could reasonably be offered by private persons who wish to use such land for livestock ranges or for forest production.

Because of these facts, there is generally, in a region that has already been settled and where the land varies in quality, some land already in farms which ought to be returned to livestock ranges, forests or other less intensive uses. In regions which have not yet been settled, there will generally be land which farmers will attempt to occupy, if they have the opportunity, but which will never provide them an acceptable living.

One of the dangers of failing to correct such a misuse of land, or of not preventing it, is that farmers who occupy sub-marginal land do not receive enough income to provide them either the motive or the means for conserving their soil resources. They receive so little return for their labour that they will exert little effort in preserving their land from erosion, and they have no money to spend on capital improvements that would help produce the same result. Soil conservation services, extension services and other agencies will be quite unable to bring about the adoption of what they would regard as sound agricultural practices, from the viewpoint of conservation, by farmers on such land. The result depends upon local soil, soil-cover, and climatic conditions. Where those are conducive to soil erosion, gullies will be formed with disastrous results to the sub-marginal land itself as well as land down-stream.

Much of our most spectacular soil erosion has resulted directly from attempts to cultivate land from which the income would not maintain the necessary farm assets and support the farm family according to acceptable standards. Some of this erosion has occurred while such farms were still occupied, but a large share has taken place after they were abandoned.

Similarly, there is a tendency for livestock men, at no net profit to them, to extend their range into areas where grazing is not economical and the land should be utilized for forests.

In view of these universal and very human tendencies, government regulation is often necessary to keep agriculture out of areas which are better adapted to ranges or forest and to keep livestock out of forest lands where grazing would be detrimental, as on steep slopes, and where grazing animals destroy desirable forest seedlings. The *exclusion* of urban and industrial development from good farm land *are* somewhat similar problems affecting smaller areas.

Where land has not yet been occupied, or where occupation is as yet very sparse, the device of zoning, such as has been applied in the State of Wisconsin, for example, may be a very effective method of regulating land use. Zoning typically prevents the encroachment of the more intensive uses upon land that is adapted only to the less intensive, thus combating the natural tendency of man to make the use of land as intensive as possible, rather than the reverse; just as dams must be built to halt the flow of water downstream but not upstream. Zoning is appropriate to prevent individuals from trying to establish farms in areas better adapted to forests or range, to prevent livestock ranges from encroaching on certain forest lands, and to prevent cities and industries from smothering the fertile plains and valleys under their concrete streets and structures.

Where there are only scattered cases of undesirable uses having been established, zoning may still be an effective instrument. It cannot well be made retroactive, but it can gradually eliminate undesirable land uses through the principle that once a forbidden use is allowed to lapse it may not be resumed.

Zoning is a political instrument closely affecting the lives of people on the land. The successful use of this device therefore requires that the people understand and approve it as a means of safeguarding their own welfare. In many countries, of course, no such ordinance could legally be put in force except by the will of the population in the affected area. This places a heavy but unavoidable responsibility on educational institutions.

Zoning prevents undesirable land uses but does not by itself ensure that the protected land will, in fact, be used for any productive purpose. For this reason, other measures may be needed. Where land best adapted to forests, for example, has been cleared for farms, it may be highly desirable that the forests be re-established by planting. Merely to forbid the resumption of agriculture on any such land as has been or may be abandoned may not be sufficient to bring the desired result. Private individuals are commonly unable or unwilling to invest any considerable capital in new forest plantings and then wait, perhaps fifty years, for any return. The government itself, on the other hand, embodies the long-term interests of the public, is perpetual and well suited to carry this responsibility.

In the circumstances described it will often be desirable, therefore, for the government itself to purchase and reafforest the farm lands in areas best adapted to forest uses, and supervise the growth and exploitation of the resulting stands of timber. Such a programme has been adopted, for example, by the State of New York. It ensures that the sub-marginal farm lands will be productively used in the public interest, so far as this can be understood by the government.

Where forest lands are already government property, ensuring their proper use requires, of course, neither zoning nor purchase, but merely that the government protect and develop the forests.

The purchase and administration of land for extensive livestock ranges by the government would be well justified in many regions as a means of preventing unwise farming ventures and making the land available for uses that are within its capacity to support on a permanent basis. In some regions a similar result might be achieved by purchasing or otherwise controlling, not the whole livestock range, but only the watering places and the small areas where plough-farming would be suitable. This would prevent the occupation of these strategic spots by plough-farmers and would keep them available for the watering of the herds and the production of supplies of tame forage for use in winter or in dry years. Nomadic tribes which have fought against the occupation of their watering places and wintering grounds by settled farmers have only been trying to protect the foundation of their livestock economy. In Africa, nomads who have lost the battle have been confined to reservations inadequate for their needs, with the result that severe damage from erosion has resulted.

National land-use policy should contemplate, of course, far more than the exclusion of agriculture from unsuitable lands and the establishment of forests and livestock ranges under public ownership. Since the lands suited to agriculture are the principal source of food, directly support the greatest population, and are the basis for the highest investment of capital and application of labour, their protection and development deserve to be of the greatest national concern.

Governments may well supervise and finance the preparation of new land for settlement where this requires expensive works for irrigation, drainage, and flood protection, or where forests or other wild vegetation must be cleared on a large scale. While a part of such development costs may properly be borne by settlers on the land, a part should be borne by other particular beneficiaries, such as users of power, and a part should be borne by the general public as a cost of national development.

On land which is naturally amenable to settlement or has been made so by irrigation, drainage and clearing, no special activity of the State will ordinarily be necessary to ensure that agriculture will be established with family-sized farms as units, or with whatever other economic units the history of the people has developed. The government should be concerned, however, that the units taken up by the settlers are as large as can be operated economically, so that the lands will have a well-supported population and yield a maximum surplus of products for urban and industrial uses.

For the most efficient agriculture, moreover, it has been established that various public services, which may or may not be government-owned, are necessary. Roads are needed for transporting supplies in and products out, as well as for personal travel. Electric power is of growing importance on farms in many countries, as well as a source of comfort in living. Schools are necessary for the farmers' children, to develop a farm population which understands its business and can adapt its practices to various conditions and new ideas. Credit is needed to enable the farmer to buy and sell without disadvantage, and to make investments which will increase his future returns. Fire insurance protects the farmer against overwhelming capital losses in a particular year. Agricultural extension or advisory services are needed to keep the farm people informed on the latest agricultural knowledge and skills.

These services, of course, cannot be furnished without cost. In a highly developed economy, land which will not yield enough to meet these costs cannot be considered suitable for agricultural use. There are, however, degrees of intensity with which many of these services are needed, depending on the productive capacity of the land. Within the general classification of land that is adapted to permanent agriculture it is possible in practice to distinguish several sub-classifications that are adapted to different degrees of intensity of agricultural use. In a class where productive capacity calls for agriculture of a relatively low intensity, fewer farm-to-market roads per square mile, less electric power per farm, and smaller loans per farm will be needed or can be paid for than on more productive land. Farm population will be less dense and fewer schools will be needed. Furthermore, the level of living of the people in the different agricultural land classes will vary. Agricultural methods and practices will also vary, and require correspondingly different extension or advisory teaching. For the highest development of agriculture and rural living on every grade of land, agricultural services of all sorts should, in fact, be closely adjusted to the needs and capacities that are characteristic of the various grades.

In the beginning of our discussion, errors of land use were divided into two classes: errors of type of use and errors of methods of use. Thus far we have spoken mainly of means to prevent the first type of error, and, beyond that, of actively encouraging the development of the right type of use on each class of land.

PRODUCTION AND CONSERVATION

Errors in methods of use occur under all types of use. Indiscriminate clean cutting of forest stands, for example, without regard for the perpetuation of the forest or the preservation of the soils on which it stood, has been responsible for tremendous losses in timber and in timber-growing resources. Over-grazing of range lands reduces the desirable and encourages the undesirable types of herbage, and gives rise to erosion. On public lands, both of these errors can be prevented by government control, if the government knows how and has the necessary popular support for control policies. On large private forests and ranges they can also be prevented, mainly through education. If necessary, and if the general public is in accord with the idea, regulation of grazing and forestry practices, such as would prevent soil erosion and maintain high production, could be extended to cover private lands.

Under agriculture there are many and various possibilities for error in methods of land-use which place a low limit on farming returns and lead to soil deterioration. These include grazing and forest-management errors, since farms often include tracts of woodland and pasture land as well as of tilled crops; and there is, of course, an immense variety of the latter. Furthermore, soils vary as to their susceptibility to erosion, even when slope and soil-cover are the same, and even on the same farm.

The problem of soil conservation on the farm is one with the problem of production itself. The farmer is trying to earn a living on the land. He is interested in next year's as well as this year's living, and is generally concerned with his sons' and grandsons' livings as well. Fortunately, the agricultural methods which will keep the farm in production, unimpaired by soil erosion, year after year, are the methods which produce the highest annual returns. This has been proven by studies of conservation farming versus soil-depleting methods.

The farmer's interests being what they are, the problem of introducing conservation practices is first of all a matter of educating farmers as to what these practices are and what they will do. Farmers will, if they can, adopt whatever practices will improve their incomes. This motive for conservation is stronger and more effective than any other that could be devised. Harnessing the farmer's natural ambition to make a good living for his family places a tremendous force behind conservation—a stronger force than any government could ever exert from the outside.

For the adoption of conservation practices farmers need, in addition to knowledge of ways and means and results, some assistance in initiating practices which require an initial outlay of capital. Such outlays are a sound basis for agricultural credit, if properly planned and executed.

A further need is a means of co-operating in soil conservation work which affects more than one farm, and sometimes exerting community power in regulating practices on one farm when they endanger neighbouring farms. It may happen that small dams need to be built to regulate a stream, or an area of steep slopes purchased and reafforested. A soil conservation organization composed of farms within a given territory should have the power to perform these duties at the expense of all members. If a farmer persists in managing his farm so that excessive water run off and soil debris damages an adjoining farm, the local organization should have authority to insist on a change in practice.

Farming for sustained production involves practically every phase of agriculture, and no boundary can be drawn to separate a conservation from a production practice. Crop rotations, animal husbandry, fertilization, methods of tillage—all are directly involved. The farmers' first task is, with the help of experts where needed, to take stock of his land and water resources and arrange to use each soil and slope for its best general use. This will mean reafforesting some land on the farm, keeping other land in pasture, and using other land for varying rotations of inter-tilled and non-tilled crops. Some land, perhaps, should be used for ponds. Beyond these details of land utilization on the farm, sustained production will involve a host of agricultural practices, which need not be discussed at this time.

What a productive world this would be, and how different from the present one, if every enterprise of forestry, grazing, and farming were situated on land best adapted for the purpose, and if each enterpriser were using the methods of sustained production! This is the result for which we must strive. The first step is to appraise and classify our land and water resources according to their best use. The second step is to prevent misuse and encourage proper utilization of the classified lands. The third step is to encourage the management of land for sustained production under each type of use. The key to success is that individuals and the general public, if educated on the facts, will find this programme to their advantage, for the present as well as the future. When this lesson is well learned, obstacles to progress will disappear.

The CHAIRMAN: Thank you, Dr. Lewis. I think we have all come to realize that the progress that has been made has been founded upon a great deal of very careful and hard scientific research. Our agronomists and our other soil scientists have been the people who have fortified and equipped those who went forth to tell the story of soil conservation with the information as to how the difficulties could be corrected. The people who supplied that kind of information, our scientists, are the people without whom the job could not have been seriously undertaken, because all we would have been doing otherwise was crying in the wilderness about a problem without offering a solution.

It seems to me that it is particularly appropriate this afternoon, that we hear from one of the soil scientists of long standing and wide reputation, who has been engaged for more than thirty years in various phases of scientific soil work in the Department of Agriculture, working in very close concert with the Land Grant Colleges, the experiment stations and the other institutions interested in this same problem. The Soil Conservation Service would not have been able to do the job in which it takes great pride; other agencies of the Department—such as the field service of the Production and Marketing Administration, and the credit agencies—would not have been able to make the progress they have been able to make, if it had not been for the equipment given to them in the form of scientific knowledge, skill and method of handling the job.

It is with a great deal of pleasure that I call upon Dr. Robert M. Salter, who is the Chief of the Bureau of Plant Industry, Soils and Agriculture Engineering of the United States Department of Agriculture, and one of the leaders in this country in agronomy and soil science.

Mr. SALTER *delivered the following paper:*

Techniques for Increasing Agricultural Production

ROBERT M. SALTER

ABSTRACT

Further development of agricultural technology based on modern science and its application offers one of the really big opportunities to make conditions for world peace—and a great challenge to those who seek it. The use of technology has been responsible for an enormous increase in the efficiency of agricultural production in many parts of the world. Still, no area has yet realized its full potentialities.

Modern science is used in many ways to attack the problems providing an abundance of crops for food and other uses. Most methods fall into one of three categories. Kinds and varieties of plants are bred and selected to thrive better under specific soil, climatic, and other growing conditions. The environmental conditions are adjusted better to fit the needs of plants through all sorts of crop and soil management practices. Efforts are made to preserve the harvest at full value until it can be used by man.

To realize the full potentialities of technology in agriculture will require greater emphasis on agricultural research, and narrowing the gap between the time new methods are developed and their application becomes widespread.

Agricultural research should be given increased emphasis in all parts of the world. Science must be constantly vigilant if technology is to keep pace with the changing conditions. Even in the more highly developed areas applied research is now out-pacing fundamental research. In some under-developed areas, fundamental research should be given special emphasis because applied research for these areas is seriously hampered by the lack of basic knowledge.

Narrowing the gap between the time of development and the application of a technique involves numerous problems. Soil, climatic, social, economic, and political conditions are all involved in transferring a technique from one area to another, introducing it into an agricultural system, and obtaining widespread use.

Full attainment of the potentialities of technology in agriculture will, in much of the world, succeed or fail in proportion to the concurrent development of industry, education, and measures for health and sanitation.

It is a high honor to be invited to take part in the discussion at this distinguished gathering. We are here talking about techniques for increasing agricultural production because of a growing recognition of their relation to world peace. That many of you represent fields of science other than agriculture is evidence of the understanding that progress in one field of science has a direct bearing on progress in other scientific fields, and that the product of all science is useful only as it serves people.

The problem of getting enough food haunted man before the dawn of civilization, and has haunted him through the ages. Civilization virtually stood still for centuries because food problems lacked solution. It was only after food supplies increased to the point where part of the population could devote its energies to other pursuits that real intellectual and material progress became possible. Rapid advancement came with the rise of democratic governments which provided a favorable environment in which science flourished.

Progress was slow at first, but as knowledge was accumulated it came at a faster rate. The stubborn problems of food supply began to yield for the first time when basic science was applied in helping man use to better advantage the resources of nature in providing his food, clothing, and shelter. Since the rise of modern science, some areas of the world have made tremendous advances in agriculture. In others little if any change has taken place. In total, however, increasing scientific knowledge has resulted in more agricultural advancements during the past century than in all previous recorded history.

Despite these gains, a shortage of food still constitutes one of the most serious world problems. How to get enough food will be debated the world over for years to come. Without doubt modern science will be given more and more emphasis in such discussions. Potentialities for increasing the efficiency of agricultural production through the application of science are so vast that to minimize them would be pure folly.

The development and application of an agricultural technology based on modern science offers one of the really big opportunities to improve conditions for world peace—and a great challenge to those who seek that opportunity. It must be admitted, however, that full attainment of the potentialities of technology in agriculture will, in much of the world, succeed or fail in proportion to the concurrent development of industry, education, and measures for health and sanitation.

Peace and abundance are interdependent. The one cannot be attained without the other, and the attainment of either is difficult. Progress will be slow. The technological difficulties are great. Yet these are probably small in contrast to complex, social, economic, and political questions largely outside of the field of agriculture. Nevertheless, as about 70 per cent of the people in the world live on the land the application of science to farm production is a matter of world importance. I shall discuss the agricultural phase of the question with you, and since growing plants are the foundation of all agriculture, I shall confine my comments largely to crop production.

ADVANTAGES FROM TECHNOLOGY

Progress in several areas of the world vividly demonstrates that improved technology can increase crop production efficiency enormously. In Europe, for example before the rise of agricultural technology, crop yields remained virtually unchanged century after century. In fact, grain yields remained under 10 bushels per acre from the time of the Roman Empire until just before the French Revolution. Then, with the spread of technology yields started to climb. The per-acre yield of many crops in Europe has been tripled since 1800 (3)[1].

Similar advances have been made in some other areas and they are still continuing. In the United States, for example, during the last twenty years, average per-acre yields of all major crops have been increased about 50 per cent. In 1948 farmers harvested the largest total of all crops ever produced on farms of the United States That total crop reflected neither an important expansion of acreage nor an accident of good weather. It was largely the direct result of extensive application of improved agricultural techniques.

Such yield increases are dramatic. Yet they measure only part of the advantage of technology in increasing production efficiency. Production per unit of material and labor is often more important than the production per unit of land. In the United States farmers reduced the number of man hours needed to produce 100 bushels of wheat from 373 hours in 1800 to only 47 hours in 1940. Similar advancements have been made with other crops (2).

The advantages of modern technology in agriculture are apparent. There are questions, however, that center around the techniques available, further advancements possible, and problems of application. Answers can be given to some, but not to others. My illustrations will be drawn primarily from experience in the United States with which I am most familiar. Equally good, if not better, illustrations are in many instances available in other countries.

Problems of improving crop production are attacked in many ways, most of which fall into one of three categories: 1. Kinds and varieties of plants are bred and selected to thrive better under specific soil, climatic, and other growing conditions; 2. The environmental conditions are altered or crop management practices adjusted the better to fit the needs of plants; and 3. Efforts are made to preserve the harvest without loss or deterioration until it can be used.

SELECTING AND BREEDING PLANTS TO BETTER FIT ENVIRONMENT

Large increases in yields have resulted from new varieties of crops resistant to diseases or insects and

[1]Numbers within parentheses refer to items in the bibliography.

tolerant of drought, heat, or cold. The improved varieties have also extended the areas in which crops may be grown (12), (13), (14), (16). In the case of wheat, for example, larger yields are harvested from fields planted to wheat varieties that combine resistance to leaf rust, loose smut, and hessian fly. Although differences in acreages and weather were important factors, it was in part such improvements in varieties that enabled farmers in the United States to harvest almost 1-1/3 billion bushels of wheat in 1948, our fifth successive crop of more than a billion bushels. Improvements in varieties and production methods accompanied by some shift in production to better land enabled farmers in the United States last year to produce our third largest crop of potatoes on the smallest acreage in nearly seventy years. Similar progress with disease control and adaptation has been made in varieties of oats, sugar beets, tobacco, and many other crops. Yet the annual toll from the known diseases of economic plants in the United States is still measured in hundreds of millions of dollars.

Important use is being made of the fact that vigor and uniformity of plant growth often can be increased by controlled hybridization of selected parent strains. With normal growing conditions farmers in the United States add at least three-quarters of a billion bushels of maize to their average annual crop by planting hybrid seed and without increasing the acreage. Each year the return from hybrid maize is more than 100 times the total government expenditure for maize breeding research during the last quarter century. Scientists have produced vigorous hybrids of several other crops—onions, tomatoes, lucerne, and sugar beets—and they are working on still more.

Plant varieties, resistant to temperature and moisture extremes, have been developed that increase yields in existing areas of production and extend production to new areas (14). Wheat varieties have been developed that mature as much as one week earlier in the Great Plains—in advance of the hottest weather. The area of commercial maize production in the United States has been extended hundreds of miles to the north and west through the development of early-maturing varieties. Better and more timely tillage with the new machines further increases the effectiveness of these varieties.

Plant breeders have succeeded in increasing the physiological efficiency of our crop plants. Small, short-season maize hybrids have been developed that are more efficient than the more leafy hybrids in synthesizing and storing carbohydrates.

ADJUSTING ENVIRONMENT THE BETTER TO FIT THE NEEDS OF PLANTS

Farmers are more effectively protecting their crops against damage from insects, fungi, and weeds with newly developed chemical compounds (16). Their widespread use has been promoted through new and improved methods of spraying, dusting, and fumigating. Certain seed-borne and soil-borne fungus diseases are being more effectively controlled with new compounds used for seed treatment. Weeds are being controlled more efficiently with new products developed in the chemical laboratory. Petroleum derivatives, plant growth regulators, and other chemicals are being used on a wide scale to supplement conventional weed control by tillage. Flame is being successfully used to control weeds in cotton and shows promise on other crops.

Efficiency of crop production is increased with techniques that permit more precision of operations. Modern machines with ample reserves of power permit more precision in timing operations for seedbed preparation, planting, controlling weeds, and harvesting. These jobs can be completed at the most advantageous time during short periods of favorable weather. Precision planting insures the farmer a better stand of plants. In order to mechanize the production of any crop effectively, precise control of planting depth and spacing of seeds must be developed first.

More efficient use of fertilizers results from precision placement. The use of radio-active isotopes in fertilizer studies is helping to define placement practices more precisely for many crops under a wide variety of soil and moisture conditions (11).

Tremendous gains have resulted from soil management and fertilizer research. Much has been learned about the significance of soil reaction and how to control it, about ways to conserve water in the soil for growing crops and to reduce erosion, about the use of crop rotations, legumes, and green manures for replenishing soil humus and nitrogen, about procedures for determining the nutrient needs of crops, and about materials, methods, and machines for meeting these needs efficiently. More and more is being learned about how to maintain soil structure—that is, the physical condition of the soil, its granulation and porosity.

Modern methods of soil classification have made it possible to put together and use more accurately the results of farmers' experience and the results of research according to definite, defined soil types (4). No other advancement in agricultural science has had more importance in sharpening the recommendations as they apply practically on a particular farm. It greatly improves the effective transfer of new information on soil and crop management from the research stage to the individual farm. After all, we must recall that decisions are made for small units—fields of farms—and therefore our recommendations must be specific enough to apply to single fields.

More extensive use is being made of fertilizers and manures in agriculture, and more efficient fertilizers are being developed (6). During the past ten years, farmers in the United States have doubled their use of chemical fertilizers, and they are now applying them in granular, liquid, and gaseous forms. The importance of the minor plant nutrients—like zinc, iron, cobalt, molybdenum, and manganese—is becoming more generally understood. When minor element deficiencies show up in various agricultural areas, ways are devised for correcting them.

In this modern world of technology the productivity of a soil in its natural state, or when first plowed, is often much lower than its productivity under proper management. The soils in eastern United States and western Europe offer striking evidence of this. The soil on hundreds of thousands of farms in those areas is much better now than it ever was under natural conditions.

PRESERVING CROPS WITHOUT LOSS OR DETERIORATION

Ways are being found to reduce losses in crop quality between the time of maturity and consumption (13) (16). Better understanding of the general storage requirements of various products and more exact knowledge of the physiological processes they undergo after maturity are leading to construction of improved storages and related equipment. Increasing use of refrigerated trucks, continuing efforts to improve rail transportation facilities, new studies of both wholesale and consumer packaging, expansions in community locker plants and in facilities for quick-freezing and handling of frozen foods all the way from the producing areas to the consumer are helping to increase the proportions of our crops that can be used for human needs.

Sun drying of foods seems destined eventually to give way to mechanical conditioning. Heated air has been successfully used to dry many crops such as hay, corn, rice, tobacco, and soybeans, and the equipment and procedures for dehydration are improving year by year. Conditioning in other cases may mean refrigeration rather than dehydration, and here again research is helping to reduce losses. The same is true with respect to losses in transportation and handling. For example, scald in apples was a costly plague to growers until science discovered that by wrapping apples in paper treated with odorless and tasteless mineral oil, or by packing apples in such paper in shredded form, the disease could be prevented. Use of this treatment is now common practice with apple growers in the principal apple growing sections of the world.

Those are just a few examples of the thousands of techniques being used to increase the efficiency of food gathering. Many more can be expected in the future.

The horizons for progress in this direction are expansive. The visible and invisible nutritional losses in crops from lack of proper conditioning and storage still reach staggering totals annually (9) (10). Research on methods of making hay, for example, has shown that as much as 90 per cent of the original vitamin A content of standing green forage and as much as 30 per cent of the protein may be lost in the period between cutting and feeding under natural curing conditions in humid areas. Even with the grains, vast quantities are lost for human consumption every year because we fail to make use of present knowledge or lack facilities for preventing damage and deterioration in food values. In the solution of such problems there is hope for further increasing the usefulness of the crops we produce.

NEW APPROACH TO CROP PRODUCTION PROBLEMS

Perhaps the greatest opportunity for the future lies in a new approach to crop production problems that combines two or more improved techniques to take advantage of interactions among plant growth behavior factors. Scientists have found that while one improved practice is beneficial, the advantages are often multiplied to an astonishing degree when two or more improved practices are used in the right combination.

Much of our modern agricultural technology has been developed through the single factor approach to agricultural problems, in which only one factor is varied while the others are held constant. For example, to determine the most profitable amount of a given plant nutrient to use on a crop, it is applied in varying rates while all other factors are held constant. After the optimum rate of use for this nutrient has been determined, it is incorporated as a constant factor in another part of the experiment where some other single factor is varied. And so on with one individual factor after another.

During recent years designs for experiments and methods for analyzing them have been worked out that permit simultaneous evaluation of several plant-growth factors individually and in various combinations. They have provided a much better way of finding and capitalizing on the most productive interactions among the various plant behavior factors. Consequently, scientists are now becoming more keenly aware of the importance of these interactions, and conduct their studies in such a way as to take advantage of them.

This multi-factor approach to problems of crop production and handling has been given a thorough testing during recent years under several different conditions. Soil and crop management experiments under irrigation in the western part of the United States have permitted study from this approach with moisture conditions under control. Similar investigations have been carried on in the southeastern part of this country where most soils belong in the Red-Yellow Podzolic group and are naturally low in fertility. The results have been striking. (5)

In our southeastern states, for example, crop yields that compare well with those of the naturally highly productive soils of the Midwest are being produced both experimentally and under ordinary farm conditions. Outstanding results are being obtained with maize, small grains, soybeans, and meadows for hay and pasture. Maize offers the best example. Yields of maize in this area had never averaged more than 20 bushels to the acre. Remarkable increases were obtained when good initial fertilization, liberal supplemental nitrogen fertilization, adapted hybrid seed, shallow cultivation, and closer plant spacing were combined. In 49 experiments over a five-year period average yields of 81 bushels to the acre were produced with the best practice combinations. More than 50,000 farmers in this area have participated in maize-growing demonstrations using the new practice combinations. Their yields have averaged above 65 bushels per acre. And more than 2,500 have produced yields beyond the 100-bushel mark.

MORE RESEARCH IS NEEDED

Without continuing agricultural research it would be impossible to retain the advantages of present technology. For example, if the work of plant breeders were suddenly to cease in areas advanced in technology, most crop varieties would probably fall victim to plant diseases within ten or twenty years, and crop yields would be drastically reduced. Science must be constantly diligent if technology is to keep pace with changing conditions.

The use of a new method itself sometimes creates problems that science must solve. Introduction of a new practice may alter the balance between plants and environmental factors. For example, to profit from a new soil management practice, the planting rate may need to be increased. More plants growing in a given area may shift the balance with environmental factors such as moisture, light, or natural enemies. Especially when plants are grown as pure stands in large fields, the hazards due to insects and diseases are multiplied. New problems may result from such shifts with plants as with people. Disease problems accompanying poor sanitation become serious, when people are crowded together in huge cities or camps, whereas they are relatively simple in the sparsely settled rural regions. Agricultural scientists must be as alert to problems of this nature with plants as social and medical scientists are with people.

Here is another point of vital importance. Fundamental research is the fountain-head of all technology. If the popular appeal of applied science is permitted to overshadow the importance of fundamental science, new technological developments will come about more slowly. The new agricultural techniques developed during recent years represent largely the harvest from earlier fundamental research. At present there is need for increased emphasis on fundamental research in all parts of the world, and more especially in the undeveloped parts of the tropics and sub-tropics. Even in the more highly developed areas, applied research is now out-pacing fundamental research.

In under-developed areas, applied research is seriously hampered by the lack of basic knowledge about the problems involved. Here fundamental research must be given strong emphasis. Some well-meaning, but misguided, agricultural administrators and boards have by law or administrative ruling restricted their agricultural scientists to "work of immediate practical value." Such restrictions may prevent the very developments the governing board is seeking. For example, it is often impossible to control an insect until its life history has been established through fundamental research. Often it is impossible to suggest effective management practices for a soil until its fundamental morphology and chemistry have been worked out. It is all right for us to insist that research supported by the public should have a practical objective in its long-time program; but to reach this practical objective, it is often absolutely essential first to do some work in fundamental science. In applied science we are using the fundamental knowledge for a practical objective. These fundamentals must be established in precise terms before there can be any rapid and orderly application. Without them, the development of farm practices appropriate to specific soil and climatic conditions, and for particular social groups, will be slow in coming. With them, there are vast potentialities for progress, provided industry, education, and measures for health and sanitation are concurrently developed.

An efficient agriculture requires an efficient industry within the same country, or the products from an efficient industry readily available (3). Tools and machines are needed that help farm people to apply technology and permit them to get more production in return for their labor. Materials of technology—fertilizers, insecticides, fungicides, medicines, fencing, and power—are also necessary for efficient systems of farming. Even that is not enough. Knowledge of technology by those who use it is essential. Without good health and education, farm families cannot and will not make full use of technology. Programs for agriculture, industry, education, and health must go hand in hand. If one lags, they will all lag. We are seeking a cultural balance within which agricultural efficiency can be high.

Among the many questions involved in developing agricultural programs for retarded areas, two are of paramount importance. How can technology from advanced areas be transferred to retarded areas? And how can more extensive use of technical methods be obtained?

TRANSFERRING TECHNOLOGY

First, let us examine the problems of transferring a technique.

The enormous differences in soils and climate among various places make the problem extremely complicated. Techniques cannot be transferred except where conditions are somewhat similar. Fundamental knowledge, however, can be transferred universally. The laws of physical chemistry, for example, are the same in Boston, Moscow, Leopoldville, and Calcutta.

In the tropics, for instance, soil conditions and the present social customs are too different from those of Europe or America for European or North American practices to be suitable, but fundamental principles of the chemistry of soils or of plant breeding are applicable. These principles can be used in devising techniques that will be successful. Industrial processes, such as the fixation of nitrogen to manufacture fertilizer, also can be used anywhere that industrial plants can be built and operated.

Among areas of similar environmental conditions, many of the methods developed through research have potentially wide application. For soils and climates that are reasonably similar to the ones where specific fertilizers are now used effectively, for instance, good recommendations and good yield predictions can be made for a given crop. On the other hand, what may be a good recommendation for the use of fertilizers in one country may be useless or even harmful in another with different soils and different crops.

Improved crop varieties that thrive under specific soil and climatic conditions in one country can be expected to thrive equally well under similar conditions in some other areas of the world. Large quantities of seed and improved crop varieties are currently being exchanged successfully over a wide area. The success that Italian farmers are having with maize hybrids from the United States (8) offers a recent dramatic example of what can be gained by such transfer in some cases. Many such successful examples could be cited. But some experiences have been downright disappointing because the varieties were totally unfitted to their new environment; the importance of similarity in ecological conditions is thus emphasized.

Improved crop varieties offer most when they are used in breeding new varieties especially for the country to which they are transferred. Plant breeders can use them to tailor-make new varieties specifically fitted to the complex elements of the local environment.

Too little is known about soils and climate on a world basis to estimate fully the potentialities of transferring technology. Extensive collection of plant environmental data from various parts of the world would be extremely helpful in the successful transfer of technology to many areas.

No accurate soil map of the world is yet available, although we may have a good first approximation of one in a few years. In the meantime we are forced to fall back on informed opinion where we should have solid facts.

GETTING WIDESPREAD USE OF TECHNOLOGY

Once a technique is introduced into an area there are complex problems of human relationships in getting it put into use generally. In no area of the world have these problems been fully met. Even in the most advanced areas, there is considerable lag between the development and use of most new techniques. On efficient farms practically all methods and most crops have been changed at least once during the past quarter century. But many newer methods and varieties than those in general use have been developed by scientists, technicians, and farmers. They represent an undeveloped potential for further increasing the efficiency of agriculture.

For example, I think it would be conservative to estimate that if farmers in the United States had made full use of the new production technology already proved, they could have produced last year's maize crop—which was the largest ever grown—on one-third fewer acres, and at the same time had more income and improved their soil. Improved grass and legume varieties that promise to increase the efficiency of forage production in the United States, at least as much as hybrid seed increased the efficiency of maize production, have been available for ten years. Yet, they are in use on only a very small percentage of farms.

One reason is that most farmers are slow about some new methods—in taking the risk—until they are reasonably sure that they will be of economic advantage to them. Some new schemes for testing and demonstrating the advantage of technology are now being tried in the United States (*7*). Another reason is the difficulty of fitting a new method or system into the going pattern of management of a farm without throwing that pattern out of balance. Some technical improvements are fitted easily into going patterns. For instance, to shift to a new crop variety, the farmer may need only to buy seed of the new variety from his customary seed supplier. Others, such as complex soil or livestock management practices, are more difficult to fit in. Widespread use of a system that requires change in farm organization, management, utilization of land or crops, or general plan of financing will at best come slowly, even in the more advanced areas.

The gap between the development and use of a new method is a great deal wider in the less developed areas of the world. Despite the availability of some new devices and procedures, many farm families still follow primitive methods much like those used a thousand years ago. The narrowing of this wide gap is another enormous challenge to those seeking to alleviate world hunger. The problems are numerous and complex. Methods for solution of many of them have not yet been found.

Agricultural scientists and other students of this problem must recognize that the economic, political, and social environment within which the farm family operates has much to do with its ability to establish and carry out an efficient system of agriculture (*1*). Circumstances such as low income or cash reserves that force farm families to produce full results immediately often seriously retard the adoption of new methods.

Long-term planning is essential. Farmers need to plan for ten-year rather than one-year periods. Many techniques or systems require several years of use to realize their full potentialities. Often a substantial investment is needed. If it must pay for itself the first crop season, it may prove to be an uneconomical investment. If, on the other hand, the investment can be charged off over a period of several years, it can pay off abundantly. For example, three to five years are usually required to obtain the full value of an application of phosphatic fertilizer. The gains from a terrace that controls water run-off are returned over a longer period of years. There is thus need for landlord-tenant contracts, or laws governing such contracts, that will reimburse tenants for unexhausted improvements.

It is impossible to do a good job of managing food and agricultural problems without doing a good job of handling the general economic and political relationships involved. The social environment of an area is an equally complicating factor. There are great differences in farm organization, community patterns, beliefs, and social customs throughout the world.

In some communities new methods and machines are readily accepted into the local pattern. In other communities, painful adjustments are needed. The way in which a change is introduced into communities is as important as the scientific correctness of the recommendation itself. To find the best way for each community is the challenge.

Some of the techniques employed in advanced areas can profitably be used in retarded areas. Others will be of little value. Some methods yet unthought of need to be invented for working with farm people not able to read and for fitting educational programs to the folk ways and customs of specific communities.

Much good has come from the use of pamphlets, charts, lectures, and demonstrations in areas where modern technology has been successfully introduced. Simply illustrated pamphlets on the various phases of farming have possible use with farmers and farm leaders who are barely able to read. Suitable publications of this type are extremely limited. Special cinemas for use by agricultural advisers and leaders in rural villages and towns would appear to have considerable possibility.

A minimum of research service and management advisory service will be needed to organize programs and help farmers and rural leaders get new techniques introduced. Much learning will have to come from demonstrations and discussions with local leaders and advisors. Techniques demonstrated on experimental farms are not enough. Demonstrations are more effective when one farmer can see a new practice in operation on a farm like his own run by another farmer like himself. It is best when demonstrations are carried on as an integrated part of a regular farm operation, rather than as something separate and distinct from the normal management procedures.

To make such demonstrations successful requires a stage of transitional development of a technique between the research farm and the demonstration farm. It might be called the "pilot plant" stage of development in which the new idea or device is worked into a balanced farm plan for a given set of soil, climatic, social, economic, and political conditions. Research of this type has only recently been introduced into a few areas (*7*).

Techniques such as those I have outlined can succeed only if the leaders within the area see the need and actually carry out careful plans for presenting them to the farmer. Programs in advanced areas have included provision for land reclamation, flood control, electric power development, irrigation, soil conservation incentives, production incentives, agricultural credit, crop price protection, and local management services. Their success has depended upon the leaders within the area where they have been used, not only leaders in national governments, but also leaders in state or provincial, local, municipal, and community governments; and on many organizations besides government organizations—farm groups, labor unions, trade associations, and so on. They are all vitally concerned with the planning, developing, and carrying out of such schemes.

CONCLUSION

Of course, the ultimate success of any agricultural method always depends upon the farmers' opportunity to use it and the satisfaction it brings to the individuals within the area. Those opportunities and satisfactions will be inadequate unless advancements in industry, education, and health of the area parallel those in agricultural technology.

All of this may appear very complex, yet it is an oversimplified statement of the many intricate problems involved in obtaining the abundant agricultural production on a sustained basis that is now made possible by modern science and technology. Abundance is, however, relative and sometimes temporary. Sustained abundance may depend on many factors outside the scope of this discussion, including future population trends.

Advances will be made faster in some areas than others, but progress generally will be hard and slow. Despite the fact that there is no short quick road, there is cause for optimism. The enormous progress of the past quarter century—made possible by the growth of modern science and technology—is only a small indication of the exciting prospect for the future.

For the first time in the history of the world, man has within his grasp the tools with which to wipe starvation from the earth. Modern man faces the greatest challenge of all times. Can we measure up to it?

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The CHAIRMAN: Thank you, Dr. Salter. As all of you know, this meeting should adjourn soon; however, there is time and it would be most appropriate if we took a few minutes to have the comments of other experts who are in attendance. I am sure they have important contributions to make to this subject. I wonder if I might call upon Dr. C. H. Edelman, the Professor of Soils and Director of the Soil Survey of the Netherlands. If Dr. Edelman would like to make some comments about the subject matter before us, we would be most delighted to have him do so.

Mr. EDELMAN: At this point, I wish to make some brief comments about one of the great difficulties that exist in applying agricultural science to tropical agriculture. In tropical agriculture you find some splendid applications of science in plantation farming, as in Indonesia, in the famous development of sugar cane, and later in the less-known development of oil palms. The difficulties do not lie in the technical problems of growing these immense crops, but rather in peasant farming.

It is not generally recognized, as far as I am aware, that extreme poverty may be a very important handicap for application of rather simple scientific results. Many peasant farmers in the tropics are working under conditions of under-consumption. People are producing their own food but it is not enough for their own consumption. If you should give such people fertilizers then they will produce more. It is an established fact that fertilizer works just as well in the tropics as in more temperate regions. This has been confirmed by very many experiments. It is not a question whether the technique works but it must be applied. When people who are living under conditions of under-consumption use fertilizers, they produce more, but then the first thing they do is eat more. The surplus production goes into consumption and at the end of the year the peasant is still not able to pay for his fertilizer. This condition, as I have explained, is not generally known. It is often thought that the application of science in peasant agriculture is a question of education. Of course, it is true, without education you can do nothing. But there are conditions of extreme poverty which are still more important than lack of education and which are a handicap to making the first start. It is different when the farms are slightly larger and more productive and there is a produce that can be sold. As soon as a critical level has been passed, then experience shows that fertilizers may be used as in other parts of the world. The main problem therefore is to bring to an end very small peasant farms that are not producing enough to give a living to a family.

Our experience in Indonesia shows, therefore, that fertilizers can be used by farms other than the smallest. As soon as fertilizers can be used, can be bought on credit, and can be paid for out of surplus production, then we get a situation where education and extension work can do its best.

I would like to point out that these considerations do not apply to the use of improved seeds. In every agriculture, you must have some seeds, otherwise you cannot produce. Even if people are hungry, they will not eat their own seed. Their seed for the next year must be saved. By replacing that seed by better seed you get a higher production without the necessity of spending capital. Therefore, it has been possible in Indonesia to introduce more productive seeds much more readily than fertilizers. I think these conditions have not been generally known and I have been glad to have the opportunity to say some words about them in a plenary session.

The CHAIRMAN: Thank you, Dr. Edelman. I would like to ask Dr. Maurice Guillaume, Director of Agricultural Services for the French Overseas Ministry, if he would comment briefly on the subject before us today.

Mr. GUILLAUME:[a] I do not propose in the short time at my disposal to deal with general considerations. I should merely like to observe that the main points brought out in the course of the Conference's discussion this morning are an integral part of the French Government's general policy in regard to soil protection in the overseas territories. Situated almost wholly within the tropical zone, these territories are peculiarly exposed to erosion. Immediately after the liberation, the French Government instituted an inquiry in all the overseas territories with the object of establishing quickly a rough estimate of the extent of the damage, of ascertaining the views of the competent experts as to the most suitable methods of restoring the situation, and of devising in broad outline an organization which would enable the necessary work to be undertaken. This inquiry revealed a wide measure of agreement as to the causes of the damage and the remedial action necessary. It emphasized how extensive was the devastation, due more to the heritage of the past—the primitive methods and the inadequate farming practices handed down to the natives by their ancestors—than to the intensified cultivation which followed the economic expansion of these territories when they were thrown open to trade. As a result of the inquiry a "Supreme Soil Conservation Board" was instituted in France with a view to guiding and co-ordinating soil conservation efforts in the overseas territories. I say guiding and co-ordinating, since obviously the initiative and the responsibility must belong to the persons on the spot. At the same time soil conservation offices were organized in the various overseas territories to draw up joint programmes for these territories and to co-ordinate the activities of the various authorities called upon, in one way or another, to cooperate in the work of renewing and restoring the land. What are the measures projected or already being carried out? The first of these is perhaps the most important, as it is the basis upon which our whole course of action rests: it is a close pedological survey of all the territories to ascertain the value of the land, to determine on the one hand the particularly threatened areas which should be put in a state of defence and left fallow and on the other hand, the territories which, by reason of their topography or the intrinsic qualities of the soil, are especially suitable for intensive and sustained cultivation. Considerable progress has been made with these pedological surveys, and we hope that in a few years' time it will be possible to issue a complete pedological map of the whole of Africa, for example.

I brought out the second point this morning in the Land meeting that at the present stage of development of agriculture in the overseas territories—and, it must be admitted, it is a poor agriculture as far as soil conservation is concerned—prevention is better than cure. What I mean is this: generally speaking, the work of restoring exhausted lands, which requires expensive equipment and expert methods, is beyond the means of an agriculture as little developed as that of the overseas territories. Such efforts and commitments are possible and justifiable only in the case of certain more populated districts where it is a matter of life and death for the population to keep the land in a state of productivity, or in the case of districts which, by reason of their topographical or geographical situation, are especially important for the ecological balance of a whole area. Hence the problem of soil conservation is considered from the point of view of all the measures tending to maintain the potential fertility of the soil by farming techniques which make it possible to stabilize the present nomad methods of farming. One of these techniques is the well-known mixed-farming system, which will, I imagine, be discussed at length in the meeting dealing with farming systems. Independently of the mixed-farming system which is especially suitable for high ground, plans are being made for a considerable development of rice growing on low-lying land suitable for under-water cultivation. These low-lying areas are protected to a certain extent against erosion by sedimentation and are thus suitable for a more stable system of cultivation and for a denser population. It is in the experimental stations and laboratories, however, that these agricultural methods have to be elaborated; and it then remains to put them into practice. That is why "pilot" sectors have been organized for this purpose in which, with the cooperation of the native farmers, the foundations of a renovated native agriculture are being laid. If these pilot sectors prove satisfactory, it will then be possible to extend the system with the full agreement of the native populations.

A further sphere in which action may be taken is that of legislation in regard to soil conservation. At the present time legislation of this kind is confined principally to forestry regulations in respect of bush fires. It should be extended so as to include in particular regulations for the introduction, where applicable, of the farming methods required for soil conservation.

Such, in broad outline, are the ideas governing our action in the field of soil conservation. We know what we want and are anxious to achieve it; for the rest, time and patience are necessary.

The CHAIRMAN: Thank you, Dr. Guillaume. I wonder if Mr. C. F. Clay, the agricultural adviser for the Secretary of State for the Colonies of the United Kingdom, would make a few remarks about this afternoon's subject.

Mr. CLAY: I must say, we have listened with admiration to the work that is being carried out in the United States toward increased crop production, and we wonder what it all boils down to when we bring it back to some

[a]Mr. Guillaume spoke in French.

of the under-developed countries with which we are dealing.

According to my experience, the biggest factor which we have to face in expansion of production in under-developed countries is the position of the peasant producer. In his usual pattern of farming, he is farming on a subsistence basis, with primitive tools which in many cases have not been altered for centuries. The hoe, the cutlass and the axe are the only means of cultivation. We have carried out research in the colonies, and we are carrying out more and more research. In my view it is not a question of new experimental techniques, but rather the application to existing communities of the results of experimentation which have been achieved throughout the world.

We, in the British colonies, feel that the time has come when we have to experiment, by means of pilot schemes, in the organization of the peasant producers of the backward countries, to try and show that by some form of reorganization—by grouping, by specialization within village communities—we can provide a satisfactory medium for the economic investment of capital. For, it is no use telling a peasant producer with a hoe, with an axe and a cutlass that he must invoke and apply all the known results which we get from modern techniques in Western agriculture. That is physically impossible and it is not reasonable to hope that it will ever occur. That is one of our fundamental problems and one with which we must be more and more concerned in the years that lie ahead, if we are to get a substantial increase in production from the peasant producers in the colonies. We believe that we require basic surveys to classify the general zones of soil, to define the farming system which is suitable for each of these classified zones and, then, by the pooling of all the knowledge we have acquired by experimentation, to test in pilot schemes our peasant development in group farms assisted by capital investment.

Mr. Chairman, the main speakers this afternoon, as you said, have been either past or present members of your Department. I feel it would be only fitting if I, as a spokesman for the agriculturists in the British Colonies, paid a tribute to Dr. Bennett for the tremendous influence which he has had on soil conservation in the colonies, in the tropics, and the way he has made people accept some, if not all, of his ideas on this subject. I wish also to pay a tribute to the Department of Agriculture in the United States for which all members of the agriculture service in the British Colonies have the highest regard, and in which they know they have sincere friends, in their search for improved planting strains for use in the British Colonies.

The CHAIRMAN: It would be said by some that it is now appropriate for the Chairman to summarize our discussion. That would be a very difficult thing to do at any time, and I certainly will not undertake it under the time limitation. I would like to express to Mr. Clay, to Dr. Guillaume and to Dr. Edelman our appreciation for their participation in the meeting; to Dr. Salter, Dr. Lewis and Dr. Bennett our appreciation for their papers, and for their views and expressions. This subject will be under further and extensive discussion in the section meeting which will follow and, therefore, as there is no other matter coming before this session, I wish to thank all of you for your participation in the meeting.

Fuels and Energy

Monday Afternoon, 22 August 1949

Chairman:

Sir Harold HARTLEY, K.C.V.O., C.B.E., F.R.S., Chairman, British National Committee, World Power Conference

Contributed Papers:

Estimates of Undiscovered Petroleum Reserves

A. I. LEVORSEN, Stanford University, California, U. S. A.

Invited Discussant:

Economics of Competitive Fuels for Various Purposes and Their Uses to Meet Future Fuel Requirements

L. JACQUÉ, *l'Institut français du Pétrole,* France

Discussion:

Messrs. MCLINTOCK, ABREU, MONTURE, ERSELCUK, E. DE VRIES, HUBBERT, BLACK, MACFARLANE, LIETZ, PICARD, WEISSMANN, CRICHTON, WEEKS

Programme Director:

Carter GOODRICH

Programme Officer:

Herbert SCHIMMEL

The CHAIRMAN: I declare open the sixth plenary meeting of the United Nations Scientific Conference on the Conservation and Utilization of Resources.

I want first to draw attention to the fact that the title of this meeting is given as "Using and Conserving Resources—Fuels." The programme omits the words "and Energy", but this must not be taken to mean that there is any idea of excluding electricity or of limiting the discussion to fuels.

As will be seen, the programme falls into two parts. First we have the paper by Mr. Levorsen on "Estimates of Undiscovered Petroleum Reserves". We shall have a discussion on the paper after it has been read, and then proceed to the second half of the programme, which takes the form of a discussion of the economics of competitive fuels for various purposes and their use to meet future fuel requirements.

I now call upon Dr. A. I. Levorsen. Dr. Levorsen is the Dean of the School of Mineral Science of Stanford University, California. He is a very distinguished geologist who has given great attention to this question of petroleum resources which, as you know, is of such importance, and about which there is such a wide difference of opinion at the moment.

Mr. LEVORSEN *delivered the following paper:*

Estimates of Undiscovered Petroleum Reserves

A. I. LEVORSEN

ABSTRACT

Petroleum reserves may be divided into two general classes—those which have been discovered and those which remain to be discovered. Obviously, undiscovered reserves cannot be measured but some idea of their quantity in terms of the future needs of the world may be gained by an understanding of the geological conditions which control their occurrence.

Petroleum occurs in sedimentary rocks. The volume of sedimentary rocks found both on the land and under the shallow waters of the continental shelf areas bordering the continents may reasonably be expected to contain an amount of petroleum per unit volume comparable to what has been found in the sediments of the explored regions. The present estimates of the amount of the undiscovered reserve are on the order of 500 times the current annual world consumption. Such estimates merely reflect the state of technical development and geological understanding at the time of the estimate. As ideas have developed, estimates have increased and may be expected to continue to increase in the future.

These reserves must be discovered to be of any use. Their discovery is determined by a combination of technological, economic and political factors.

The petroleum reserves, either of the world or of any producing nation, may be divided at any time into two classes:

Class one consists of petroleum underground which has been discovered, developed, and which can and is being produced under the present technology and at the present prices. This is the proved known reserve. It amounts to approximately 70 billion barrels for the world; divided roughly into one half in the eastern hemisphere and one half in the western hemisphere. This is on the order of 20 times the annual consumption of the world. The known producible reserve in the United States of 24 billion barrels is twelve times its annual consumption. The proved reserves are, in effect, working stocks.

The second class is petroleum underground which has not been discovered. This is by far of the greater importance of the two classes of reserves. It is from this class of reserves that the annual additions are made by discoveries which replace the amounts consumed from class one.

Obviously, undiscovered petroleum reserves cannot be known quantitatively. It becomes necessary for national planning, however, to obtain some idea or estimate of their amount and distribution. An estimate is especially useful in a nation such as the United States where the steadily accelerating demand for petroleum and its products gives cause for alarm to many persons in regard to the adequacy of our future supply. Other nations, where the current demand compared to supply is not so great, are not faced with the same problem at this time, but as the uses of petroleum increase throughout the world, questions of continuing supply will have to be faced by nation after nation.

Probably the best that can be done in the way of an estimate of the quantity of petroleum yet to be discovered is to decide whether it is large or small in terms of the annual national needs, in the case of a single nation, or whether it is large or small in terms of the future needs of the world as a whole. Such an estimate is based upon an understanding of the nature of the occurrence of petroleum, the manner in which discoveries are made, and the relative volumes of unexplored rocks compared with the volume of rocks in which petroleum has already been developed. Since the problem is one which deals with the rocks in the earth, it is essentially geological in nature.

A geologist does not physically "see" an oil or gas field any more than a meteorologist, for example, sees a low- or high-pressure area, even though both commonly use contour lines to describe the ideas they intend to convey. Both are presenting mental concepts of the conditions as they are thought to exist. Until a discovery well has been drilled, any undiscovered oil or gas pool at best exists only as an idea in the mind of the geologist. In a like manner, the basis for any undiscovered petroleum province—a petroleum province is a region in which there are a number of oil and gas pools occurring under related geological conditions—exists only in geologic thought. The nature of such thinking therefore should be understood in order to gain a better understanding of the problem of appraising the undiscovered reserves.

OCCURRENCE AND DISCOVERY OF PETROLEUM

Petroleum is found in pools trapped deep in the ground, many pools in the United States now being developed at depths below 10,000 feet. There is nothing in science to date, in advance of drilling, which gives anyone any direct evidence of the presence of such a pool. Consequently, the modern methods of exploration rely almost entirely on the geological interpretation of various physical measurements of the rocks into terms of the presence of a trap or container which *may* hold an oil and/or a gas pool. When such a situation is found, one or more test wells are drilled with the hope that the trap is present as the evidence indicated, and that it contains oil or gas. A discovery results when such a test well finds petroleum in commercial quantities.

The geological evidence indicating the presence of a deeply buried trap may be found in the rocks at the surface; it may be developed from the information secured from other test wells, dry holes or producing wells; or it may be determined by geophysical measurements of various rock properties such as density, magnetic susceptibility or the property a rock has of reflecting energy sent down into the earth from the surface. The shallower and more easily discovered deposits of petroleum are generally found first, following which the search for traps becomes progressively deeper and more complex—and with the increase in depth and complexity, the cost increases.

The common denominator of all petroleum accumulations is their intimate association with sedimentary rocks. Sedimentary rocks are deposited chiefly in marine basins or along shore lines where the debris from the land is carried into the oceans by streams and rivers. Some sediments are of continental origin and are spread out on the land by rivers coming down from nearby eroded mountains. While most oil and gas pools are found in or close to sediments of marine origin, there are enough deposits found throughout the world in rocks of continental origin so as not to preclude such rocks as potential producers. Accumulations are found occasionally in igneous and in metamorphic rocks, but geological experience indicates that such occurrences are anomalous and the result of special circumstances.

Because of the intimate association of petroleum deposits with sedimentary rocks, we may conclude that any region on the earth where an important volume of such rocks are found may be considered as potential oil- and gas-producing territory. It is as if a fisherman was to say that any body of water might be considered as potentially favourable fishing grounds. Success in either case depends largely on the skills developed and upon the persistence of effort. A corollary conclusion might therefore be stated, that the apparent absence of oil and gas from a large volume of sediments may denote lack of skill or lack of persistence in the discovery effort.

Since sedimentary rocks generally overlie the igneous and metamorphic rocks which form the basement rocks of the earth, they are commonly found in the basins and lowlands while the basement rocks are exposed to erosion in the mountain ranges. The term "sedimentary basin" has come therefore to mean those regions in which large deposits of sediments are either deposited in a basin or deformed into a basin-like shape. The distribution of such sedimentary basins throughout the world is shown in Figures 1 and 2.

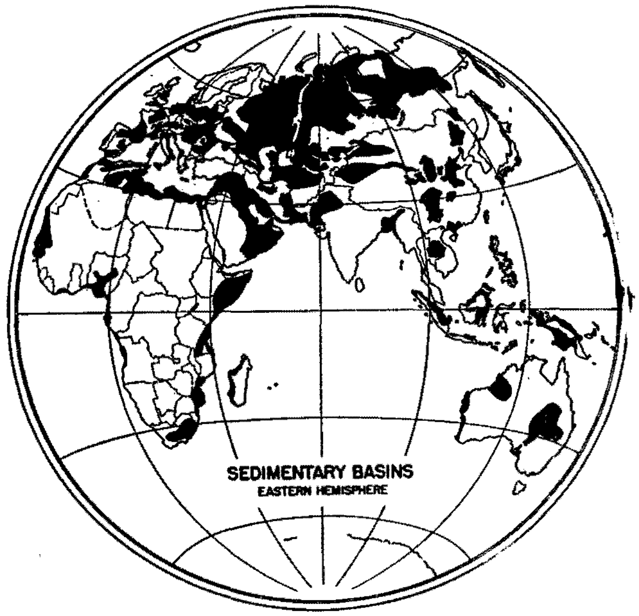

Figure 1. Sedimentary basins in the eastern hemisphere, by Weeks.

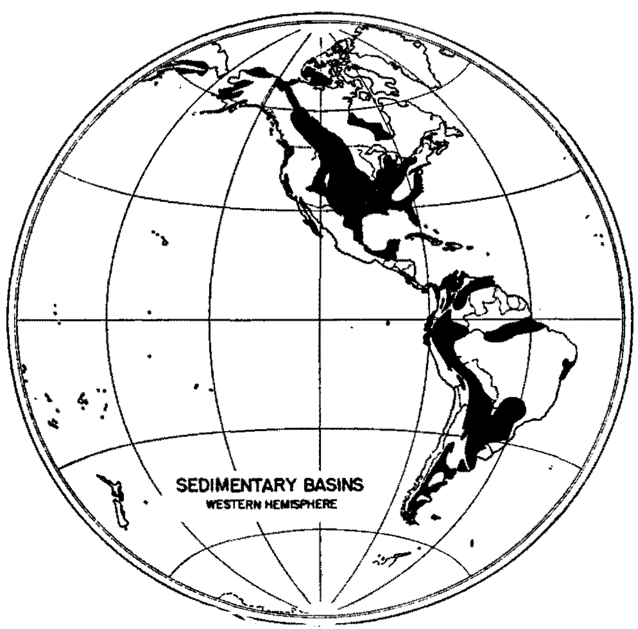

Figure 2. Sedimentary basins in the western hemisphere, by Weeks.

The most promising sedimentary basins of the world for the discovery of substantial new petroleum reserves are already producing or are adjacent to those provinces already producing oil and gas. More is known of the underground conditions in these areas; more drilling is being done; and the opportunities for discovering deeper sands, lateral extensions and unforeseen conditions are much greater. The most important of these regions are the lands bordering the Caribbean and the Gulf of Mexico; the Near East; the islands of the East Indies; and the plains of western Canada. The less-explored regions of the earth with greatest prospects for becoming petroleum provinces include the many continental shelf areas; the arctic regions; and the eastern slopes of the Andes in South America. Numerous lesser potential petroleum provinces exist on every continent, as can be seen from the two basin maps.

After a fisherman arrives at the lake or body of water, he may obtain some idea of the prospects for obtaining fish by studying various factors, such as the presence of reefs, abundance of feed, character of the bottom or muddiness of the water. Similarly, the geologist has certain criteria which he applies to the sedimentary basin he is considering as a place to explore for petroleum.

He prefers to see marine sediments, for example, variable in extent both laterally and vertically, and the more volume of sediments, the better. He likes to see some potential reservoir rocks such as sandstones or limestones in the region. Evidences of petroleum, such as oil or gas seepages, oil springs or oil or gas showings in wells, are important since they indicate the presence of a source rock. At present, no one knows what constitutes a source rock, but when direct evidence of petroleum is found, there must be a source rock, whatever it may be.

The presence of one or more unconformities in the sedimentary basin is of special importance in appraising its potentialities. An unconformity is defined as a break in the stratigraphic continuity—a hiatus with varying quantities of sediments missing which are present elsewhere in the normal rock sequence. It often reflects a period of erosion, and the extent of the hiatus ranges from short to long in duration. The rocks above and below the unconformity plane range from parallel to highly discordant in attitude.

The importance of unconformities in appraising the undiscovered petroleum possibilities of an explored region is twofold:

1. Most oil and gas pools are associated with unconformities. The traps may be found above the unconformity in the form of sand lenses, sand bars, spits and other sand deposits associated with shore lines; or below the unconformity due to the truncation of tilted reservoir rocks in the underlying formations; or they may be due to the solution of carbonate rocks during the period of erosion, thereby developing porosity and permeability traps.

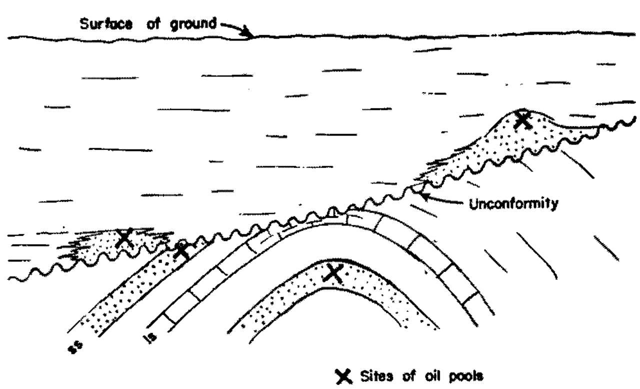

Figure 3. Idealized section showing common relationship of oil and gas pools to unconformities.

2. Unconformities mask the underlying geological conditions. They are, in effect, boundaries separating different layers of geological phenomena—each with its own pecularities of oil and gas accumulation. There is no clue in the overlying rocks as to the conditions below an unconformity. Consequently, many surprises occur at such boundaries. The underlying rocks may be quite different in their petroleum possibilities from those above, often the underlying rocks are folded, faulted and otherwise deformed into traps to a much greater extent than are the overlying formations.

Some unconformities may be observed from the surface outcrops, particularly in the bordering mountains. Others are not known until deep wells have been drilled and much geological work has been done in correlating the sediments. The presence of one or more widespread unconformities in a sedimentary basin definitely improves the chances of its becoming productive—almost to the extent of doubling the favourable area.

ESTIMATES OF UNDISCOVERED RESERVES

Any estimate of the undiscovered reserves is merely the projection into the unexplored regions of the present state of our geological knowledge of the known producing regions. Prior to the discovery of the rich oil deposits in Arabia, for example, an estimate of the undiscovered reserves under the Arabian desert would necessarily have been merely nominal. Likewise, it would have been impossible to have convinced anyone of the enormously rich potential oil content of the plains of western Canada before the discoveries near Edmonton only a few years ago.

There are many factors which may be considered in making a projection of our geological ideas into the unknown, but the most reasonable and the one most commonly used is a comparison of the reserves per unit volume of sediments in the known regions with the volume of sediments underlying the unknown region. For example, within the United States where petroleum exploration has been the most aggressive anywhere in the world, 55 billion barrels of petroleum have been discovered in a volume of 2½ to 3 million cubic miles of sediments. Based on this past record of discovery, Weeks (1)[1] has estimated that there is an equal amount remaining to be discovered in the United States. He further estimates by similar reasoning that the undiscovered reserves of the world are 154 billion barrels in the western hemisphere and 333 billion barrels in the eastern hemisphere or a total undiscovered reserve in the land area of the world of 487 billion barrels. (See Table I.)

Table I.

Recent estimates of undiscovered reserves of petroleum on the land areas of the world

(In billions of barrels)

	Western hemisphere	*Eastern hemisphere*	*Total, World*	*USSR*	*United States*
Joseph E. Pogue Summer 1946	145	345	490	100	50
L. G. Weeks April 1948	154	333	487	139	54

[1]Numbers within parentheses refer to items in the bibliography.

Pogue (2) has estimated in a like manner the future il discoveries of the land areas of the world to be 145 illion barrels for the western hemisphere and 345 billon barrels for the eastern hemisphere; this compared vith a past discovery of 125 billion barrels in the world f which 55 billion barrels have been produced.

Both estimates, which are remarkably close together, lace the undiscovered reserves of the land area of the vorld at nearly 500 billion barrels (over 150 times the resent annual consumption). Both Weeks and Pogue ave had a wide experience in the oil industry and both ave access to the best available information. Their estimates are a reasonable reflection of the present state of ur geological knowledge.

The sea floor underlying the marginal shallow waters hat border the continents of the earth and sloping down o a depth of 100 fathoms (600 feet) below sea level, is nown as the continental shelf. It has received much ttention lately as a vast potential source of additional uture discoveries, largely as a result of the exploration nd discoveries on the shelf in the Gulf of Mexico off the oasts of Texas and Louisiana. Twenhofel (3) estimates he area of the world's continental shelf, mostly under vater less than 300 feet in depth, as being 14 million quare miles. An average thickness of two miles gives a volume of sediments of 28 million cubic miles as potentially productive—a truly important volume of sediments.

Pratt (4) has estimated that the continental shelves of he world should contain 1,000 billion barrels of oil or pproximately 300 times the world's present annual consumption. He arrives at this figure by comparing the oil content per unit volume of sediments in the United States with the volume of sediments of the continental shelf areas of the world.

A factor which gives added assurance of the ultimate high productivity of the continental shelf regions is that throughout most of their extent they consist of and are a part of the Tertiary sequence of rocks. These are the younger rocks in the geological succession and have accounted for over 60 per cent of all the past petroleum discoveries. They are generally soft rocks, easily folded and deformed into traps, and they are high in organic content. They have suffered less erosion than the older rocks which may account in part for their higher productivity. For reasons such as these, they are much favoured geologically.

The chief drawback to the exploration on the continental shelf areas is the difficulty of operating under water, and the fact, as can be seen in Figure 4, that a large proportion of the area is located in the arctic regions of the earth.

Carsey (5) has estimated the undiscovered oil on the small segment of the continental shelf off the coast of Texas and Louisiana as on the order of 4 to 5 billion barrels. He bases this on a comparison with the density of pools and the rich oil and gas production which has been found in the equivalent parallel band along the land side of the coast. Reasoning that similar producing conditions should extend as far seaward as they extend landward, he arrives at a reasonable figure of future expectations for this area. A decade ago, figures such as these would have meant little since there was no known

CONTINENTAL SHELF AREAS

-Adapted from map by Nibler

Figure 4.

way in which the oil could be obtained even if anyone thought it was there. This increase in the potential undiscovered oil is due, therefore, largely to the improved drilling technology which makes operations possible in the varying depths of water encountered on the continental shelf.

The total of the best current estimates of the undiscovered petroleum reserves in the world, on land and under the water, adds up to the impressive figure of 1,500 billion barrels. Reserves such as these are of use only if and when they are discovered. Many non-geological factors bear on their discovery and a discussion follows of a few of the more important elements of the availability of these reserves.

One does not ordinarily catch fish unless the fish line is in the water with a baited hook on the end of it. Likewise, reserves will not be discovered unless exploratory wells are drilled. It may require only a few wells, such as the 150 wildcat wells necessary to discover the vast reserves of Iran, Iraq and Arabia (6); on the contrary, it may require the record of nearly 7,000 wildcat wells drilled last year in the United States to maintain the discovery rate and replace its annual consumption. The density of test drilling varies in different regions, and it is difficult to say when a basin or province has been completely explored. Discoveries in some of the older producing regions in the United States are still being made where dry holes or failures are less than a mile apart.

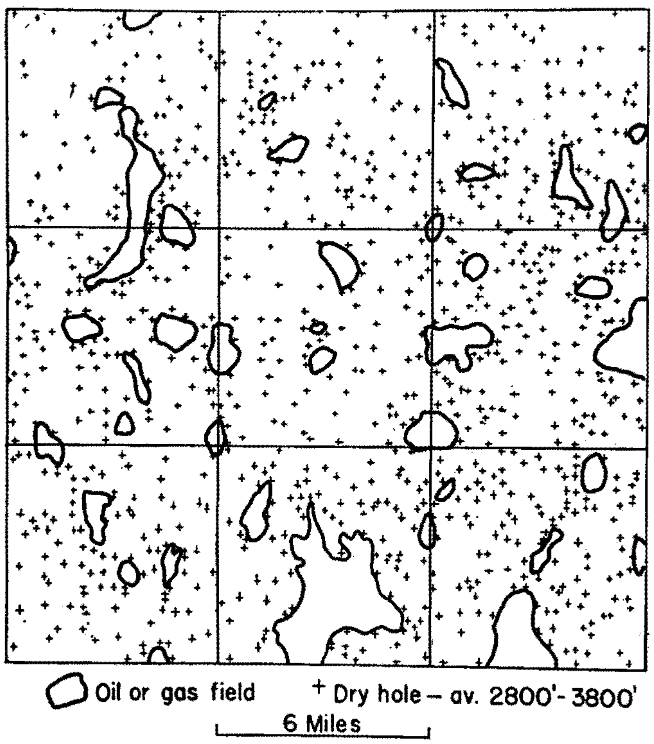

Figure 5. An area typical of many in the United States showing the density of drilling. Even in such an area, a new pool was discovered recently.

It has often been said that because the ultimate number of oil and gas pools is finite, the discovery of each new pool means one less in the number remaining. The same statement would also apply to the discovery of each new province—it should mean the end of discovery is that much closer. Such statements are true—but meaningless. The discovery of the new province below the waters of the continental shelf area of the Gulf of Mexico has opened up in our thinking dozens of new possible provinces within the continental shelf areas of other parts of the world. Whether these areas are ultimately found to contain 100, 1,000 or 10,000 billion barrels of petroleum—they have been changed overnight from areas of only scientific interest into areas of undreamed potentialities for oil and gas production. Instead of thinking of the discovery of the Gulf Coast continental shelf province as one less province—it is much more realistic to think of it as the beginning of many more similar discoveries to come.

The Athabaska River "tar sand" deposit of northern Alberta, Canada, presents an interesting phase of the problem. This is a deposit of sand and black viscous asphaltic oil which is exposed to erosion along the banks of the Athabaska River near McMurray. It covers an area of more than 8,000 square miles and is variously estimated to contain from 100 to 300 billion barrels of petroleum. It is not economical to operate at present since it is far removed from the markets and the oil sand has to be obtained by mining methods. This single deposit contains on the order of one half of the total undiscovered petroleum estimates of Weeks and Pogue.

This deposit is exposed to view only because of the chance coincidence that the Athabaska River flows through the area and cuts a channel through the overlying rocks. How many other deposits of this sort are there buried under the rocks of the western plains of Canada, which may be discovered by drilling? And the petroleum of which would contain more of the lighter hydrocarbons and presumably would be in a liquid state and more easily produced? If there is one such, there may well be others. We may some day, therefore, multiply our present world estimates of petroleum several times in this one region alone.

Undiscovered reserves in a region of adverse political or economic climate will tend to remain undiscovered and are thus only of academic interest. Geologically, the United States, for example, appears to be no more favourable for petroleum accumulation than many other areas on the earth. Yet it has led the world in its ability to discover the thousands of oil and gas pools which lie hidden deep below its surface. This success can be attributed in a large measure directly to its laws of mineral ownership whereby the individual owns the petroleum under his land and can do with it what he wishes. Petroleum discovery means something to him personally. The hope of a reward for discovery, whether the hope is in the heart of the individual or of a great corporation, is a powerful stimulus to the discovery effort.

It has been amply demonstrated in the United States that the free-enterprise—profit-incentive—system is most effective in the successful search for new petroleum deposits. The intense competition that it stimulates requires that every clue which suggests the presence of an oil pool be followed to the limit. As a result, the American petroleum industry is continually exploring at the fringes of its knowledge, taking calculated risks which would not be dreamed of were the incentive lacking, and by this experience, advancing steadily in technological "know how" and discovery ability. The end result is petroleum discovery.

There seems to be ample evidence of the abundance of undiscovered petroleum reserves in the world in terms of the future needs of the world. Any failure of world supply to meet world demand over the next several hundred years will certainly not be due to a lack of undiscovered reserves but rather a failure of the discovery effort for one reason or another. Experience suggests that failure of discovery is more often the result of failure to provide a healthy political and economic climate than it is a failure of technology. Whatever the cause, the crux of the problem is discovery—that is, to reduce these undiscovered reserves to possession.

As the light from new knowledge concerning the origin, migration and accumulation of oil and gas enters our thinking, it lights up an ever-widening circle of new regions to be explored and of new principles to apply. The current estimates that the total undiscovered reserves are on the order of 1,500 billion barrels are the best and most reasonable that can be made under the present state of our geological knowledge—but by no means can they be taken as final. As a matter of fact, it is doubtful if they would have been a tenth as large one quarter of a century ago—and they may well constitute but a fraction of the undiscovered reserves which will be estimated twenty-five years from now. The problem finally resolves itself, not into a question of the adequacy of the undiscovered reserves, but rather into our ability to discover them.

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The Chairman: We have with us a number of geologists. I hope that they will now come to the rostrum one by one in order to have a good discussion on Professor Levorsen's very stimulating paper.

Mr. McLintock: I am not an oil geologist; I am a geologist who is interested in oil. My job in life is to look after the geological survey of Great Britain. In the course of that rather varied existence I have found time to take an interest in some of the more important and newer oil fields of the world which have been described so clearly by Professor Levorsen this afternoon. I just wish to deal with one or two points connected with those fields, because I feel that the paper which Professor Levorsen has so kindly provided might lead to grave misunderstandings among those of you who perhaps do not have a personal and intimate knowledge of the Middle Eastern oil fields.

In Professor Levorsen's paper the statement is made that the proved known reserve amounts approximately to 70,000 million barrels. I take it that those are world figures.

I am old enough to remember repeated occasions on which, particularly on this continent, technologists have had periodical nervous attacks about the amount of oil available and the world reserve position. This figure illustrates to some extent the reasons that very often underlie that nervousness. For total world reserves this figure of 70,000 million barrels is, of course, extremely low. It is so conservative as to be, I say it quite definitely, quite wrong. Perhaps I could illustrate that best by my own personal experience, if you will excuse my being personal for a few minutes.

I first had the opportunity of examining the Iranian—or, as they then were known, the Persian—oil fields, part of a great oil-bearing belt that stretches for several hundred miles in a northwest-southeasterly direction, in the year 1926. At that time two oil fields were in operation. One of them was the original discovery, the well-known field, Masjid-i-Sulaiman, which has produced hundreds of millions of barrels of oil, and is still operating. The other field had recently come into production, and was known as Haft Kel. The business of the geologists was, if possible, to discover fresh fields, although at that time the engineer and the oil technologist took rather a cautious view of Iranian prospects.

Now what is the position today, twenty-three years after that time? Masjid-i-Sulaiman and Haft Kel are still producing. Naft-i-Shah, a small field on the boundary of Persia and Iraq, is also producing. The great Iraq petroleum field has come into production, producing four million tons a year. It has an extent of about sixty miles in length and two miles in breadth. Other Persian fields are Gach Saran, with reserves of the order of one to two thousand million tons of oil, Agha Jari, a field of comparable size, and several smaller fields. I would also mention Kuwait, Bahrein, Qatar and the five or six considerable fields in Saudi Arabia, with aggregate reserves of the order of 5,000 million tons of oil. Totalling all those, I think it is true to say that the aggregate reserves of the known fields in Iraq, Iran, Saudi Arabia, that is the Middle East generally, amount to something between 70,000 million and 100,000 million barrels.

Mr. Abreu: I am somewhat embarrassed because it is very difficult for me to speak English. I shall try to explain my views on the speech of Dr. Levorsen.

We have heard one of the most interesting papers in this conference, one dealing with a most important subject for an industrialized world—the future petroleum supply. Dr. Levorsen is well known by his important studies on petroleum in this country. He is a teacher in one of the great universities of the United States, and he is not at all a theoretical man about petroleum; he knows the practical end of the business, and as far as I am concerned he has applied his theories with much success in the mid-continent area.

After brief general statements about petroleum occurrence in the world, he concludes—taking into consideration the statements of other distinguished petroleum geologists of world-wide experience, like Weeks, De Golyer, Pratt and Pogue—that we must not be afraid of a lack of petroleum in the coming years, a fear which has been expressed several times. We are beginning to be accustomed to hear statements that the petroleum reserves of the world are sufficient only for the next twenty years. But as a matter of fact, notwithstanding the enormous increase in the consumption of petroleum in every country in the last few years, considerable reserves have been added and the prospects of new potential areas are, according to Dr. Levorsen, not bad.

He estimates that the undiscovered reserves amount to five hundred times the annual consumption, but he points out that these undiscovered reserves may be discovered. May we comment briefly upon the nature of these undiscovered reserves? They consist of two kinds of deposits—those lying in the continents and those underneath the seas. The conditions regarding the chances of discovery in both types of occurrence are different, and they involve many problems of a technological and political character.

It is true that a very promising area for future supplies is represented by the continental shelf in the Gulf of Mexico and, perhaps, in South America off the shores of Patagonia, where many wells are already producing from undersea pools. It may be that another promising area will be the shelf near Sumatra and Java, where large pools are already known.

The exploration of large quantities of oil in the non-developed areas will, in my opinion, be very embarrassed by national feelings—I mean the narrow nationalism which is being developed in most countries in our days. As far as South America is concerned I do not believe that the petroleum potentialities will be placed at the service of several South American populations in large quantities in the next few years. They will certainly be developed, but at a slow rate since each country is trying to develop them on its own and with its own capital.

According to the widely agreed estimates of Pogue in 1946 and Weeks in 1948, the undiscovered reserves of the Western Hemisphere are around 150,000 million barrels. We do not know what is the proportion relative to South America. It may be less than one-half, or perhaps only one-third. What I want to emphasize in the light of my knowledge of the general situation in South America is that an exaggerated national feeling is the most influential factor against new discoveries of oil being added to the proved reserves of the world.

Dr. Levorsen must be very well informed concerning the political situation in South America, since he pointed out in his paper this vital question concerning the development of South American potentialities. "Undiscovered reserves in a region of adverse political or economic climate will tend to remain undiscovered, and are thus only of academic interest", says Dr. Levorsen. Dr. Levorsen attributes the success of the oil industry in this country to "its laws of mineral ownership", and this is just the reverse of the general feeling in South America, where an intensive movement towards nationalization, full state control, and so on, are considered the best ways of developing the unknown mineral resources. I suppose that most of us will agree with Dr. Levorsen in considering that failure of discovery is more often the result of failure to provide a healthy political and economic climate than it is a failure of technology. At least, with regard to South America, that is my feeling.

Mr. Monture: I am sure we are all grateful—all of us who have to drive cars or who have to get around New York City—for the very optimistic spirit of Dr. Levorsen's paper. I just wish to comment on two features of it. My first point concerns his concluding statement that the problem finally resolves itself not into a question of the adequacy of the undiscovered resources, but rather into one of our ability to discover them. I think that perhaps the history of Canada's oil bears out very conclusively Professor Levorsen's concluding remark.

We made our first really important oil discovery in 1912 in what later became the Turner Valley Field in Alberta, and while petroleum exploration and geological work was carried on rather intensively elsewhere in Western Canada I might say that we did not have any great success until the fall of 1947 when we discovered the Leduc Field in northern Alberta. That, I think, shows what must go into the search for oil.

The application of geological information entails physical and other scientific prospecting and the expenditure of tremendous sums of capital in the way of money for drilling equipment, and finally we have the great contribution of the oil-drilling engineer who has devised equipment which permits drilling to 10,000 feet or deeper.

I should like to point out that in Canada we have the two types of oil—the light and the heavy—and that the heavier oil, at least, presents a refining problem. Again, to comment upon Professor Levorsen's statement about the tar sands of the Athabaska River, or, as we call them in Canada, the bituminous sands, I notice that Professor Levorsen gives an extent of some 8,000 square miles underlain by these sands. We hope that his estimate is correct, but perhaps a word of caution might be advisable here.

While we know that this area may be favourable to the occurrence, we have not yet done sufficient work to show that it is capable of being economically developed. We did some drilling during the war when we found that the sand varied in bitumen content, and there were certain other problems that arose in the physical development so that I think we must regard the bituminous sands of Canada not as an accepted petroleum resource at this time in the sense in which we think of natural petroleum coming from wells. It presents special mining problems which would have to be overcome because of the large tonnages to be handled, the abrasive quality of the sand and its effect on ordinary mining equipment, and, finally, the problem of actually separating the bitumen from the sand. We feel that that is, perhaps, the first problem, and in Canada we are devoting some time and effort to working out a method of removing the bitumen from the sand so that we should then have a product that was suitable for further processing or refining. Here again, we shall be presented with a problem, but I am sure that scientists, the chemists and the physicists, will come to our rescue.

That is all I have to say, but I felt that I might leave that word of caution with Professor Levorsen.

Mr. Erselcuk: I am not a geologist; I am in charge of the resource programme at Purdue University. I should like to submit one question concerning the very excellent paper which has been presented; it has to do strictly with the economic and financial side of the problem.

No doubt, we have about 1,500 billion barrels of oil either on the continents or near the continents. But the question is this: Is it going to be possible, financially and economically, to get all of that oil? Already we know that in the United States the price of oil is gradually going up because the cost of production is going up, and eventually we shall reach a point, I believe, at which substitute fuels coming from other energy sources may compete with oil, and perhaps we may not be able to get a very large portion of those 1,500 billion barrels of oil.

The CHAIRMAN: If nobody else wishes to continue the discussion, I shall ask Dr. Levorsen to answer some of the points that have been raised.

Mr. LEVORSEN: As far as the last speaker's question is concerned, there is no doubt that competition with other fuels will enter the picture sooner or later. As we have heard at the meeting so far, a great deal of work and experimentation is being done toward providing alternative sources to liquid oil. That may be some time in the future. Certainly, I believe that at the present time we can get a lot more for our money by prospecting for oil than by working out either oil shale or oil from coal. That does not mean that the latter should not be done. But certainly at the present time, as nearly as I can find out, the advantage is very much in favour of oil.

Whether we shall ever need this amount of oil is another question. I think it is there to be had if we need it, and possibly much more if we want to think ahead.

As regards the figure of 70 billion barrels that I used, I realize it is very low. However, those are the published figures, and it takes a meeting like this to smoke out some of the folks who have the inside information as to what these fields actually will produce.

The CHAIRMAN: I wish to thank Dr. Levorsen once again for his most stimulating and encouraging paper, which, I think, also produced a very interesting discussion.

We now go over to the second half of our programme. Perhaps I may be allowed to make one or two remarks about the significance of the work of the Fuels and Energy Section for the general theme of the Conference —that is, raising the standard of living by increasing production—and particularly in enabling the more backward countries to build up a more productive and more diversified economy.

In order to obtain an idea of what energy means to a country, I plotted Mr. Colin Clark's pre-war estimates of the average income in each country against the average consumption of energy. With a few exceptions, there was a very close correlation between the two, showing how essential supplies of energy are if a reasonable standard of living is to be maintained.

There seems to be a doubt in some people's minds as to which is the cause and which is the effect. I think the answer is extremely simple because, after all, power is the multiplier of the productivity of human labour. Just think of the nineteenth century. It was the use of the free energy of coal which made that great development possible. It was the power-driven machine, the steamship and the railroad, which made available the world resources of raw materials and food and provided those great new markets for industry. In the later part of the century came the discovery of petroleum, the internal combustion engine, the first power-station, the distribution of electricity and the steam-turbine, which increased enormously the availability of power and diversified its uses.

The main fruits of those developments were harvested in our own century, which, I think, has had its own revolution—which I call the Domestic Revolution: the scientific application of heat and power in the home, which has raised so enormously the standards of health and comfort. Perhaps that can be regarded as the repayment by the technician of a long-deferred debt for some of the social consequences of the mechanization of industry in the nineteenth century.

Secretary Krug emphasized the interrelationships of our problems and the need for co-ordination, and, in reading the papers in the other sections, I have been struck by the frequency with which the application of energy has been fundamental to the solution of some particular problem. Take, for instance, the Minerals Section, in the extraction of metals from their ores. Take the Land Section. The mechanization of agriculture, I suppose, is almost as far-reaching a revolution as the mechanization of industry. There is the use of power in the dairy and in the barn; in the preservation of food; there is the new partnership of agriculture and chemical engineering. They were competitors, but now, I think, they are partners in the processing of agricultural products, which does offer the opportunity for a more diversified economy in agricultural countries, but which is dependent, of course, on the availability of heat and power.

Then there is the question of transport, which, after all, is the key to development, and which is dependent entirely on power, by making possible the movement of raw materials and individuals and the exchange of goods.

How are the needs of the world for energy, for heat and power being met today? Coal, 1,500 million tons a year; oil, 500 million tons; natural gas, 150,000 million cubic metres; wood, 800 million cubic metres; hydro-electricity, 300,000 kilowatt hours.

By themselves, those figures are not very significant, except by comparison with previous estimates, showing the very big increase in the contribution of oil and natural gas. But if you assign an efficiency figure to them, you can calculate the percentage contribution of useful energy which is being made by each of those resources, and the figures would come out roughly like this: coal, 55 per cent; oil, 25 per cent; natural gas, 7 per cent; wood, 7 per cent; and hydro-electricity, 6 per cent.

I think there are two significant facts: the large contribution made by oil and natural gas—and, in that connexion, it is very encouraging to have heard Mr. Levorsen's paper—and the relatively small contribution, vital though it is, made by hydro-electricity; steam-generated electricity is only slightly greater. The unused water power resources of the world are very great, but they are mostly relatively remote from the great centres of energy consumption. If the potential water resources of the developed portions of the world—North America and Europe—were harnessed, they would supply only a small proportion, perhaps 20 per cent, of our total energy requirements. That means that we have to continue to rely on fuel, and that the theme of this Conference—the conservation and the economic utilization of our fuel resources—is therefore of major importance.

There is just one point I should like to throw into the discussion in advance of Mr. Jacqué, if I may. That is the question of the transport of energy, because I have emphasized the importance of energy to the development of the more backward countries, and that problem constantly is going to arise. What is the most economic way of transferring energy? Is it by a pipeline of oil? Is it by high-pressure gas main? Is it by high-tension transmission of electric power? Is it by coal by road or rail? That is, I think, a relevant question for the discussion we are going to have.

I am not going to stand any longer between you and Mr. Jacqué, who is going to introduce this discussion on "Economics of Competitive Fuels for Various Purposes and Their Use to Meet Future Fuel Requirements." Mr. Jacqué is a distinguished technician and is President of the Petroleum Institute of France.

Mr. JACQUÉ:[a] When a pupil arrives late for class, he is usually punished. The contrary has happened to me since, though I arrived only this morning. I have experienced the great honour of being asked to introduce today's discussion on the "Economics of Competitive Fuels for Various Purposes and their Use to Meet Fuel Requirements". I apologize for the fact that, being extempore, my reflections are necessarily incomplete. It is my chief desire that they should be the occasion of a general interchange of views and information among the specialists in the field who are with us today and who are far more competent and experienced than I.

The question is indeed vast. The problems it raises are not merely technical, but economic and political. Moreover, it has no general solution to offer, for the simple reason that conditions vary between one country and another and between one region and another in the same country.

All here are bent on working for the bettering of human standards of living, with due regard for the wise use of known, imagined, or yet unknown reserves, whether (as is hoped) they are capable of renewal or not. Our aim is certainly that of improving the standards of living of our contemporaries and immediate descendants, but we are also anxious that later generations shall not be able rightly to reproach us with having wasted their inheritance.

As Sir Harold Hartley pointed out, all the problems dealt with, either in this section or others, resolve themselves into problems of energy. Directly or indirectly, fossilized fuels, that is to say living matter transformed into carbon, and fossilized carbonaceous compounds (coal on the one hand; petroleum and natural gas on the other) are today of the first importance. Our Chairman has just pointed out that approximately 80 per cent, if not more, of all energy is divided more or less equally between the two classes of fuels. That does not mean that considerable and sustained efforts are not being made to put ever-renewable solar energy at the disposal of mankind; steady progress has already given us a considerable output of hydro-electric energy. There can also be no doubt but that, in the years to come, human ingenuity will succeed in the economic harnessing of other forms of that eternally lavish source of energy—the sun.

Before dealing very briefly with some specific points regarding desirable developments in our methods of utilization, I should like to stress that, generally speaking, however concerned we may be to husband a particular form of energy stored in the earth, certain considerations are inescapable. The factors which guide the choice of energy and, in the case of carbonaceous fuels, the type of fuel used, must necessarily take account of:

1. The practicability, in the present state of our technology, of its use for a particular purpose, whether related purely to energy (production of heat or electricity for domestic uses or transport), or reactive (in metallurgy or chemistry, for example)—since the latter is always bound up with problems of pure energy;

2. The cost and various limitations connected with its use. Among these considerations should be included not only the initial cost of the energy or carbon used but means of transport, the flexibility of plant (especially as regards the possibility of changing rapidly to more or less intensive production) and, finally, a factor that should not be forgotten—the human work involved, since we are determined, as part of improved standards of living, not to ask of others that they shall undertake unduly burdensome labours.

Thanks to its many advantages from various points of view, such as those I have just mentioned and in spite of the somewhat limited and uncertain nature of its reserves (Professor Levorsen has just opened for us future horizons far wider than those of the past), petroleum is playing an increasingly important part even in the rapidly growing sphere of world consumption of energy.

Given the factors which I have just put before you, the development and, perhaps, the proportionate increase in methods of exploitation and utilization will depend upon the progress made in that direction. There can be no doubt but that the research now in progress in all industrial countries on mechanical means of extracting solid fuels, on better ways of transporting them or, as in the case of compressed synthetic or producer gas, on converting them into liquids in order to make transportation even easier, will make it possible to have greater recourse to reserves of the kind which, all things considered, are today more considerable and more evenly distributed than reserves of petroleum.

I will now deal with a rather more specific field.

The uses of energy fall into two clearly defined categories. There is first the use of energy itself, either to produce heat, light, and means of transport or to supply power for mechanical, chemical or electrothermic transformation—the type is of little importance. There is also, however, the utilization of carbon as such—a very different matter from using energy in its reactions, either metallurgical or chemical in the most orthodox sense of the word. The production of pure energy appertains to the former. The choice of a given fuel therefore largely depends on the possibility of using it in a flexible form. For example, the gas industry in Europe is at present occupied in findings ways to satisfy consumer needs at seasonal or daily peak periods by means of gas-producing installations capable of rapid increases in production. That is consequently one field in which the problem of peak loads is leading to the use of gaseous or liquid fuels.

Similar problems must be solved with regard to electricity and during the last years we have seen a development of the use of gaseous or liquid fuels to ensure the production of electric power at peak periods.

Among metallurgical problems, the development of

[a] Mr. Jacqué spoke in French.

various smelting industries is subject, to a very large extent, to the consumption of energy. It should be noted that the geographical situation of certain foundries has been influenced more by the proximity of fuel than by that of ores. The zinc-smelting industry is a typical example; it has developed in regions like Belgium which are relatively far away from zinc ores but which have large quantities of coal.

In other cases, on the contrary, the availability of coal and ores in not too widely separated regions has made possible the development of the iron-smelting industry. With regard to the latter, I should like to point out that technology can also lead to evolution in the use of a particular fuel.

I think that research is being undertaken in various countries on the transposition and reduction of iron ores which react in fluid media; that research is following similar lines to those developed for the catalytic reactions of petroleum. If that is the case, in a few years we may witness a transformation of the iron and steel industry and that transformation will have major repercussions on the coking industries; it will no longer be a question of manufacturing a solid and mechanically resistant fuel having a certain reactivity but, on the contrary, of manufacturing, at the most favourable price possible, a reducing gas by means of which the reactions which I have just mentioned may be produced.

The synthetic reactions of organic chemistry are another example. Beginning in the middle of the last century, industries developed based on the organic synthesis first of vegetable derivatives, in particular fermenting alcohols, then of carbonized coal derivatives (leading to the rapid expansion of the synthetic perfume industry), later of calcium carbide derivatives, that is to say acetylene, and finally of synthetic products based on compounds of carbon monoxide and hydrogen. In that field too the raw materials changed and evolved according to the ease with which the original structures could be transformed into the final product which it was desired to obtain. In most cases, in chemistry as well as in metallurgy, I think that the energy necessary to effect the transformations is far more important than the quantity of carbon which must be used either as a reducing agent or as the constitutional base for the organic compounds.

In conclusion may I say, with regard to the diversity of conditions which exists between one country and another, that in Europe we are, generally speaking, in a very different position from the United States, for example; in the latter country coal can be produced at a much lower price than in Europe so that in European countries the problem of obtaining a raw material requiring the least possible amount of energy for our transformations is even more acute than in the United States.

These are a few of the remarks which I wished to make in the hope that they might lead to an exchange of views between our colleagues from different countries.

The CHAIRMAN: Thank you very much, Mr. Jacqué. Who will continue with this discussion?

Mr. DEVRIES: In the course of the very interesting discussion I should like to pose a question. After all, the production of energy for use in society is a product of labour, and ultimately the cost of the fuel and the competitive value of the fuels must be determined by the human labour that is invested in it. Even if we use machinery to extract energy from fuel, human labour is invested in the capital. This probably is a process that goes on and perhaps is auto-catalytic. In this way, the investment in machinery to extract fuel and energy will give us new energy which we can use again for more energy still to be used in human society. I should like to ask this question of the people who know about the competitive value of fuel and energy: Can they give us some idea of how far we can go in this respect, and about what would be the ultimate range of human labour necessary for the production of certain quantities of fuel and energy from different sources?

Mr. HUBBERT: I wish to revert to some of the remarks of Mr. Levorsen who, it appears to me, has followed two independent and incompatible lines of reasoning which have led to two different and irreconcilable results.

Mr. Levorsen's first line of reasoning is essentially a physical one whereby, after considering the amount of oil that the sedimentary rocks have been found to contain in the better known areas of the world, and the approximate amounts of sedimentary rocks throughout the world, an estimate is reached of the ultimate amount of oil which may be found in the entire world. The figures cited are 500 and 1,000 billion barrels of undiscovered reserves for the land and continental-shelf areas of the world, respectively.

This method of reasoning appears to me to be a valid one and the figures cited of the proper order of magnitude.

As contrasted with the foregoing, Mr. Levorsen's second line of reasoning is essentially metaphysical in character as exemplified by his statement: "Any undiscovered oil or gas pool at best exists only as an idea in the mind of the geologist. In a like manner, the basis for any undiscovered petroleum province—a petroleum province is a region in which there are a number of oil and gas pools occurring under related geological conditions—exists only in geologic thought."

In pursuit of this thesis he dismisses as true, but irrelevant, the physical reasoning that, since the ultimate number of oil and gas pools is finite, the discovery of each new pool means one less in the number remaining. He is thus led to his two principal conclusions, namely:

1. That the figure of 1,500 billion barrels is only a current estimate which may constitute but a fraction of the reserves that will be estimated twenty-five years from now;

2. That the world is assured of sufficient undiscovered reserves of petroleum to meet all its demands for several hundred years.

These conclusions are mutually complementary in implying a *present* estimate of undiscovered petroleum reserves which is an indefinite but significant multiple of the 1,500 billion barrel figure originally cited.

Not only am I concerned with the validity of these conclusions, but even more with the validity of the reasoning by which they have been obtained. It is quite true that our activities in the exploration for petroleum are in part determined at any given time by our opinions concerning the probability of the occurrence of petroleum in given areas and by the data available. This works negatively, however, as well as positively. In fact it is on just such a basis, supported by a well-authenticated body of knowledge, that we are prevented from engaging in futile and costly exploration efforts in the areas of the pre-Cambrian shields, for no amount of optimistic thoughts about the huge petroleum reserves of such areas is likely to lead to the discovery of a single drop of oil.

It is also true that in the past the estimates of the ultimate reserves of petroleum have usually been wrong on the low side—and often grossly so. Such estimates, however, were not comprehensively made by means of a detailed inventory of the sedimentary rocks of the whole world, and are, therefore, not comparable in validity to those which have been so made in the light of recent data. Nevertheless, it should be borne in mind that the reserves of petroleum in the earth are a physical quantity resulting from slow accumulation during some 500 million years of geologic history, and that the magnitude of the quantity, which during human history will experience negligible increment, is in no manner influenced by our thoughts or opinions concerning it.

With regard to the length of time during which petroleum reserves will be sufficient to satisfy world demands, we must take into account not only the magnitude of the reserves, but also the rate of production. If one plots a curve of annual production of petroleum as a function of time (see Chart), the cumulative production up to any given time will be represented graphically by the area beneath the curve up to that time. Since petroleum reserves are finite, this area is necessarily limited and may approach, but cannot exceed, the amount of oil initially present. Hence, the production curve, starting from zero, will rise, pass through one or several maxima, and ultimately decline to zero. Thus, while within these limits there is an infinity of shapes such a curve may have, the higher it rises the sooner will its peak occur and the sooner and more rapid will be the decline.

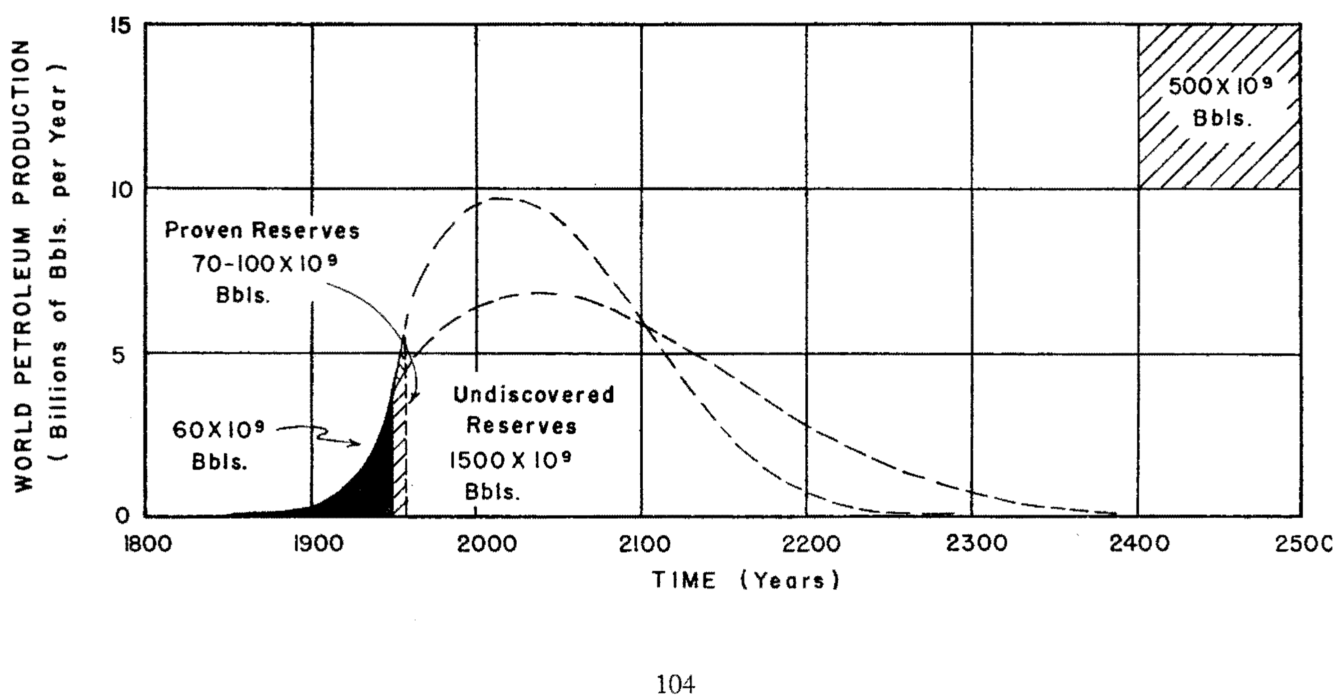
With these points in view, the production of petroleum up to the present is plotted in the attached chart and two possible projections into the future are made assuming an undiscovered reserve of 1,500 billion barrels. The cumulative production to the present is about 60 billion barrels and the present rate of production is 3.5 billion barrels per year, and still increasing at such a rate as to double in about 15 years. It is virtually certain that the rate of production will continue to increase for some time into the future.

If the ultimate peak of production is of the order of twice the present rate, it appears that this should occur within about 75 years; if it reaches three times the present rate it is likely to occur within 50 or 60 years. In either case, once this peak is passed the industry will manifestly not be able to meet world demands, and unless production is drastically curtailed the reserves should be well on their way to exhaustion within an additional century.

To summarize my remarks, I can see no basis for Mr. Levorsen's optimism that the petroleum reserves of the future will be significantly greater than his figure of 1,500 billion barrels. Accepting this figure, his conclusion that the undiscovered petroleum reserves will be sufficient to meet world demands for several hundred years appears to be without foundation.

Dr. Levorsen: Mr. Hubbert's statement is correct—the amount of oil in the ground is a fixed amount. But our idea of what that amount is, is changing continually. I remember in 1936 or 1937 I sat on a committee with a number of geologists in the United States who were attempting to estimate the future reserves in the United States. I remember the figure at that time of 15 billion barrels of proved and unknown reserves underground. There were quite a few at that time who believed that we were just about running out of oil and that the curve turnover point would come within the next few years. Since then, I believe we have produced 15 billion barrels —a billion-and-a-half or two billions a year and we now have 24 billion barrels which we know are underground.

It is true that the amount of oil is fixed, but our ideas are changing and it is on these ideas of the ultimate



amount of oil that we do our planning, pass laws, and enter into the exploration business and the oil business.

It is what we think about these reserves that are all we have to go on. No one knows what they actually are.

The CHAIRMAN: In the absence of any further speakers, I should like to take one specific example which seems to me to bear on the question raised by Mr. Jacqué. I take the example of the locomotive. The steam locomotive using either coal or oil as a fuel has an extremely low efficiency, say about 5 per cent.

The steam locomotive is being replaced very rapidly in this country, and less rapidly in other countries because of certain physical conditions, by the diesel electric locomotive which has an efficiency at least five times as great. In this country alone it is estimated that the replacement of the coal-fired locomotive by the diesel electric locomotive would result in an economy of over 100 million tons of coal a year.

But now we have the next development in an experimental stage, with the possibility of a coal-fired gas turbine locomotive which might not have, under certain conditions, quite as big an efficiency as the diesel locomotive, but which would use fuel which in this country, I think, would cost about one-fifth as much as diesel oil. This is an example of the way in which this competition between the fuels leads to successive developments, and here you have a case of the competition between efficiency and cost. I think that that is the kind of example which Mr. Jacqué had in mind, and I wish that some of those present would produce similar examples to illustrate Mr. Jacqué's point.

Mr. BLACK: I am just an economist who does not know anything about petroleum, but when the Chairman broadens out the discussion to talk about energy perhaps it is permissible for me to make a comment or two.

There has been a reference to the extent of energy resources in the world which are not well developed. Why do we not go about developing them? Why do we sit around and let all this water pour down our streams without harnessing it at once? The Tennessee Valley Authority came along and gradually developed an immense system of power. What did they do with it? It is a territory that is pretty well filled up with people. The average income in the Tennessee Valley counties before the war—gross income per farm—was $700. What did we do with all this power when we got it? We used it in what I suppose was a very expensive way—electro-metallurgy. You have to have power pretty cheaply and abundantly before you can use it in that way.

Then we started hydro-electric development way up in Saguenay north of the St. Lawrence, during the war when we needed it. Why did we not develop Passamaquoddy? There is lots of power there. As a matter of fact, this development is held back by the growth of the world population and the demand for the use of this power, as much as by anything else. We could use it to very good advantage if we had it and had it cheaply, but we have other uses for our capital and we held back in the development of a tremendous amount of these undeveloped resources.

We know this to be true in hydro-electrics, and Dr. Levorsen's chart showing the undeveloped sedimentary resources of petroleum indicates that it is also true of petroleum. Way up in the Arctic regions and in continental shelves in very cool climates there are not many people. We are not going to develop a whole lot of resources in northern Siberia or in northern Canada until we have people there, and when we have people there they will not themselves consume a large part of what they produce. We shall have to find a market somewhere else for the product of the development of these resources.

In other words, I am pointing out that there is an economic order in which all these resources become developed and tied up with population and the location of populations. Then we go ahead and assume that it is just a question of time, that the population of the earth is increasing at a tremendous rate and that we shall need all these resources. I wonder if we are so sure that it will continue to increase at this tremendous rate? We must not look at the population of the earth as if it were one total. As a matter of fact, over 40 per cent of it lives in countries where the resources and the population have come into a balance, where the standard of living is rising, and where the progress of the arts is more rapid than the progress of the population in those countries. This is true of the United States and of most of Western Europe.

Even in India today an appreciable fraction of the families have no more children than can be brought up in comfort and given an education and a reasonable chance of a healthy life. This is also true in China; and the proportion of families of that description is expanding in all parts of the world. In time most of the countries will have a dominance of families of that kind. That is a long way off, but it is a hope of a comfortable, happy existence in countries like India, Japan, and the East Indies.

We have no business looking at the population growth in terms of a total as if the human race were a vast drove of hogs feeding out of one food trough. Neither is it a vast body of animals growing out of one source of energy. Country by country, certainly, there is a great deal of international exchange of food and of power, but there is a much larger amount which is not exchanged. We are not going to feed India: India is going to have to feed herself in very large part. That is the way in which the history of the world is developing.

Our energy resources along with our food resources are developing mainly country by country. There is international exchange, but it is limited. This has held back the development of the world's energy resources—coal resources, hydro-electric resources and so on—and will continue to do so. A realistic history of the future for the growth of resources has to recognize these things, and the circumstance that so large a part of the resources is in very cold climates or very hot climates, faced by all kinds of difficulties and obstacles, is a contributing factor to retarded development.

Mr. MACFARLANE: The argument of the last speaker, as I understood it, was that it was not necessary to develop increased power resources in the world because the population of the world is not to be expected to increase at the rate at which it has been increasing. I suggest that that is not necessarily a logical conclusion. As I see it, in the countries where there has been a check in population increase, there has been a vast increase in the power requirements. The matter might be put this way: in our grandfathers' houses, there were twelve children and no electric motors; in our houses today, there are at least twelve electric motors and perhaps no children. I think you will find, as a matter of statistical fact, that the power increases per head of the population are taking place in just those countries in which the population is not increasing very much.

I should like to refer to a point made by the Chairman when he was talking about the great decreases in requirements of fuel that would result from such technological changes as the substitution of the diesel for the steam locomotive. I should like to suggest that many nations—certainly the United States and most of the countries of Western Europe—are at present in a position of serious disequilibrium as regards the efficiency with which they use their fuel.

Naturally, the efficiency obtained from fuel, whether it be domestically or industrially, turns primarily on the price that has to be paid for the fuel. Capital cost, as the last speaker suggested, is the determining factor as to efficiency of use. Comparing today's prices of fuels with those before the war, we see that there has been a very marked increase in most Western European countries and in the United States. As a consequence, I think we must expect a great deal of attention to be paid in the next few years to improving the efficiency of utilization, and I have no doubt whatever that very substantial improvements in efficiency can be made at very low capital cost. The difference between the efficiency of utilization by good practitioners of fuel efficiency and average ones is at the present time quite staggering.

Between the wars, we saw a vast improvement in the efficiency of electricity generation. In the next twenty years, I think, we may expect substantially similar improvements in all other branches of utilization. It is not that I am suggesting that the electricity industry will not go on from strength to strength; I am merely suggesting that it has shown the path which others will follow.

Mr. LIETZ: While I agree fully with Mr. Macfarlane's opinion that we will see a continuous improvement in the efficiency of utilization, we should also expect a similar improvement in the efficiency of recovery of the crude oil deposits.

Mr. Levorsen's figure of 70 billion barrels of proven reserves is based on the efficiency with which today we are able to deplete our known reservoirs. Although improvements have been made in the last years there is still a large percentage of reservoirs in which ultimate recoveries range from 20 to 40 per cent of the oil in place.

With the extensive research now under way we will undoubtedly be able to improve these efficiencies considerably, while research into the possibilities of secondary recovery may well lead to substantial increases in the recoveries obtained from a great number of fields developed and produced in the past.

It is conceivable that as a result of such improvements in technique, the recoverable reserves from the presently known reservoirs could be close to 100 billion barrels without discovering any new fields.

Mr. PICARD:[b] I should like to return to Mr. Jacqué's statement and to point out that this idea of fuel efficiency is a complex one.

Efficiency of fuel utilization comprises at the same time: efficiency of extraction of which the preceding speaker has just spoken, efficiency of transmission of raw fuel when it is transmitted a considerable distance, efficiency of conversion of this raw fuel into usable fuel, efficiency of conversion of this fuel into power, and then efficiency of conversion of this power into positive results—motive power for aeroplanes, cars, lorries, generation and transmission of electric power.

It is necessary, in order to have an exact idea as to what is the best possible utilization of fuel, to bring all these efficiencies into play one by one and that is why as our Chairman observed a few moments ago, types of fuel are succeeding each other periodically in the principal utilizations.

I shall quote two examples of these facts.

The first example is that of the utilization of coal and fuel oil in electric power generation. First, coal was used in the large electric power-houses, then—above all in the countries which produced oil on a large scale—fuel oil began to compete with coal, but it was the price of the calory when it entered the power-house which decided what proportion of each should be used; in some countries, such as this one, some large power-houses are equipped so that they can operate at the same time on coal and fuel oil and one type of fuel or another is used according to the price.

In France, where we have large quantities of coal containing a great deal of ash, a technique has been developed whereby power-houses are using coal containing as much as 40 and 50 per cent of ash, which was previously completely useless and was thrown away at the head of the mine and which can thus be salvaged and put to use. Such fuel, at first, costs nothing since it was thrown away.

It can thus be seen that coal is regaining a position of which it appeared that oil would deprive it.

There is also an idea which did not appear altogether plainly in Mr. Jacqué's statement and which should, I believe, be taken into account; it is that of the consumer.

Much is said of efficiency and of calories; the calory however is a physicist's unit and the consumer does not count in calories but rather in dollars or francs; he establishes the cost price in his own country's currency and it is quite possible, according to the various economic systems, that the utilization which makes the most sparing use of natural resources, that is to say which uses the least number of calories as the physicist would say, might not be the one which the consumer prefers.

There is yet another idea which should be taken into consideration: ease of use. The consumer looks for the minimum of difficulty in use, he wishes to have a machine which will make no noise and which will not give off an unpleasant odour. It is for this reason, for instance, that we have seen that oil, in the form of gas oil, did not take the place in relation to petrol expected of it by certain economists, since gas oil gives off certain odours and since the diesel engine makes much more noise than an engine run on petrol.

We have had a very interesting example in the utilization of wood and charcoal for road transport by means of the gas-generator. Before the Second World War, the French Government had, in order to further the use of home-produced fuel, encouraged lorry owners to use

[b]Mr. Picard spoke in French.

gas-generators and it had allowed them a reduction in the tax on the running of motor vehicles. The gas-generator had not been developed. However, when the cost price was calculated, results were favourable since wood was cheap. The reason for that failure is simply that the use of wood or charcoal is dirty and causes infinitely more work than either petrol or gas oil.

These few examples illustrate the complex nature of the problem. The choice between different types of power for a specific use does not raise only technical and economic problems; it also raises psychological problems which it is difficult to settle by means of legislation. It is in the final analysis the consumer who decides on the choice of fuel, and this choice is not always made in the way in which we think in this Conference.

Mr. WEISSMANN: I should like to return to the suggestion made by the Chairman and discuss some examples of how waste in fuel can be avoided. It has been said that changing over from steam locomotives to, let us say, diesel locomotives would save quite a lot of fuel. I think the same might also be said with regard to railway wagons which are, in general, too heavy for many purposes and obsolete. These wagons use too much energy to move around. At the same time, at present, we have a situation in Europe where about 15 per cent of the workers in the engineering industry are idle. In the field of the transport equipment-producing industries, the percentage of idleness is about 50 per cent. It would then apparently be a wise idea to start changing over these railway wagons. By so doing, we should not only be utilizing unused capacity in the engineering industry, but also conserving fuel.

Mr. CRICHTON: I am a little amazed at the extravagant figures of the world oil resources. I understand from the American Petroleum Institute figures that the yearly increases we have been hearing about—after the amount that has been used—is due largely to increased recovery estimates and extension of known fields. In the last decade or so, during the time we used 13 billion barrels of oil, we have discovered in new fields only 4 or 5 billion barrels. The question that disturbs me and others is how we can be sure that, just because of certain discoveries in explored sedimentary areas, we are going to find oil in the same quantities in unexplored sedimentary areas. I think there is grave doubt about that. I am not a geologist, I am just a coal miner, but it reminds me a good deal of the figures of coal reserves which are put out by the United States Geological Survey.

These coal figures are so extravagant that I think they are a bit pathetic. In my humble opinion, we do not have more than 10 per cent of the recoverable coal that is claimed by the United States Geological Survey. I think the figures in the area east of the Mississippi River show pretty clearly what I mean. For instance, Ohio is shown containing 96 billion tons by the United States Geological Survey, but the Ohio State Geological Survey shows 10 billion tons of recoverable coal. The coal recoveries so far from many fine seams in the eastern coal fields have been less than 50 per cent. In some of the big seams of the Rocky Mountain areas today they are recovering only 15 per cent of the coal, due to mining and economic conditions. This Conference is concerned with conservation, and I think it should know that at the present time the oil industry, in its ruthless competition with the coal industry, is selling residual fuel oil in New York harbor at prices equivalent to two-and-a-half dollars under the cost of a ton of coal. It is sold at more than a dollar a barrel under the cost of the crude oil. Of course, every time they reduce the cost of fuel oil, they increase the price of gasoline, and many present, whether motor carriers or private owners, have noticed this recently. I think it is pathetic that 20 per cent of crude oil today is being sold at a price which is shutting down many of the coal mines of the eastern area. They cannot possibly survive. It means the loss and the abandonment of many mines of which the cost to reopen later on will be prohibitive. And it means the loss of additional millions of tons of coal in America.

To my mind, there is no longer any excuse for this intense competition between two fuels in America which are scarce and should be conserved. What is twenty-four years' known supply of oil in the life of this nation or in the life of any nation, that it should be thus wasted? I understand that by known processes all of the oil, or practically all of it, could be converted to the higher uses. And while they are converting 1½ per cent more of this residual fuel oil this year than last year, that process of change—that is, the changing of the refineries to produce the yield the market requires—is being carried on far too slowly. In the eastern area of the United States, east of the Mississippi River, where 92 per cent of the coal is produced and used, I venture the opinion that we do not have a hundred years' supply of coal—and in some of the most important fields where we are producing in good quantity—largely underground mines—there is not fifty years' supply.

I do not speak as one without some knowledge, because I have travelled over these coal fields and have examined mines in most of the areas. The recovery of coal is mostly a matter of economics, but the loss of tonnage is a serious matter with us. The statements we have been hearing during the past few days as to the enormous deposits of coal in America, I warn you that you had better discount them very materially. We have but a fraction of the coal predicted by the United States Geological Survey—and I anticipate the same thing regarding oil. Because we have found a certain quantity of oil in known sedimentary areas throughout the United States, I cannot see that you can project that throughout the entire world and expect to find relatively as much. And even if you can, you have to consider the economics of the situation. We are now drilling 16,000 feet or more in America, in the search for oil, and we have not found very much oil at extreme depths. I think we should also drastically discount the Professor's figures.

Mr. WEEKS: Mr. Crichton, who has just preceded me and who spoke from experience as a coal miner, said that he believes that the U.S.G.S. estimates of our coal reserves are greatly exaggerated. Basing his reasoning on his views with regard to coal, he expressed grave doubts about the figures of oil reserves cited by Mr. Levorsen. Earlier, Mr. Black, speaking as an economist, posed a number of pertinent questions. He asked, how can we be sure that population is going to increase at the rates predicted, based on past experience. Also, how do we know that we can develop and find a market for oil from large areas of the continental shelf in the Arctic, and so on. These are all good questions. We can appreciate that there are many things which cannot be accurately estimated. There is a saying that nothing is certain except death and taxes, and I sometimes get the feeling that the latter is the more certain of the two.

The estimates of undiscovered petroleum reserves in the world cited by Dr. Levorsen in his paper, and which he showed you on the screen, were prepared by me quite a number of years ago. Some modifications have been made since my first estimates were prepared, but the general order of magnitude of these estimates for individual areas has not changed. Moreover the effect of such revisions on the totals for the world and its major subdivisions has been even less noticeable. This does not mean that large revisions may not have to be made in the future.

Certain of these figures had been published prior to my publication of them. Two sets of figures were shown on the screen. Dr. Levorsen remarked that they were very similar. I think that the only reason why one of the sets of figures is a little bit different from mine is that I revised my earlier figures a little bit before I published them.

Since I am the culprit, I would like to discuss briefly the status of these estimates, which I like to call estimated potential reserves estimates, as distinct from proved reserves. (The dictionary defines potential as anything that may be possible; a possible development.) Clearly, they are not proved reserves and they should not be so regarded and used. On the other hand, I feel that unless the processes of analysis and reasoning resulting from long and extensive worldwide studies of sedimentary basins and the incidence of oil occurrence are understood and appreciated, their status might also be underestimated.

In my opinion it is more satisfactory to express one's ideas of the potentialities of an area, basin or region in terms of total oil, or in barrels per unit of area or per unit volume of sediments or per unit of exploratory effort, than as, say, "fair", "excellent" or by any of a number of other vague classifications such as are commonly used. Expressing the prospects of an area or basin in terms of ultimate recoverable oil forces thinking and analysis. It not only presents a definite picture of what you have in your mind but it offers a concrete basis for comparison of ideas and discussion.

The estimates of oil reserves were arrived at after extensive worldwide studies and careful analyses to find out empirically what the factors are that control the incidence of oil occurrence. Preliminary and basic studies include the origin and development of basins, and their classification based on origin, history, physical form or architecture and composition. They involve a study of sedimentation and deposition environment, the effects of the changes that occur progressively with different stages of the deposition cycle. These and many other factors determine the conditions which control the incidence of oil occurrence. They need to be understood in order to make the best analysis. We do not necessarily need to know exactly how oil is formed and accumulated in order to note and appreciate the basic facts regarding the incidence of its occurrence. There is a vast amount of empirical evidence on this available for analysis. Satisfactorily adequate data are not available in some cases. Fortunately, however, study and experience have shown that the features concerning which the data are less evident are intimately related to and controlled by the more obvious features of basin classification and architecture, regional history, etc., so that a fairly satisfactory evaluation can usually be made for the more difficult cases. There is not time here nor is this the place to go into a discussion of these technical features.

After arriving at an estimate of potential ultimate recoverable oil for a sedimentary area or basin or for any part or element thereof, various units may be used to measure the estimated productivity. The same units may be used to measure the proved productivity of extensively developed basins, such as many of those in the United States for example. The following units of measurement of productivity may be cited: barrels of oil per square mile, per cubic mile (cubem), per cubic kilometre (cubek), per unit of volume of sediments of certain facies, per unit of exploratory effort, per cent of the area of a basin or of any element thereof that should prove commercially productive, and estimated barrels of oil per acre considered average for fields under like circumstances.

History curves (trends) of discovery under any or all of the different units of measurement are built up for extensively or partially developed basins or areas. While the many possible units of measurement may be used as yardsticks in predicting by analogy what may be expected in little developed or undeveloped basins or elements of basins, there is no magic in any so-called yardstick. It is more accurate to call them units of measurement rather than yardsticks. Their principal virtue lies in their usefulness as a means for comparison or rating. Their successful employment in estimating the potentialities of the least explored or developed basins absolutely requires an understanding of the factors that control or determine the incidence of oil occurrence. The degree with which we are successful in their use depends upon the degree to which we as geologists can develop this understanding of oil occurrence or, may we say, the degree to which we have acquired wisdom with regard thereto.

Dr. Levorsen stated that prior to the discovery of the rich oil deposits of Arabia an estimate of the reserves would necessarily have been merely nominal. He also said it would have been impossible to convince anyone of the rich potential oil content of western Canada prior to the recent discoveries near Edmonton. Both of these statements might be true if we had nothing more upon which to base estimates of potential reserves than some major regional or world average figure of reserves per unit volume of sediments, which, Dr. Levorsen said, is the basis most commonly used for making estimates. That is not the method that I used to arrive at my figures. It is only a means used to measure and compare them. It so happens that my figures of potential ultimate recoverable reserves for western Canada were made long before the great discoveries of recent years. Actually my figures have been moderately reduced since.

My figure of 150 billion barrels of oil for the Middle East was prepared before most of all the major developments known today had been proved. The figure is one-fourth of my estimate for the world and is certainly not nominal. Mr. McLintock, who has closely followed developments in the Middle East, stated in his discussion that the proved oil reserves in that region now total between 70 and 100 billion barrels. Such figures are equal to or greater than Dr. Levorsen's figure of proved reserves for the entire world including the Middle East. Thus my figure of 150 billion barrels for potential ultimate recoverable, though truly enormous regardless of the "yardstick" applied, looks as if it may be somewhat too small.

This brings us to a further consideration of the distribution of petroleum in the sediments, a subject mentioned earlier and to which it will pay us now to briefly revert. Hydrocarbons are normal constituents of sedimentary rocks, just as gold, iron, coal, uranium, salt and so on, are normal constituents of the earth's crust. As with these other elements or compounds, the great bulk of the commercially recoverable petroleum occurs in certain specially favoured situations. It is not an exaggeration to state that fully 80 per cent of the commercially recoverable hydrocarbons in the world are accumulated in pools that are scattered through 20 per cent of the total volume of sediments or beneath 20 per cent of the total sedimentary area. Certain very definite conditions control the occurrence of all natural phenomena. One of the speakers in another session has shown that over half of the world's population lives on 5 per cent of the land area, mainly in the great river basins. In the case of petroleum, food and environmental conditions, and other interrelated features existent in the original deposition basin, controlled the growth, accumulation and preservation of the parent organic matter and the evolution and accumulation of the resulting hydrocarbons. Even though we do not understand all that we would like to understand about those conditions there is, fortunately, a vast amount of empirical evidence on the relation of oil occurrence to a great number of observable features of geology having to do with basin development, sedimentation, etc. Herein lie the true yardsticks, the recognition and use of which require much intensive analytical study and broad experience.

Even the best equipped geologist probably finds that there is a general tendency to arrive at underestimates for the most prolific basin areas and to overestimate the potentialities of the larger less important basin areas or regions. It is very dangerous for anyone blindly to compare areas, basins or countries on an area or volume basis. No two basins are alike even though they may be of the same class or genetic origin or architecture. Each has certain definite and major elements in its architecture or framework. The incidence of oil occurrence may vary much more between these different major elements or parts of any basin than it does between two basins of quite different class. The entire area of certain major parts of the most prolific of basins may be barren or largely barren of oil. Again, the present structure basin may constitute but a fraction of the original deposition basin to which oil occurrence is fundamentally related. A very large part, not uncommonly as much as three-fourths or more of the original deposition basin, may be now incorporated in the mountain rocks, and of course is out of the picture as far as oil occurrence is concerned.

As a general rule, an average figure for any of the units of measurement (so-called yardsticks) that I have listed can be more safely applied to very large regions or to whole continents. That stands to reason. The excesses and deficiencies of smaller areas over and below the averages tend to cancel out. However, there are important exceptions even here.

Barrels of oil per cubic mile of sediments, or any of the other units of measurement, may be used with discretion for checking the reasonableness of estimates for analogous situations. Again, if we are willing to agree that a large highly developed region with an average spread of basin and oil occurrence conditions, such as that of the United States, is approximately representative of the average situation throughout the world, we have here a basis for checking the reasonableness of the totals arrived at for the world. Let us briefly consider this comparison.

In the United States there had been discovered up to January 1, 1949, some 62 billion barrels of oil, of which about 37 billion have been produced, leaving close to 25 billion barrels of proved reserves. This is a discovery to date of 31,000 barrels of oil per cubic mile in the roughly two million cubic miles of effective basin sediments in the United States. Similar figures for various states or basin areas run from as little as 6,000 to 8,000 (Kentucky and Indiana) to as much as 200,000 (California) barrels of oil per cubic mile. Assuming that the volume of total ultimate oil discoveries in the United States, based on present conventional recovery practices and economics, will be 100 billion barrels (I think that my totals were 110 billion) that will amount to 50,000 barrels per cubic mile for the country's two million cubic miles of prospective basin sediments. The prospective basin area and the corresponding sedimentary volumes for the world are each roughly ten times the corresponding figure for the United States. By comparison with the United States, my 600 billion barrel figure of estimated ultimate proved and potential oil represents only 30,000 barrels per cubic mile for the approximately 20 million cubic miles of prospective sediments in the world's basins. In other words, the United States has already found an amount of oil equal to my estimate per cubic mile for the world. My world estimate of 600 billion barrels is six times that for the United States and ten times that of the volume already found in the United States.

I did not arrive at my estimate for the world by this "yardstick" method, but it does provide one of various means that can be used and have been used to cross-check or test the plausibility or reasonableness of estimates. I look upon my estimates for the United States as reasonable at this time. Furthermore, I now know of no good reason for considering that the incidence of oil occurrence in the United States should be much, if any, above that of the average for the world. As previously stated, I feel that the actual measure of oil recoverable by conventional methods and under present economies is more likely to be 50 per cent larger than 10 per cent smaller than my estimate of same. However, again I must warn that these are not proved reserves. The actual figure of ultimate reserves may very easily vary from my figure by considerably more than the percentages I have just cited.

In conclusion I would like to offer a few comments concerning the continental shelves. Dr. Levorsen cited a potential oil reserve estimate for the shelf sediments of a thousand billion barrels, a figure that is 66 per cent greater than my figures for all of the land areas of the world. I cannot go into all of the reasons here why I feel that this estimate for the shelf areas may be too large. Assuming for the moment that my figure of 610 billion barrels for the land is approximately correct, I think that a figure of 400 billion barrels of oil for the shelf sediments is more nearly comparable. I am willing to admit, however, that actual figures could be much more in each case.

A classification of the area and an estimate of the potential reserves for the shelves were made up by me several years ago. Although I came out with a figure approximately the same as the 600 billion barrel figure that I obtained for the land areas of the world, I have since considered this estimate to be too large for various reasons in comparison with that for the lands. The following discussion will briefly touch on some of the reasons.

Rather careful planimetering of the shelf areas on oceanographic maps shows that their area is scarcely 10 million square miles, or is not as large as the 14 million square mile figure cited by Levorsen. The area of the continental slopes adjacent to the shelves is approximately the same as that of the shelves; in other words, their area also is not as great as given in some published statements. A very large percentage of the shelf areas of the world comprise the continental platform edges of pre-Cambrian regions. Many of the wide shelves of the Arctic, which Mr. Black inquired about, are of this nature. During the past ten years, more or less, we have been learning a lot that is contrary to what we were taught in college about the distribution of sediments on the shelves, and about the nature of the geology under them. We shall, I feel, be learning a great deal more along these same lines about the entire ocean bottom geology in the next ten years, and this knowledge may greatly modify some of our ideas concerning continental platform and ocean bottom relationships and the corresponding physical changes in the crust through geologic history.

The final point that I wish to mention here is that oil in the sediments cannot be considered to constitute reserves unless it can be economically exploited. The cost of producing oil from the shelves will probably be appreciably greater than from the lands, hence the average minimum yield of commercial pools will be higher for the water areas. A study of oil occurrence shows us that in spite of the fact that the number of small oil accumulations greatly outnumbers the large, much the greater part of the discovered oil of the world is in the moderate-sized to large pools. There appears to be no good reason why this will not prove true for the water areas. As yet we have not had sufficient experience to tell us where the economic margin for water operations may lie.

[c]Mr. Jacqué spoke in French.

Mr. JACQUÉ:[c] The discussion which we have just heard and in the course of which very interesting points of view have been expressed has covered the field of evaluation of petroleum reserves, summarized by Professor Levorsen, as well as the future problems of rational utilization of solid and liquid fuels and of other forms of energy. It would seem from this exchange of views that the world is not threatened with a shortage of coal as well as of petroleum in too near a future, but that access to non-exploited reserves is becoming more difficult; in other words, man's ingenuity must evolve new methods either to reach deep-lying deposits or to utilize types of fuel too difficult to use in the past.

I wish to stress once more the fact that the relative position of the various fuels differs widely in the various regions of the globe. I have been struck by the sharp competition—which I can only hope will be remedied—existing in the United States between the heavy fuels derived from petroleum and certain kinds of coal, a competition which seems at times to take a tragic turn and which raises difficulties that can be solved only by a better balance. And what of Europe, where coal is generally obtained with far greater use of labour than in the United States?

Perhaps one of our United States colleagues could tell us on the average what amount of labour is needed to produce a ton of petroleum or an equivalent amount of energy derived from petroleum, and to produce the equivalent in coal. I can only say that in Europe coal production (my figures are subject to correction) is roughly a ton or a ton-and-a-half to two tons per man per day, while in the United States I think it is often three, four, six or more tons, depending on the mine.

The production of petroleum, on the other hand, generally averages a few dozen tons, or at least ten to fifteen tons per man. Thus we see that in many European countries which have to import coal, petroleum requires less labour and, as has been pointed out, also costs less.

That is one of the reasons why I hope, without partiality towards any particular fuel, that the development of mining techniques and coal use will permit coal to play a more important part and thus bring about a balance in the utilization of our resources.

The CHAIRMAN: I think no one can complain of any lack of a high diversity factor in the course which the discussion has taken. The subject of competitive fuels is a difficult one to discuss because, as has been said, it does depend so largely on local conditions; there is no general answer to it. I think we have had some very interesting opinions from various sides.

In closing the meeting I should like to thank all those who have taken part in the discussion, and particularly Professor Levorsen for his paper and Mr. Jacqué for introducing the discussion.

Metals and Minerals

Tuesday Afternoon, 23 August 1949

Chairman:

Fernand BLONDEL, Director of the *Bureau d'Etudes géologiques et minières coloniales,* Paris, France

Contributed Papers:

Metals in Relation to Living Standards in Industrially Under-Developed Countries

D.N. WADIA, Geological Adviser, Department of Scientific Research, Government of India

Metals and the Standard of Living

Howard MEYERHOFF, Administrative Secretary, American Association for the Advancement of Science, Washington, D.C., U.S.A.

Conservation of Mineral Resources

Donald McLAUGHLIN, San Francisco, California, U.S.A.

Discussion:

Messrs. DREUX, ERSELCUK, KEENLEYSIDE, SCHIMMEL

Programme Director:

Carter GOODRICH

Programme Officer:

Herbert SCHIMMEL

Mr. Wadia's paper was presented by Mr. M.S. Krishman, Director, Bureau of Mines, Government of India

The CHAIRMAN:[a] The Secretary-General has conferred a great honour on me by selecting me to serve as the Chairman of this plenary meeting which will deal with the problems of minerals, and I hope that as your temporary Chairman, I shall not disappoint you.

The importance of the mineral industry in modern life is a generally admitted fact. Similarly there is no need to point out that historians have divided the history of humanity into large periods defined by minerals: the Stone Age, the Bronze Age and the Iron Age. We are now in the Atomic Age, which likewise depends on mineral resources. But we, the mining engineers and geologists, are none too proud of that fact. We are beginning to realize ever more clearly that we have been the sorcerer's apprentices who have released forces and created problems which, for the time being, are beyond our powers. We are no longer able to deal with many of these questions. And we are therefore beginning to reflect on the human, economic and social consequences of these developments.

This frame of mind is relatively recent, at least as expressed in a systematic form. I am teaching in Paris the first course entitled "Mineral Economy". And to my knowledge the books which have dealt with these questions in a systematic manner can be counted on the fingers of one hand. But we have begun to reflect in view of the unexpected results of the extraordinary development of mineral production. Those who dreamed used to think—many still think so—that mineral production would usher in the Golden Age. Those who have taken part in international affairs and who have considered these problems carefully are none too certain of that, and even wonder if we are not hastening towards some tremendous catastrophe provoked by the unforeseen results of all these discoveries and exploitations.

However that may be, the problem of mineral resources and of their use remains. It is certainly a very important subject of this Conference. We will not be able to deal with the subject exhaustively. We can only point out some of its elements.

I think that Mr. Keenleyside, in his remarkable paper presented at the plenary meeting of 18 August, drew attention to the essential points. I cannot do better than recall the three fundamental questions which should be studied in detail in order to understand this problem. As indicated by Mr. Keenleyside, they are:

1. The demand for the consumption of mineral products will continue to increase as a result of the development of the world population and the rise in the standard of living;

2. In order to meet that increasing demand, an attempt should be made to utilize to the best advantage the presently known deposits;

3. Moreover, new deposits should be found by increased prospecting.

The third question, that of prospecting, will be the subject of a paper which I shall submit in the plenary meeting of next Monday. Today, the reports which have been submitted deal with the first two questions. Let us glance over them rapidly in order to understand the meaning of the papers we shall hear and discuss.

In the first place, the demand for the consumption of mineral products has increased prodigiously since the last century. There is no need to repeat that fact. But what is the economic truth on which that recent rapid increase and the probable future increase are based? That is the first point which the two papers, by Dr. Wadia and Dr. Meyerhoff, will analyse this afternoon.

It is generally said that a people's standard of living is higher in proportion as its consumption of mineral products is greater. Dr. Meyerhoff will discuss that often repeated statement. But it is easy to note that the geographical distribution of mineral consumption is very unequal, whether related or not to the standard of living. Dr. Meyerhoff will make some pertinent remarks on that subject.

Dr. Wadia, on the other hand, stresses the situation of the peoples of Asia, whose mineral consumption is relatively insignificant if compared to that of Western nations. The problem of the world distribution of mineral resources arises. Dr. Meyerhoff will reply to that question.

Whatever position is taken with regard to that subject, there is no doubt that the demand for mineral products will continue to increase. In order to meet that increasing demand, the deposits at present exploited should give the greatest returns possible. That is the question on the agenda which will be dealt with by Mr. McLaughlin. Better returns are obtained by better technique, but will that better technique not necessarily result in the better, total utilization of a deposit? That is the meaning which can be given to the problem of the conservation of deposits. Mr. McLaughlin will give his answer, which can of course be discussed.

That is the programme we are proposing to you today. As you see, it covers fundamental problems in the study of mineral resources. I suggest that the three papers should be submitted first, in turn, and that the discussion of these three documents should then follow. There is, in fact, a very close connexion between the three questions, and I think that a general discussion is preferable. I shall therefore begin by giving the floor, not to Dr. Wadia, who unfortunately is not present, but to Dr. Krishnan, Director, India Bureau of Mines, who will present Dr. Wadia's communication.

Dr. Wadia is a well-known scientist from India. He was a Professor of Geology, and has been a member of the "Geological Survey of India". He was then a mineralogist of the Government in Ceylon, from 1939 to 1944, and was the Mineral Adviser for the Indian Government in 1945.

I feel that it is hardly necessary to introduce Dr. Krishnan; everyone knows him, especially since he presided this morning over the meeting on mineral resources.

Mr KRISHNAN *delivered the following paper:*

[a]The Chairman spoke in French.

Metals in Relation to Living Standards (In Industrially Under-developed Countries)

D. N. WADIA

ABSTRACT

The *per capita* as well as the aggregate consumption of metals in industrially under-developed countries of the East has been insignificant for domestic, agricultural and industrial uses. The role of these countries has been to mine and export raw ores of tin, manganese, chromium, antimony, tungsten etc., and the problem of metal depletion facing Europe and America has not yet become grave to them. But a growing trend towards conservation of mineral resources and their utilization for national benefit, or barter on a more reciprocal basis, will be the most significant development of the coming decade in these countries. India and many eastern nations have made five-year or ten-year development plans for industrialization, agricultural development, mechanized transport, hydro-electric and other multi-purpose water-power schemes etc., which will need fabricated metals in unprecedented quantities from the industrially developed countries. This demand should be adjusted against capacity to supply their mineral and metal surpluses compatible with up-to-date principles of resource conservation. To foster such interdependence of countries for mutual benefit, should be the goal of the United Nations Conference.

INTRODUCTION

Metals form one of the earth's most important resources in the support and enrichment of human life. In ancient and mediaeval times, metals helped man directly in his various avocations, his arts and crafts, raised his standard of living and lent grace to life by their use in the fine arts. Modern man today needs metals as much for the munitions of his destructive wars as for implementing human welfare in daily life.

The depletion of the earth's store of metals has increased progressively since the eighteenth century, but with the twentieth century era of world wars it is going to become one of the biggest problems of the next century. Since 1914, more basic metals have been used up (a large part either destroyed or irreclaimably locked up) than during the whole of human history. The diminishing reserves of metals such as tin, lead and zinc have already become a problem. The eighteenth International Geological Congress held at London in August 1948 devoted a special section to the discussion of "The geology, paragenesis and reserves of the ores of lead and zinc" which brought out this feature in relief. Doubtless in some measure the substitution of plastics and alloys of the light metals which are in more abundant supply, and discovery of new reserves in the remaining unexplored countries, together with resort to deeper mining and developments in the practice of ore-refining and upgrading, may put off the scarcity for two or three generations, but the lesson of metal depletion from the accessible parts of the earth's crust should be taken as nature's grim warning that man is spending away a prime treasure which is non-replenishable.

The critical shortage in metals is most seriously felt up to now only in respect of tin, lead and zinc, but signs are apparent that accessible deposits of copper, nickel, manganese, wolfram and antimony are diminishing and new discovery is not keeping pace with demand. The extractable stock of platinum, silver and gold left for future needs within minable depth, is becoming meagre. The situation, though general for the whole world, however, is becoming acute in the Western Hemisphere, chiefly the countries around the North Atlantic border, where modern standards of life demand an inordinate use of metals; for the Eastern countries whose consumption of metals is comparatively insignificant and who have only played the role of miners of tin, manganese, wolfram, antimony and their accessories, for wholesale export to the West, the situation is not so grave. This dis-equilibrium in the world's mineral economics calls for adjustment by wise and equitable solution and not by resort to the old policy of colonial exploitation, tariff barriers etc., against weaker nations.

TRENDS IN THE USE OF METALS

Since the advent of the industrial era, the under-developed countries of the world have been exploited for their metals and ores by the industrially developed countries. Tin, manganese, wolfram and antimony have thus flowed in increasing volume from Malaya, Siam, India, Burma, China, Indonesia, to Europe and North America. The *per capita* consumption of these metals in the producing countries has been negligible, and to the extent to which their mineral production has helped the development of metal industries of the world since 1850 must be measured their share in the spread of the industrial civilization of the last century. But the material return obtained by these countries for this service has been disproportionately small in most instances. This factor will tend to restrict, in the coming era of self-determination for each nation, the flow of minerals and metals in future, except for more substantial gains. A growing trend towards conservation of mineral resources in hitherto backward countries and their utilization (or barter) for national benefit will be the most significant development of the coming decade. The natural result of this may be that the large engineering and manufacturing industries of the world will not be able to draw so unrestrictedly as in the past, on ores and raw materials except on the basis of reciprocity and on more liberal terms of exchange with manufactured goods which these backward countries need in building up a more healthy national economy and standard of living.

India has supplied 40 million tons of manganese ores of the higher grade since 1900 at a price but little above the cost of mining and transport to the consumer. Malaya, Indonesia, Siam and China have supplied 5½ million tons of primary pig-tin during the same interval and still continue to furnish the major part of the world's demand for this essential metal, for which no substitute is in sight. The largest supply of the strategic metal tungsten (78 per cent) has come from China, Burma and Malaya, ever since the discovery of its high potential in war and defence. China's mines supply 71 per cent of antimony, maintenance of which is vital to a number of industries. In a similar category must be placed the regular pre-war exports of over two million tons of iron-ore to Japan, an industrially developed country, by Malaya and other undeveloped countries. Ceylon has supplied 1¼ million tons of superior graphite (indispensable for metal smelting) during the last sixty years.

LACK OF POLICY OF CONSERVATION

None of these countries had any mineral conservation policy in the past and mining practice was unscientific, uneconomic and inefficient. A national conservation policy must imply complete and accurate appraisal of resources by organized resource surveys. With the exception of India, where an official geological survey has been in existence for nearly a century and which has since the war been quadrupled—and to a less extent in China, Burma and Malaya—no scientific agency for mineral resource estimation, sampling and geological exploration on modern lines has been at work in Asiatic countries until very recently. The technique of aerial survey and mapping, geo-physical investigation at depth, statistical control in resource assessment and mining, are being gradually applied in India after decades of experience of unsound mining and the despoiling of depletable and non-renewable resources for export purposes.

But new trends are appearing in these post-war years. India has now a Bureau of Mines which is planning a programme of detailed appraisal of mineral deposits with systematic testing, stoppage of haphazard mining, ore beneficiation and use of statistics in enforcing conservation by local processing and utilization. Education and training of technical and mining personnel for putting into practice the chief elements of this programme have been undertaken since 1945. It is only a matter of time for other countries of south-east Asia, which have metalliferous minerals, to follow in the wake of this programme.. In these countries the pressure of increasing population, rising living standards, especially of food and public health, is creating an insistent desire for proper development, conservation and utilization of their mineral wealth, viz., use of new techniques, and effective controls of export of raw products, in place of the *laissez faire* attitude of the past. Everywhere there is a sustained drive to bring into use mineral resources as yet untapped, to build up with the revenues obtained from this source more productive and diversified economies. The idea has slowly dawned that national resources must be cultivated for enriching the life of the people by judicious use and conservation.

The general lack of trained geological and mining personnel, technicians, engineers and other experts in the specific fields is being made good slowly by an intensive educational effort in training in local institutions, overseas scholarships and engagement of foreign experts on contract.

EXTENT OF METAL RESOURCES OF INDIA AND COUNTRIES OF THE FAR EAST

The resources of India in certain metals and ores are fully adequate to support higher living standards for the masses, which is the aim of national planning. They are of a scale to ensure supply of indigenous needs for centuries and still leave an exportable surplus margin. The measured and estimated deposits of iron, manganese, aluminium, titanium-ores and the ferro-alloy metals, chromium and vanadium, give promise of India's becoming in the foreseeable future an important metallurgical centre for ferrous metals and alloys and for the light-metal alloys. The strategic metals thorium and beryllium have been located in deposits of considerable size. Against this, the position in respect of the non-ferrous metals, lead, zinc, copper, cobalt and nickel is one of scarcity which future more detailed exploration may in part remove, and of a more permanent deficiency in respect of tin, silver, platinum and mercury. A few notes on the existing proved and prospective metal resources of India, with statistics of production and reserves, are given on pages 115 to 117.

Burma has notable resources of wolfram and ores of lead, zinc, tin, nickel; China is believed to have the biggest iron reserves in the western Pacific region, next only to the vast reserves of Singhbhum—Orissa in India, while her known tungsten and antimony reserves are yet of considerable magnitude. Sixty per cent of the tungsten and 71 per cent of the antimony of the world is mined from these two countries from deposits which are regarded as ample for future needs. Malaya has moderate supplies of magnetic iron-ores, the chief source of supply to Japan. In tin, the south-east Asiatic countries Malaya, Indonesia, Siam, China and Burma virtually dominate world production, though both production and distribution of tin has long been controlled by the international tin cartel, which has prevented some of these countries from reaping the full benefit of their valuable natural asset. An indispensable accessory to metallurgical industries is graphite, of which Ceylon holds large reserves of pure crystalline and flake graphite, enough to last the world for a long period.

OUTLOOK FOR DEVELOPMENTS AND POTENTIALITIES

Expansion of these resources by discovery of new, or partly explored, or suspected deposits in the industrially under-developed countries named above, is distinctly promising. On the other hand, the promise is limited by the difficulty and cost of the new methods of exploration, geophysical and geochemical, and insufficiently trained personnel. These features will retard the rate of discovery of new resources. These adverse factors have in the past, however, proved to be not wholly disadvantageous, as they were the very factors that tended to conserve the underground resources of many undeveloped countries from too rapid depletion. In the race for export of ores for which no indigenous market existed, and the inducement of small immediate gain, the majority of the metal resources of these countries was mined haphazardly and unsystematically, the last consideration being given to any aspect of conservation. In countries which mine principally for export, this is the only aspect of conservation that needs effective safeguarding today as it is the most serious threat to the world's mineral economy. The other aspects of metal resource conservation, viz., conservation of ore milling and concentration and conservation by substitution, reclamation, utilization of scrap, etc., are problems of the future when the mining industry will have reached the second stage, viz., manufacture of the products of mines.

METAL REQUIREMENTS FOR INDUSTRIAL AND AGRICULTURAL DEVELOPMENTS

Accurate data and statistics of metal and ore production for export as well as for local consumption are unavailable for most Asiatic countries. Whatever ore is mined (and a considerable aggregate quantity as well as variety is mined) is mostly for trade purposes, for export overseas. The return for this is principally in the shape of consumer goods of general description and very subordinately in the form of processed or fabricated metals. Thus the *per capita* use of metals in the everyday life of the people of these countries is not ascertainable through official statistics, beyond the knowledge that it is as yet abnormally small. A trend toward increased use of metals is slowly setting in, not for ordinary domestic or private life, but for such general utility purposes as public-works, engineering, railways, river navigation, etc.

The use of metals in agriculture in all the Asiatic countries is limited to a few primitive iron tools which the village smith fashions out of the local ores, with forest fuel. All through the ages man in Asia has made little use of metals in industry and agriculture, but he has developed a remarkable skill in fashioning and alloying the metals, iron, copper, zinc, silver and tin, for his domestic utensils, the most obvious military weapons and articles of fine art. Ancient India acquired a high reputation in the metallurgy of iron and steel, copper, zinc and bronze. The fame of the ancient Indian steel wootz, in demand in Europe for sword blades, the fourth --century iron pillar of Delhi, a solid shaft of rustless wrought iron, 16″ in diameter, and 23′ 8″ high, and the ornamental bronzes and statuary of the fifth to tenth centuries are examples.

It would perhaps be too much to say that the comparatively small productivity of Indian agriculture in cereals, livestock and commercial crops is related to the small use of metals, or that more use of metals would mean better tillage. The age-old peasant traditions in India lend no support to these presumptions; at the same time on a broad view of the problem, metals and machines are a *sine qua non* of large scale agricultural practice, collective farming, reclamation of waste land, swamps and forests. Mechanized transport would bring fields, farms and factories nearer to markets. These are obvious facts, but rural and agricultural India, divided into 700,000 villages, reacts slowly to new forces.

Signs of mechanization of agriculture in some Asiatic countries are already becoming visible and the tractor-plough might become as popular in time as the motor-bus in the less remote parts, at any rate, of rural India. In industry, the pace is much quicker and the demand in India for pig-iron and steel, which used to be satisfied with about two million tons of the former and one million tons of the latter, put out by the Indian iron and steel plants in pre-war days, has increased fourfold at the present day. Better housing, road building, motor transport, electrification programmes, cottage industries and the spread of air-conditioning in tropical climates, will continue to swell these demands for metals in time. These, with heavy engineering plant and machinery required for the various multi-purpose water-power, irrigation and industrialization schemes which India and several Asiatic countries have launched since the war, will bring about a revolutionary rise in the East's demand for fabricated metals from a few hundred thousand tons to several million tons. To a limited extent, the indigenous resources of the Asiatic countries will be able to cope with these steeply rising needs in metals but a good part will have to be satisfied with imports from abroad. This demand will have to be adjusted against their capacity and willingness to continue to supply raw materials to the more advanced industrial countries. To foster such interdependence of countries on the world's material resources and thus attempt to establish an equilibrium between these two sets of countries into which the world is unhappily divided today, should be the goal of the United Nations Economic and Social Council. A desire for a friendly and satisfactory adjustment of this demand and supply for metals and minerals in meeting each other's wants and deficits in the coming years, will be the best guarantee for the war-damaged peace of the world.

PRINCIPAL METAL RESERVES OF INDIA, PRODUCTION STATISTICS ETC.

Data and statistics regarding the following twenty metals found in deposits of workable size in India are given below:

Aluminium: Ore reserves are computed at about 250 million tons (Al_2O_3 + 50 per cent); the deposits are fairly widespread throughout the country, in Bihar, Central Provinces, the Western Ghats, Kashmir and Madras. The annual production of aluminium in India is yet small: 4,000 tons, against a requirement of 15,000 tons.

Antimony: A deposit in Pakistan (Chitral) supplied about 1,000 tons of ore per year during the war. The smelting and refining was done at Bombay. China is the world's largest producer of antimony (about 16,000 tons in pre-war years), the largest deposits being found in the province of Hunan. The ore is smelted near the mines.

Beryllium: During the war India exported considerable quantities of beryl. Beryl from Rajputana and Bihar is prized because it contains 11 to 14 per cent of BeO. The export of beryl has been prohibited since 1946. Research on the isolation of beryllium and beryllium oxide is being carried out by a committee of the Board of Scientific and Industrial Research.

Chromium: Chromite is produced in Bihar, Orissa and Pakistan (Baluchistan), the last locality possessing large reserves. The production has been around 50,000 tons per year, the bulk of which was exported. Possibilities of upgrading lean chromite ores and manufacture of ferro-chrome are being investigated.

Cobalt: The only area within the geographical limits of India which has reported deposits of cobalt is Nepal but the geology and probable reserves are not yet investigated.

Copper: The chief producing area is Singhbhum (Bihar) which has an annual output of about 6,500 tons of metallic copper. Reported deposits are under investigation. A number of abandoned sites where a copper industry flourished till a century or two ago are known; these supplied all the needs of India in copper and brass in mediaeval times. Burma produced copper matte (about 13,000 tons in the pre-war years) but the ore reserves are not large. Annual consumption of copper in India is 40,000 tons.

Gold: Annual production averages 300,000 fine ozs. The gold mines of Kolar (Mysore) are now over 9,200 feet deep, the deepest metal mines in the world. The ore persists at this depth, but the problem of rock-bursts is increasing in severity.

Iron: India's resources in iron-ore are of vast extent. In the district of Singhbhum and adjoining parts of Orissa the reserves occurring at the surface are computed at over 8,000 million tons (metal content 60 to 65 per cent). The reserves in the Central Provinces and parts of Madras are also large. In contrast with the vastness of ore reserves, however, the annual production of pig-iron and steel still remains small (2 million tons of pig-iron and about 900,000 tons of steel). New steel plants are being installed and the manufacture of a range of ferro-alloys is being considered.

China's iron-ore reserves are next only to India's, though they have not been fully investigated and the production still remains small.

Lead: Production of lead in India is insignificant at the present time though two centuries ago considerable ingot lead was produced in several parts of the country, mainly for military requirements. India's annual lead import is about 8,000 tons.

Burma produced 75,000 tons of ingot lead in pre-war years. Reserves of lead-zinc-silver ores at the Baldwin Mines are calculated at 4 million tons, containing 16 oz. of silver to the ton.

Magnesium: Magnesite deposits of large extent and a high degree of chemical purity occur in Madras. In Salem the estimated reserve is 90 million tons, analysing over 96 per cent of magnesium-carbonate. A considerable part of the annual output is exported. Research on the preparation of metallic magnesium and light-metal alloys, principally with aluminium, is under investigation by the Board of Scientific and Industrial Research.

Manganese: Annual exports from India of high grade manganese have often touched the 1 million ton mark during the last twenty years. Proved reserves of the richer grade ores (48 to 70 per cent) are computed at only about 15 to 20 million tons; the reserves of lower grade ores (Mn 40 to 30 per cent) are several times this magnitude. Beneficiation of the latter by simple mechanical means will greatly add to the country's resources in this metal. Manufacture of ferro-manganese in India is being investigated and the unrestricted export of manganese ore has now been controlled by the Government.

Nickel: There is a paucity of nickel-ore in India; the only notable occurrence of nickel-ores is reported from a locality in Nepal, but detailed prospecting and geological examination have not been done to ascertain the quantity and extent of the deposit.

The Baldwin mines of Burma produced nickel speiss, averaging 3,000 tons annually during the pre-war years, containing 25 to 30 per cent of nickel. Annual consumption of nickel in India is about 2,000 tons.

Strontium: Large deposits of remarkably pure celestite, aggregating about a million tons each, occur in the Trichinopoly district of Madras and in a West Punjab district (Pakistan). The mineral has not found industrial use in India yet.

Thorium: The thorium resources of India are considerable. ThO_2 is a constant ingredient of the mineral monazite occurring in the form of beach sands, covering large areas of the Travancore coast. These beach deposits constitute a large potential source of thorium, which has now assumed strategic importance as an atomic fuel or a source of atomic energy. The export of monazite for strategic reasons is now prohibited by the Government.

Titanium: The mineral ilmenite is widely distributed in India and constitutes an important mineral asset of the country. It occurs as highly concentrated black sand along a hundred mile stretch of the Travancore coast. About 75 per cent of the world's requirements in titanium, ranging between 200,000 to 300,000 tons per annum, was, prior to 1940, supplied by Travancore. The percentage of TiO_2 in Travancore ilmenite runs to 52 to 62; the total reserves of ilmenite are estimated at over 300 million tons. Rutile is associated with ilmenite sands.

A considerable accumulation of ilmenite occurs in association with the alluvial deposits of tin-ore in Malaya from which it is separated by magnetic concentration.

Tin: This metal does not occur in India in any appreciable quantity. Malaya is the world's largest supplier of tin-ore, the quantity varying from 33,000 to 77,000 tons per annum (pre-war production), constituting about one-third the world's basic tonnage in this metal. This figure represents the entire output of Malayan mines. During the last twenty years many of the richer placers have been exhausted. The largest proportion of the ore is obtained by dredging the alluvial and eluvial deposits. The remaining ore reserves are considered to be large. Indonesia and Siam are the next largest producers of tin-ore in south-east Asia, their share being 19,000 and 10,500 tons respectively per annum. China comes next with 6,500 tons. All the ore is mined by more or less primitive methods from shallow alluvial flats.

Tungsten: A small deposit of this metal was worked in India during the war years. The world's largest producer of this valuable alloy metal is China which still maintains its leadership in this metal in spite of disturbed political conditions. The production in pre-war years was 11,000 to 17,000 tons, the present output being much smaller. The ore is worked from large placer deposits of detrital stream-tin. The next largest exporter is Burma with 5,000 to 6,000 tons (pre-war), followed by Chosen, 1,500 to 2,000 tons, and Malaya, from a few hundred to 2,000 tons. No part of the ore extracted is used indigenously in these countries.

Uranium: Sporadic deposits of uranium-bearing minerals have been found in various localities in India, the largest being segregations of pitch-blende in mica-pegmatites in Bihar, from which a few tons were obtained some years ago. Geological work has revealed that such deposits are incapable of supporting continuous mining. Minerals containing the rare earths and metals have been observed in pegmatites traversing the mica fields of Bihar and Madras, viz, samarskite, gadolinite, columbite, tantalite, allanite, triplite, torbernite and thorianite.

Vanadium: Considerable reserves of this metal have been localized in parts of Bihar and Orissa as vanadium-bearing iron-ores; the vanadium occurs in these areas in amounts varying from 0.8 to 3.0 per cent. The total reserves of vanadiferous iron-ore is estimated at 3 to 5 million tons. The utilization of these ores for manufacture of vanadium-steel is under consideration.

Zinc: Zinc lodes have been observed in a few localities in India but no smelting of zinc is practised there today. Slag deposits of large size in these districts suggest a flourishing zinc industry in mediaeval times, the zinc being refined for manufacture of brass and bronze for local consumption. The annual consumption of zinc in India, at present about 30,000 to 35,000 tons, is wholly met by imports.

Zirconium: Reserves of this metal are ample, but at present an irregular output of only 100 to 1,500 tons of the mineral zircon is worked for purposes of export.

The CHAIRMAN: Ladies and gentlemen, you have certainly not failed to note with what clarity, in Dr. Wadia's paper, which Dr. Krishnan read to us, the mineral problem was raised with regard to the underdeveloped countries of the Far East. It is doubtless unnecessary for the time being to dwell further on that point. I shall merely draw attention to the particular gravity of the problem.

I now invite Dr. Meyerhoff to take the floor.

Dr. Meyerhoff is at present the Secretary of the American Association for the Advancement of Science and is a Professor of Geology at Smith College. He has exercised his profession in Puerto Rico. He was Councillor to the Dominican Government, and he has also worked in Argentina. You will thus realize that his international career has been a distinguished one. And you will be convinced of that when you have heard his paper, for which I thank him in advance.

Mr. MEYERHOFF *delivered the following paper:*

Metals and the Standard of Living

HOWARD A. MEYERHOFF

ABSTRACT

The rapid increase in the volume of metal production since 1914 has tempted experts to correlate metallic output and living standards. Upon analysis it is found that the correlation factor is low if based on production, and only moderately higher if based on consumption. Living standards depend upon productivity, which is a function of integrated regional economies. The natural or geographic regions that comprise the earth's economic units are unrelated to political boundaries, and integration is seriously impaired by artificial restrictions imposed by nationalistic interests. The expanding geography of metal supply demonstrates the international, rather than national, character of the world's economy; and if the production, processing and utilization of metals are to make their proper contribution to improvements in living standards, there must be regulated but unrestricted exploration, exploitation and movement of all essential raw materials and of the manufactured goods that foster higher productivity and create exchange.

What we choose to call "modern industrial civilization" is so obviously dependent upon metals that scientists, economists, and even diplomats have from time to time indulged in much loose thinking about the relationship. Historically, the industrial revolution derived from the blast furnace, in which coking coal and iron ore were combined for the mass production of machines. Credit for the ensuing radical changes in the standard of living has, for the most part, been shared by coal and iron. It is pertinent to ask whether the credit has been correctly assigned.

Superficially, a case can be made for the fuel and the metal which have played this vital role. Britain, where the industrial revolution had its birth and where it first developed into maturity, exploited native coal and iron, and rose to power with the backing of her own mineral wealth. Ruhr coal and Lorraine iron brought industrial and military pre-eminence to Germany. In larger countries, such as the United States and the Union of Soviet Socialist Republics, industrial patterns evolved in genetic relationship with coal fields and accessible deposits of iron ore. Appalachian and Eastern Interior coals have been conveniently joined with Lake Superior iron, and an important development has centered around local deposits of these two raw materials in Alabama. In the Ukraine and its margins, the Donets Basin has furnished the fuel for the Krivoi Rog iron, and the producing areas from the industrial nucleus of European Russia.

Elsewhere in the world, however, heavy industry has taken root more slowly, and it is in these regions that we can more critically analyze the factors affecting growth. In western United States, for example, innumerable studies and surveys have been directed toward the establishment of steel mills whose products might compete with those shipped overland or via the Panama Canal from eastern centers of production. The exigencies of war forced the issue, and the steel mill at Fontana, California, was compelled to seek its coking coal from mines 800 miles away in Utah. Russia assembled raw materials that were mined 1200 miles apart when steel centers were constructed in Western Siberia at Magnitogorsk in the Ural Mountains and at Stalinsk in the Kuznetsk Basin. Brazil is trying to meet the domestic demand for steel by bringing mediocre coal from Santa Catharina and iron ore from Minas Geraes together at Volta Redonda. The most recent effort to solve domestic problems of supply is in Chile, where ores from the Coquimbo district, 250 miles north of Santiago, are being processed with low-grade coal from the Concepción district, 300 miles south of the capital city. Whether these newer developments in heavy industry are founded on a sound economic structure that will enable them to endure has not yet been proven, but they illustrate a trend that calls for analysis.

Although coking coal and iron ore are the *sine qua non* of heavy industry, it does not follow that high standards of living in the countries that possess either or both of these raw materials are directly or even genetically related to them. One need merely compare the poverty of the masses in Singhbhum and Orissa in northeastern India, where one of the largest steel operations in Asia is located, with the relative prosperity of the Danes, who have neither coal nor iron, to realize that possession of mineral raw materials bears at best a casual relation to standards of living. Or, if the contrast chosen is not convincing, prewar living standards of the mill and agricultural workers in the Fushun center of heavy industry in Manchuria may be compared with those of the Uruguayans, who lack coal and iron.

In brief, it is not the possession or the fabrication of metals that makes a nation and its people poor or rich. Nor should it be concluded that the proverbial wealth of metallic resources has been diverted to make the capitalist rich and to keep the masses at subsistence levels. For the steel mill laborer of Pittsburgh or Gary, employed by American capital, knows a far higher standard of living than the mill hand at Magnitogorsk, who works for the Communist government. And the latter is far better off than his counterpart in the Tata Iron and Steel Works of northeast India, where operations are managed by private interests. The facts offer no support whatever for ideologies.

Labor organizations may claim some credit for the high wage levels and hence for the standard of living achieved by workers in American mills; and it is true that it has taken pressure from organized groups to increase wages and to improve working conditions to such limits as the steel industry can bear. The industry can hardly point with pride to the sordid housing conditions that it condoned, and even maintained, until a comparatively recent date in the coal-mining and steel districts of the United States and Britain; it is a fact also that those enterprises which were initiated under state capitalism have, in general, started on a higher economic and sociological plane than those begun by private capital. But all the ventures that owe their origins to state capital started late in the history of the steel industry and hence had advantages that were unavailable to private capital. The latter pioneered and built the industry; it staked hard-won savings, knowing that the cost of failure was bankruptcy; it created employment where none existed and, for the most part, under conditions where standards of health, safety, housing, and general living were nonexistent or only vaguely defined. Belatedly entering the field, state capital, on the other hand, found an established industry, with clearly delineated markets; with taxpayers' money to back the enterprises, risk of financial failure was minimized; with the technological improvements made chiefly by private industry at their disposal, the state enterprises had no need and little incentive to contribute to the technical advance of the industry. The greatest contribution of state-financed mining and steel operations has been in the sociological field. Responsible to the public, and conscious of the hard-fought battles for better wages and more tolerable working conditions carried on by organized labor, the state shrewdly made the most of the economic and sociological *status quo*, and, as a consequence of starting where private industry left off, its industrial relations have been unimpaired by embittered memories of former strife.

On this historical basis it can be—and has been—argued that organized labor and state enterprise have been the champions of higher living standards against private capitalism. But even if the argument be conceded, it does not explain the disparity in such standards in different industrial districts in many parts of the world, or the comparability of industrial and nonindustrial regions elsewhere. Upon analysis it becomes evident that economic and sociological battles have been won only in those areas where wealth has been and is being created, and hence where wealth is available for distribution. Our question, then, is whether metals contribute substantially to the wealth that makes high living standards possible; and if so, how.

The point which has been made for iron applies to all other metals: No nation is rich by virtue of the simple fact of possession, nor is the act of exploitation in itself of vital significance in determining standards of living. It is, however, the first step in the creation of new wealth, and to this extent the mining industries may be regarded as a cornerstone in the foundation of distributed wealth, which is the basis of good living. Over 90 percent of the nations contribute to the world's stock of metallic raw materials, and, in a degree that is roughly proportional to volume times value of the metals mined, the mining industry makes its small contribution to national income and well-being.

The rising tide of nationalism in recent years has led many an uninformed politico to overestimate the economic value of mineral production, which makes it doubly important to see this value in proper perspective. The precious metals add directly to wealth in that they can be instantly converted into acceptable media of domestic and international exchange, with universally recognized though fluctuating exchange values. It is important to note that the increment added to national wealth is not the total value of the metal mined, but rather its value minus costs of production; yet the costs of production play a significant part in economic conditions, too. Although they utilize wealth already produced, the expenditure of this wealth accelerates the velocity of monetary circulation, and in this manner standards of living in countries that mine gold which quickly finds its way into international exchange will improve both to the limits of the profit on the operation and to the degree that money already in circulation changes hands at an accelerated velocity by participation in the mining operation.[1]

[1]Although there are additional factors that should be considered, the value of a mining industry to a country or region may be approximated by use of the following formula:

$$L = \frac{(V-C)u + (C-d)ua}{P}$$

where L = increase in living standards by addition to individual income, V = market value of the metal mined, C = all costs of production per unit, u = units or quantity of metal produced, d = depreciation, a = rate of acceleration of money utilized to defray operating costs, and P = population directly or indirectly affected by the operation.

In the case of the ferrous metals and alloys, as well as the base and light metals, mining produces ores that have low values in comparison with the prices of the refined metals obtained from them, and several processes, including especially the formidable expense of handling and long-distance transportation, may lie between the ore at the mine mouth and the marketable metal. Obviously, values increase and the velocity of expenditure is materially accelerated if any or all of the processes can be carried on in the country or area of origin, and there is too often a temptation on the part of the partisan politician to base judgments and to formulate restrictive legislation on political rather than economic considerations. Extraction and free movement of ores are being hampered by misguided efforts to retain processing operations that cannot be performed economically in the country of origin. In addition there are those extremists, parading under the banner of conservation, who advocate non-use of domestic metallic resources that cannot be processed within the country of origin, in preference to exploitation and shipment for use abroad.

The futility of conserving minerals for some hypothetical nationalistic advantage in the remote future is self-evident. The mining of metallic ores and the use of metals is geared to today's technology and to current demand. Tomorrow, one or both may change. It is thus as safe to gamble that a specific mineral deposit will have a lower value as it is to hope its worth will be enhanced twenty to a hundred years hence. Only one fact is certain: Unused resources contribute nothing to the standard of living; and unless known deposits are economically unavailable or are in excess of current needs, their nonuse is likely to be a disservice to the people both of the countries that own them and of the world that needs them.

The rate and conditions of exploitation of specific metallic deposits are matters of serious import. Rate of extraction is likely to be determined by economic factors too numerous for analysis in this brief paper. Mineral deposits are expendable, and as mining proceeds, reserves approach zero as a limit. Plainly, the rate of extraction must bear a direct relation to the size, form, and accessibility of the deposit and to a reasonable rate of amortization. From an economic-sociological viewpoint, however, other factors assume greater importance. Mining is a localized activity that may result in the concentration of thousands of people at a site which provides no other means of support. It would be difficult, for example, to imagine the 15,000 people at Sewell in Chile finding local employment when the copper ores of El Teniente are exhausted. Yet this property of the Braden Copper Company is finite, and within a calculable period of time there will be 15,000 displaced people seeking other employment in Chile. Yet, from the economic standpoint, it is uneconomical—even impossible—to stretch out an operation, for whether ores are mined by underground or open-cut methods, there are optimum rates of extraction below which production is obtained at a penalty to profits. From a business point of view, there is no advantage in accelerating production above the optimum, for this, too, is usually costly; it may also result in tonnage yields that exceed the capacity of mills and transportation facilities; and there is no sound reason or incentive to shorten the life of an operation by undue acceleration.

Political considerations may at times conflict with the economic principles by which mining enterprises must be guided. In many countries governments collect royalties on production. (Witness the Chilean government, which for many years was run from royalties and export taxes on copper and nitrates.) Tonnage thus becomes a major concern, but of no less importance is the maintenance of production. A steady source of tax income and a dependable addendum to living standards are productive of economic and political stability, and what political group does not welcome both? It is the habit of governments, however, to increase expenditures to match income, and if political expediency warrants, to exceed income. It follows that, in many countries where state income has depended on the exploitation of resources, political pressure has been placed on mining companies to maintain, or even to increase, the level of production, commonly in the face of adverse economic conditions, growing competition, or depleted ore reserves. The catastrophic results may be analyzed in the case of Chile, when competition from synthetic nitrates and African copper combined with world-wide depression to blast the foundations of the country's prosperity and stability.

A study of Chile's plight in the early thirties inevitably spotlights the significance of general economic conditions in the metal-mining industries; to achieve perspective, the relationship of metal production to demand must be reviewed. Mine output responds directly to the requirements of current consumption. Inventories may accumulate in the finished metal products category, but never in ore or concentrates. The controversy that has raged over the question of stockpiling strategic ores is, in itself, a commentary on the unusual nature of accumulating surpluses. It follows, then, that mineral exploitation is a feast-or-famine industry—good while times are normal or booming, bad when the level of consumption is low. Obviously, this examination of metals in relation to the standard of living will not be complete without an examination of metal consumption.

The per capita consumption of metals has been used as a direct measure of living standards in the several nations of the world, but actually metal consumption per capita is a more accurate measure of the level of industrialization achieved than it is of the living standards affecting the mass of people. For the latter, food intake in calories is a more accurate measure. Yet neither metal nor food consumption is the diagnostic factor, but rather productivity. Metals affect living standards primarily as they enhance man's ability to produce. Since man's ability to produce is determined by several factors, it is essential not to overestimate the importance of metals.

The increased production of goods and of foods that has dominated economic history since the industrial revolution started in England has affected constantly expanding areas. Founded on the mass production of steel, the revolution became effective through the production of machines which, in turn, mass-produced consumer goods. Mass production involves substantial increase in output per worker with material decrease in cost per unit. Continued expansion of markets for machine-made goods depended initially on lowered prices but ultimately on increased purchasing power and sales pressure or, more politely, "education." The progress of the revolution would soon have been impeded had there not been correlative, if belated, improvements in the applications of energy to manufacturing and to transportation. Even so, manpower and food shortages were averted only through the mechanization of agriculture, which enabled fewer farmers to produce more food per acre on more acres.

As basic inventions have been integrated into the industrial economy, the latter has undergone refinements that have extended their influence to every corner of the earth. Ferrous metallurgists have enhanced the versatility of machines and other steel products by developing alloys that are especially adapted to every use. The collection of the alloying ingredients has brought many a remote region into the orbit of the steel economy. The Soviet Union, Cuba, India, Brazil, and the Gold Coast of Africa supply most of the world's manganese. Canada produces nickel. Chromite comes from Rhodesia, Turkey, and Greece; tungsten, from China, Indo-China, Burma, and Portugal; vanadium, from Peru. Only two of the fourteen countries named are themselves important steel producers, but the other twelve play no less vital parts in the modern steel industry, even though most of them are unable to manufacture steel.

The industry is also combing the earth for new reserves of iron ore, and the movement of this basic ingredient in steel has become international in scope. Before the war the furnaces of Britain and the Ruhr depended on the mines at Kiruna, Sweden, for beneficiating ores, and Norway became involved in their transport through the port of Narvik. High-grade iron was also shipped from Bilbao in Spain, and from the North African possessions of France and Spanish Morocco. Japan leaned upon the Malay Settlements and the Philippine Islands for ores of high iron content to such a degree that she coveted these British and American dependencies, along with the British and Dutch tin deposits in Burma, in the Malay peninsula, and on the islands of Billiton and Banka. Sierra Leone and Liberia may be brought into the steel industry's expanding web just as Cuba, Chile, and Venezuela have become sources of ore supply for tidewater furnaces in the United States. Brazil is also beginning to tap its vast reserve of hematite, not only for use at Volta Redonda, but also to relieve the pressure of demand on the greatly depleted deposits around our own Lake Superior. The Dominican Republic and Labrador may likewise be called upon for raw material to feed American furnaces.

Except for the large deposits in the vicinity of Baux, France, and in Arkansas in the United States, the world's major sources of bauxite are situated in nonindustrial countries, at best but imperfectly equipped to process the raw material. As a consequence of the geographic distribution of this important ore of aluminum, British and Dutch Guiana, Hungary, Yugoslavia, and potentially the Greater Antilles are critical sources of supply. Although magnesium is widely dispersed over the face of the earth, with the salts of the ocean serving as one source of raw material, production of the metal makes such heavy demands on electrical energy that the industry seeks sites of abundant and cheap power for its operations.

The base metals lead and zinc are more domesticated than most metallic raw materials, yet private capital has ventured deep into Australia and Yunnan, not to mention the remote Andes of northwestern Argentina, to mine rich deposits. Impending scarcities of both these metals promise to widen the search. Except to the United States, copper has always presented more of a problem; and now, with the partial exhaustion of the Michigan deposits, this country is showing keener interest in the deposits in Chile, and in the Belgian Congo and Northern Rhodesia, which are also the principal suppliers of Europe's needs. Tin has taken mining enterprises to southeastern Asia and to the bleak Altiplano of Bolivia, and now uranium and the other radioactive metals are drawing prospectors into equatorial Africa and to the Canadian Arctic.

List the names of the countries that have been mentioned in this quick review of major sources of metals, and it reads like the roster of the United Nations. The list is more nearly complete when those nations that contribute agricultural, animal, and forest products to the world economy are added. If lines of international trade are plotted, several facts become evident and several conclusions are inevitable: Our industrial civilization is—and must be—oblivious of political boundaries, and our industrialists are the truest, if not the most altruistic, internationalists. Barriers to trade are political, and nationalism is inimical to the normal flow of goods and raw materials and, in the long run, to living standards, which depend upon the free movement of essential raw materials, machines, and some consumer goods. Basically, there is no such thing as a well-rounded "national economy" even among those nations that nature has favored.

Again, however, the facts of geography and of international trade offer little encouragement to utopian ideologies. Economically this is an international world, but not "One World." There are clearly defined industrial nuclei that dominate trading areas of varying sizes and importance. The nuclei are few in number, and some of them merge, or overlap, and compete on their peripheral trading margins. All the nuclei are localized around centers of maximum energy production, and the larger coal fields have consistently furnished industry with its energy requirements. The Appalachian-Eastern Interior fields of the United States, the Midlands of Britain, the Ruhr of western Germany, and the Donets and Kuznetsk basins of the USSR are the primary nuclei, with secondary centers in Silesia, Czechoslovakia, northeastern China and Manchuria, Karaganda, northeastern India, eastern Australia, and perhaps the northern Union of South Africa and Southern Rhodesia. Tertiary centers are growing around the more accessible sites of hydro-energy supply, but oil is too mobile to have localized major industries, though it is an auxiliary factor in southern California and the Gulf region of the United States, and in Transcaucasia in the Soviet Union.

It is mainly to the primary centers that the world's raw materials move; and, insofar as standards of living within the trading areas tributary to these nuclei depend upon the prosperity of the nuclei, international attention should be focused on the vital task of creating sound economies, unhampered by the artificial trade barriers imposed by political boundaries, politicians, and the spirit of nationalism, within these natural geographic regions. Only a few natural resources are so unique as to lie beyond the orbit of some one natural region.

Among the metals, tin, certain of the ferrous alloys, platinum, to some degree copper, and perhaps the radioactive minerals are in this category, and materials of this nature may serve to bind the regions together in economic union.

Living standards are not the problem of the sociologists or of the lawmakers, though the former may diagnose social ills and the latter may protect social gains. The standards themselves are the by-products of sound and unhampered regional economies that recognize no political boundaries. Metals, as sources of new industrial wealth and as media for increased productivity, have made, and must still make, substantial contributions to living standards. As expendable resources they must be exploited and used with discretion; but intensive exploration for new reserves, wise extraction, and judicious and ingenius use can do as much to improve the economic status of the human race as any other major economic activity.

The mineral economist must humbly remember, however, that minerals comprise but one of the ingredients of a regional economy. Foods, fibers, and forest products are of no less importance, and it follows that production of these raw materials must likewise be integrated into the economic pattern. Proper integration will inevitably create a characteristic regional form, in which political boundaries are incidental and in which there is division of labor and free movement of raw materials and finished products. In such an economy Danes can enjoy as high a standard of living in the dairy industry as Germans in the coal mines and steel mills; and both can share their living standards with Uruguayans in exchange for wool and meat, and with Sweden in exchange for Kiruna iron ore. If our diplomats would direct their energies toward the solution of the practical international problems of making a living for the people in natural regions, living standards would take care of themselves.

The CHAIRMAN: Ladies and gentlemen, I think that, like myself, you have found Dr. Meyerhoff's paper particularly interesting. I use the word "paper", but I should really say "set of papers". Indeed, if we wish to examine in detail all the points which have been raised, all the ideas which have been presented to us, we would have sufficient subject matter for a discussion of several days. I wish to extend my heartiest thanks to Dr. Meyerhoff. I hope that at this Conference we will be able to consider in detail a certain number of points which we shall certainly not be able to examine this afternoon. I therefore invite Mr. McLaughlin to take the floor.

It is hardly necessary for me to introduce Mr. McLaughlin to you. You are aware that after a distinguished career as a geologist, he went into large mining undertakings some time ago. I have no doubt that we will find his statement highly instructive. He is the President of the Homestake Mining Co., an American firm.

Mr. MCLAUGHLIN *delivered the following paper:*

Conservation of Mineral Resources

DONALD H. McLAUGHLIN

ABSTRACT

Serious depletion of mineral reserves can not be avoided if the huge requirements of the modern industrial world are to be met. The available supplies are finite and by no means large in relation to the demands. Yet, except for avoidance of the shocking wastes of war, the rate of consumption of most minerals can not be curtailed without seriously impairing the welfare of the major nations.

The ultimate supply, however, is likely to be considerably greater than quantities that can now be formally estimated. Improvements in the technology of exploration and exploitation and in utilization can confidently be expected. As scarcities develop and as relative prices for specific metals rise, practices that promote conservation will almost automatically be favoured in a free economy.

Three examples of technical developments that have served to enhance the available mineral supplies of the world are cited, viz.: 1) The practices that in the first decade of the present century led to the discovery and exploitation of the low-grade porphyry copper deposits; 2) the greater Butte project, now in active preparation, whereby large tonnages of ore, left in earlier operations, are to be caved and milled; and 3) the Cerro de Pasco enterprise, where twelve or more valuable products are now being recovered, as a result of elaboration of metallurgical processes. These and comparable achievements justify hope that the time of practical exhaustion of the scarcer minerals and metals may at least be postponed to a significant degree.

With few exceptions, the metals and minerals on which our industrial civilization depends are derived from relatively small and rare geologic bodies that have been formed by natural processes of concentration. They are for the most part accumulations of extremely scarce elements over vast periods of time and are a rich heritage available for man's many complicated activities. Once consumed, they can never be replaced, at least within any period of time significant to the human race. Furthermore, only those deposits that are within the short range of our technical skill in drilling and in mining are available to us, and this virtually restricts them to a skin-thin layer on the planet.

Man in the last hundred years has become an extraordinarily active geologic agent. The industrial revolution and the accelerating pace at which scientific discoveries have been made and put to work, with their manifold effect on population, on use of machinery and on food consumption, have enormously intensified the rate at which deposits of ores and minerals have been sought and exploited, as well as the rate at which the products made from them have been consumed and dissipated. Indeed, man's demands on his mineral heritage have become so insistent and so selective that within the century ahead we can see the exhaustion of practically all known ore deposits in which the metal content represents a notable concentration above that found in certain common rocks.

Pessimistic predictions are, of course, dangerous in an age of science and technology in which the achievements of each succeeding decade compound the record at an astounding rate. We are justified in having a substantial measure of confidence that man will succeed in attaining greater and greater mastery over his environment and continue to surmount one apparent limitation after another. The possibility—or rather the probability—of new scientific miracles and technological developments beyond our present understanding profoundly stirs the imagination. They are by no means vain hopes—though it must be admitted that nothing in the range of our knowledge today affords any definite grounds for thinking that we can escape from our dependence on metals and minerals if our industrial world maintains its present character and is to continue to function at no less productivity than at present. And this means dependence on ore deposits and other rare localized accumulations for our source of supply of these essential materials. Consequently, it is vital for survival even at our present level of activity to perfect our knowledge of the nature of these special geologic bodies, to develop the utmost skill in exploring and exploiting them, and to use the products with efficiency and with minimum of waste.

The record to date that has been made by the mining and metallurgical engineers and the industry they serve is not a bad one from the point of view of conservation. Under the discipline of supply and demand, with prices and costs determined in a free market under competitive conditions, enlightened self-interest promotes efficiency and avoidance of waste which are essential elements of any effort toward true conservation. Free prices restrict current operations to those deposits where grade, nature of the ore and environment, and geographic location make it possible to achieve costs low enough to yield a profit. Other less favoured occurrences are left untouched for the future. Adjacent marginal ores, it is true, might be lost as mining progresses; but such cases in my judgment are far less common than they are believed to be. Usually in the effort to find more ore, mining tends to probe beyond the limits of profits rather than to stop at the exact line and the resulting dilution from wall rock or low-grade material is of more concern as a cause of waste (and indirectly an enemy of conservation) than the amount of material of marginal grade that might be abandoned. Where any substantial tonnage of low-grade ore is temporarily passed by, it is rarely if ever lost, for the chances are it will eventually be recovered when conditions warrant. (The Greater Butte Project mentioned later is an excellent example of this.)

Within this framework, which is essential in a free economy, policies have been and should continue to be worked out that promote intelligent exploitation of the world's mineral deposits with proper emphasis on realistic conservation.

Depletion, as mineral deposits are discovered, developed and mined, obviously cannot be avoided. The available supplies are finite and by no means large in relation to the demands that will be made upon them, even in the short life-span of nations. The accelerating rate of exploitation in the past half century is a proper cause for anxiety; yet, except for the shocking wastes of war, is there much that the conservationist could change without seriously retarding the great material growth and the continuing industrial activity of the major nations? For better or worse, we now have this vast, complex, world-wide plant in active operation. Even though some troubled prophets might have preferred a slower pace with more left in the ground for future generations, the fact is that vast populations have been created and levels of social welfare established that require far more to support their way of living than has ever been the case in the past. The demand must be expected to continue at this high level. To meet its most basic requirements, metals and minerals must continue to be provided in tremendous quantities—and the available sources will continue to be depleted at a rate which admittedly is increasingly difficult to match by new discoveries.

Faced with this probable condition, what policies should be followed to meet the situation most effectively, what prospects for change exist and what is most reasonable to anticipate?

Conservation, within the limits imposed by the unavoidably huge activities of the age we are in, must be promoted by efforts 1) to find and make known the needed increment to the reserves of ores and minerals as they are consumed, 2) to mine and recover final products in the desired form with a minimum of loss, 3) to improve technology to permit profitable mining and treatment of leaner ores, 4) to achieve maximum efficiency in use, with adequate attention to employment of specific materials in the right places, 5) to avoid extravagances and carelessness in consumption of metals and minerals, and above all 6) to end the shocking wastes of war.

Of all the ways the mineral wealth of the planet is dissipated, the latter is overwhelmingly the worse. Think of the ships loaded with irreplaceable ores, concentrates and bars of metal that were sent to the bottom of the oceans, and of the precious materials scattered over the world and hopelessly lost, to say nothing of the destruction of industries. When the concept dominates that everything is expendable to attain a required military end, the opposing idea of conservation receives little consideration. (The sinking of ships at sea in target practice is a sad carry-over of the concept. The loss in metal involved, when translated into tons of ore, would shock any good mine management.) The price that is paid in terms of irreplaceable mineral resources is desperately high, even for the apparent winners who have to continue to live on the planet.

It is with the first three factors, however, that geologists, miners and metallurgists are most concerned. My own assignment this afternoon is with the second and third points, and to them I will address myself more specifically.

We have no reason to be apologetic in the mining and metallurgical profession either for the results achieved in providing metals and minerals or in showing due consideration for the principles of conservation. Naturally, in the exploration and development of the then remote and empty spaces of the continents, the richest and most easily worked deposits received first attention. With depletion of the rich deposits—in some cases abrupt and in others slow and still in progress—the insistent and steady demand led inevitably to efforts to work lower-grade ores or to obtain more complete returns from the ores that were worked. Without pretending to give more than a few illustrations of the thrilling record of increasing technical skill and accomplishments, the following high spots are mentioned as examples of the way mining and metallurgical engineers have met the situation and the way further progress may be expected.

In mining history, no achievement ranks higher than that of D. C. Jackling shortly after the turn of the century, when he recognized the existence of vast tonnages of low grade disseminated copper ore in Bingham Canyon in Utah and devised the smoothly integrated sequence of steps by which ore was mined in huge open pits and huge tonnages were concentrated on a scale that gave competitive costs in spite of the low copper-content of the ore. His success pointed the way to other skillful and resourceful engineers and led to the development of the enterprises known as the "porphyry coppers" without which the world today would be most seriously short of the red metal (1)[1]. By this achievement, copper was kept at a price that permitted its widespread use and promoted the growth and extension of the electrical and related industries in which it is an indispensable material.

Further steps were the adaptation of caving methods of mining to deeper ores of the same type, with the inclusion of many more porphyry copper deposits in the group that became successful and profitable producers.

With these improvements in mining came timely application of new methods of concentration, with the result that copper was provided in quantities adequate for the growing industrial needs of the first half of the century and capable even of meeting the excessive demands of two wars. These great deposits, particularly in North and South America, contain the world's major known reserves of copper today. In spite of the depletion resulting from the war, they are still in vigorous production. But most of them are well into middle age. Only a few, however, have become senile and several of substantial promise are still in the period of gestation, with the latest to be born—the Morenci operation—already one of the most active and productive members of the great group.

This notable achievement was possible 1) because there were vast low-grade deposits of copper ore in addition to the more easily found rich occurrences and because engineers and geologists possessed the skill to recognize them in spite of barren leached outcrops, 2) because there were men such as Jackling and others, among whom Cates, Krumb, Lakenan and Maclennan might be mentioned in the group that deserves special recognition, who had the imagination to devise new techniques of mining and concentration, and 3), and by no means least, because a system of free enterprise was fostered by enlightened governments that provided adequate security of titles and preserved conditions under which the incentive of fair profits could be effective under competitive free-market conditions.

There has been a minimum of waste in the technology of the prophyry coppers. The ores have been found and delimited with a surprisingly little consumption of materials and effort in futile work. Mining proceeds to limits that leave no significant tonnages of marginal ores—indeed in most cases the tonnage of ore recovered has gone well beyond initial estimates—and the tailings from the mills are still available if anyone is optimistic enough to think he can get a few more pounds of metal from them.

The newest effort in maintenance of reserves of copper is the Greater Butte project of the Anaconda Copper Mining Company (2).

Butte is pre-eminent among mining districts in the value of its products. Starting as a gold placer of rather little consequence, it first achieved distinction as a silver producer. It was soon recognized, however, that its great veins of high-grade copper ore were its major asset. With geologic guidance that has been the admiration of the mining world, the multiplicity of veins and their faulted segments have been so skillfully developed and carefully mined that no misgivings need be felt on the part of the most anxious conservationist about loss of any significant tonnage of ore. Furthermore, with advances in metallurgy, the many metals of the district have all been made sources of profit, with corresponding enlargement of the limits of ore.

As the extent and character of the tremendous block of mineralized ground were gradually revealed through intense geologic study and more and more detailed exploration, and as technical possibilities became better and better realized through research and experience in practice, the project for immensely enlarging the operations gradually took form. Blocks of shattered and altered granite, between the stronger veins of rich ore or in intricately fractured ground known as horsetail areas from the pattern shown on geologic maps, were eventually revealed as ore bodies of sufficiently great tonnage to be mined by caving and handled in quantities adequate to result in costs low enough for profits from the relatively small quantity of metal per ton. Consequently, this great undertaking is now going ahead, involving heavy initial expenditures with confident expectation of technical and commercial success. The initiation of a venture of this magnitude with such assurance would be possible only where competent men had acquired the precise understanding of the problem in its many aspects from geology to separation of metals, and where they could see a proper return in metals recovered and in the prolonged life of the district.

Such efforts are indeed conservation in its best sense.

Another outstanding example of conservation, in which copper ores played the leading part but in which the recovery of other metals was a critical factor in achieving success is to be found in the record of the Cerro de Pasco Copper Corporation in Peru (3). This enterprise, now approaching the end of its fifth decade,

[1]Numbers within parentheses refer to items in the bibliography.

started as a producer of copper with subordinate silver and gold from the ores of the Cerro de Pasco district, high in the Andean plateau of central Peru. Mining had been in progress there since the early 17th century, when the district had first achieved fame under the Spaniards as a silver producer. Difficulties of transportation, wet workings, and lack of power and metallurgical facilities checked its progress after the exhaustion of the rich silver ores until the technology of the 20th century became available, and until the acquisition of properties there by a group of mining men who were willing to make the large investments necessary in a railroad, mine plant, coal supply and power. Availability of rich copper ores led to quick success in the early years; but with their diminution the enterprise would have ended without the elaboration of the metallurgy, accompanied by more intensive exploration of the region, that resulted in the present complex operations.

In the course of these developments, the great Oroya plant of the Cerro de Pasco Copper Corporation not only maintained its place as the leading copper producer of Peru but became the largest bismuth producer in the world and the largest silver, lead and gold producer in South America, as well as winning some return from zinc, antimony, sulphuric acid, indium, tin, cadmium, calcium carbide, calcium arsenate and white arsenic. Through skillful application of differential flotation, copper-silver, lead-silver and zinc concentrates were separated from complex tetrahedrite, galena and sphalerite ores. Dust and fumes from roasters, reverberatory furnaces and converters treating copper-silver ores and concentrates were precipitated electrostatically. Lead concentrates were smelted and the bullion refined electrolytically with recovery of various by-products from the sludges. Losses in smoke and slag were reduced to low figures. New uses were found and markets were cultivated for products such as bismuth alloys that had been little appreciated, and even the insect pests of the coastal valleys contributed to the gross income in a small way by providing an outlet for part of the arsenical compounds, heretofore regarded merely as troublesome impurities. Products that were necessarily wasted in earlier years, when techniques were still undeveloped and when capital was not available and markets limited, thus became sources of revenue. Ores that could not be profitably mined due to their low content in one metal are now being exploited and copper won from material once regarded as hopelessly low-grade. This achievement deserves to be cited as another example of true conservation, resulting from skillful exploitation of the opportunity to take risks to win profits.

The results in the Cerro de Pasco enterprise illustrate with particular clarity the opportunities for conservation through recognition of the many sources of valuable products in a complex ore and the manner in which their recovery is possible, even though the content in any one of them alone might be hopelessly below that at which a profit could be made. A number of other large operations on complex ores have accomplished similar results, but many more places still exist where with adequate imagination and skill the principle can be applied.

Practically all of these technical improvements today have occurred without the stimulus of drastic increases in prices of the metals or minerals. This in itself has been a remarkable achievement, when the added effort due to low-grade ore, remotely situated mines, higher taxes and mounting costs of labour and supplies in an inflationary cycle are taken into account. They have, however, had the assurance of steady and enlarging demands that took care of the additional quantities available for sale without a disastrous fall in prices.

Unless unexpectedly good results are forthcoming from exploration, however, it seems to me inevitable that most metals and mineral products will become more and more valuable in terms of other commodities. This in itself will lead to some enlargement of available supplies and is certain to promote cleaner mining and higher extraction as well as economies in use. Lower priced and more abundant metals and minerals will be substituted more and more for others whose price is rising and the latter will be effectively conserved by restriction of their use through the influence of free prices to those purposes for which they are uniquely suited.

Conservation through utilization of metals or other products derived from materials that are in abundant supply is best exemplified by the winning of magnesium from sea water. The achievement of the technical staff under the distinguished leadership of Willard Dow, whose recent untimely death was a major loss to American industry, resulted in production of magnesium from this inexhaustible source at a price that allows it to be substituted for other metals for a number of purposes where its special qualities can be advantageously employed.

The record of the Aluminum Corporation of America and the newer companies in making aluminum plentiful and actually reducing its cost even in depreciated paper dollars is a most commendable achievement and one that is reassuring for conservationists. Bauxite ores, on which the operations depend, are far from plentiful within the United States, but fortunately they are in abundant supply within reasonable range of sea transportation. The prospects for additional reserves through exploration are better than for many scarcer metals, and there is also the possibility of extracting the metal if necessary from relatively plentiful materials such as clays and syenitic rocks at a cost that may not be prohibitive, although high in relation to current production. The use of aluminum and its alloys will grow as the prices of competing metals rise and demands on them are reduced except for their most needed services, with postponement of the time when deposits of their ores will be exhausted.

In conclusion, I find myself on one hand accepting the pessimistic view that the depletion of the ores of most metals is serious and is certain to lead to their growing scarcity within periods that are short in relation to the lives of nations. Yet on the other hand I must recognize that the returns from more intensive exploration, directed with constantly improving scientific understanding and better techniques, are more likely than not to exceed even the most generous estimates of reserves based on known ore-bodies and their probable extension. The eventual, successive exhaustion of ores of one scarce metal after another must be expected unless new miracles of science and technology relieve us of our present dependence on minerals, but it is likewise certain that the process will be gradual, and that the time when extreme scarcities begin to pinch painfully will be pushed farther and farther into the future through economies and through more efficient use of available materials.

If a century of peace with free enterprise could be granted to the world, with consistent and steady policies adopted by governments that will provide the protection of wise mining and social laws, that will support bureaus or surveys competent to provide scientific, technical and economic data essential for guidance, that will insure safe and respectable working conditions and fair treatment of labour, and will restrict taxation to levels that still allow the prospect of profits to serve as an incentive, I am confident that really troublesome shortages could be postponed for many generations—perhaps long enough to enable the modern magician of the laboratory and industrial world to devise ways and means that will make us less dependent on our diminishing heritage of minerals.

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(3) (Various authors,) "The Cerro de Pasco Enterprise", *Mining and Metallurgy,* (A.I.M.E.), vol. 26 (November 1945), pages 507-594.

The CHAIRMAN: Mr. McLaughlin's great experience has enabled him, as you have noted, not only to present to us a certain number of problems in a general manner, but also to illustrate those problems with examples from different parts of the world, which enable us to understand still better the way in which those problems arise. I extend my warmest thanks to him for having been good enough to leave his important occupations to come and present this very interesting study to us this afternoon.

The discussion is now open.

Mr. DREUX:[b] Although I am not a technician, and although my present functions lead me rather to consider the economic aspect of problems, I shall nevertheless take the floor here because of the clearly marked economic character of the developments described this afternoon by the two previous speakers, who presented to us very remarkable papers.

Since this morning, I have been very much impressed by the statement that the metals most indispensable to our civilization are becoming scarcer and scarcer. The highly interesting numerical data which Mr. Pehrson[c] presented to us this morning enables us to state that among those metals there are certain ones which are particularly scarce in the sense that the probable length of time for which they will be available to us appears, according to the studies of specialists, much shorter than the average time for other metals.

I was also struck by a second point, namely the really considerable lack of proportion existing, on the one hand, between the consumption in the United States of metals as a whole, and more particularly of the rarest metals, and, on the other hand, the consumption of metals in the rest of the world. It is no doubt this situation which has gradually turned America into a "have-not nation", which is henceforth obliged to obtain abroad a certain number of essential products, among the most important being metals. Thus America develops its remarkable civilization by contributing, far more than the rest of the world, to the impoverishment of the globe in the most important metals.

This morning a member of this Conference dared to speak—he was an American—of the extravagance of the American economy. I did not want to take up this term, but I was struck by the fact that, in order to defend what he himself had described as extravagance, this conferee told us that such extravagance at least gave the world something which was very important: the means to pursue research, to improve technical methods, to raise in this way the standard of living, not only of America, but of the whole world.

I wonder how far such "extravagance" could not be remedied and some contribution made towards an improvement in the world economic situation by a method which might be a temporary one, but which appears to to me to have the advantage of following the same lines as the technical solutions which the experts have expounded today, and along the same lines as the economic problems which are discussed in other places or at other times in this very hall.

The second speaker this afternoon expounded a very liberal concept with regard to world circulation of products, and particularly metals. I cannot altogether agree with him on this point and, in any case, the solution which I wish to propose is in clear contradiction with his beliefs.

Every time that the experts have spoken to us, in the course of the last few days, of the conservation of resources, they have stressed the fact that the intensive development of prospecting, the more comprehensive nature of extraction in the mines in exploitation, or finally of economies in use, particularly by the substitution of other replacement metals for scarce metals, could only be bettered by higher prices for the metals used.

Certainly, we are told, and evidence goes to show, that just as natural resources become exhausted, prices rise. But I am led to put the following question: if we are truly anxious to see the supply of metals exhausted—and it is you, Gentlemen, who have communicated this anxiety to me—should we not find cause for gratification if, without any complicated controls, by giving the machinery of prices full play (for I am a liberal), some increase in the prices of the scarcest metals could be obtained? I should say that in using this convenient method, we have a certain philosophic justification which even the most ardent liberals could not dispute. Scarcity of supply has been an essential factor in the fixing of prices. However, hitherto—due to the fact that little was known about the phenomenon of the exhaustion of supplies, the phenomenon which was responsible for the calling of this Conference—scarcity only influenced prices instantaneously, so to speak, through the immediate gap between demand and supply. Our Confer-

[b]Mr. Dreux spoke in French.
[c]Mr. Pehrson's paper was introduced at the Minerals Section meeting and will be included in the proceedings of that Section.

ence now makes it possible to arrive at a new idea which I shall call potential scarcity.

The mere fact of publicizing our work will certainly make this potential scarcity known and this will automatically result in an increase in the prices of the metals which you will have recognized as the most scarce. This process could however possibly be accelerated. The solution is the usual one; it would consist in taxing, in the producing countries, those metals recognized as the most scarce. Automatically, in giving the machinery of prices full play aside from this tax, the prices of scarce metals would increase and the whole process which I have just described would be brought into play.

I should like to emphasize the fact that such a solution, which follows exactly the same lines as the technicians' problems, would at the present time have the very real advantage of also following along the same lines as the economists' problems. Indeed,—and I shall be very brief on this point—the modern economic crisis, the economic crisis of 1949, one might say, is the lack of sufficient dollars in the world and the lack of sufficient American purchases. It is true that a lowering of customs duty on European manufactured products would enable the problem to be partly solved; but it is quite certain that if America, which needs these metals so much, let us say for its extravagance, could pay a higher price for its metals, it would immediately, by that very fact and without any complications, put at the disposal of the rest of the world and particularly at the disposal of those nations which have the most deposits—often the nations which are the least developed economically—the precious dollars of which the world is in such great need.

The CHAIRMAN: I think, Gentlemen, that you have particularly noted Mr. Dreux' statement which is not merely academic in nature since it contains a perfectly clear and positive proposal to solve the problem before us.

I hope many of you will give your views on Mr. Dreux' proposal as well as discussing the three memoranda submitted this afternoon.

Mr. ERSELCUK: The last economic analysis was no doubt an excellent one, but I should like to point out what is perhaps one small fault therein, namely, that if every nation controlled its own deposits of underground resources, then the nations concerned, by increasing the prices of their commodities, might perhaps be able to obtain large amounts of dollars or pounds sterling or, it may be, even francs. It so happens, however, that most of the underground resources of the world are controlled by few nations.

If we take copper, for instance, we find that roughly 80 per cent of the world's copper resources are controlled, either directly or indirectly through stock ownership, by American, British and Belgian interests. The same applies in the case of oil. More than half of the world's oil is owned directly or indirectly by American interests. If this ownership is borne in mind the previous economic analysis—which is a good and sound one—has to be somewhat modified.

Mr. KEENLEYSIDE: I shall take just a very brief moment, if I may, to make a comment on the exceedingly interesting address which we have heard from Mr. McLaughlin. There seems to be an impression that there is some conflict between the thesis that was expounded in Mr. McLaughlin's address and something that I said in my introductory statement on mineral resources. In that statement I said that in the case of minerals which are not renewable there has been practically no effort, except in time of war, to interfere with the free play of a market that is primarily interested only in profits, and I suggested that this situation was not likely to continue indefinitely.

Mr. McLaughlin's thesis, as I understood it, was that in private industry, operating in a free competitive market, all the ore that could be handled at a profit would be used, and that improving techniques were constantly increasing the supply of ore that could be so handled. With this argument I find myself in complete agreement. I have no criticism to make of that whatsoever. I think it is quite true and I congratulate Mr. McLaughlin on the clarity with which he developed the argument in support of that thesis. However, I think it is fair to go on a step further and to suggest that there are some cases, or that there are likely to be some cases, in which it would probably be desirable that the possibility of making a profit should not be the deciding factor. It might, for example, be nationally or internationally beneficial to slow down rather than to speed up the exploitation of any given deposit or any given mineral, dependent upon the circumstances of the time.

It might also be desirable, under certain conditions, that we should provide for the exploitation of a deposit or of a mineral vein, although such exploitation could not be carried forward at a profit. Finally, I still think that there is an anomaly in the situation in that we find that governments have not hesitated to interfere—and interfere quite extensively on some occasions—in the development of forest, sea or land resources, all of which are renewable, and yet have failed to intervene, and apparently are expected to continue to fail, in the case of resources such as those with which Mr. McLaughlin dealt and which are not renewable. As I say, it seems to me that there is some anomaly in the procedure which leads to governments interfering in something which can be restored but failing to interfere in something which cannot be restored.

Mr. MEYERHOFF: Some of the arguments which have been presented require more analysis than they can be given in this rebuttal. I should like to point out that the very fact of extravagance in the United States has led to so many new developments that it has been, perhaps, a substantial blessing to the world, even though it should proceed in the future with some controls. In the first place, the extravagant use of minerals and metals, specifically, has brought about the exploration of foreign countries, which has further led to the development—even though it may be only localized development—of those countries.

I am thinking specifically of the deposit with which Mr. McLaughlin is so familiar, the Cerro de Pasco development in Peru, or of one with which I am familiar, the El Teniente Braden Copper development in Chile. There absolute wildernesses were opened up. To this extent, therefore, I believe that the energy of the Americans—though it be or has been accompanied by extravagance which I frankly admit—has certainly accomplished one important purpose in the development of these countries.

There is another point. As I tried to show in my paper, in going into these countries we have purchased the supplies of ore. We may own them, as was said by the second speaker in the discussion following the regular papers; we may own them—or the British or the French may own them—corporately speaking, but they are still deposits within the specific countries involved. They call for the expenditure of money for equipment from the country which develops them, it is true, but they also call for the payment of labour in the country which actually possesses the minerals, and to that extent there is a development and an expenditure of money which would not otherwise take place. The whole matter of how much is paid becomes a much more difficult problem, because it must be remembered that market price determines what will be mined, as Mr. Mc Laughlin has so ably shown us. It is impossible for any country possessing a specific mineral completely to control the price because it depends on market factors which may be entirely outside that country.

We in this hemisphere have been grieved, I know, at various times in the past about the complete control of the price of silver in London. Yet very little silver was mined in any of the British possessions, relatively speaking, except Canada. Mexico and the United States were the main producers, but thanks to the use of silver in India it was London that controlled the price. Thus our mining was conducted, in those circumstances, against a price which was set in London, and prices are more often set, I think, by strictly economic factors so that I am not sure that we Americans, if we are extravagant and if we use more minerals than other countries—use them up and waste them to a degree—are in complete command of price factors. We may point, for example, to the situation which developed in the early Thirties in the development of African copper deposits which at that time, could have been placed upon the market for about 4¼ to 4½ cents per pound as against an over-all average mining cost in the United States—it is just an average—of something nearer 8 cents and, in Chile, something nearer 6 cents. African mining, which at that time was in the control primarily of Belgians, French and British, could have put Chilean and American copper mining out of business, save as those countries were able to protect themselves, in the case of Chile by subsidy, in the case of the United States by the tariff which was placed on our copper deposits to the extent of 4 cents a pound.

Thus there are these market factors which exert themselves and which very often are quite beyond the complete control of the country which may own the mines or operate them. I wonder also if the expenditures for the development of countries—the expenditures for the purchase of the metals, for labour and so on—may not be a substantial contribution.

There is one final point. We note the fact that the reserves of practically all metals known at the present time are greater in absolute figures than they have ever been at any time in the past, because we are carrying on exploration more intensively and so know more about the earth than we did before. The expansion of known reserves has also taken place as the result of improved technologies which enable us to use lower grade ores. Actually, most of the scarcities are related to one factor—the ratio between current consumption and known reserves is less than it has been at times in the past in certain measure. The absolute figures for most of them are, I think, actually greater than they have been in the past. Perhaps, with improved technology, the use, for example, of clays or other silicates for aluminium instead of bauxite, which is relatively scarce, will enable us to survive impending threats of scarcity. I suspect that there are real advantages in being scared of impending shortages.

Mr. McLaughlin: I should, perhaps, say just a word or two in reply to some of the very interesting points which Mr. Keenleyside made, and with which I find myself in complete agreement since I think that they supplement my rather inadequate remarks very helpfully.

The first point which he made was that at times there might be a need to slow down the production of certain types of deposits. That is true. I should, however, expect that falling prices would be a very effective factor in such a slowing down. I notice that at the moment we get more miners in the gold camps than we did a few months ago, and as you know prices have fallen recently which certainly shows that there has been a slowdown in production in a number of our important base metal districts. I am sorry for the base metal miners, but it did help us in gold mining.

I think that the point with regard to exploitation without profit for certain minerals brings into consideration many other factors—the nationalistic need for security, for example. It is a very desirable thing, of course, for a nation to have within its boundaries a plant capable of producing what it might need in an emergency from ores which could not compete ordinarily; obviously there is a need—and there are reasons perhaps—for supporting such enterprises. In a well-ordered world, however, I should hope that there would be fewer and fewer occasions where great nations would need to support uneconomical operations simply for security, but unfortunately that need apparently does exist today.

With regard to government interference with and direction of enterprises which are dealing with exploitable minerals, surely if the government directs the proper exploitation of forests, which can replenish themselves, and so on, a strong case can be made for government controls to some extent which would ensure the wise exploitation of our mineral resources also. I can well imagine that a government agency might forbid a coal miner from extracting a certain seam and cave the ground overhead, losing forever a slightly less valuable coal seam above. Ordinarily, I think, enlightened self-interest takes care of that pretty well in the mining profession. I rather dislike having government agencies acquiring more and more powers to direct the details of operations in mines in the guise of improving conditions and conservation. For the most part our experience has been that no matter how good the intentions, many of those things are carried out by people with much less experience than the people who are running the mines, and I feel that there is a great deal of danger in that, although I recognize the need to a degree.

The Chairman: I thank Mr. McLaughlin for the reply he has just given Mr. Keenleyside. Before adjourning the meeting, I give the floor to the Deputy Executive Secretary of the Conference, Dr. Herbert Schimmel, for an announcement.

Mr. SCHIMMEL: Following the Conference, proceedings will be published containing the texts of the papers presented at all of the meetings, together with a record of the discussion. In order to expedite the preparation and printing of these proceedings, it is essential that authors of Conference papers who are attending the Conference and have not yet furnished corrected copy of their papers to the Secretariat should do so before leaving Lake Success.

The CHAIRMAN: I should like to express my thanks once more to all the speakers who have taken part in the debate, and especially to our main speakers.

Creatable Resources: The Development of New Resources by Applied Technology

Wednesday Afternoon, 24 August 1949

Chairman:

S. ZUCKERMAN, Professor, University of Birmingham Medical School, Deputy Chairman, Advisory Committee on Scientific Policy, United Kingdom

Contributed Papers:

Creatable Resources: The Development of New Resources by Applied Technology
F. Neville WOODWARD, Director, Institute of Seaweed Research, Inveresk Gate, Musselburgh, Midlothian, Scotland

The Contribution of Chemurgy
G. E. HILBERT, Chief, Bureau of Agricultural and Industrial Chemistry, United States Department of Agriculture

Wood Fibre: Creatable Resource of Wide Utility
J. A. HALL, Director, Pacific Northwest Forest and Range Experiment Station, U.S. Forest Service, Portland, Oregon, U.S.A.

Fat Synthesis by Micro-organisms and its Possible Applications in the Food Industry
Harry LUNDIN, Royal Institute of Technology, Stockholm, Sweden

Food Yeast in the British Empire
A. C. THAYSEN, Colonial Microbiological Research Institute, Trinidad, B.W.I.

Agricultural Products as Starting Materials for the Chemical Industry
Ernst D. BERGMANN, Weizmann Institute of Science, Rehovoth, Israel

Discussion:

Sir Harold HARTLEY, Messrs. GOODRICH, ERSELCUK, KING, RAUSHENBUSH, HUBBERT

Programme Director:

Carter GOODRICH

Programme Officer:

Herbert SCHIMMEL

The CHAIRMAN: In opening this plenary meeting I am going to avail myself of a Chairman's privilege by saying I find its title somewhat ambiguous. It seems to imply there are two categories of resources, creatable resources as opposed to some other variety of resources. Needless to say, we must assume that all the resources which we are using today, and which have therefore been created, were once upon a time creatable. The one category merges into the other. We cannot, therefore, draw any fine line between the various materials which man uses in his social complex, and in industrial civilizations in particular. We can, however, for convenience differentiate primary raw materials from a group of secondary raw materials. I do not wish to elaborate on these definitions, because we are going, in any event, to trespass from one to the other in the course of this afternoon's discussion. I might merely exemplify what I mean when I say that Chilean nitrate is a primary material and ammonium sulphate made from fixed nitrogen a secondary material, both playing the same part in our agricultural complex. In the same way, we may recognize oil as a primary commodity and acetic anhydride made from refinery tail gases as a secondary commodity.

We are essentially, but not exclusively, concerned this afternoon with the second category of resources. Alternatively, we could say we are more concerned with unconventional than with conventional methods of production.

We might at the start ask ourselves what new resources have, in fact, been created during say the past fifty years. Again I do not want to attempt any detailed analysis, but at the start of this discussion, it is useful to remember that neolithic man, thousands of years ago, had already provided himself with the main agricultural commodities which we use today. Very little has been added since. He, or his immediate successors, also knew about the use of metals. The use of these commodities and these resources, created at that time of human history, developed gradually up to the Industrial Revolution, which was essentially a period in which ferrous metallurgy and the steam-engine forged ahead. In the past fifty years or so the major resources which have appeared are oil and natural gases, light metals and alloys, possibly new sources of electric power, and the wood pulp used in the paper, synthetic fibre and plastics industries. Put broadly in this form, all this reads like very little, and in a very general way one can, in fact, say that in the course of his recent history man has created few new resources, although he has made great use of those he has, as well as of the old ones. In fact, the classical ages, as taught at school, still retain their descriptive usefulness—the Bronze Age the Iron Age and so on, and the Plastic Age of today These ages of man were more or less typified by the resources and commodities in use at the time.

In detail, however, the pattern of resources is constantly changing according to variations in supply. Previous meetings of this Conference have suggested that the pattern of resources is likely to be changed, because of exhaustion, in a dramatic way in the course of not very many years, irrespective of any artificial and local shortages in resources and commodities due to economic dislocation.

For that reason, we scientists must continue to search for new resources, must continue to call in new materials to take the place of the old ones as they become exhausted and, more than that, in order to enrich our social environment.

There is, of course, a logical sequence in the development and application of new resources. New knowledge reveals new possibilities of satisfaction, creates new needs, and so on. One example of this process can be seen in the recent history of light alloys. We also know—and this is the particular point, I believe, of this plenary meeting—that there is a logical sequence which emerges when needs are unsatisfied, when the commodities are not available to satisfy requirements which must be met. For example, we all know that the forests of Great Britain were largely destroyed in the manufacture of charcoal for smelting purposes, and that when the forests were exhausted, new resources were sought and coal and coke were exploited. There we have a good example of a logical sequence which emerges from an unsatisfied need.

The papers we have before us today are focused on only a part of the whole field of creatable resources, but all of them are illustrative of the problem. They deal mainly with the questions of food production, fibres, and the interaction of agriculture and industry. Two of the papers—those by Dr. Bergmann and Dr. Thaysen—have been circulated and will be taken as read, although the material they contain may come up in other papers which will be delivered. In their presentation the papers will, I hope, concentrate on general rather than particular matters. I have been told that several people wish to take part in the general discussion. We hope to have about an hour to consider the various issues which will emerge from the main papers before us.

With these opening words, I should like to call on Dr. F. N. Woodward, Director of the Institute of Seaweed Research in Scotland for his paper.

Mr. WOODWARD *delivered the following paper:*

Creatable Resources: The Development of New Resources by Applied Technology

F. N. WOODWARD

ABSTRACT

The possibility of alleviating potential and actual food and industrial raw material shortages by the application of chemical, applied biology and engineering techniques is reviewed.

Principal amongst the techniques capable of creating new food resources are believed to be nutriculture and the possible production of proteins, fats and carbohydrates by the macroculture and processing of such micro-organism as "fat" and "food" yeasts and fresh water unicellular algae.

Creation of new industrial raw materials by means of applied technology from such abundant commodities as the air, the sea, forests and coal, is a well established and rapidly expanding practice. Hitherto untapped renewable resources which are probably capable of similar development and expansion are typified by the marine algae, agricultural commodities, by-products and wastes, forestry and fishery by-products and wild plants.

Considerable attention has been devoted recently to the ills of the world resulting from unchecked population increases, the frittering away of its non-renewable resources, bad conservation practices and the like. Many and varied cures have been suggested, ranging from enforced checking of the rate of population growth on the one hand to the widespread application of the physical sciences to our problems on the other, leading up to an economy based essentially on synthetic foods, clothing and building materials.

The problem although vast and heterogeneous and dependent upon the breakdown of national traditional patterns of living, in the limit, is simply defined. The world population is now about 2,000 millions and in fifty years if it increases at the present rate, it will be half as much again. For the first time in history there are no new territories to discover and exploit so man will be driven to feed, clothe and house this staggering potential population increase from the same land and sea resources, which up to now he has been destroying at an alarming rate, and in so doing, has failed signally to reach or maintain a reasonable standard of living for more than one-third of the present inhabitants of the earth.

How will he accomplish this? Firstly by such steps as are being advocated at this conference: the conservation of our limited fuel, mineral and land capital by means of improved utilization and conservation techniques; the more intelligent utilization of the world's growing and renewable commodities—livestock, forest products, agricultural crops, fisheries and the like—and the rapid dissemination of improved conservation techniques and their enforcement where necessary and possible. Even if such an enlightened programme could be implemented in the foreseeable future and the general level of education and mass communications improved sufficiently to enable this to be done, there are many who consider it debatable whether the problem of deficiency can be solved at all or at least in time to obviate ultimate disaster.

For this and the more obvious reasons forced upon us by the urgent needs of a world at war twice in one generation, considerable though and ingenuity have been devoted during the last few decades to the possibility of creating new food and industrial resources. This has been attempted with a measure of success in a variety of ways.

A new technology, somewhat unfortunately called "chemurgy", has emerged, involving the utilization of agricultural commodities and wastes as raw materials for secondary industries.

Established and novel starting materials are being produced by applying technical, chemical and engineering techniques to materials readily available in apparently inexhaustible quantities, such as the air, the sea, timber, coal etc. Attempts have been and are being made to produce useful products from commodities such as marine algae, peat, bracken and wild plants, which heretofore have been considered of little or no industrial value; increasing effort is being made to use photosynthesis and the macroculture of unicellular organisms as a means of producing the basic food constituents, carbohydrates, proteins and fats and the essential vitamins without recourse to the land. Nutricultural techniques have also been developed with the same object in view. More and more stress is being placed on food and commodity production by techniques not using the land, as current soil usage is enormous.

NEW FOOD RESOURCES

The most advanced soilless techniques yet developed for food production are nutriculture—or more specifically, hydroponics—and the micro-biological production of food yeast. Neither technique has yet become fully established or contributes significantly to the world food stock-pile, although both have been operated with reasonable success on the production scale for a number of years.

Nutriculture: The terms *soilless culture or nutriculture* imply the growth of plants in any material other than soil and at the present time three general methods are recognized, 1) sand culture, 2) water culture (hydroponics) and 3) sub-irrigation culture, also called gravel or cinder culture.

In sand culture the soil is replaced by fine sand, the surface of which is watered with a nutrient solution. This method is simple and with proper control is capable of producing good crops. It is useful for experimental studies but is not well suited for large-scale crop production as it is wasteful of water and nutrients.

In the water-culture method which has received much more attention, the plants are grown with their roots suspended in a nutrient solution contained in shallow tanks. The need for aerating the solution and the difficulty of supporting the plants are disadvantages of the method. Control of the composition of the nutrient solution is also somewhat more exacting than in other methods of culture.

In the sub-irrigation method of culture, watertight beds or benches are filled with gravel or other suitable inert material which is irrigated by circulating nutrient solution from the bottom of the bed. This method overcomes some of the limitations of the sand and water culture systems.

The chemicals used in the nutrient solution must supply relatively large quantities of nitrate-nitrogen, potassium, calcium, magnesium, phosphate and sulphate, and are usually applied as potassium nitrate, calcium sulphate, calcium phosphate and magnesium sulphate. Certain other chemicals such as iron sulphate, manganese sulphate and boric acid must also be available in small quantities.

It is now generally recognized that nutriculture has a definite, if small, place in agriculture, its chief value lying in two applications: the first is in areas wherein suitable agricultural soil does not exist but the climatic conditions are suitable for crop production. The second is in its use as an improved type of forcing technique in greenhouses for growing crops which have a high return value.

In the former category fall the U. S. Army Air Force nutricultural gardens on Ascension Island, in British Guiana, on Iwo Jima and in Japan, where an 80-acre garden provides the occupation forces with three to five servings of fresh vegetables per week. Successful units have also been operated by the oil companies in the Islands of Aruba and Curaçao, N.W.I., since 1944.

In the second category primary interest in the United States appears to be in the production of lettuce, radishes, cucumbers, tomatoes, onions, peppers and flowers.

Nutricultural techniques are receiving increasing attention, the more active centres of investigation being at Purdue University, the California and New Jersey Agricultural Experimental Stations and the Bureau of Plant Industry, U. S. Department of Agriculture, Beltsville, Md., in the United States; Rothampstead in the United Kingdom; and the Hydroponic Research Centre, University of Brussels, in Belgium.

Proteins from micro-organisms: The introduction of yeast into human dietary is not new; yeast cells as contained in food and drink fermented by naturally occurring yeasts have formed part of the diet of man from the earliest times. The manufacture of strains of yeast for use as a major component of animal and human food is new, however, being first seriously considered in the First World War by the Germans, who planned to use molasses as the raw material. Shortage of sugar prevented these plans from being carried out on a significant scale. Interest was revived again during the pre-war Nazi regime, when an attempt was made to produce high quality protein required for self sufficiency from waste products other than sugar. In this they were par tially successful as by the end of 1944, six factorie were producing at the rate of 7,000 tons per annum using the wood sugars in sulphite waste liquor from th pulping industry, for the rapid growth of the food yeas *Torulopsis utilis,* in high yield. Five further plants pro duced another 9,000 tons, using wood hydrolysed by th Scholler or Bergius processes as substrate.

Work on the manufacture of *Torulopsis utilis* on a experimental scale was started independently in Londoi in the early days of the Second World War, under th direction of Dr. Thaysen, whose paper describing thes investigations and their development has been presentei as an experience paper to this session. On the basis o this work a British Government undertaking, Colonia Food Yeast Ltd., was started in Jamaica, B.W.I., ii 1944, with a rated output of 12 tons per 24-hour day using waste materials from the sugar industry as a source of supply of the necessary carbohydrates.

Despite the success of these ventures, the industry is not yet firmly established; processes and equipment are still in a stage of rapid change and development; and the economic soundness of the project still appears to depend largely on place and conditions. Neither is foo yeast yet generally accepted. There appears to be littl doubt, however, that as production techniques improv and as more palatable forms become available, there wil be a growing demand for food yeast on its own merits These are of a high order as has recently been prove by the Medical Research Council in London, whose extensive trials showed that it is an acceptable and generally palatable food for humans, containing proteins ir amounts equal to about half its dry weight, and whe included in a diet of which the protein is otherwise derived mainly from cereals, possesses a high nutritiv value, approaching that possessed by milk proteins. It has the additional advantage of being one of the riches known sources of the B-vitamins, riboflavin and nicotinic acid, in this respect being only rivalled by liver.

Compared with all other proposals yet made for increasing the availability of protein, the food yeast proposition is many more times effective. The position may be altered if the animal protein factor, which is soon to be made available to the food industry, or if the replacement of one-third of certain ruminants' protein diet by ammonium or urea salts, prove to be as effective as initial experiments suggest.

Fats and carbohydrates from micro-organisms: Although the estimated world production of 20,000,000 tons of fats and oils in 1947 fell short of the average production during the period 1935-1939 by 1,500,000 tons, micro-biological fat production is relatively less urgent than protein as, in a subsistence-level diet, fat can, if necessary, be almost entirely replaced by carbohydrate. Even so, the finding of additional sources of food fat is of urgent importance to large areas in the world, such as India, China and parts of South America, where fat supplies have always been deficient although in normal times considerable volumes of sugar cane molasses have gone to waste. The possible production of fats from micro-organisms is therefore of real significance to these countries and to those which have to import their fat and oil requirements.

Early German attempts to produce the fat-containing yeast *Endomyces vernalis* and the mould *Oidium lactis* on an industrial scale were unsuccessful. Recent work has revealed three new fat yeasts of much greater promise, all capable of production by deep culture techniques, i.e. *Torulopsis lipofera* (43 per cent fat); the so-called "soil yeast" (55-62 per cent fat) isolated in 1946 by Starkey, and the pink *Rhodotorula gracilis.* This latter would appear to hold out more promise than the others, for besides producing 50 to 65 per cent of a fat resembling palm oil, it is unique in producing 16 to 19 parts of the fat per 100 parts of sugars and, in addition, can grow without lowering of fat yield in a medium such as molasses, having a very high nitrogen content.

A determining factor common to both food and fat yeast production is the availability of cheap carbohydrate containing or capable of providing the sugars necessary for their growth. For the present, wood sugars and molasses only have been used, although attempts have been and are still being made, with varying success, to use hydrolysed straw and oat hulls, cheese whey, fruit and canning wastes. Despite the potential availability of large quantities of by-product and surplus sugar, the search for new sources is continuing.

The reason for this is obvious: all currently available sources of carbohydrate find their origin in the land. With this very real difficulty in mind, the imagination of conservationists has recently been stirred by the implications of the fundamental studies carried out by Pearsall and his collaborators in London, and Calvin, Gaffron, Winakur, Myers, Spohr and those associated with them in the United States.

These investigators have separately been studying the biochemistry of photosynthesis for a number of years, in nearly every case using unicellular fresh water algae such as *Chlorella vulgaris* and *Scendesmus obliquus* as their biological starting material. Whilst these studies are only in their initial stages, it now seems certain, on the laboratory scale at least, that moderate light intensities, not necessarily applied continuously, induce astoundingly large growth-rates of such algae given the necessary inorganic nutrients and trace elements. Calculations made on the basis of the admittedly inadequate information at present available indicate that the potential yield of algal carbohydrate per acre of pond surface is many times as great as that obtained per acre of land using the best agricultural techniques known. These findings alone are fraught with possibility, but when considered in the light of the recent work of Spohr and Milner at Stanford University, their implications become incalculable. This team has carried out a thorough study of the influence of different environmental factors on the composition of certain unicellular fresh water algae. As a result, they are now able to define conditions whereby *Chlorella pyrenoidosa* can be cultured on the large laboratory scale with a controllable variation in fat content ranging from 5 to 75 per cent of the dry weight. If this technique can satisfactorily be translated to the production scale, its impact both on the food and commodity industries will be appreciable, as the fats thus synthesized are highly unsaturated and of a quality adequate for edible and certain industrial purposes.

Before leaving the algae, some consideration can usefully be given to the marine forms and their utilization, the consideration of which, at this stage, is logical, as they serve as the natural link between new food and non-food resources.

NEW INDUSTRIAL RESOURCES

Marine algae: The true seaweeds are usually and most conveniently classified by colour: brown, red, green, blue etc. Of these, the first group, the *Phaeophyceae,* is in great preponderance, and with the exception of the use of the red weeds for agar production, is the only group which has been exploited industrially. Strangely enough, although we tend to look upon algal chemistry as of recent origin, actually in one form it is one of the oldest branches of industrial chemistry. As far back as the early 18th century brown seaweeds were collected in France, Ireland, Scotland and Norway and burnt to an ash known in Europe as kelp, first to provide soda for the growing soap and glass industries, and later potash and iodine. The industry based on these inorganic chemicals virtually ceased to exist at the opening of the present century, having failed to resist the competition of these chemicals obtained from cheaper mineral sources.

Before the kelp industry entirely collapsed in Scotland, however, Stanford, a chemist long interested in the project there, discovered that the high proportion of organic matter in seaweed which his company and those preceding them had been burning for 200 years contained, amongst other things, a rather remarkable colloid very similar to cellulose in chemical constitution, to which he gave the name alginic acid. His discovery came too late to save the kelp industry although he did, quite unwittingly, pave the way for the 20th century seaweed organic chemical industry. Before examining the achievements of this new industry and its potentialities, it will be necessary first to review the world's seaweed resources.

Over 70 per cent of the surface of the earth is covered with water, and the sea contains all the minerals required for life and compares favourably with good garden soil in fertility. Acre for acre it is more productive than the land and there is no danger of drought or violent temperature fluctuations and relatively little fear of disease. It has been estimated that half the total photosynthetic fixation of carbon dioxide into organic matter equivalent to 1.5×10^{11} tons of carbon a year is brought about by marine plankton and algae. This suggests vast untapped resources of organic matter. Why, then, have these not been exploited before now?

The answer is simple. Oceanography and marine biology are young sciences so that relatively little is known about what goes on in the sea; also until recently it has been quite easy to win all the foodstuffs and industrial raw materials we needed from the land, without venturing into the comparatively unknown depths of the ocean.

The urgencies of two world conflicts in one generation coupled with the growing exhaustion of the land, have tended to alter that. Potash and acetone shortages in the 1914-1918 war forced America to survey and use the beds of the giant floating weed *Nacrocystis Pyrifera* growing between low water mark and 15 fathoms off the Pacific seaboard. A survey in 1913 showed that there were about 45,000,000 tons of seaweed of this type growing there. Recent surveys have shown that there are, in addition, 17,000,000 tons of similar seaweed around the Falkland Islands, and it is also known that there are comparable but, as yet, unsurveyed beds off the Peruvian, Chilean, Argentinian, Tasmanian and the New

Zealand coasts, as well as around most islands in southern circumpolar waters. In addition to this reserve of giant buoyant seaweed, there is a vast but as yet mainly unassessed and untapped quantity of bottom-growing, non-buoyant seaweed typified by the *Laminaria* species growing down to about 6 fathoms in the sublittoral zone off the North American Atlantic, British, French, Norwegian and Japanese coasts. It is impossible, at this stage, even to make an intelligent guess as to the amount potentially available, although the recent thorough survey of the Orkney Islands to the north of Scotland revealed 1,250,000 tons of this sublittoral seaweed growing in 90 square miles of inshore waters between low water mark and 6 fathoms which, expressed another way, means that in this by no means prolific area the annual photosynthetic production of carbohydrate in the form of marine algae alone is more than twice that produced by the "average" tree.

Whatever their origin or species, the brown weeds appear to be alike in chemical composition: they contain 75 to 85 per cent water, their dry content is rich in minerals and carbohydrates, relatively poor in protein and almost devoid of fats—the ratio of one constituent to another fluctuates with the season and environment. The carbohydrate fraction is, in the main, made up of alginic acid, mannitol and laminarin, corresponding to the cellulose, sugar and starch of land plants, respectively, together with fucoidin, about which little is yet known.

Of these four carbohydrates, potentially available in considerable tonnages, only mannitol, which is in steady demand in the synthetic resin field, is currently obtainable from sources other than the sea. So far only alginic acid has been exploited commercially, but its position in the food, pharmaceutical, cosmetic and textile industries now seems assured, and alginate-producing units have been operating successfully in Great Britain, United States, Norway, France and Japan, during the last 20 years. Laminarin shows some promise as a substitute for blood plasma, whilst fucoidin is an obvious source of fucose in bulk. A more significant outlet for these algal carbohydrates may well be in the use of their hydrolysates to support the growth of micro-organisms of commercial value. If this eventuates, a technical interdependence of marine and fresh water algae may well result.

Agricultural commodities and by-products: Chemurgy is not a new science, neither is it really a new idea. It is perhaps better to define it as a philosophy whereby the joint activities of organic chemists, plant geneticists and engineers are directed towards the development of non-food uses for agricultural commodities and by-products.

At first sight chemurgy would appear to be incompatible with the aims of this conference. Actually this is not the case, as although the idea was first sponsored in the middle 1930's to provide outlets for United States agricultural surpluses, wheat and cotton in particular, subsequent emphasis has been on the use, as raw materials for industry, of such parts of plants as have no food value and heretofore have been dismissed as useless. As will be seen from a study of Dr. Hilbert's paper, typical American achievements in this direction are the production of building boards from straw and sugar-cane bagasse, cigarette paper from seed flax, furfural from corn cobs, oat hulls etc., pectinates from citrus and tartrates from winery wastes. Similar emphasis has been placed on the finding of new crops of potential industrial value capable of growing on marginal or waste lands: as typified by the production of strains of "waxy" corn and sorghum of high amylopectin content capable of being grown in commercial quantities in the arid south-west, the introduction into Arizona of guar, an Indian drought-resistant legume containing a manno-galactan gum of value to the paper industry, and the discovery that canaigre, a small annual native to south-western United States, has a high tannin content.

Many examples of how chemurgy can create new resources without further drain on the land could be given, but one must suffice.

As is well known, the use of trees is a grossly inefficient process. In North America alone, where forestry conservation was born, the annual depletion of forests amounts to about 188,000,000 tons, of which about 70 per cent is wasted in lumbering and processing operations. About 15,000,000 tons of this are used in the sulphate, sulphite and soda pulping plants in North America, of which amount 50 per cent is lost as soluble by-products. It has been estimated that the sulphite mills alone each year run into waste 500,000 tons of mixed sugars and 1,250,000 tons of lignin. Although the mixed pentoses and hexoses are technically capable of producing food yeasts of the *Torulopsis* type and the hexose content, amounting to 65 to 70 per cent of the whole, is fermentable to ehtyl alcohol, neither these nor any other use yet absorbs significant quantities of these wasted chemicals. The annual loss of these sugars and lignin still remains a challenge to the ingenuity of technical chemists and engineers.

Although the United States has, during recent years, been most active in the scientific development of its industrial resources of biological origin, largely through the setting-up and operation of its four magnificent regional laboratories, other countries have not been backward. In the British Commonwealth, for instance, Canada is operating a Prairie Resources Laboratory at Saskatoon and two others are planned. The Australian Council for Scientific and Industrial Research is actively seeking new plants of possible industrial value. The British Colonial Products Research Council has for some years been surveying the renewable resources of the Colonies and has sponsored a number of projects designed to develop certain of them to the commercial scale. Typical of these is the project of Haworth and Wiggins and their colleagues at Birmingham, who have been exploring the various transformations which sucrose, obtained either from sugar-cane or beet, can be made to undergo. Amongst a wide variety of compounds they have prepared from this starting material are the hexitols, mannitol and sorbitol of proved value to the synthetic resin and plastics industries, their anhydro compounds useful as plasticisers and resin raw materials, and their diamino derivatives which have been shown to be of possible use in the preparation of sulphanilimides and polyamides of the nylon type. Different lines of attack on the chemical utilization of sucrose have produced: hydroxylmethylfurfural, a fruitful source of materials for the commercial production of plastics and high polymers; levulinic acid, a source of solvents, therapeutics and an anti-freeze; and lactic acid in such high yield as to prove a likely competitor to the product produced by the biochemical fermentation method.

The recent work of Cori and his school in America and that of Hanes and Peat and their colleagues in England on the enzymatic degradation and synthesis of the components of starch and glycogen open up even wider possibilities in that they have shown that it is now possible to synthesize enzymatically starches of predetermined specifications. Starch-like polysaccharides possessing all the properties of the two most important natural components of starch—amylose and amylopectin—have already been synthesized in the laboratory. The potential importance of these findings is obviously enormous.

With few exceptions, the techniques discussed in this paper have, as yet, been insufficiently tested to become accepted practice. This approach to the problem has been deliberate, not only because the achievements of chemurgy and the cellulose, plastics and synthetic rubber technologists have been outlined by acknowledged experts in the other papers before this session, but also in the belief that much of the future happiness and well-being of mankind depends upon the proper understanding and development of some of these novel processes. It is hoped, in addition, that sufficient evidence has been produced to show, that when properly applied, the combined skills of the chemist, the agriculturalist, the microbiologist and the engineer can do much to alleviate if not eradicate the ills consequent upon food and commodity shortages in this shrinking world.

The CHAIRMAN: Thank you, Dr. Woodward. The next speaker will be Dr. G. E. Hilbert, Chief of the Bureau of Agricultural and Industrial Chemistry, in the United States Department of Agriculture.

Mr. HILBERT *delivered the following paper:*

The Contribution of Chemurgy

G. E. HILBERT

ABSTRACT

Chemurgy is defined as the application of science and technology to the processing of agricultural commodities for both food and non-food purposes. The value of chemurgic advances made by countries other than the United States is acknowledged. Chemurgic objectives are discussed, and it is indicated that their attainment involves further development of traditional methods of utilizing farm products as well as discovery and exploitation of new industrial uses for agricultural materials.

The importance of modern food technology as a chemurgic endeavor to create and conserve food resources is pointed out. Several recent developments in food preservation are described.

The processing of agricultural commodities to recover and utilize their constituents in food and feed products and as industrial raw materials is discussed. The wet-milling of corn (maize) and grain sorghum and the processing of soybeans and other oilseeds are cited as examples of chemurgic enterprise in this field. New developments in fermentation and in the utilization of alcohol as motor fuel are mentioned.

Reference is made to facilities and information available in the United States to aid in the chemurgic training of scientists and technicians of other countries. It is emphasized that progress in chemurgy depends upon coordinated effort in many fields, and that efficient agricultural production, adequate scientific research, advanced technology, and aggressive industrial enterprise all contribute to chemurgic success.

I

I am honored to have the privilege of discussing with this distinguished international group the contribution of chemurgy to the conservation and wise utilization of agricultural resources. The term "chemurgy" is hard to define precisely, but I shall interpret it here to mean the application of science and technology to the industrial processing of agricultural commodities for both food and non-food purposes. Chemurgy involves an effort to use farm products and byproducts more effectively, and to create from them new resources of foods, feeds, and industrial raw materials.

In my remarks I shall speak chiefly of chemurgic developments in the United States and refer to several research contributions by my own organization, the Bureau of Agricultural and Industrial Chemistry, U. S. Department of Agriculture. I am well aware, however, of the important chemurgic advances made in other parts of the world and by other research organizations in this country and elsewhere. I should like to acknowledge here that we in the United States have profited greatly from the pioneering work in chemurgy done by other nations. Many of you can take justifiable pride in the chemurgic achievements of your countrymen, who have done admirable work under difficult conditions and often with very limited technical facilities.

I might mention also that certain chemurgic developments which have been highly successful in other countries are relative failures here because of the different agronomic and economic conditions that exist in this country. At the same time, we in America with our highly industrialized economy have been able to engage profitably in some chemurgic operations that so far have not proved feasible for nations of less advanced industrial development. But despite the different problems faced by different countries, I believe chemurgy is a subject that concerns us all. If my remarks can help in some degree to stimulate international interest in chemurgy and to encourage international cooperation in chemurgic endeavors, I believe we shall all benefit.

The word "chemurgy" was coined about fifteen years ago to express with convenient brevity a complex idea —the idea of developing new industrial uses for farm commodities, of establishing new crops to supply industrial markets, and of making profitable use of farm wastes and residues. A fundamental premise of chemurgy is that farm and forest products can be reproduced, while mineral resources cannot. Chemurgy is based on the living and lasting foundation of agricultural production. It proposes that we should try to develop practical means of substituting *reproducible* products of the soil for at least some of our *unrenewable* resources, including coal and petroleum. Another basic chemurgic principle is that while man's need for food is limited his appetite for industrial products seems virtually insatiable. Proponents of the chemurgic idea in the United States during the 1930's visualized that by creating new industrial outlets for farm commodities, and by providing farmers with new crops to be grown specifically for industrial uses, it might be possible to eliminate burdensome crop surpluses. The chemurgists were acutely aware also that in traditional practice about half our total output of farm-grown materials is unmarketable waste. They emphasized the need for converting farm residues such as wheat straw, corncobs, and vegetable and fruit wastes into useful products.

In these essentials the chemurgic idea has not changed much since it was first propounded. Nevertheless, the general concept of chemurgy has tended gradually to broaden. As Wheeler McMillen, the outstanding spokesman for the chemurgic movement in this country, stated recently, "The definition of chemurgy keeps bursting out at the seams." Chemurgic objectives include the development of wider markets for farm-grown materials and the creation of "new riches from the soil". These objectives are hardly new—they have challenged man's ingenuity for centuries, perhaps since the beginning of agriculture itself. But chemurgy seeks to attain them by new methods, based on the latest advances in chemistry and allied sciences, and with the aid of modern engineering. It is evident that achievement of these chemurgic aims requires the expansion and further development of *traditional* methods of utilizing farm products, for food and other purposes, as well as the discovery and exploitation of *new* industrial, non-food uses for them.

II

If we accept this general concept of the meaning and purpose of chemurgy, it appears that modern techniques of food preservation constitute one very important field of chemurgic effort. Converting fruits and vegetables into more stable form by canning, freezing, and other methods lengthens the season and expands the area in which these perishable farm products can be made available, thus providing wider markets for the farmer and greater food resources for consumers. It is also a partial answer to some of our most persistent farm-surplus problems—the geographical and seasonal surpluses of perishable crops that often occur in limited areas for short seasons.

It seems to me that the international importance of recent developments in food preservation can hardly be overestimated. If modern food technology could be applied more widely throughout the world, it could raise substantially the nutritional standards of millions of people. The major techniques of food preservation—dehydration, canning, and freezing—are generally familiar to you all. We are continuing through research to improve each of these methods, to extend their use to a greater variety of farm commodities, and to increase the palatability and food value of the finished products. I should like to mention two or three new developments along this line which have potentially wide application. Although these particular accomplishments are perhaps not of great immediate significance from the standpoint of total world food supply, they are interesting as examples of modern progress in food technology.

As you know, the most spectacular recent advances in food preservation have been made in the field of frozen foods. They now make it possible for most housewives in the United States to serve fruits and vegetables of many kinds virtually "field fresh" at any season. One new product, the result of applying a new principle of food preservation, is *frozen concentrated orange juice*. Its production this year—some 7 or 8 million gallons—will consume about 10 percent of the orange crop in Florida, as well as a portion of the California crop. This concentrate, when mixed with water, makes orange juice that is almost identical in flavor and nutritional value to fresh orange juice. Yet the concentrate itself has only one-quarter to one-third the bulk of the fresh juice and will keep satisfactorily in frozen storage for more than a year. Both grape and grapefruit juices are now processed commercially in this way. The new method of concentration and freezing might be extended with advantage to other fruits, particularly some of those produced in the tropics.

Another development of considerable promise, now in an advanced stage of experimentation, is *dehydrofreezing*. This process combines the virtues of quick-freezing fruits and vegetables with the advantages of reduced weight and bulk made possible by partial dehydration. Dehydrofrozen peas, apples, apricots, and other products have excellent flavor and are easy to reconstitute in the kitchen. They occupy only about half the space in frozen storage and have about half the weight of conventionally frozen products. Experimental results show that the additional costs involved in drying are more than offset by savings in packaging, transporting, and storing these new products.

Still another new development is a method for recovering and concentrating the natural *flavor essences* of apples and other fruits. In manufacturing many fruit products, the full flavor of the fresh fruit is often completely lost. But now equipment and techniques have been devised for capturing the volatile flavor constituents of fresh fruits, so that they can later be added to fruit products in the final stages of processing to give them better flavor. Commercial production of apple essence by this method is already underway, and the process is applicable to many other fruits. Like the production of frozen fruit concentrates, the recovery and concentration of fruit essences—particularly those of various delectable tropical fruits, which have not yet found a place in international trade—has promising possibilities.

III

Besides giving us new techniques of food preservation, chemurgy has contributed greatly to our wealth of "creatable resources" through the processing of farm products to obtain starches, sugars, oils, proteins, and other constituents that can be used in the manufacture of foods and feeds and as industrial raw materials. The wet-milling of corn, or maize, and the processing of soybeans and other oilseeds are major chemurgic enterprises of this kind.

The *corn refining,* or wet-milling, industry achieves almost complete utilization of one agricultural product, the maize kernel. This industry consumes substantially more than 100 million bushels of maize each year. Its output of sugar, starch, corn oil, gluten, and other materials—which totals several billion pounds annually—finds scores of industrial, food, and feed uses.

A new chemurgic crop of increasing importance today is *grain sorghum.* It grows better than maize in semiarid climates and is therefore of particular interest to farmers in the southwestern United States. Research has given us a wet-milling process for grain sorghum and laid the foundation for a new industry in the American Southwest. One large plant in Texas is now producing starch, commercial feeds, sweeteners, fermentable sugars, and vegetable oil from this grain.

The *soybean* is the outstanding example of a crop recently introduced into the United States which has achieved true chemurgic success. As you know, soybean oil, protein, and other constituents are now used in literally hundreds of food and industrial products. When World War II cut off American imports of vegetable oils and fats from the Far East, the soybean was the only domestic oilseed that could be grown in sufficient quantity to meet the deficit. Production of this crop was almost tripled during the war, and in 1947 it reached a record total of 1½ billion pounds of soybeans. The agricultural achievement of the Midwest has made it possible for the United States to help supply Europe with badly needed vegetable fats and oil in the years since the war.

A great deal of research still needs to be done to develop improved methods of processing soybeans, to increase the flavor stability of soybean oil so that its food uses can be expanded, and to improve the drying quality of the oil for wider use in paints and other protective coatings. The fermentation of soybean meal to produce high-protein "cheeses" and similar products—which have long been important in Chinese diets—is now receiving attention in this country. This method of utilizing the soybean should be of especial interest to countries that have critical shortages of animal proteins.

The same type of research that is helping to expand markets for soybeans in the Midwest is being applied to problems of processing and utilizing peanuts and cottonseed in the South. Adaption of solvent-extraction procedures to these important oilseeds is a major objective of current research in this field. The future of chemurgy in the southern United States seems generally bright, and developments in this region may well provide the key to chemurgic expansion in other areas of the world with a similar climate.

Perhaps the most important chemurgic development in the United States during the last few years has been the tremendous expansion in the *fermentation industries,* which produce antibiotics, feed yeast, vitamins, industrial alcohol, and other needed products. A great impetus was given to developments in this entire field by the discovery of penicillin and the perfection of methods for the large-scale production of this vital drug by submerged-culture fermentation. The fermentation industries provide, among other things, substantial outlets for agricultural wastes and byproducts. Millions of pounds of corn steepwater, a byproduct of the wet-milling of maize, and lactose, or milk sugar, a byproduct of butter and cheese manufacture, are now used as nutrients for growing the microorganisms that produce penicillin and streptomycin. Fruit pulp and waste juices from the fruit-preserving industry are other agricultural wastes that find use in fermentation processes.

One interesting new development in fermentation is the production of mushroom spawn in submerged culture. This product has as good nutritional quality as food yeast and can be grown in equal quantities by similar methods. But this type of mushroom mycelium is superior in flavor to yeast—it tastes like ordinary mushrooms. Riboflavin, or vitamin B_2, is another new product of fermentation. An intensive search is now underway in the United States to find a microorganism that will produce vitamin B_{12}, the "animal protein factor" or anti-pernicious-anemia vitamin. This substance has been furnished in livestock feeds chiefly by meat scraps and fish meal, but these materials have recently been in short supply.

No discussion of chemurgy would be complete without some mention of the production of *industrial alcohol* from grains and other agricultural materials and its use as a supplementary motor fuel. This is a complex subject and I can only touch on it briefly here. A tremendous amount of work is being done in the United States to develop new and cheaper methods of producing alcohol and to utilize it as motor fuel. Perhaps the most significant development in this field, which may be of interest to many countries, is the use of alcohol as an anti-knock agent in engines by direct, automatic injection into the engine manifolds of automotive vehicles.

Until recently, alcohol has been employed as motor fuel chiefly in blend with gasoline, and a number of other countries have had more practical experience with this method than has the United States. The advantage of the direct-injection method is that the alcohol is used only when needed—that is, when the automobile or other vehicle is under heavy load, as in starting, accelerating, or climbing hills. This occurs only during about 5 percent of normal driving time. Using alcohol in this manner as an anti-knock agent permits efficient use of relatively low-octane gasoline as the main fuel. If widely adopted, this procedure could make possible a significant extension of a nation's petroleum resources.

IV

In this brief discussion I have had time to mention only a few of the highlights of chemurgy's present and potential contribution to the conservation and use of agricultural resources and to the creation of new resources. I have tried to show how chemurgy enables us to create new wealth from reproducible agricultural materials, giving rise to new industries and increasing employment. We all realize that Fortune has not dealt equally with the nations represented here in regard to the distribution of mineral resources. But the distribution of rain and sunshine and tillable soil has been in general more equitable. By making possible more efficient use of these resources and of the annually reproducible crops they yield, chemurgy can and should contribute greatly to the welfare of all countries.

Science and technology, and the facilities for making them effective, are indispensable for the achievement of world advances in chemurgy. Workers for chemurgic laboratories and factories must be trained in greater numbers in many countries. The United States is already taking steps to assist other nations with such training, in line with "Point Four" of President Truman's Inaugural Address. We have only made a beginning, and much more should be and undoubtedly will be done. My own Bureau has for some years provided laboratory training for scientists and technicians from other countries. This program is being continued, and we hope that these trainees will be able to plant the seeds of chemurgic enterprise all over the world. The Bureau has available a great deal of information on fundamental and applied chemurgic research, and we are interested in disseminating this information to all who can profit by it.

In closing I should like to emphasize that the contribution of chemurgy is made jointly by agriculture, science, and industry. Chemurgic progress can be achieved only as a result of effective coordination of many diverse lines of effort. It requires a high degree of efficiency in all phases of planting, cultivating, and harvesting crops, in processing and utilizing agricultural materials, and finally in marketing new chemurgic products. Good farming practices and soil conservation; energetic and forward-looking research; industrial enterprise and engineering "know-how"; efficient, well-organized transportation facilities; even aggressive advertising and merchandising—all these have an important part to play in the success of chemurgic undertakings.

Although the contribution of chemurgy to the national welfare of this and other countries is already considerable, it will surely become even greater in the years ahead. We know that the crops can be produced, and that they can be converted into an increasing number of needed products. Chemurgy is an outstanding example of how freely organized human effort—expended in agriculture, business, and industry; guided by science; and made effective through applied technology—can create new wealth and the materials for a better human life from the world's elementary resources.

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The Chairman: Thank you, Dr. Hilbert. The next speaker will be Dr. J. A. Hall, Director, Pacific Northwest Forest and Range Experiment Station, United States Forest Service.

Mr. Hall *delivered the following paper:*

Wood Fibre—Creatable Resource of Wide Utility

J. A. HALL

ABSTRACT

***Per capita* annual consumption of industrial wood fibre and derivatives ranges from less than 2 pounds in Asia and Africa to 244 pounds in the United States and Canada. There is a broad relationship between level of living and these figures.**

The fields of usefulness of wood fibre cover building boards, paper in its thousands of forms, and artificial fibre and plastics in a never-ending variety. For shelter and clothing, these products of industrialization represent the ability of man to derive a wealth of goods from land unsuited to the plow.

By-products of pulp manufacture are alcohol and food yeast, both of which lessen the impact upon food-producing lands. Likewise, increasing use of wood for rayon lessens the necessity of using land for fibre production.

Most powerful potentiality is the production of crude sugar from wood hydrolysis and the conversion of this to industrial materials and food. Through this avenue, in the long run, wood offers a vast opportunity as a creatable resource of first rank.

These opportunities can be realized only through the spread of industrial techniques throughout the world and the rehabilitation and wise use of the world's forests.

The existence of any universally satisfactory criterion with which to estimate the relative well-being of peoples is doubtful. If one uses any of the specific indicators that have been suggested, errors of omission usually predominate over revealed factual relations. Also, there must first be established a reasonably accurate meaning of the term "relative well-being", and this is impossible as between economists, technologists, and politicians, to say nothing of the difficulties created by the theologians.

From some points of view, wood, or rather its use, offers a satisfactory base for evaluation, but, even then, the use of wood in total volume cannot be an accurate criterion. In territories where wood in abundance is used for fuel, there may still be a low living standard. In others with abundant mineral fuels, a high living standard may be maintained with a low consumption of wood. Let us centre our attention on products derived from wood fiber and see how their uses relate to relative standards of living.

A table released by the Food and Agriculture Organization in 1949 (*Pulp and Paper,* vol. 23, no. 5, page 50) is quite revealing. It is given partially here.

Table 1. Consumption of wood pulp products, 1949

High		Medium	
Country	*Pounds per capita*	*Country*	*Pounds per capita*
United States	251	Ireland	44
Sweden	196	France	42
Canada	174	Cuba	31
Finland	132	Austria	22
Norway	128	Mexico	18
New Zealand	115	Italy	18
Australia	110	Dutch West Indies	15
Denmark	88		
Netherlands	81		
Belgium	79		
Switzerland	68		
United Kingdom	57		

The rest of the world averages mostly less than 2 pounds *per capita* annual consumption of wood pulp products with a few exceptions reaching to 5 to 9 pounds. Figures for Russia and her satellites are, of course, not available.

Table 2. Consumption of wood pulp and products, 1947

	Pounds per capita
All of the world	30.87
U. S., Canada, and Newfoundland	244.75
Oceania (Aus., New Zea., New Cal.)	122.45
Europe	46.3
Latin America	17.00
Near East and North Africa	4.41
South Asia and East Asia	0.08
South Africa	2.00

These tables serve to set forth dramatically the following roughly factual conclusions:

1. About half the world population uses so little wood pulp products as to be almost negligible in the total.

2. Illiteracy, disease, and chronic hunger are most prevalent in this half of the world.

3. There appears a broad relation between degree of industrialization and rate of consumption of pulp products with some notable exceptions, for example the United Kingdom, that are explicable on other grounds.

It would be easy to fall into error by assuming a broad causal relationship between wood fibre consumption and level of living. The best that can be adduced is the not too firm conclusion that a high level of consumption of wood fibre products tends to accompany a high living standard, and it is then necessary to seek the fundamental reasons why this should be true.

It must be recognized, also, that very high levels of wood pulp consumption may represent extravagant and wasteful uses, and that medium consumptions may represent efficient use of the material in a reasonably abundant general economy.

One thing emerges clearly. Either the presence of a high degree of industrialization, or the resources with which to buy the products of industry, or both, invariably accompany large consumption of wood pulp products. It might be inferred that a high degree of industrialization creates a high demand for wood pulp, but it is perhaps more accurate to state that the same conditions that create a high state of industrialization also create consuming capacity for wood pulp.

Chemical wood pulp and its products are creations of the modern industrial economy. Conversely, modern industrial economy increasingly makes use of wood fibre for the production of myriad forms of goods ranging in technical complexity from the crudest use in simple building boards to the sheerest of silken fibres for luxury wear. There is no visible limit to the amount of wood fibre that *could* be used by the peoples of the world. But there are very serious limitations on the ability of these peoples to make use of this remarkable material and its versatile capacity to satisfy human needs, not only for paper, fibre, and building materials, but for food.

These limitations do not lie in the inherent qualities of the material, nor in the lack of technological skills with which to effect the conversion of wood fibre into its manifold forms. They lie rather in the unavailability of industrial techniques to those peoples who most bitterly need them, and in the lack of forests to those countries which could best use their products to alleviate some of their ills.

It was not by accident that the industrial system bloomed in Europe and reached its present high state in America. Juxtaposition of coal, iron and abundant wood gave the basic raw materials for the development of the industrial system. They awaited only the catalysis of steam power, and later electric and hydrocarbon power to give rise to the marvelously complex and integrated system that we call modern industry. Not the least of the important factors in this complex was wood, without which coal and iron are not widely mined nor transported. And above all, wood fibre furnished the medium upon which the written word became rapidly circulated, technological information, scientific and economic news became universally available, and a literate community became possible.

The industrial system fed upon its own products and grew from its own strength. Only a system capable of fabricating huge and powerful metal machinery and vessels and chemicals in mass could produce the volumes of wood fibre products that characterize the industrial nations today.

The wood cellulose industry is less than a hundred years old. It is founded upon a comparatively few basic scientific facts and these are only now being elaborated so that the future holds greater promise than even the rich present in the capacity of wood fibre to serve our needs and wants.

Fundamentally, wood fibre is a quite complex affair, bound together in the form of solid wood. Physically, it varies in length and thickness and structure according to tree species and thus is introduced a variable that has a great deal to do with the industrial use of defiberized wood, a term generally used to describe the product of the reduction of solid wood to its component parts, the fibres themselves.

These are usually spoken of as mixtures of cellulose, lignin, and an ill-defined group of materials of variable composition denominated as hemicelluloses. Lignin is thought of as a sort of cementing material that not only impregnates the fibre itself but joins the fibres into the solid state of wood. Actually, there is a great deal of argument as to the structure of wood and the nature of lignin. Wood, treated in various ways by various chemicals, can be reduced to several fractions, of which something called lignin is one. The form, character, and chemical structure of lignin vary quite broadly in accordance with its method of preparation. There is no firm evidence that it exists in the primordial wood in the form in which it is isolated, and there is reasonably good evidence that it exists in the wood in a different form, probably in combination with the cellulose and hemicellulose components of the fibre.

Thus it can be seen that wood fibre is a complex system. A thoroughly inaccurate but perhaps illustrative description might be to conceive a core of cellulose, surrounded by envelopes of hemicelluloses and then an envelope of lignin. Thus chemical treatments, as in chemical pulping processes, attack the lignin, dissolve part of the hemicelluloses and leave the cellulose. Actually, nothing of the sort takes place, for lignin and hemicellulose appear to be throughout the entire fibre.

About 125 years ago, proof was given that cellulose consisted of glucose molecules joined together. Much later, in fact within the last 25 years, we have learned not only the structural mechanism by which they are joined, but a great deal about the length of the chains thus created. We have learned that wood cellulose itself is quite highly variable as regards the length of the chains of glucose molecules constituting it, and that the length of these chains has a great deal to do with the properties of the various fibres and films made from it.

The so-called hemicelluloses are more complex still. They consist of various kinds of molecules of several six- and five-carbon-atom sugars plus an occasional oxidized sugar making up another family known as the uronic acids. Generally speaking, about half the wood fibre is cellulose, about a fourth lignin, and about a fourth hemicelluloses.

The simplest form of industrial wood fibre is produced by mechanically subdividing wood into its constituent fibres. The most common form of this process consists in holding the wood billet against a rapidly revolving abrasive stone, while playing enough water on the point of contact to keep down heat and wash away the liberated fibre. This is the "ground wood" that makes up a large proportion of newsprint. The fibre produced is short and broken, contains all or most of the natural lignin and hemicellulose content, and is mostly useful for its mechanical properties in combination with other types of pulp.

The next simplest form of producing wood fibre consists of softening the wood by heating with water or steam, followed by mechanical defiberizing in a special type of attrition mill. Yields of coarse fibre up to 85 per cent or more of the weight of wood are obtained. These fibre bundles are extremely useful for structural boards and roofing felt.

By using mild chemical agents and heat to soften the bonds between the fibres, probably loosening lignin-hemicellulose bonds, and then using mechanical means to effect defiberization, a very useful pulp, semi-chemical, is obtained. Numerous of these so-called semi-chemical processes have been developed and are entering industry. They produce high yields of wood pulp, up to 78 per cent or more, and are promising to be of broad usefulness in many grades of paper where strength and not white color are of greatest value. These semi-chemical pulps can be bleached satisfactorily with yields up to 55 per cent.

It will be noted that these processes, the mechanical and semi-chemical, depend upon mechanical means to effect the desired sub-division of wood into fibres. Strangely enough, the earliest pulping processes did not use these principles at all. They depended rather upon chemical treatments to dissolve away the lignin and most of the hemicellulose components, leaving the fibre skeleton of more or less pure cellulose for subsequent manufacture into paper and other pulp products. Through various stages of development, two major types of industrial chemical pulping processes have developed: 1) acid processes, exemplified by the sulphite process, principally applied to the spruces, true firs, and hemlocks; and 2) the alkaline processes, exemplified by the "kraft" or sulphate process, principally applied hitherto to the pines, but finding increasing applicability to a wide range of hardwood or broad-leaved species.

Both these processes have as their aim the solution of the lignin and the leaving of the cellulose in fibre form. The strength of chemicals used, and the time and temperature of the cooking process, have much to do with the yield and characteristics of the pulp produced. These conditions and the wood species used are varied widely in accordance with the desire to produce wood pulps that can meet an enormous variety of requirements. These may cover the entire range from nearly pure "alpha-cellulose" for rayon manufacture to a crude, unbleached pulp for manufacture of a fibre board; from a high-grade "bond" paper to a coarse "butcher's wrapper". Fortunately, by proper choice of species and conditions, reproducible materials can be manufactured, an inescapable requirement of our complex industrial system.

It is to be noted that the length of cellulose chains and the size of "giant" cellulose molecules produced in the pulping processes are dependent in large degree upon the relative severity of the chemical treatments to which the wood is subjected. Herein lie certain potential advantages of the "semi-chemical" pulps for further manufacture into artificial fibres, for the mild treatment in these processes leaves the original cellulose more nearly unchanged. Processes have been designed to remove the hemicelluloses and lignin from these pulps, with remarkably high yields of alpha-cellulose in forms suitable for textile or sheet plastic manufacture.

A further new process of pulping, still under development in the United States, dissolves the lignin by a very mild process, leaving the carbohydrate mixture of two-thirds cellulose and one-third hemicellulose. This may be used as pulp or further separated into alpha-cellulose of high purity and the hemicellulose fraction. This latter is really a new industrial raw material of wide potential usefulness.

Paper and pulp products from these various processes constitute literally thousands of useful items that are so familiar in the modern industrial world that we hardly give them a thought. Yet the newer uses are worthy of a second glance. A huge new industry has been built on wood pulp in the form of building boards, softboard, quarterboard, or hardboard, some taking the place of lumber and plywood and some finding their own new spheres of usefulness. With the advent of the new synthetic resins, various types of hard, dense, facing materials are bonded to cores of wood pulp, to give strong and beautiful construction materials never before seen. Paper sheets, impregnated with resin, compressed and formed under heat, yield new materials, hard, strong and dense, fireproof and impervious to moisture, unique substances but basically wood fibre.

During the late war, paper packages were developed in which new resins were incorporated into the pulp stock to produce greater strength when wet. The aim was to produce packages that could be floated ashore and withstand the tropical climate. They were successful and now fill an ever-widening sphere of usefulness in the packaging of peacetime goods for transport.

For the most part we have been discussing wood fibre and its products that depend upon the preservation of the original form and structure of the fibre itself, at least in so far as the arrangement of cellulose is concerned. While these uses bulk very large in tonnage consumed and are of tremendous importance in all aspects of modern industrial civilization, other manifestations of the versatility of wood fibre render it almost omnipresent in our civilization. One can never tell by looking whether one is dealing with wood cellulose of some sort in a new form.

For the most part these new forms take on two general characters; either they are cellulose fibre derived by solution of the original wood cellulose and reprecipitating it in fibre or sheet form, or they are some chemical derivative of cellulose appearing as a plastic or mixture of plastics in some form or other.

Perhaps the oldest of the plastics family was celluloid, which was essentially cellulose nitrate plasticized by the addition of camphor. Originally most cellulose nitrate, whether for celluloid manufacture or later for guncotton, was manufactured from cotton linters. As the volume and purity of wood cellulose have increased, more and more of the cellulose chemical industry has been based upon the use of wood fibre. This new raw material has developed into one which is easily reproducible and not subject to seasonal variations and climatic changes.

The earliest synthetic fibre was based upon the solubility of cellulose in cuprammonium solution and its reprecipitation in fibre form. Later came the treatment of cellulose with acetic acid and the recovery of acetate rayon as fibre, sheet, and plastic castings. And finally came the viscose rayon processes by which cellulose is converted to cellulose xanthate and then regenerated as fibre or film. The last process has grown very rapidly and now dominates the rayon field.

The relative importance of rayon in world economy may be appreciated by setting its annual production, nearly 2,500 million pounds, against world production of cotton, about 11,000 million pounds. Thus rayon production approaches 25 per cent of cotton production. This figure does not include tonnages of regenerated cellulose, cellulose esters and ethers used in the extensive plastic molding industry and sheet plastic industry that have grown upon a cellulose base.

It is of great significance that in the United States, in 1948, 81 per cent of the rayon production was from wood pulp. For a long time wood pulp was used mostly in viscose rayon, as its production in higher refinement was not sufficiently perfect for wide use in the field of acetate rayon. However, recent development of a new method for making rayon pulp in the United States out of southern hardwoods by an alkaline two-stage cooking process is expected to increase the availability of wood cellulose for the manufacture of cellulose acetate products.

There is a long list of commercially important cellulose esters and ethers that are being manufactured for both general and special uses in lacquer and plastic fields.

Much of the progress in recent years in the field of adapting wood fibre to this expanding field of usefulness has grown from our broadened knowledge of the basic nature of the wood fibre itself and the fundamental chemistry of the cellulose molecule. It is only in recent years that the chemistry of high polymers has been so well cultivated that we have reached the stage in which we can speak of cellulose molecules and chains with some degree of accurate meaning. Chain length and molecular size have all to do with the tenacity and strength of regenerated cellulose fibres and films made from wood cellulose. As pointed out before, this is a widely variable property, according to the method of preparation of the wood pulp. Only recently has meaning been given to the term "reactivity" as applied to cellulose. We are witnessing more and more the advent of new materials based on cellulose that require the production of alpha-cellulose of high purity and of predictable properties in industrial quantities. As our knowledge of the fundamental reasons for the variable properties of industrial cellulose of high purity, and of predictable properties, in the content of alpha-cellulose, but the average chain length and limits between which chain lengths may vary and the specific reactivity of the cellulose chains under definite conditions. These requirements for highly specialized properties in wood cellulose are now known to be characteristic not only of its method of preparation, but of the manner of its formation in the living wood. In the future we shall select species for special uses and give them even more highly specialized methods of cellulose extraction.

Increasing production of the fibre requirements of the world from wood fibre in some form or other is not without significance to world food supply. For it is to be remembered that these fibres are produced by industry from land that is for the most part ill-suited for agriculture. Thus wood, through the medium of synthetic fibres, tends to relieve the pressure on agricultural land for fibre production and thus serves to augment the potential food supply.

Not only in the production of fibre but in the production of sugar and sugar derivatives can wood fibre take over a large part of the burden borne by agricultural land. This fact arises from the long known fact that wood fibre can be chemically resolved into its component simple sugars and lignin. Although this basic fact has been known for over 125 years, it has only been in comparatively recent years that technical and engineering knowledge has advanced far enough to warrant the establishment of a large industry based on wood sugar.

The acid pulping process, notably the sulphite process, splits off considerable quantities of sugar from the wood fibre during the chemical treatment designed to yield wood pulp. Generally speaking, the waste pulping liquors from these factories contain from 1.5 per cent to 3 per cent of sugar in solution. As would be expected, this sugar content is a mixture of simple sugars, about 60 per cent being glucose or close relatives, and the rest being five-carbon-atom sugars, mostly xylose.

Most of the five-carbon-atom sugars are derived from the previously mentioned hemicelluloses by a process known as hydrolysis, which is essentially the addition of water to the complex molecule through the action of the dilute acids of the pulping liquors. Part of the six-carbon-atom sugars are formed at the same time, and by the action of the pulp liquors part of the cellulose is also hydrolyzed, giving rise to larger quantities of six-carbon-atom sugars.

This mixture of sugars is characteristic of the simple sugar solutions always produced by the hydrolysis of the wood fibre. It is to be observed that in pulping processes the objective is to dissolve lignin away from the wood fibre, leaving the carbohydrate material untouched, but this cannot be done in such a way as to effect a clean operation. Therefore, part of the cellulosic material is actually changed to sugars. In alkaline pulping processes, due to the action of the alkaline medium, the sugars are destroyed.

Now it happens that five-carbon-atom sugars and six-carbon-atom sugars can be treated quite differently, even in the same solution. Some organisms can ferment six-carbon-atom sugars, for example, to alcohol while leaving the five-carbon sugars untouched. Others can ferment all, with the production of quite an array of materials. Commercially successful processes for the fermentation of sulphite waste liquor have been in use for many years in northern Europe, and there are now three successfully operating plants in North America manufacturing industrial ethyl alcohol by the fermentation of the six-carbon sugars of sulphite waste liquor. In some plants in Sweden and Switzerland the unfermented sugar residue, after the removal of the alcohol, is further used as a medium for growing certain varieties of yeast, either for human or animal consumption. As a matter of fact, the yeasts that are used in the production of alcohol by fermentation, under different conditions of supply of air produce little or no alcohol and merely multiply themselves. The separation and preparation of the resultant yeast is not a highly difficult process and leads to a nutritious food stuff that is about half protein and quite high in certain desirable vitamins. In North America, initial operations in the production of yeast from sulphite waste liquor have been successfully executed.

The utilization of waste pulp liquors from acid pulping processes is obviously confined to countries producing woods capable of being pulped by such liquors, and these are not scattered widely over the face of the earth. They are, for the most part, the spruces, true firs, and hemlocks. Hardwoods are not easily pulped by sulphite liquors, nor are the pines after they have reached the age when heartwood has begun to form. Also, the capacity of sulphite waste liquor to produce industrial raw materials or food is strictly limited to the base capacity of the pulp plants themselves, and these exist almost entirely in highly industrialized countries. Because of these limitations, men have sought to utilize successfully the tremendous reservoirs of available carbohydrate material, represented in the world's wood crop, in the production of cheap sugars, both as industrial raw material and potential food supply.

Early attempts were made in Europe and in North America in the first years of the 20th century. The first plant in North America was attempted at Port Hadlock, Washington, in 1905. During the First World War two factories operated in the United States that successfully produced industrial alcohol from southern pine sawdust by batch treatment with dilute sulphuric acid under steam pressure and fermentation of the resultant crude sugar solution to alcohol. These plants were abandoned at the end of the war, for several reasons, principally their inability to compete with cheap West Indian molasses as a base for industrial alcohol, and, as a second but important reason, the virtual exhaustion of the timber supply tributary to the sawmills with which they were connected.

Research has continued, especially in Europe, to the present time, and has been exceptionally active in the United States since 1941.

The well-known Scholler process for the hydrolysis of wood to sugar by percolation with dilute sulphuric acid was modified during the Second World War by chemists at the Forest Products Laboratory at Madison, Wisconsin, and a plant was built at Springfield, Oregon, designed to produce about 5 million gallons of industrial alcohol per year from sawmill waste. The war ended before this plant was activated, and it has not yet operated on anything but an experimental basis.

In the meantime, intensive research has continued at Madison on improved techniques for the production of sugar solutions in a pilot plant based on this process and the conversion of those sugar solutions into alcohol and yeast. Likewise, research has continued on the production of a 50-per-cent wood molasses from the approximately 5-per-cent sugar solution that is produced by the process.

At the same time, intensive feeding experiments have been conducted at various agricultural colleges throughout the United States, in which wood molasses has been fed to poultry and livestock, and yeast (*Torula utilis*) grown on wood-sugar solution has been fed in many combinations. The results have been quite good, and there appear to be no technical obstacles to the large production of abundant wood molasses for livestock feed and abundant wood yeast for the same purposes.

It is to be observed that in the North American economy little attempt has been made to move in the direction of adapting wood sugar or wood yeast for human consumption. Always in the background, however, lies the truth that in case of necessity it can be done. It is an easy calculable fact that all the sugar requirements of the United States could be produced from the forest and mill waste of the Pacific Northwest if it became necessary to do so.

There are several aspects to the potentially large production of wood sugar, and products derivable from it, that bear directly upon the world-wide food problem. In the first place, industrial alcohol is an increasingly important raw material. The shrinking petroleum supplies and the never-ending demands for internal combustion fuel indicate that in the future combined use of alcohol and hydrocarbon fuels must demand the attention of engineers. The use of alcohol in combination with hydrocarbon fuels has been repeatedly demonstrated to increase the efficiency of the use of the latter. However, the two most important materials for the production of industrial alcohol are: 1) fermentation of sugars or grains which are agricultural products, and 2) refinery waste gases or other by-products of petroleum manufacture. It is to be observed that industrial alcohol production in the first case may be conceived as competing for food supply and in the second case competing for important materials needed for power and transportation.

Wood can relieve agriculture and the petroleum industry of the task of producing industrial alcohol. Whether or not it will, remains in the realm of economic prognostication.

Unfortunately, the production of wood sugar and the products that can be made from it is possible today only in countries already possessed of two basic requirements: 1) forests and forest industries, and 2) highly developed industrial organizations and technical knowledge. It is important to recognize that both of these important factors do not exist together in very many countries of the world, and one, or both, are conspicuously absent from most of the parts of the world in which chronic hunger prevails. It is well that those countries that have the forest resources and the industrial ability should develop the technology for broader use of this tremendous potential contribution of wood to basic world economy. But it is well, also, to realize that the full power of the contribution of wood cannot be felt unless and until both these factors have become more wide-spread.

In the recently released *Forest Resources of the World,* put out by the Food and Agriculture Organization, the world-wide shortage of forests is very well portrayed. There are only a few bright spots in which we may confidently expect steady progress in the production of forest materials. As a general thing, wood volumes and forest areas are still decreasing. It is tragic, also, that the more primitive the community and the lower it is on the industrial scale, the greater the impact is likely to be upon the forest. And yet, world-wide abundance of forests, coupled with a world-wide distribution of industrial facilities, could probably make as great a contribution to the alleviation of world-wide want as any resource that we can conceive. For, remember, the forest generally grows on land that is not suited to the plow. It is true that historically there has been, and still continues, a never-ceasing competition between the nomadic herds of sheep, or goats, or cattle and the forest. Likewise, the exhaustion of the forest usually follows upon the crowding of population upon fuel supply in those countries where coal and petroleum are not known.

There is probably, world-wide, enough forest land to meet all the tasks that might be asked thereof if all the forests were productive. But, generally speaking, this is not the case. For example, the total forested area of the world is estimated in this report to be 3,978 million hectares, of which two thirds is classed as productive. In Africa, often thought of as abundant in forests, the nonproductive proportion reached 64 per cent of the whole.

We are discussing creatable resources, and I submit that because of the versatility of wood fibre, because of the many ways in which it is already contributing, and the many ways in which it can contribute to a much greater degree to the subsistence and economic stability of the world, the forest is, indeed, to be considered as an important creatable resource.

It is estimated in the FAO report mentioned above that the forests of the world are capable of providing reasonably adequate supplies of their products to a population larger than now exists, but with the proviso that productive forests must be treated as renewable crops and the wide-spread devastation of forests must be stopped.

Glesinger, in his book *The Coming Age of Wood,* estimates that there are 3,000 million acres of forest now in use supplying annually not quite 1,200 million tons of wood. He estimates, conservatively, that there can be from this land a perpetual harvest of 3,000 million tons of wood a year under proper management.

There are 5,000 million acres of virgin forest in Africa, South America, Alaska, and Siberia that will be brought into the world economy and, if well handled, can produce an annual 10,000 million tons of wood in perpetuity.

Of the 4,000 million acres of the earth's original forest that have been destroyed by man, 1,000 million might well be replanted to forest, especially since much of this land exists where the population is most greatly in need of the products of the forest.

The potential output of the 9,000 million acres of world forest properly managed could be 14,000 million tons of wood a year and millions of tons of industrial products derivable therefrom. One may reduce this figure by any degree of conservatism that seems desirable and still conclude that the forest through the medium of wood fibre and its derivatives can make a tremendous contribution to the amelioration of world-wide hunger and want.

I have made a simple calculation. The cost per day of the Second World War was a little over $500,000,000. At present in the United States it costs about $25 per acre to reforest denuded land. The cost of one day of the Second World War would reforest 20 million acres. The cost of that war for fifty days would have reforested the entire 1,000 million acres that Glesinger estimates could be properly reclothed with trees. I am not so naive as to believe that we are on the verge of any such undertaking. But we are in the possession of scientific knowledge, industrial skill, and industrial plant with which to spread the potential benefits of the forest to the uttermost ends of the inhabited earth.

The CHAIRMAN: Thank you, Dr. Hall. I now call on Dr. Harry Lundin of the Royal Institute of Technology, Stockholm, Sweden, to deliver his paper.

Mr. LUNDIN *delivered the following paper:*

Fat Synthesis by Micro-organisms and Its Possible Applications in the Food Industry

HARRY LUNDIN

ABSTRACT

By aerated cultivation of the type employed in the manufacture of baker's yeast or *Torulopsis utilis* (protein yeast) and employing a special fat-producing micro-organism, *Rhodotorula gracilis* (fat yeast), it is possible to produce a cell substance containing over 60 per cent fat, dry basis.

In order to attain a high yield of fat, it appears suitable to divide the cultivation into two phases: a continuous growth phase with moderate fat formation and a continuous fattening phase in which the fat formation is very prominent. During the growth phase (6 hours) the ratio nitrogen:sugar in the substrate should be high, which causes the organism to increase at a considerable rate. During the fattening phase (approximately 2 days) the ratio nitrogen:sugar should be low. The organism thereby consumes most of the sugar, converting a considerable part of it into fat. In industrial production these phases may suitably be separated.

The fat yeast formed has the following composition:

Fat	42 per cent	Carbohydrates	31 per cent
Protein	23 per cent	Mineral substances	4 per cent

The composition of the component fatty acids of *Rhodotorula* fat is rather close to that of the fruit coat fats (palm oil fat).

The components of the vitamin-B complex and the provitamins A and D are present in the fat yeast.

From 100 kilogrammes of sugar are obtained the following: 14.7 kilogrammes of fat, 8.1 of protein, 10.8 of carbohydrates and 1.4 of mineral substances.

Cane-sugar molasses has been used as a raw material with good result. In the Far East molasses is very cheap. Cheap sugar containing solutions may also be obtained from the prehydrolyses of plant material, such as straw, prior to the production of cellulose. So far, however, such prehydrolysates are produced only in a few places and in limited quantities.

The costs for chemicals, fuel, electric power, repairs, packing, freights, insurance, salaries, and for capital investment are difficult to estimate but may amount to about $0.25 per kilogramme, dry basis, of fat yeast. The cost of sugar in the raw material (molasses, prehydrolysates) per kilogramme of dry yeast produced may vary from zero to $0.30. The total costs for the production of one kilogramme, dry basis, of fat yeast may thus vary between $0.25 and $0.55.

From the physiological as well as economical point of view it is advantageous to use the fat yeast as such as a food, without preparatory treatment other than washing, autolyses, drying and grinding. In this way not only the fat of the yeast but also the proteins, vitamins and mineral salts are utilized. The taste of the fat yeast is superior to that of *T. utilis* yeast. It should preferably be incorporated in other foodstuffs as, for example, preserved foods (or flour) in such quantities that a daily consumption of 24-48 grammes of fat yeast, containing 10-20 grammes of fat, 5.5-11 grammes of protein, 200-400 microgrammes of thiamin, 500-1,000 microgrammes of riboflavin, 3,000-6,000 microgrammes of niacin,[1] and appreciable quantities of the other B-vitamins and the provitamins A and D, are provided for. The quantities of the essential fatty acids, linolic and linolenic, and of the essential aminoacid lysin, are appreciable in *Rhodotorula* fat yeast. Such an addition of fat yeast will improve the utilization of proteins and carbohydrates in the diet—especially if the diet mainly consists of cereals—and help in preventing such avitaminoses as occur in cases of deficiency of the vitamins mentioned.

[1]These quantities of thiamin, riboflavin and niacin correspond to about 20-40 per cent of the daily requirement.

Micro-organisms contain a certain amount of fat as part of the cell structure. Some micro-organisms can, in addition, store great quantities of fat in their cells.

It has been known since the First World War that fat produced by the mould *Endomycopsis vernalis* can be used for food without further processing, and that its composition resembles that of vegetable fats. It was used in the baking of bread, for spreading on bread instead of butter and so on. Tested on animals it was found that about 60 per cent of the fat could be absorbed if the fat containing mycelium was fed directly without previous fine grinding or extraction. If, on the other hand, the fat was extracted, the digestibility was nearly 90 per cent, thus approximately the same as the digestibility of the ordinary fats in human food.

Investigations concerning the possibilities for industrial production of fat by certain species of *Rhodotorula* yeast were initiated in Sweden in 1941 by the Wartime Research Organization following a suggestion by Professor Edy Velander. This work was mainly carried out at the Royal Institute of Technology in Stockholm by Dr. L. Enebo and co-workers of the Division of Technical Biochemistry and by Dr. N. Nielsen and co-workers of the Division of Food Chemistry. Certain parts of the work have been carried out in the laboratories of Professor R. Nilsson (Institute of Agriculture, Upsala), Professor K. Myrback (University of Stockholm) and Dr. S. Brohult (the L.K.B.-Research Laboratory, Stockholm).

A comparative investigation was first carried out with twelve different *Rhodotorula* species. It was shown that the different species behaved very differently both in regard to rate of growth and in the matter of fat-producing capacity and filterability. *Rh. gracilis,* Rennerfeldt, proved to be decidedly superior to the other eleven varieties in these three respects (Enebo, Velander, Berg, Lundin, Nilsson, Myrback, 1944, and Enebo, Anderson, Lundin, 1946.)

An observation made by Lindner in 1915, indicating that the fat content of *Endomycopsis vernalis* increases if the content of nitrogenous assimilable compounds in the substrate is decreased, was confirmed for *Rh. gracilis* for fermentations of short duration (about 20 hours). As long as sugar and nitrogen (ammonium sulphate) are simultaneously present in the substrate in large amounts and the cells are young the protein content will be high and the fat formation will be obstructed. The contents of fat and protein in *Rh. gracilis* yeast are to a certain extent in an inverse proportion to each other so that if the fat content is low the protein content is high and *vice versa.* When working with young cells it is feasible to stimulate the formation of fat by decreasing the supply of nutritive substances necessary for the formation of protein, by decreasing the nitrogen-containing nutritive substances. If, however, the cultivation of *Rh. gracilis* is continued for a long time (about 25 hours or more) in a medium rich in sugar and nitrogen, old yeast cells with a rather high content of fat (40 to 50 per cent on the dry basis) will result.

Figure 1 shows the sugar content of the substrate and the quantities of yeast and fat as functions of time. The highest fat content obtained was 63 per cent, dry basis, of the yeast.

The diagram indicates that the cultivation process consists of two distinct phases, namely, one growth or protein-formation phase and one fat-formation phase. During the *growth phase* there should be an ample supply of sugar and nitrogen (ammonium sulphate). The number of yeast cells increases rapidly until about 12½ hours have elapsed from the start. The time of generation of the yeast cells is short (2 to 3 hours) or about the same as in the cultivation of baker's yeast and *Torulopsis utilis.* The fat content is low; the protein content high. The *fattening phase* commences when most of the nitrogen in the substrate has been consumed. During this phase, ample quantities of sugar are added—but no nitrogen. The growth slows down and the fat content increases rapidly (after 17 hours). The time of generation of the yeast cells increases to 15 to 18 hours. The sugar curve shows a uniform slope, which means that the transition from the phase of rapid yeast formation and slow fat formation to the subsequent phase does not influence the consumption of sugar.

From a technical point of view the low rate of growth of *Rh. gracilis* during the period of fat synthesis is less

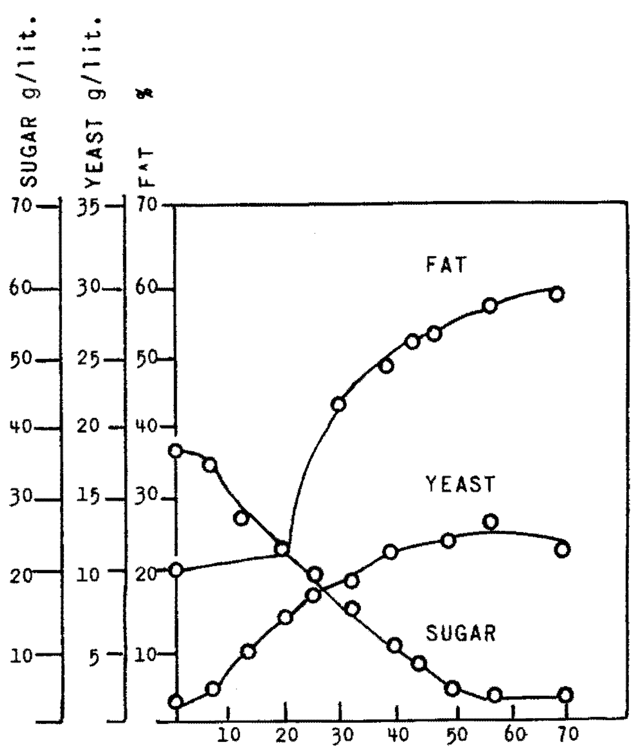

Figure 1. Sugar Content, Quantity of Yeast and Fat Content as Functions of Time.

satisfactory. In comparison with baker's yeast and *Torulopsis utilis* yeast, for which the time of fermentation is some 8 hours, *Rh. gracilis* requires 50(-60) hours and equipment of accordingly greater size.

As fat formation from the point of view of energy requires a larger quantity of sugar than does the formation of proteins and carbohydrates, the yield, obtained from the same quantity of sugar, of a yeast rich in fat (a yield of 30-35 per cent) is lower than that of a yeast poor in fat and rich in protein (a yield of 45 per cent). The yield of energy obtained from the same quantity of sugar is, however, as great for a fat yeast as for a protein yeast, the caloric value of a fat yeast being higher in proportion to the fat content than the caloric value of a protein yeast.

Industrial synthesis of fat, through production of *Rh.* yeast rich in fat, may be carried out in such a manner that the mass of *Rh.* yeast formed during a short "growth-phase", in special closed fermentation vessels with abundant supply of nitrogen, is transferred into simple open fermentation vessels, where, during a "fattening phase", the fat formation takes place in a medium low in nitrogen over a comparatively long period. A diagram for the production of 5,000 tons of *Rh. gracilis* yeast (with 42 per cent of fat and 23 per cent of protein) per year, i.e. 16 tons per 24 hours, according to this method is shown in Figure 2. This diagram represents only one of several possible ways.

Both the growth phase and the fattening phase are continuous.

As raw material a solution of sugar cane molasses is used. *Rh. gracilis* can grow in a synthetic medium containing no biofactors. On the other hand, if the density of cell population is low the addition of certain growth

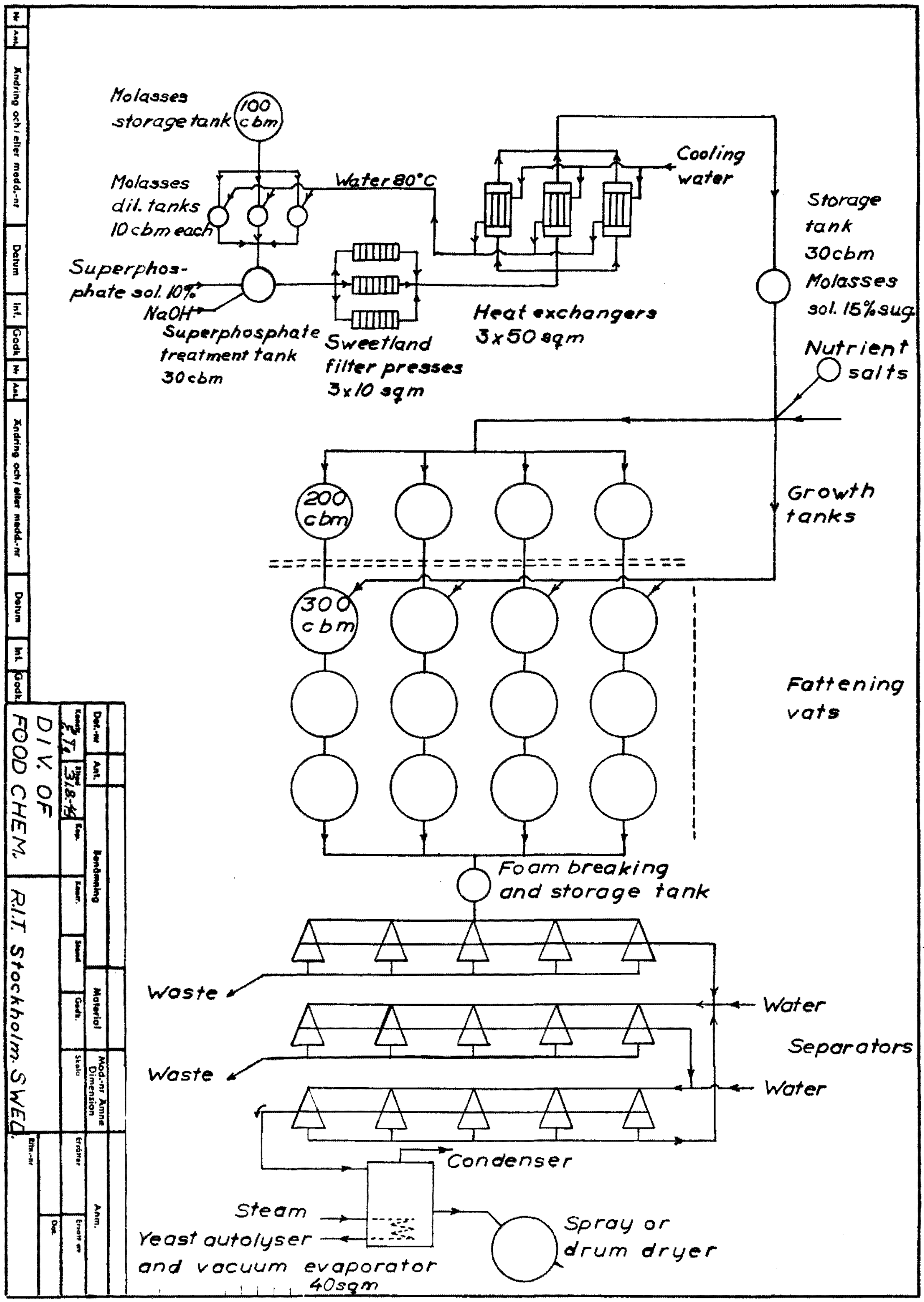
Molasses storage tank
100 cbm
Molasses dil. tanks 10 cbm each
Water 80°C
Cooling water
Storage tank 30cbm Molasses sol. 15% sug.
Superphosphate sol. 10%
NaOH
Superphosphate treatment tank 30 cbm
Sweetland filter presses 3x10 sqm
Heat exchangers 3x50 sqm
Nutrient salts
200 cbm
Growth tanks
300 cbm
Fattening vats
Foam breaking and storage tank
Waste
Water
Separators
Waste
Water
Condenser
Steam
Yeast autolyser and vacuum evaporator 40sqm
Spray or drum dryer
DIV. OF FOOD CHEM.
R.I.T. Stockholm. SWED.

Figure 2.

factors will accelerate the growth as all growth factors are not produced by *Rh. gracilis* in optimal quantities. Molasses contains such growth factors.

Prehydrolysates of wood and of plant waste material (e.g. straw) obtained prior to the production of cellulose could probably also be used. In such hydrolysates a large proportion of the sugar consists of pentoses. As pentoses, however, are not readily assimilable by *Rh. gracilis,* it is necessary that the yeast, previous to its being used as a fat producer, through a process of adaptation acquires the ability to assimilate pentoses with sufficient speed. This adaptation requires only a few days. So far, however, such prehydrolysates are produced only in a few places and in limited quantities.

From the storage tank molasses is taken to three tanks for dilution with hot water. In the superphosphate treatment tank the solution is heated with direct steam and calcium is precipitated with superphosphate. The acidity is adjusted. After filtration in filter presses the clear solution passes through a heat exchanger and thereafter through a storage tank and is finally pumped continuously into the growth tanks, where it is fermented with *Rh. gracilis* under heavy aeration.

The hot water which is generated during the cooling in the heat exchanger is used for dilution of the molasses.

Nutrient salts and water, sterilized with hypochlorite, for dilution, are added to the fermenting solution in the growth tanks.

Fermenting mash, still containing most of the sugar, is continuously drawn off from the growth tanks to the fattening vats at such a rate that the yeast cells stay for a mean time of about 6 hours in the growth tanks for reproduction. In the fattening vats the cells stay under aeration less than 48 hours. During this time they take up large quantities of sugar from the mash, converting the sugar into fat. From the fattening vats the yeast is continuously pumped through a defoaming tank to a set of separators where the yeast is washed and concentrated. The separation process is carried out in three steps. After the first and second steps the yeast is diluted 10 times with water and washed.

The wash water from the last separation, which contains a certain quantity of yeast cells not removed by the separators, is used together with fresh water as wash water after the first separation, in order to reduce the loss of cells.

After this process of separation the concentration of yeast cells corresponds to 10 g of dry yeast in 100 ml of suspension. In a vacuum evaporator the yeast cells are autolyzed and the content of dry matter is increased to 20 per cent. Finally the yeast is dried in a spray or drum drier to a moisture content of 8 per cent.

During the growth phase the composition of the substrate should be optimal for growth (rich in nitrogen, phosphorus and sugar).

The growth tanks should preferably be closed and aerated with sterilized air in the same way as in a penicillin factory but they need not be provided with mechanical stirrers.

During the fattening phase, ample quantities of sugar but no nitrogenous compounds are added to the substrate. Although there is a comparatively small increase in the number of yeast cells, there is a considerable increase in the size of the cells; from 40(-50) cubic microns to 60(-70) cubic microns. This is due to a formation of large quantities of fat within the cells. The vats may be open and need not be aerated with sterilized air. One hundred tons of sugar give tons 14.7 of fat, 8.1 of protein, 10.8 of carbohydrates and 1.4 of mineral substances.

The costs for chemicals, fuel, electric power, repairs, packing, freights, insurance, salaries, and for capital investment may amount to about $0.25 per kilogramme of dry matter of fat yeast. The costs of sugar in the raw material (molasses, prehydrolysate) per kilogramme of dry yeast produced may vary from zero to $0.30. The total costs for the production of one kilogramme, on dry basis, of fat yeast may thus vary between $0.25 and $0.55 depending on the costs for the sugar.

The costs of construction of this plant will amount to less than $3,000,000. All costs are calculated according to Swedish prices, which probably are close to American prices. The tanks for the molasses, the tanks and the vats for the fermentation process, the separators, etc., are made of stainless steel. The capacity of the refrigeration system (6,400,000 kg cal/hr) is dimensioned to meet the requirement of tropical climates.

The component acid composition of *Rhodotorula* fat has been found to come rather close to the fruit coat fats as will be seen in Table 1. The yeast fat contains appreciable quantities of linolic and linolenic acids which are called "essential" fatty acids as they are not produced by the animal body and thus have to be supplied with the food.

Table 1

	Saturated acids per cent			
	C_{14}	C_{16}	C_{18}	$C_{20/22/24}$
Palm oil[a]	2.4	41.6	6.8	trace
Rh. gracilis	1.1	29.8	8.8	1.4

		Unsaturated acids per cent C_{18}			
	C_{16}	*oleic*	*linolic*	*linolenic*	C_{20}
Palm oil[a]	1.8	38.0	9.5	0.1	—
Rh. gracilis	1.8	40.1	11.2	4.8	1.0

[a]Hilditch, Neara and Roels (1947).

The amino-acid composition of *Rhodotorula* protein is shown in Table 2, which contains two columns, one for the composition of the protein in such *Rhodotorula* as is rich in protein (and poor in fat) and the other for such as is poor in protein (and rich in fat). The essential amino acids, which cannot be synthesized in the body and thus have to be supplied with the food, are contained in both kinds of *Rh.* yeast.

The contents of the B-vitamins, thiamin, riboflavin and niacin in *Rh. gracilis* with high fat content are shown in Table 3. If these contents are referred to 1 gr. of protein, it is seen that *Rhodotorula* rich in fat has the same vitamin content as baker's yeast.

The fat yeast should be used as a food substance in the same way as *T. utilis* yeast, without preparatory treatment other than washing, autolyses, drying and grinding. In this way not only the fat of the yeast but also the

Table 2. Amino-acid composition of *Rh. gracilis*

	Yeast I *Rich in protein; poor in fat*	*Yeast II* *Rich in fat; poor in protein*
ã—alanine	+	++
arginine	+	+
aspartic acid	+	+
glutanic acid	+	++
glycine	+	+
iso-leucine	+	+
leucine	+	+
lysine	+	+
proline	+	+
serine	+	+
threonine	+	+
tyrosine	low content	low content
valine	+	+
tryptophone	++	+

β—alanine, phenyl-alanine, cysteine and histidine probably also are present in *Rh. gracilis.*

Table 3

(vitamin content in micrograms)

	Rh. gracilis	
	Per 1 g. of dry yeast with 55% of fat & 14% of protein	*Per 1 g. of protein*
Thiamin	5	35
Riboflavin	13	90
Niacin	71	500
	Baker's yeast	
	Per 1 g. of dry yeast with 50% of protein & 5% of fat	*Per 1 g. of protein*
Thiamin	25	50
Riboflavin	34	70
Niacin	255	500

proteins, vitamins and mineral salts are utilized. The taste of the fat yeast is superior to that of *T. utilis* yeast. It should preferably be incorporated in other foodstuffs, as for example preserved foods, in such quantities that a daily consumption of 24-48 grammes of fat yeast, i.e. 10-20 grammes of fat, is provided for.

It is evident, however, that the economic factors necessitating the industrial utilization of the synthesis of fat are not present under normal conditions, when fat can be produced more cheaply from, for example, the coco-palm. In time of emergency, however, economic considerations might be of secondary importance. As is well known such conditions are now prevailing in large parts of the world. It seems desirable that synthetic production of fat and protein on a large scale should now be started in countries where the population is suffering from shortage of fat and where the supply of carbohydrate-containing waste materials is abundant. These conditions exist particularly in the Far East, where over 700,000 tons of molasses are produced annually and largely wasted.[1] It is probable that agriculture in tropical countries now could produce additional quantities of fat at a much lower price than is possible with the aid of micro-organisms, but unfortunately there is a shortage of available agricultural land. (On the other hand, the space needed for a yeast factory is negligible.)

A factory producing 5,000 tons per year of fat yeast containing 42 per cent of fat and 23 per cent of protein—that is 2,100 tons of fat and 1,150 tons of protein per year—can provide 575,000 people with 10 grammes of fat daily. At the same time these people would further receive 5-6 grammes of satisfactory yeast proteins per day.[2] The populations of the Far East (India, China, Japan) hardly obtain, in their present diet, 10 grammes of "visible fat" per day, and their protein intake is largely of plant origin (cereals) and thus deficient in regard to, *inter alia,* the essential amino-acid lysine. This acid, on the other hand, occurs in yeast in especially high concentration, and the intake of yeast protein substantially improves the diet in regard to amino-acid composition. As Sure (1946, 1947) has shown, the utilization of protein and carbohydrates is greatly improved if dried yeast is added to a diet in which the proteins are furnished by cereals. Fats also increase the utilization of proteins (and carbohydrates) and of the fat soluble vitamins A and D.[3] Finally as a food stuff yeast is very rich in the B-vitamins thiamin, riboflavin and nicotinic acid and contains appreciable quantities of all the other B-vitamins. *Rhodotorula* yeast also contains the provitamins A and D.

A daily ration of 24-48 grammes of fat yeast contains:

10-20 grammes of fat
5.5-11 grammes of protein
200-400 microg. of thiamin corresp. to about 20 per cent of the daily requirement
500-1000 microg. of riboflavin corresp. to about 20-40 per cent of the daily requirement
3000-6000 microg. of niacin corresp. to about 20-40 per cent of the daily requirement

and appreciable quantities of the other B-vitamins and of the provitamins A and D.

The production costs for a daily ration of 24 grammes of dry fat yeast vary between 0.6 and 1.3 cents, and for a ration of 48 grammes between 1.2 and 2.6 cents, depending on the costs for the sugar.

However, the quantities of yeast which can be produced in the near future will represent only a very small contribution to the improvement of the food situation of the world. The need is so great, however, that every possibility for increasing food production should be investigated—for example, the purely chemical synthetic production of fat for food purposes, although it is expensive, as used in Germany since 1938. As is well known the population of the world increases at present at such a rate that it will be doubled in the next 80 years. It will be necessary to develop procedures for the industrial production of great quantities of new food stuffs, and the microbiological method for the production of fat and protein is such a procedure.

In a few hours or days suitable micro-organisms accomplish a synthetic task, which would require years if carried out by agricultural methods. In the future the raw material, sugar, for these micro-organisms has to be furnished mainly by the forests, so that for this purpose no agricultural land is needed.

[1]In the West Indies, on the other hand, molasses is utilized and commands a high price because large quantities are exported to the United States to be used for the production of alcohol.

[2]If the whole quantity of molasses being wasted in the Far East were utilized for the production of fat yeast, 12 million people would receive an additional quantity of 10 grammes of fat and 5-6 grammes of protein per day.

[3]Fats cause the food to remain for a longer time in the stomach whereby the utilization of proteins is improved and also that of carbohydrates, if large quantities are consumed.

The CHAIRMAN: In the absence of Dr. A. C. Thaysen, Colonial Microbiological Research Institute, Port of Spain, Trinidad, British West Indies, his paper has been circulated and will be considered as read.

MR. THAYSEN'S *paper follows*:

Food Yeast in the British Empire

A. C. THAYSEN

Twice within living memory has political expediency and economic necessity driven Governments to seek a solution to some of their nutritional problems by enlisting the powers of micro-organisms to synthesize protein from inorganic nitrogen. It was in 1915 that the German Government encouraged their scientific workers to investigate the value of yeast in cattle feeding and to study the production of yeast from inorganic sources of nitrogen. In 1940 the British Government had to adopt similar measures in preparation for a possible blockade of the United Kingdom by submarines.

I. MANUFACTURE OF FOOD YEAST

In response to this urgency the Royal Society were invited to sponsor a fresh investigation of the existing knowledge of the value of yeast in animal and human nutrition, and of the production of yeast by improved technical processes.

These terms of reference required that a suitable strain of yeast should be selected which, in addition to being able to synthesize its protein from inorganic sources, could build up also most, if not all, of its water soluble vitamins from simple organic and inorganic compounds. The strain of yeast which might finally be accepted on the strength of such qualities would have to be able to satisfy its carbohydrate requirements from either hexoses or pentoses so as to increase the range of suitable raw materials for yeast production. Further, the selection strain should yield a palatable yeast preparation which should be attractive in appearance. With these demands fulfilled, pilot plant production of yeast would have to be undertaken to supply material for feeding trials and for many other purposes, including a study of improved production methods.

Among the many types of yeast which were examined one, *Torulopsis utilis,* was found to possess most of the needed characteristics. It had already been used by Hayduck (1915) in Germany for the production of animal feeding stuffs.

Torulopsis utilis synthesizes its protein from ammonia and most of its B vitamins from inorganic or simple organic compounds and it uses as energy for this purpose either hexoses or pentoses. When washed and dried, it has a pleasant meaty or nutty flavour and is of an attractive straw colour. One drawback to its large scale use, its size, with many cells not reaching a volume of $200\mu^3$, was eventually overcome Thaysen, Morris 1943) by the preparation of a giant *Torulopsis utilis* var. *major* which had an average volume of $644\mu^3$.

The larger strain was obtained by exposing growing cells of the original *Torulopsis utilis* to the action of camphor. The effect of a limited exposure was to kill off the bulk of the introduced cells and to increase the cell volume of the survivors. The new strain, taken from the survivors, may perhaps be regarded as a mutant since its enlarged size is maintained for an indefinite period of generations when it is grown under favourable conditions.

In its physiological behaviour the "mutant" resembles the original strain; its rate of growth is definitely not slower than that of the original; but its phosphorus content appears to have been slightly increased, perhaps due to an increase in nuclear material.

Food yeast production on orthodox lines was started in Teddington in 1940 in a pilot plant capable of a daily maximum output of 120 pounds of air dried yeast. A heavy concentration of yeast, some 10 per cent of the weight of the total carbohydrates to be fermented, was introduced into a volume of wort containing about 0.5 per cent of available carbohydrates and a certain concentration of mineral salts as aditional food substances. The

Table 1

Time	*Hourly addition of a molasses of 6.4% strength*	*Total volume of wort in gallons at the end of:*	*Density of cell population per ml of wort at the end of:*	*Total cell population at the end of:*	*Residual concentration of carbohydrate in wort at the end of:*	*Weight of yeast per 100 ml wort at the end of:*
	gal.	*gal.*	$\times 10^6$	$\times 10^{12}$	%	*g*
0 hours	20.0	129.0	841	488	0.17	0.7958
end of 1st hr.	4.5	129.0	1148	666	0.10	0.9598
end of 2nd hr.	5.5	133.5	999	600	0.10	1.1826
end of 3rd hr.	6.5	139.0	1515	947	0.10	1.2136
end of 4th hr.	7.5	145.5	1300	851	0.16	1.3306
end of 5th hr.	9.0	153.0	1732	1183	0.10	1.4376
end of 6th hr.	10.5	162.0	1875	1367	0.14	1.5052
end of 7th hr.	12.5	172.5	1552	1205	0.19	1.6398
end of 8th hr.	15.0	185.0	1945	1619	0.13	1.8160
end of 9th hr.	—	200.0	1744	1570	0.21	1.8984

volume of wort taken was approximately half of the contemplated final volume of wort.

After inoculation the wort was kept at 28 to 30°C and vigorously aerated. Following one hour's incubation an additional quantity of strong wort with between 6 and 7 per cent of available carbohydrates was added continously in predetermined increasing volumes until, after nine hours incubation, the final volume of wort had been built up. Vigorous aeration of the wort was maintained throughout the period of fermentation.

If a detailed analysis be made of the rate of growth of yeast cells under such conditions, certain interesting data emerge which may be discussed on the basis of the data in table 1.

These data were obtained from an actual pilot plant fermentation in the Teddington plant. The counting of the cells was done with a Gower haemacytometer and all the cells counted were taken as viable since but a short interval elapsed between the beginning and the end of the experiment.

Column 5 of this table shows that at the end of the experiment the total number of cells in the fermented wort had increased slightly more than threefold over the initial total number. The increase in weight of yeast was 3.7 fold.

From hour to hour the increase in total number of cells was somewhat irregular. This may have been due in part to bad sampling, but in part to actual varations in generation time at various stages of the fermentation.

Using Buchanan's (1928) formula the generation time of a microbial culture can be calculated when the total population is known at all relevant times.

The formula—

(i)
$$g = \frac{t \times \log 2}{\log b - \log B}$$

assumes that: t represents the time in hours during which growth took place; B signifies the initial total number of cells present and b the final total population.

With these data and using Buchanan's formula the overall generation time of the cells in the fermentation quoted was found to be—

(ii)
$$g = \frac{9 \times 3010}{3.2700 - 2.6900} = 280 \text{ minutes}$$

For a given strain of yeast the generation time of a single cell placed under optimal conditions for growth might be determined by direct microscopic observations. For *Torulopsis utilis* this was done and it was found that, in 8 separate determinations, involving the mother cell and members of three subsequent generations, the average generation time was 84 minutes.

At this rate one *Torulopsis utilis* cell should in 9 hours produce 64 daughter cells, a 64 fold increase compared with the 3 to 4 fold increase of cells, and presumably of weight of cells, obtained in the fermentation of table 1. The output of yeast per volume of plant in this fermentation must therefore have been very much smaller than should have been possible theoretically.

Further light was thrown on the growth rates of *Torulopsis utilis* in another pilot plant fermentation of which fairly extensive data are available.

In this second fermentation the standard fermentation technique was employed with the one difference that the number of yeast cells used for seeding the initial wort was about 50 times smaller than usual.

The logarithms of total populations plotted against the hours during which growth proceeded for the two pilot plant fermentations are shown in chart form (see Figure 1, Appendix A).

The curve of the second fermentation B falls naturally into three fairly clearly defined sections: an initial period of slow growth with a generation time of some 247 minutes, followed by an 8-hour period of fast growth, with a generation time of about 99 minutes. During the third period, covering 10 hours, the generation times rises again to 240 minutes. This third period approaches the average generation time of the first fermentation (curve A), of 280 minutes, and probably cial conditions of manufacture, since the first fermentarepresents the rate of yeast production under commertion was conducted on such lines.

In its main features the curve (b) of the second fermentation embodies three stages of a typical microbial growth curve as defined by Buchanan (1928): (i) the phase of positive growth acceleration, between zero hour and the end of the second hour; (ii) the phase of logarithmic growth between the beginning of the third and the end of the tenth; and (iii) part of the phase of negative growth acceleration, between the beginning of the eleventh and the end of the nineteenth hours.

The parallel course taken by the growth curve of fermentation A and that of negative growth acceleration in fermentation B seems significant and probably implies that, apart possibly from an initial brief period of positive growth acceleration, Buchanan's third period prevails throughout commercial yeast manufacture.

The logarithmic phase of reproduction in that case seems to have been completely eliminated with all that this must entail from a biological point of view in loss of uniformity of cell structure and cell content.

For these reasons the usual commercial technique of yeast production does not appear to be particularly suitable for large scale food yeast production where a standardization of the chemical composition of the individual cell is of prime consideration. A technique based on the logarithmic rate of growth would be much more likely to fulfil these requirements if its shortcomings, its brief duration and its apparent dependence on a low concentration of cells in the fermenting wort, could be overcome. Considerable time was devoted at Teddington to explore these difficulties.

In practice it was clear from the start that progress in devising an improved method of fermentation could be made only if it could be shown that the growth behaviour of *Torulopsis utilis* and of its newly developed variant *T. utilis var. major* could be made to conform to theoretical expectations. To test this, fermentation schemes were drawn up on the basis of such expectations.

In all cases it was assumed that allowance had to be made for the existence of an initial lag period, or growth accelerating phase, during which each mother cell would produce one fully grown daughter cell within 4 hours, or 240 minutes. Under such conditions the total number of cells present at the start in the medium would double within four hours. As the lag period was

Table 2. Scheme for the study of the logarithmic rate of growth of *Torulopsis utilis* at a maximum cell popuation of 1000 million cells per ml.

Time	*Total weight of yeast present at the end of the:*	*Hourly addition of available carbohydrates starting at the end of the:*	*Hourly addition of a 6% molasses solution starting at the end of the:*	*Hourly addition of sterile water starting at the end of the:*	*Total volume of wort at the end of the:*	*Density of cell population at the end of the:*	*Total cell population at the end of the:*	*Generation time*
	g	*g*	*ml*	*ml*	*ml*	$\times 10^6$	$\times 10^{10}$	
0 hours	1.372	0.454	8.3	—	1000	100	10	
end of 1st hr.	1.644	0.516	9.6	—	1000	120	12	
end of 2nd hr.	1.954	0.612	11.2	—	1010	139	14	240″
end of 3rd hr.	2.322	2.126	38.6	—	1021	167	17	
end of 4th hr.	3.598	2.874	52.2	—	1060	245	26	
end of 5th hr.	5.322	4.710	85.6	—	1112	318	39	
end of 6th hr.	8.148	6.414	116.6	—	1198	499	59	
end of 7th hr.	11.998	10.964	199.2	—	1315	685	90	
end of 8th hr.	18.574	16.144	293.4	253	1514	898	136	100″
end of 9th hr.	28.260	24.164	439.2	611	2060	1000	206	
end of 10th hr.	42.760	36.600	665.2	935	3120	1000	312	
end of 11th hr.	64.720	57.300	1041.4	1399	4720	1000	472	
end of 12th hr.	99.100	—	—	—	7160	1000	716	

assumed to end after three hours' growth, the total number of cells present at the end of this time would be less than double the initial number. The actual numbers after 1, 2 and 3 hours' growth could be calculated from Buchanan's formula (i) provided the initial total number of cells were known. The value for g. in this case was known to be four hours.

After a lapse of three hours of slow growth the logarithmic rate of reproduction was assumed to set in and to continue for the remainder of the fermentation period. During this phase the generation time was taken as 100 minutes, for it was felt that the observed minimum generation time of 84 minutes might not be attainable under ordinary working conditions.

With the aid of Buchanan's formula it was again possible to calculate the total number of cells present at any given hour of the logarithmic phase, since both the initial number and the generation time were known.

These calculated data are set out in column 8 of table 2, constructed to illustrate a fermentation scheme in which the logarithmic phase had been extended to 12 hours.

To calculate the weight of carbohydrates required for the maintenance of growth at planned levels it was necessary to know both the weight of the yeast cells taken as inoculant, the hourly increase in weight of cells; and the yield of dry yeast which could be obtained under favourable conditions from a given quantity of carbohydrates. For purposes of calculation this third factor was assessed at 60 per cent, a figure which it was known could be reached in practice.

The weight of the cell population used as inoculant was not so easy to assess, for actual weighings differed considerably. In five separate determinations the weight of 50 x 10^{10} fresh cells of the standard strain of *Torulopsis utilis* varied between 5.875 gr and 8.514 gr with an average of 6.860 gr, the figure finally adopted.

Though it is probably correct to say that the weight of a given number of cells of *Torulopsis utilis,* as of all other living cells, will vary at different periods of their life cycle, for the theoretical calculations here considered, it was assumed that the weight of yeast produced during growth would increase at the same rate as the cell population and that the weight of yeast, therefore, would double in four hours during the lag period, and in 100 minutes during the logarithmic phase. On this assumption the weight of yeast present at all hours was calculated. This is shown in column 2 of table 2.

On the basis of the yeast weight figures, and on the assumption that 100 parts of carbohydrates would yield 60 parts of dry yeast, it was possible to calculate the hourly requirements of the former. These figures are set out in column 3 of table 2.

The corresponding figures in column 4 give the volumes of molasses wort containing 6 per cent available carbohydrates which corresponded to the required quantities of carbohydrates. In explanation of these figures it should be mentioned that the molasses carbohydrates used contained 9.4 per cent of Fehling reducing substances which were unavailable for yeast growth.

Since it was intended to have 100 million cells present in each ml. of the initial wort, the total volume of this could be calculated by dividing the density of cells (100 x 10^6 per ml.) into the total initial number of cells (10 x 10^{10} per ml.). The increase in volume from hour to hour would be governed by the hourly additions of wort, at any rate during the first 8 hours. With a density of population not exceeding 1000 million cells per ml. of wort, it was necessary, after the eighth hour to dilute the fermentation wort beyond the volume increase obtained by the hourly additions of wort.

For this purpose water would be added hourly in increasing volumes, the actual quantities needed being calculated by dividing the required density of cell population into the anticipated total population for a particular hour and by subtracting from the figure obtained the volume of wort present at that hour. The figures in column 5 of table 2 give a set of such calculated data.

Table 3 records data collected in an actual fermentation conducted on theoretical lines. In this experiment the temperature was maintained throughout at 30°C,

Table 3. Experimental fermentation to show the logarithmic rate of growth of *Torulopsis utilis* with a maximum cell population of 1000 million cells per ml. of fermentating wort

Time	*Total weight of yeast present at the end of the:*	*Hourly addition of available carbohydrates starting at the end of the:*	*Hourly addition of a 6% molasses solution starting at the end of the:*	*Hourly addition of sterile water starting at the end of the:*	*Total volume of wort at the end of the:*	*Density of cell population at the end of the:*	*Total cell population at the end of the:*	*Generation time*
	g	*g*	*ml*	*ml*	*ml*	$\times 10^6$	$\times 10^{10}$	
0 hours	0.8700	0.454	8.3	—	1000	99	9.9	
end of 1st hr.	—	0.516	9.6	—	1000	122	12.2	240″
end of 2nd hr.	—	0.612	11.2	—	1010	138	44	
end of 3rd hr.	2.1197	2.126	38.6	—	1021	217	22	
end of 4th hr.	—	2.874	52.2	—	1060	287	30	
end of 5th hr.	—	4.71	85.6	—	1112	352	39	
end of 6th hr.	7.2358	6.414	116.6	—	1198	463	56	
end of 7th hr.	—	10.964	199.2	—	1315	680	89	
end of 8th hr.	—	16.144	293.4	253	1514	1024	155	105″
end of 9th hr.	27.8622	24.146	439.2	621	2060	1072	221	
end of 10th hr.	—	36.60	665.2	935	3120	932	291	
end of 11th hr.	—	57.3	1041.4	1399	4720	1003	473	
end of 12th hr.	91.8348	—	—	—	7160	975	698	

the reaction at pH 4.2 to 4.5 and the hourly air supply at 1 cubic foot of air per litre of fermenting liquid. The air was supplied continuously at the rate mentioned through ceramic blocks with apertures not exceeding 12μ.

Food substances, other than carbohydrates, were added to the initial wort before its inoculation and subsequently at frequent intervals; nitrogen in the form of a 10 per cent solution of ammonium sulphate; phosphates as diammonium hydrogen phosphate. The phosphate was contained to the required quantities in the 6 per cent molasses wort added hour by hour.

The results obtained in the fermentation approximated closely to theoretical expectation and it may be concluded, therefore, that the logarithmic growth rate can be prolonged beyond its usual 8 hours' duration. Its maximum duration, however, is not revealed.

Further experiments in which a population density of 2000×10^6 cells per ml. were aimed at could also be maintained for a period of 12 hours. Here a wort with 9 per cent of available carbohydrates was taken since a 6 per cent wort would have made it impossible to reach a density of 2000×10^6 cells per ml. wort.

On the basis of the weight of 50×10^{10} cells given previously, a fermenting wort containing 1000 million cells would contain about 1.3 per cent of dry yeast, and a wort with 2000 millions about 2.5 per cent. The latter percentage would represent a yeast concentration which could be economically recovered.

The figures in column 5 of table 3 imply that at the period of maximum density of population the hourly volume increase of total wort is of the order of 50 per cent. In theory this means that in fermentations conducted on such lines it should be possible to obtain an hourly throughput of yeast equal to half of the yeast contained in the total volume of wort.

Neither at Teddington, England, nor on a commercial scale in Jamaica has this been possible, at least when aiming at a cell density of 2000 million per ml. But an hourly replacement of wort to the extent of 25 per cent of the total volume has been quite practical and has been maintained in a continuous fermentation running for a week or more.

In such fermentations fresh wort, containing the necessary phosphates, was fed continuously into the top of the fully charged fermenting vessel and the equivalent volume withdrawn from the bottom for separation of the yeast in centrifuges.

Figure 2 (Appendix B) has been plotted to show the relationship between percentage replacement and growth rate, as determined for 120 minutes, 140 minutes and 150 minutes per generation. From this it appears that a 25 per cent hourly replacement of the total wort corresponds to a growth rate of approximately 170 minutes.

At this rate one ton of yeast, assuming this to be the weight present in a fully charged fermentation vat, would produce one ton of yeast every 2 hours and 50 minutes or in a day of 24 hours, almost 8.5 tons.

By the ordinary methods of yeast manufacture, one ton of yeast would increase to a maximum of 4 tons in 9 hours or with 2 fermentations conducted in one vat during 24 hours to a maximum of 8 tons. But 2 tons of this yeast would have to be returned to process so that the net output of yeast per 24 hours would amount to 6 tons.

The continuous method based on the control of the growth rate is superior, therefore, as regards output by a given unit of plant, to the usually adopted discontinuous method, even when the rate of reproduction of the yeast falls as low as one generation every 170 minutes.

With a reduction in generation time the advantages of the continuous method would, of course, be greatly enhanced. A further effort to achieve this would be of appreciable practical interest.

Even at the low rate of growth hitherto obtained, protein synthesis by yeast far exceeds that known by other methods.

In animal husbandry for instance, a bullock, weighing half a ton, will synthesize slightly less than one pound of protein in 24 hours. A similar weight of yeast grown by the continuous method and with a generation time of 170 minutes will yield over 2 tons of protein in the same period. In agriculture, soya beans, for instance, might in a year and under favourable growth conditions, yield one ton of beans from 40 pounds of seed. This would represent a daily protein synthesis of some 86 pounds for each half a ton of seed planted.

II. FOOD YEAST IN NUTRITION

A survey of the nutritive value of food yeast was undertaken between the years of 1941-44 by a committee appointed jointly by the Medical Research Council and the Lister Institute, London, England.

This survey was by no means exhaustive, neither from the point of view of the chemical composition of yeast nor of its value in nutrition. Nevertheless, the report of the committee issued as a White Paper (1945) records some interesting observations made on food yeast (*Torulopsis utilis*) as manufactured at Teddington, England.

The nutritive value of food yeast as compared with certain other dried yeasts and common food stuffs is recorded in table form in the report. This table is reproduced below as table 4.

Table 4. Nutritive Value of Dried Yeast and of Some Other Common Foodstuffs, Recalculated on a Dry Matter Basis from Table 1

Composition of the Edible Portion of the Raw Foodstuffs per 100 g. Dry Matter

Material	*Protein N x 6.25 g.*	*Fat g.*	*Carbo-hydrate g.*	*Calories*	*Ca mg.*	*Fe mg.*	*Vitamin A I.U.*	*Vitamin B_1 mg.*	*Ribo-flavin mg.*	*Nicotinic acid mg.*	*Vitamin C mg.*
Yeast, dried food, *Torula utilis*...	47.0	2.6	3.3	224	138	22.0	0	5.4		43 to 49	0
Brewer's *Saccharomyces cerevisiae*	53.0	1.0	—	—	84	21.0	0	2.1 to 10.5	4.2	32 to 47	0
Baker's *Saccharomyces cerevisiae*	47.0	2.1	—	—	42	26.0	0	3.2	7.4	32 to 42	0
Flour, whole wheat..	13.2	2.8	76.0	383	37	5.2	0	0.38	0.26	5.1	0
Egg	48.0	44.0	3.5	604	231	11.5	3850	0.58	1.54	0.23	0
Milk, whole	27.5	30.0	37.0	525	1,000	0.8	580 to 1,170	0.37	1.25	0.9	8 to 12
Beef	39.0	58.0	0	673	24	9.8	120	0.19	0.61	24	0
Liver, ox	57.0	20.0	17.0	473	33	46.0	50,000	1.33	10.0	83	0
Potato	9.1	0	74.0	332	36	3.2	0	0.54	0.23	5.4	136
Cabbage	19.0	0	62.0	325	812	12.5	11,200	0.94	0.62	3.7	870

Table 5. Vitamin B_1 (Aneurin) and Riboflavin Content of Dried Yeast

			Vitamin B_1 mg. per 100g.		*Riboflavin mg. per 100g.*
Variety	*Mode of cultivation*	*Method of preparation*	*Thiochrome method*[1]	*Azo method*[2]	*Biological method*[3]
Torulopsis utilis	Molasses	Freeze dried	—	—	6.0
	Molasses	Roller dried	1.4 to 2.3	—	6.9
	Molasses	Spray dried	—	—	9.1
	Molasses grown at 36°C	—	—	1.2	8.2
	Pure saccarose	—	—	—	8.2
	Potato mash	—	2.7	—	8.3
	Straw mash	—	—	—	6.5
	Apple pomace	—	—	—	5.6
	Banana wort	—	—	—	7.6
	Bracken fronds	—	2.0	—	7.1
	Bracken rhizomes	—	2.2	—	5.2
Torulopsis utilis var. *major*	—	—	—	—	7.5
var. *thermophilia*	Grown at 36°C	Fresh	—	1.9	10.8
	Grown at 36°C	After storage	—	—	9.0
Saccharomyces cerevisiae					
Distiller's	—	—	—	—	5.3
Brewer's	—	—	—	—	9.0

[1] Harris and Wang, 1942.
[2] Platt and Glock, 1943.
[3] Copping, 1943 (a).

Variations in aneurin content of food yeast as made from various raw materials, and as influenced by the methods adopted in drying are referred to in another table, reproduced here as table 5.

The value of food yeast protein in animal nutrition is discussed in the report on the basis of Macrae (1942) and his coworkers' feeding trials on pigs and on the observations of the workers of the National Institute of Dairying (Braude, Kon & White, 1943). While both groups of workers agree that food yeast protein possesses a marked value as supplement to vegetable proteins, it is of interest to record that both groups, but particularly the Reading group, found that food yeast given in excessive doses, 10 per cent of the total food intake or more, causes a stiffness of the limbs and a lameness of the experimental animals, which was diagnosed as rachitic in nature.

The true cause of these symptoms was not discovered but it was found that they disappeared on the supply of cod liver oil and calcium salts to the test animals, or by their exposure to sunlight coupled with administration of additional calcium.

With smaller doses of food yeast up to 5 per cent of the total food intake, the rachitic symptoms did not develop when the test animals had access to sunshine (personal communication).

Experiments with young dairy cows at levels higher than 6 per cent showed food yeast to be an excellent protein concentrate causing no rachitic symptoms. The latter observation is interesting in view of the normal nutritional habits of ruminants to ingest the microflora of their rumen content.

The Reading workers also found food yeast to be a useful supplement to the balancer meal supplied to poultry.

The value of food yeast as a source of B vitamins was explored at the Division of Nutrition of the Lister Institute and at the Nutrition Laboratory, Coonoor, India.

The workers at the Lister Institute record that rats receiving a "white" flour with 5 per cent food yeast thrive better than those given wholemeal flour and, that even those given 2.5 per cent food yeast in "white" flour grew slightly better than rats fed on wholemeal flour.

The Lister Institute workers concluded from their observations that food yeast given at the rate of 2 per cent on a diet consisting mainly of "white" flour will supply sufficient B vitamins including aneurin for the normal growth of young rats.

Some very interesting feeding trials on rats were carried out at Coonoor with yeast prepared locally with a strain of *Torulopsis utilis* supplied from Teddington, England.

The diet of the rats was based on a "Poor European" diet as drawn up for the Committee on Scientific Food Policy. Certain modifications to suit Indian conditions were made in the diet. For some of the Indian experiments milk, meat, fish and cheese were eliminated from the modified basal diet and replaced by food yeast. Control experiments contained high grade protein either in the form of milk, equivalent to 10 oz of liquid milk; meat to the extent of 3.4 oz; and fish 1.1 oz.

Calcium carbonate was added to all basic diets to bring the calcium intake to the level of the requirements of the Medical Research Council.

The conclusions arrived at by the Indian workers were that the addition of food yeast greatly improved the nutritive value of a diet whose protein was otherwise derived mainly from cereals, the biological value of the mixture of the cereal protein with those of yeast being equal to that of a similar mixture with milk. The good effects of the addition of food yeast to a "white" flour diet demonstrated its value as a source of B vitamin.

Feeding trials with food yeast on human subjects are reported in the White Paper as having been carried out both in England and in Colonial territories. On the whole the food yeast, when given in doses of from 8 to 15 gr per day, was well tolerated. Some of the colonial experiments which were based on much heavier doses generally caused no ill effect, though it had been established by Mellanby and confirmed by Platt that food yeast given in doses of from 5 to 15 gr per day caused an increase in acid secretion in the stomach of dogs and humans.

Some of the most interesting experiments on the use of food yeast in human nutrition were those of King on children evacuated from Gibraltar who were suffering from a gingival disease strongly resembling the preulceration stage of Vincent's disease. Of twenty-four affected children given 3.5 gr of food yeast daily seventeen showed complete recovery, four were much improved and only three were unchanged. Of seventeen children receiving no food yeast only three showed spontaneous recovery and five slight improvement.

In Nigeria subjects with symptoms of riboflavin deficiency showed striking improvement or cures after 5 to 7 weeks' treatment with from 4 to 7 gr of food yeast daily.

III. COMMERCIAL FOOD YEAST PRODUCTION IN JAMAICA

On the strength of the favourable feeding trials which meanwhile had been carried out and on the basis of the Teddington production trials, the Colonial Office (1944) undertook the financing of a food yeast factory in Jamaica, B.W.I.

The factory is situated at Frome, Westmoorland, in close proximity to a sugar factory established there by the West Indies Sugar Company of London, who consented to act as Technical and Commercial Agents for the undertaking.

The advantages of coordinating the activity of the food yeast factory with that of a modern sugar factory are self evident and, in designing the former, full advantage was taken of the availability on the site of surplus steam, power and water, as well as normally of an abundance of molasses, the carbohydrate which it was decided to use as raw material.

The design of the food yeast factory is based on the Teddington observations that a continuous method of yeast production can be maintained over a prolonged period by the hourly replacement of 25 per cent or more of an actively growing yeast population.

The fermentation section of the factory, the core of the plant, consists of 10 stainless steel vats of 3000 gallons capacity each. Each of these vats is fitted with cooling coils for the maintenance of a constant temperature during fermentation, and with an aeration unit consisting, now, of candles made of sintered phosphobronze. Initially ceramic candles had been used, but these were found incapable of standing up to the rough handling given them by unskilled local labour and had to be replaced by the unbreakable but much more expensive metallic candles.

Through these candles a continuous stream of air is pumped into the wort contained in the fermenting vats.

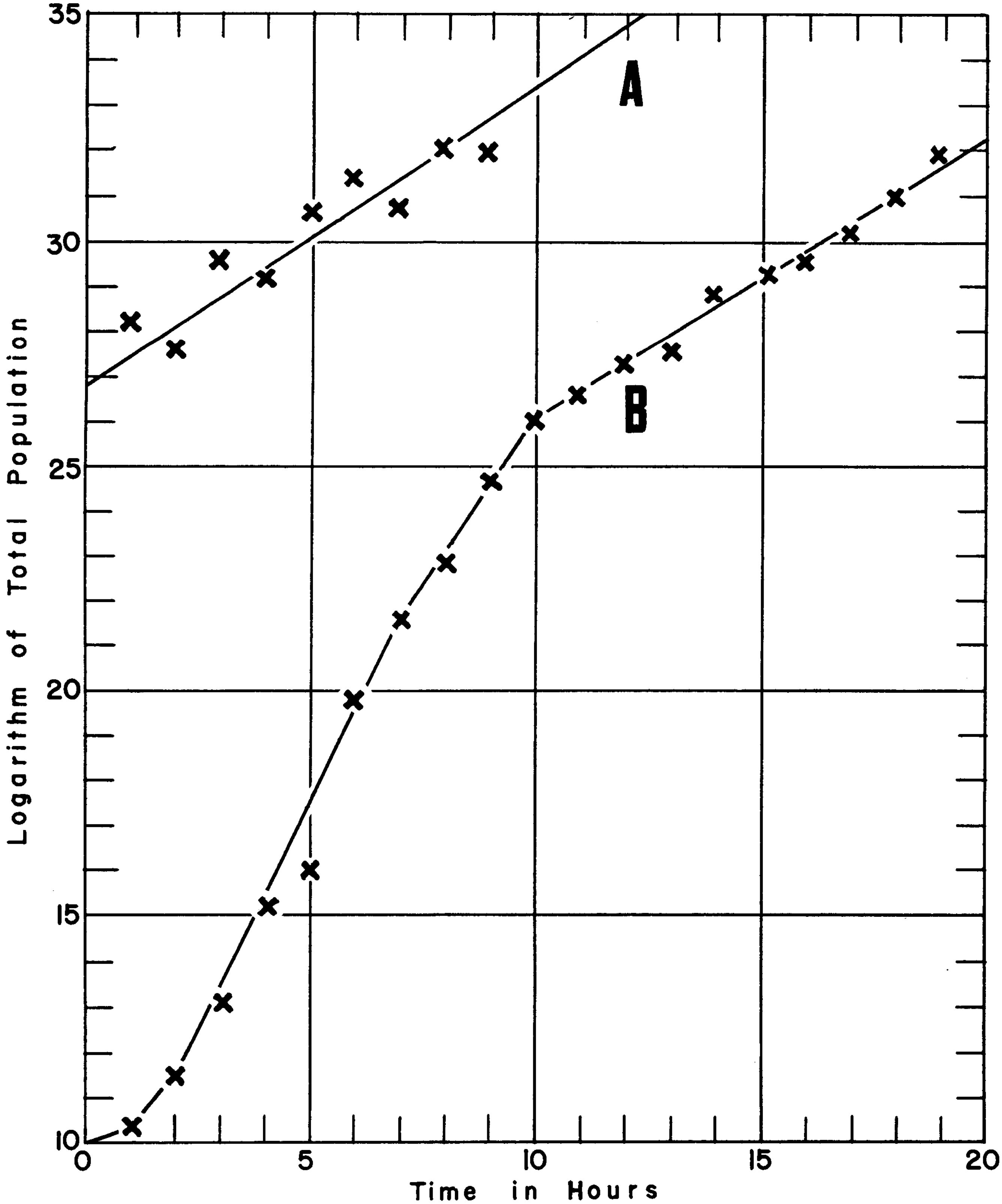

Figure 1
Appendix A

The exact volume of air needed for a maximum yeast output has not yet been definitely ascertained. There are indications that, with the increase in height of the vat and therefore of the fermenting wort column, an increase in air supply is needed, and that the volumes found sufficient at Teddington on a laboratory scale, 1 cubic foot per hour per litre of fermenting wort, are insufficient on a factory scale.

But it is possible also that a purely mechanical interpretation of the occasional decrease in growth rate, observed during factory working and tentatively attributed to insufficient air, is incorrect. For it has already been ascertained that the rate of reproduction of *Torulopsis utilis* and its "major" variety is adversely affected by certain salts, including iron, aluminium, copper and lead, and that iron concentrations of 20 parts per million seriously affect the growth rate. It is for this reason that the factory equipment has been largely constructed in stainless steel.

It is not the place here to give a detailed description of the factory lay-out and of the technical details of its working. This has already been done fairly comprehensively by Floro (1947). But certain observations made during the running of this plant appear of sufficient general interest to deserve a brief reference.

Besides being adversely affected by iron and other metals, it has been established that the rate of growth of *Torulopsis utilis* is slower than normal when the fermenting wort contains an excessive concentration of amino acids and peptides. As estimated by Formol titration (Sorensen 1908), the growth retarding action of these substances is noticeable when the Formol figure exceeds 1.0. In food yeast manufacture, therefore, the Formol figure is kept below this point at about 0.5-0.8 by carefully adjusted frequent additions of ammonium sulphate.

This observation that a certain concentration of amino acids, calculated as 0.0665 per cent if taken as aspartic acid, inhibits the rate of reproduction of yeast, is not without theoretical significance, besides its practical importance.

The temperature of the fermenting wort is apparently far less critical than was anticipated. Normal reproduction rates for *Torulopsis utilis* can be obtained at temperatures as high as 36°C, an important practical observation for a fermentation plant situated within the Tropics.

Similar observations have been made with regard to the reaction of the fermenting wort. At Teddington the pH of the wort was carefully maintained between 4.2 and 4.5. The experience at Frome is that this is not essential. In fact large scale production has been carried out satisfactorily at a reaction as low as pH 3.2 to 3.4. This is important since many bacteria which normally invade the fermenting wort under factory conditions are retarded in their growth at this level of acidity.

Before the start of factory operations the question of the elimination of infections from a fermenting wort was regarded as a problem of major importance. Work at Frome has shown this not to be so, partly no doubt because the acid reaction of the fermenting wort slows up the growth of most infections entering the vats and partly also because the continuous method of fermentation replaces the whole of the fermenting wort in a vat every fourth hour and thereby eliminates by dilution any airborne or other contamination of the wort before it has time to establish itself.

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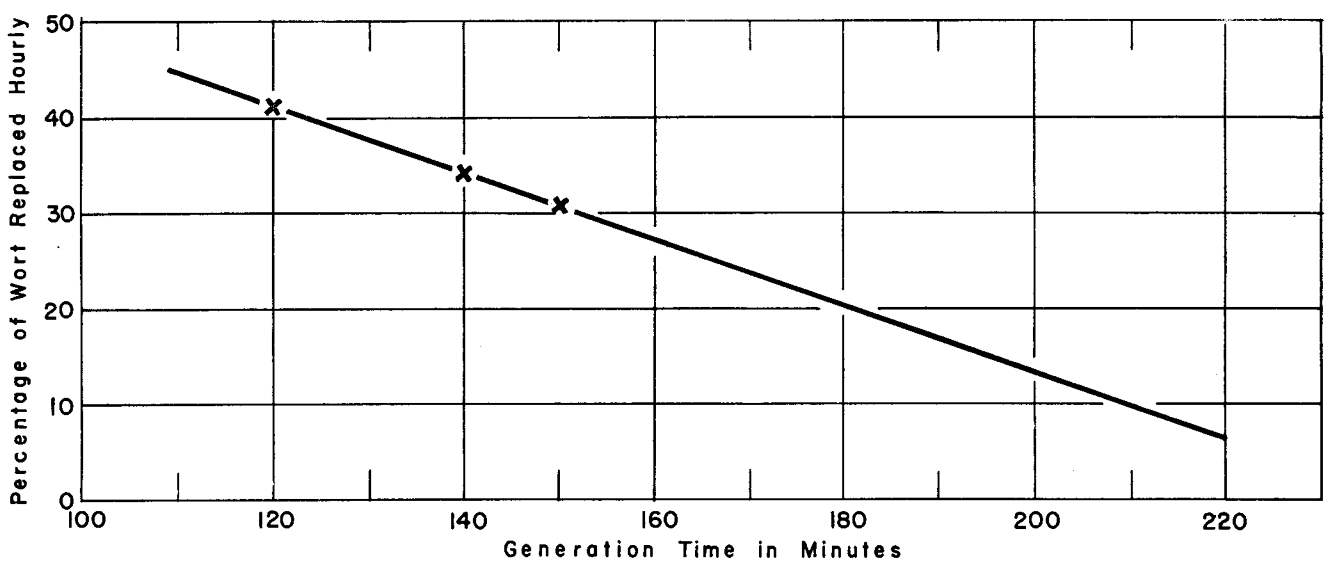

Figure 2
Appendix B

The CHAIRMAN: In the absence of Dr. E. D. Bergmann of the Weizmann Institute of Science, Rehovoth, Israel, his paper has been circulated and will be considered as read.

Mr. BERGMANN'S *paper follows:*

Agricultural Products as Starting Materials for the Chemical Industry

ERNST DAVID BERGMANN

According to the Greek legend, the giant Anthaios was invincible only as long as his feet stood firmly on the soil. This legend reflects the instinctive belief of primitive nations that their strength is derived from the soil, its resources and its unlimited creative power. Indeed, the development of any country must begin with a sound agriculture.

However, agriculture alone cannot form the basis of a stable economy. The history of the last generation has shown that the continued performance of agriculture had to be supported by government subsidies, and an analysis proves that this instability is due to the dependance of classical agriculture on the food market as the only outlet for its products. The present paper will try to prove that this general difficulty can be overcome by dovetailing agriculture and industry and thus creating a new outlet for agricultural products. There is no need to consider these two fields of human endeavour as mutually exclusive; there is an industry which can be based on agricultural produce as its starting point.

Until less than a century ago (about 1860), the commercial dyestuffs were extracted from plants, and even today there are still drugs so complicated that the chemist cannot compete in their preparation with the synthetic methods of nature (morphium alkaloids, digitalis glucosides, etc.). However, the general trend of modern industry in these fields is away from nature and towards synthetic products. In many cases, it has even been possible to imitate in the laboratory the processes which normally occur in the plant cell. (1)[1] This imitative method cannot be applied to those natural processes in which enzymes play a part; there are very few cases in which the chemist has been able to replace the natural catalysts by synthetic ones. It is for this reason that for the supply of carbohydrates such as cellulose, we have still to rely on nature, and the manufacture of cotton goods, of artificial silk, of nitrocellulose, are typical examples of industries based on agricultural products as their starting materials.

Very frequently, especially in countries with high wages, agricultural products are expensive, if compared with coal or petroleum as raw material. In such cases, one has to find new ways of utilizing these agricultural products and equally any by-products of such industrial processes as can be based on the agricultural commodities. The castor tree, e.g., is of interest for agrotechnical reasons, as it is able to stabilize migrating sand dunes; however, its cultivation could not become an economically sound proposition before industrial uses were found for the constituents of the tree; one such method is the manufacture of dehydrated castor oil, as substitute for other highly unsaturated natural oils in the varnish industry. The proteinic residues of the oil industry can be processed into artificial, wool-like fibres; this method increases considerably the value of the oil crops and makes their cultivation more attractive for the farmer.

It is obvious that from the point of view of modern industry, only those agricultural products are of interest which are obtainable in large quantities and large yields per unit area. The fact that these prerequisites were not fulfilled for most of the natural dyes and drugs was one of the stimuli for research in the synthetic field. If, however, these conditions do apply, agricultural products may be considered as not less satisfactory a source of raw material than coal or petroleum: agricultural products are being reproduced by nature continuously—whilst the forces which have led to the formation of our mineral resources, amongst them coal and oil, have ceased to operate.

CONVERSION OF CARBOHYDRATES INTO INDUSTRIAL CHEMICALS

A particularly interesting example are the carbohydrates to which brief reference has already been made. Carbohydrates are being produced by the green plants from carbon dioxide, the end product of all those metabolic and industrial processes which are based on natural carbon compounds, both of the living and of the inanimate world. In using carbohydrates, therefore, we only perform one step in a cycle; in using petroleum or coal, we are destroying irreversibly a material which ultimately was formed by the same forces as the carbohydrates, namely, the radiation of the sun.

A fairly large number of reagents have been employed in the attempt to convert carbohydrates into normal industrial chemicals. Following Berl's (2) fundamental observations, cellulosic materials are reported to have been treated on a commercial scale, e.g. in France, with alkali under high pressure and at high temperature and thus transformed into liquid mixtures of hydrocarbons and oxygenated compounds (alcohols, ketones) which served as motor fuel (3).

USE OF BACTERIA INSTEAD OF CHEMICAL REAGENTS

However, it appears that a much more elegant method for such conversion consists in the utilization of bacteria instead of chemical reagents. The complicated enzyme systems of the bacterial cell permit the transformation of carbohydrates into a large number of useful chemicals, useful by themselves or by virtue of their transformability to other products, characteristic of the organic-chemical industry. In the following table a survey is given of the variety of substances which are easily

[1]Numbers within parentheses refer to items in the bibliography.

available by bacterial fermentation; the notion of fermentation has been taken in its widest meaning so that bacterial reactions are also included, which are not accompanied by the gas evolution characteristic of fermentation processes in the classical sense—or in which the desired final material is only a minor product of the metabolism, as e.g. in the case of the antibiotics.

Special attention should be given to the so-called acetone-butyl alcohol fermentation which converts starch or sugar into a mixture of acetone, butyl alcohol and ethyl alcohol (10:20:3)—because these three substances are virtually hydration products of the three olefines, propylene, butylene and ethylene, on which most of the modern processes of the petroleum-chemical industry are based. It appears possible therefore, in principle, to convert sugar by means of Clostridium acetobutylicum (Weizmann) into the same fundamental products into which petroleum can be transformed by cracking processes (4).

Another biological process which appears to hold out great promise, although it has hardly been used industrially, is the methane fermentation, because it gives the possibility not only of producing a fundamental hydrocarbon, but also of basing on carbohydrates all those transformation reactions of which methane is capable. It is of particular interest that the methane fermentation can use cellulose as starting material; normally, bacteria do not attack cellulose and hemi-celluloses unless those polysaccharides have been first hydrolyzed to reducing sugars. It will be interesting to search for other micro-organisms which can convert cellulosic materials directly into fermentation products other than methane, in the same way in which certain bacteria transform starch into those lower carbohydrates which are capable of direct fermentation, without necessitating the additional and separate step of artificial saccharification.

Another distinct advantage of bacterial fermentation is the fact that its results can be influenced, at least to some extent, by modifications in the nutrient solution on which the bacteria are acting. This has become particularly interesting in such cases as the production of various penicillins (6); but a similar effect is known also in the more common fermentations, for instance in the acetone-butyl alcohol fermentation in which an addition of acetate and butyrate to the fermenting mash leads to an increase in the amount of acetone and butyl alcohol produced by the bacterial cell (7).

This picture of the utilization of carbohydrates for purposes of the chemical industry would not be complete if reference were not made to the direct industrial uses of natural carbohydrates, amongst which the case of the textile industries based on cellulose has already been mentioned. To this must be added the industrial use of pectin and, more recently, of alginic acid (8).

CASTOR TREE AS A STARTING POINT FOR A CHEMICAL INDUSTRY

Mention has been made above of the castor tree as a starting point for a chemical industry based on an agricultural product. The cracking of castor oil, or of the corresponding methyl ester of ricinoleic acid, leads to a variety of interesting products summarized in the following scheme (9) (which refers to the decomposition of the free acid).

$CH_3 \cdot (CH_2)_5 \cdot CHOH \cdot CH_2 \cdot CH = CH \cdot (CH_2)_7 \cdot COOH \rightarrow$

(a) $\rightarrow CH_3 \cdot (CH_2)_5 \cdot CHO + CH_2 = CH - (CH_2)_8 \cdot COOH$
heptaldehyde — 11-hendecenoic acid

(b) $\rightarrow CH_3 \cdot (CH_2)_5 \cdot CO \cdot CH_3 + HOCH_2 \cdot (CH_2)_8 \cdot COOH$
2-octanone — 10-hydroxy-decanoic acid

(c) $\rightarrow CH_3 \cdot (CH_2)_5 \cdot CHOH \cdot CH_3 + HOOC \cdot (CH_2)_8 \cdot COOH + H_2$
2-octanol — sebacic acid

(d) $\rightarrow CH_3 \cdot (CH_2)_5 \cdot CO \cdot CH_2 \cdot CH_2 \cdot CH_2(CH_2)_7 \cdot COOH$
12-keto-stearic acid

The reaction which leads to undecylenic acid and heptaldehyde has found particular interest in recent years. From heptaldehyde a fairly large number of substances can be prepared, e.g. α-amyl-cinnamic aldehyde (synthetic jasmine) (10), all characterized by the straight chain of seven carbon atoms. From undecylenic acid which in itself finds a certain use in the cure of fungal diseases, e.g. the disease known as athlete's foot (11), undecalactone (12) has been made which also finds use in the perfume industry; its isobutylamide is of insecticidal

Substances Available by Bacterial Fermentation

Product	*Micro-organism*
Methane	Methanobacterium omelianskii and others
Ethyl alcohol	Yeast
Acetic acid	Bacterium oxydans, Bacterium aceti, and others
Propionic acid	Propionic acid bacteria
Butyric acid	Clostridium saccharobutyricum
Isopropyl alcohol	Clostridium Beijerinckii
Butyl alcohol, Acetone	Clostridium acetobutylicum Weizmann
2, 3-Butyleneglycol	Aerobacillus polymyxa, Aerobacter aerogenes
Methylacetylcarbinol	Acetobacter suboxydans (from 2,3-butyleneglycol)
Glycerol	Yeast, e.g. Saccharomyces ellipsoideus
Lactic acid	Lactobacillus Delbrueckii, Rhizopus oryzae, and others
Citric acid	Aspergillus niger and others
Fumaric acid	Mucorales species, Rhizopus nigricans
Gluconic acid	Aspergillus niger
5-Ketogluconic acid	Acetobacter
2-Ketogluconic acid	Pseudomonas
Itaconic acid	Aspergillus terreus
Penicillin	Penicillium strains
Streptomycin	Actinomyces griseus
Streptothricin	Actinomyces lavendula
Aureomycin	Streptomyces species
Chloromycetin (Chloramphenicol)	Streptomyces venezuelae
Riboflavin	Chloromycetin (Chloramphenicol) guilleirmondia, Eremonthecium ashbyii

value(13), and some of its esters with unsaturated alcohols are useful in the manufacture of polymers(14), because they lead to cross-linking to a mild extent. Perhaps the most interesting use, however, is the conversion into 11-amino-undecanoic acid which since the fundamental papers of Carothers is known to be polymerizable to a polyamide of the Nylon type, but differentiated from ordinary Nylon by the much longer carbon chain connecting the polar groups, and by the ensuing differences in chemical and physical properties.

UTILIZATION OF PROTEIN WASTE PRODUCTS

Equally, the utilization of protein waste products, which has briefly been mentioned before, deserves a more thorough discussion. Such waste products are plentiful in the industry of vegetal oils and in the fermentation industry, and it is curious to note their abundance in comparison with the scarcity of animal protein. The explanation of this anomaly lies in the fact that our organism digests and utilizes vegetal proteins to a much lesser extent than animal ones. The present method of bridging the gap is that one feeds the vegetal protein to cattle whose digestive tract is more adapted to it, and recovers it as animal protein in the form of milk or meat. However, a careful analysis of the situation has led Slade and his co-workers(15) to the conclusion that in this way only 9 per cent of the protein is recovered directly in the form of meat protein and 15-18 per cent in the form of milk protein.

Many attempts have been undertaken to make vegetal protein better available to the human body by hydrolyzing it, either partially, to peptones, or completely, to amino acids. The use of chemical reagents in this case, mainly acids, which have been applied most frequently, suffers from several disadvantages, amongst them that certain amino-acids are destroyed or converted into nutritionally valueless products, and that certain other amino-acids are racemized and thus partly withdrawn from the pathways of metabolism. Here again, the application of the more subtle instrument of the living cell proves to be of distinct advantage. The breakdown of vegetal proteins by means of the proteolytic enzymes of yeast leads to products in which the amino-acid content of the natural protein is maintained in quantity and, as far as the steric configuration is concerned, also in quality. These products can be expected, and have been proven, to be equivalent to animal protein(16).

In the preceding pages an attempt has been made to clarify our ideas on the possibilities of the utilization of agricultural products for chemical manufacturing processes. It does not appear impossible that a systematic application of these principles and of the experience already gained may lead to a revision of current ideas on the paramount value of petroleum and coal, and may thus help in the pacification of a troubled world. In any event, these methods may certainly become a tool in the development of those areas which lag behind in their industrial development and in the standard of living of their population, although in many cases they are the areas which in other respects have made no mean contributions to our present civilization.

It would be gratifying if Israel, which appears for the first time as a member State in a congress convoked by the United Nations, should become the pioneer on this new road.

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The Chairman: I think you will all agree that we have had six extremely valuable papers, illustrating in their several ways what could be done to create new resources, whether of food or of industrial materials. In opening the general discussion, I think it would be useful to refer to certain aspects of the problem which have not in general been touched upon.

Dr. Lundin, in his paper, has mentioned the fact that the method which he has been describing for producing fat from micro-organisms may at present prove uneconomic in competition with fats produced from coco-palm. The point he makes is a salutary one. Economic considerations hedge technical possibilities. Moreover, this is an international meeting and our economic points of view are somewhat different at the present moment.

Dr. Hall, in his paper, said that there are two basic requirements for securing the best from the timber resources of the world today: forests and forest industries, and highly developed industrial organizations and technical knowledge. Clearly, there is a third set of variables which we have to consider: the economic factors.

Dr. Hilbert remarked that, if modern food technology could be applied more widely throughout the world, it could raise substantially the nutritional standards of millions of people. That is perfectly true. The technologist can show the way. But the question is: At what rate and at what cost? How quickly can these things be applied? And here we enter the field of economics and hard realities. In England, where conditions at present are not as satisfactory economically as some of us would like, we are always looking around for alternative sources for the materials which are conventionally used in industry and agriculture, as well as for new materials. In this search our economic friends are constantly reminding us that many things which are technically feasible are economically undesirable. They point to the example that it may be possible to grow bananas at the North Pole, but they ask whether such things are really necessary and whether the expense is justified. The answer is that, in most of these cases, the expense is not justified because there are alternative and cheaper ways, particularly in view of the manner economic matters have been organized over the past years, to satisfy our wants.

If we take our minds off the fact that the rate at which new materials and new sources of supply can be tapped depends upon economic factors, we shall be misleading ourselves about the speed with which science and new technology can come to the aid of a world which, so the prophets assure us, is going to outrun its sources of food and its sources of raw materials.

The problem, however, is not simply one of the economics of production. We have also to consider the economics of distribution. Even if, for example, it were technically feasible to produce all the fat and all the protein we wanted from algae by the methods referred to by Dr. Woodward, could we be certain that that protein would be distributed any better than the protein which at present exists in the surplus grain which exists in certain parts of the world? We ought to know about the answers to such questions when we encourage any major adventures into non-conventional methods of production.

I am deliberately making these provocative remarks from the Chair as a stalking horse for the discussion. With your permission, I should like to pursue the economic issue just for a few more moments.

Scientists, as such, can do extraordinarily little to solve the general problems of economic maldistribution. They can, however, undoubtedly help when it comes to the consideration of the differential economics of production. Science is something which, as we all know, leaps ahead of custom and tradition—custom and tradition based upon common knowledge—and by so doing scientists create a gap between themselves and those other professional forces which determine the economic context of a period. The gap, which is often a gap between scientists and economists, is sometimes an extremely serious and dangerous one. We have been discussing new technical knowledge this afternoon, and we have had indicated what could be done if the opportunity were there. In the first instance, however, knowledge does not imply control over resources. It means control only when it becomes part of all the factors, economic and political, which determine the context of development.

At the present moment, for example, economic forces in certain areas prevent the full exploitation of even conventional methods of production. For example, it does not pay us in England to produce much aluminium and magnesium. It does not pay us because, even though world trade is not in as happy a state as it might be and should become, we can do better by customary methods of trade than we can by developing at high cost the materials from domestic resources. We have got to ask ourselves, therefore, a number of questions about resources which could be created by unconventional methods.

When we consider any one of the projects that have been mentioned today, we have to see first whether or not we can obtain the substance concerned more economically by the unconventional than we can by conventional methods. We have to consider the economics of eliminating the waste of materials produced in conventional ways. We have to remember that things which are quite possible in an economy such as the United States—a country with a big agricultural surplus—are out of the question economically in many other parts of the world. Chemurgy, for example, can make vast leaps ahead here which it cannot possibly do elsewhere. Countries which are nowhere near self-sufficiency in food supplies present a state of affairs quite different from that which prevails here, where it is possible to use agricultural surpluses as a basis for industrial raw materials.

It is perfectly plain, therefore, that the economics of unconventional production will vary with the different regions we consider. A plant to make fat by the use of micro-organisms would be one thing in Sweden; if it were to be put up in Burma it would be something completely different; and if it were put up in Northern Rhodesia, it would represent yet another problem. There is no single simple answer to the economics of unconventional methods of production.

I am, as I have said, making these points simply to raise one or two controversial issues for the sake of discussion. Another point I should like to hear discussed is that of scale. By how much, relatively, can unconventional methods of production supplement the output of conventional methods. For example, it would be useful to know how much fat it is feasible to produce from micro-organisms in relation to the total amount of fat that is consumed.

The search for new knowledge, for new methods and new resources must go on, and will go on. The question is whether or not we can accelerate its progress. New resources have fitted into the scheme of things when it has paid to fit them in. Today, forces other than economic ones are urging us forward to create new resources as shortages become apparent in the old and as new needs develop. It is not a case of the scientist not having the time, as it were, to start to solve the problems raised by potential shortages and scarcities. It is a case of asking whether, under existing political and economic conditions, the scientist is going to be given enough time to succeed in the task of developing these vast new schemes of wealth, of which samples have been given us this afternoon.

The whole subject is open to general discussion, and I trust you will not be slow in coming forward. I call first on Sir Harold Hartley who was Chairman of Monday's meeting.

Sir Harold HARTLEY: The Chairman, speaking as an economist and scientist, has given us a very timely reminder which, coming from him as a scientist, carries articular weight. It is that we scientists must not mislead the world by our enthusiasm, and that in all these new possibilities great care must be taken to use them in such a way that we get the benefit from them without indulging in uneconomic development at this period of the world's history when we have to be so very careful in the use of our resources.

I should like to start by paying tribute to the papers to which we have listened this afternoon and which, taken together, do represent a most admirable and lucid account of these developments in the field of creatable resources, the development of which has been spread over a considerable number of years.

There is this new partnership—of which you have had such a graphic description this afternoon—between the farmer, the forester and the chemical engineer which has, I think, great significance for the future. As I said on Monday, it was formerly a competition, and I shall quote a remark which Steinmetz, the genius of Schnectady, made to Bosch, the head of the I.G., the great German chemical combine, and which I had from Bosch's own lips so that it is authentic. They were discussing the question of the future of tropical agriculture, and Steinmetz said, "Well, Bosch, I know you can make indigo cheaper than God. Some day you may make rubber cheaper than God, but you will never make cellulose cheaper than God." There is a great deal of truth there, which has a direct relation to our Chairman's reminder that we have to keep the economic significance of these developments very clearly in mind.

Secretary Krug, at our first plenary meeting, laid great stress on the importance of the interrelationships of the Sections of this Conference, and I should like to take up two very significant aspects relating what we have heard this afternoon to the plenary meetings on the two previous days.

Reverting to the first day, when we were discussing energy, all these possibilities of which we have been hearing today are dependent upon supplies of energy, fuel and power being available at the right places. They are also dependent in the energy field on transport, as the Chairman pointed out to us when he was speaking of the economics of distribution. I shall come back to that a little later.

Yesterday morning we had in the Mineral Section meeting an outstanding paper by Mr. Pehrson[a] on the world resources of minerals, and he pointed out that there was a great contrast between the world reserves of minerals in the metallic field and in the world reserves of potash, phosphates and coal—and in coal we have the energy to produce fixed nitrogen. The result is that whereas the mineral resources are measured in a hundred or, in many cases, less than a hundred years, those of potash and phosphates are measured in one thousand six hundred years, and those of coal in over two thousand years. Thus there is a great contrast, but from the point of view of the subject we are discussing today—creatable resources—we are secure in the future of an agricultural economy because we have the fertilizers and the energy.

That seems to me to emphasize the importance of these developments, because in many cases there is, in these processed agricultural materials and synthetic chemicals, the possibility of gradually replacing a number of the uses of metals which, if we look at Mr. Pehrson's figures, is something that we have to face up to.

There is another point in Mr. Pehrson's paper, namely, the rate of consumption of these metals in different countries where there is that very great contrast between the consumption in the United States and elsewhere, a factor which is very considerable—one to ten, one to twenty, one to thirty. Which means that if we take President Truman's Point Four, the raising of the standards of living in the backward countries, then, as was pointed out in Mr. Wadia's paper yesterday, if we contemplate the same kind of civilization—and the papers at yesterday's plenary were devoted to the raising of the standard of living—then that would produce almost a physical impossibility as regards certain metals.

On the other hand, if you consider today's papers in relationship to the development of backward countries and significance to those countries of the processing of farm and forest products, you will see what a great significance that may have to giving those countries a balanced economy. But it does mean giving them a considerably greater amount of metals.

There is one quantative point that I should like to come back to, which has a bearing on this question of the relationship of these creatable resources, that is farm and forest products, and the output of minerals. I made a survey just before the war, and my figures, which were in fairly close agreement with Zimmerman's, showed that on a value basis, 88 per cent of the farm and forest products today represent food and 12 per cent a contribution to the raw materials of industry. And on the same value basis, the mineral raw materials represented about twice as much as the farm and forest products. So that, roughly, you can say, of these primary materials—I hope that I am not misusing the term "primary materials", because you, Mr. Chairman, gave the definition—that about 70 per cent are used as food and about 30 per cent as industrial materials. And with the growing depletion of metal reserves, I could detect a certain tendency of that 12 per cent—the amount of farm and forest products which are being used in industry—to rise.

Looking at this question of development, and the figures which Mr. Pehrson gave us, it does seem to emphasize the importance of having accurate surveys of raw materials, because, going back to the Chairman's point on economic development, you must base that development on the raw materials which are immediately available, and you have to link up the availability of those raw materials with the availability of energy, with sources of fuel and power for their processing. You will remember that Secretary Krug stated how much he regretted that the proposal to focus here a comprehensive survey of resources had had to be dropped for the time being. So one of the lessons which comes out of this Conference is how essential such a survey is, if we are to get an orderly development, along economic lines, of these raw materials, and achieve the right sort of balance, with the limited resources which we have at our disposal. It is important to get the right priorities for the use of our limited capital resources so that they will go to places where they can make the largest contribution, while, at the same time, giving the scientist his head and letting him range as widely as possible in ex-

[a]Mr. Pehrson's paper was introduced at the Minerals Section meeting and will be included in the Proceedings of that Section.

ploring and bringing to a stage of possible application, all these possibilities of the type that we have been listening to this afternoon.

I feel that today's contribution does provide a pointer to what may be the future pattern of civilization, in view of what we know about mineral resources.

The CHAIRMAN: I call on Dr. Goodrich of the Preparatory Committee.

Mr. GOODRICH: I should like to make one brief comment to say how much I think this particular meeting falls within the centre of the spirit of the Conference, not merely because the speakers have indicated new and exciting lines of progress, but because each of the speakers, and you, Mr. Chairman, and Sir Harold Hartley, have all dealt with the point of applicability; that is, where can these things be put into effect, and can they be put into effect in the less-developed countries?

You will notice that these questions of applicability have appeared in various forms in the discussion. There is the question of applicability in terms of needs. As Mr. Lundin suggests, perhaps some of the techniques of which he spoke would be better put into effect in the Far East than in his own country, because there the needs for the substance were the greater. Other comments have dealt with the applicability from the side of supply; that is, does the new method need an elaborate technique and "know-how"? Well, obviously all of them do. But you will notice that Mr. Hilbert was speaking of attracting technicians to his laboratories who could take back the techniques to other countries which had not yet developed the techniques. On the other hand, for a number of these techniques, it has been pointed out that their application required considerable capital and required a complex industrial organization; and, in other cases, Mr. Hall pointed out that the application required a particular set of resources; that is, in his case, the resources in wood.

I think that the speakers ought to be congratulated on formulating their technical points in relation to this question of applicability—applicability to particular sets of countries and particular sets of conditions. Possibly, if they have an opportunity in the discussion, they might push that point even further; but I think that we should be very grateful to them for the extent to which they have kept it in mind in their presentation.

The CHAIRMAN: Mr. Hall wishes to take up this last point.

Mr. HALL: I am not going to attempt to reply to all of the discussions by these eminent economists. I have had lots of trouble with economists before. We always, it seems, come to the same point in these discussions. We take a look at the cost when we analyse what we are doing with respect to food supplies or some other matter; it does not make any difference what it is, for we conclude that what we propose to do will probably cost more and, therefore, nothing can be done. I do not think that we ought to end on quite that much of a note of pessimism. Certainly we are not going to grow bananas at the North Pole, unless we begin to mine metals at the North Pole and have to feed somebody and, in so doing, have to have bananas. In that case, growing bananas at the North Pole will prove to be economically sound.

I want to emphasize a point that I tried to make perhaps inadequately in the main part of my discussion. During the course of the war it became necessary to consider extraordinary means of getting protein in concentrated form to the soldiers of a certain country. We could get tools of war to them, but they were so hungry they could not carry them. It was necessary to figure not how much it would cost but how we could do it. Obviously, they had wood. Quite obviously also they did not have anything else. The total sulphuric acid capacity of that country per year was approximately equivalent to the production of sulphuric acid in the United States in one eight-hour shift. Sulphuric acid was an utterly inescapable requirement of the process we proposed to put into effect.

All right, we were licked. The economics of the situation had nothing whatever to do with it; we were simply licked before we started because the conditions were insurmountable. However, we went ahead and calculated the costs of transporting sulphuric acid in the required amounts by aeroplane if it were necessary to do so.

This is an absurd illustration in a way, and yet what I am trying to say in my weak way is this: If we are going to get at the job of translating into utilizable food resources some of the things we have all discussed here today, it will take daring, it will take capital, and it will take above all something that has not yet come forth—some form of international credit organization with a very long term point of view. On that note I think I should close.

The CHAIRMAN: I call on Dr. Erselcuk of Purdue University.

Mr. ERSELCUK: As an economist I agree with Mr. Hall. I think economists as well as other people are somewhat confused on the issue of what is economic and what is not economic. They are confusing the two terms: financially desirable and economically desirable. The cost problem is usually one of finance. It is possible, in my view, to make great use of the wastes. That may cost a great deal perhaps financially, but it still may be economically desirable as long as in the process of substituting one raw material for another we do not use other scarce raw materials. In other words, in the process of substitution, we can use labour—and in some cases there may be much of it available—and in some cases we may be able to substitute plenty of cheap capital. Of course, the cost of that varies from one country to another. In the United States it is available at very low rates—2 to 3 per cent per year. In China it is not available even at rates above 10 per cent. Due to these substitutions of labour which may be available, and due to substitutions of capital which may be available, a substitution that may appear rather expensive at this time from a financial point of view may be perfectly desirable from a technical and economic point of view in the over-all picture. After all, it may be more desirable to pay the labour to convert certain sugars to alcohols than to pay that labour through the WPA or some other form of relief.

The CHAIRMAN: I call on Dr. King of the United Kingdom delegation.

Mr. KING: I should like to return to a point which was raised a few minutes ago by Sir Harold Hartley, in relationship to the very interesting papers we have had today which have shown us so many new possibilities for the future, the immediate economic desirability of which appears from the discussion to be very debatable.

No doubt there are many new resources which could be put into operation in slightly different economic circumstances. I suspect that quite a few of the processes and materials which have already been discussed in this connexion here and elsewhere are marginal from this point of view. Consequently, with slight changes in the economic atmosphere, either in a world sense or in certain localities these techniques might possibly prove to be extremely valuable.

One of the chief probabilities of an over-all change affecting the demands of consumption of raw material resources has been raised, or threatened to be raised, at quite a few of the plenary meetings of this Conference. I should like to stress this matter again. Quite apart from population increase, which we have discussed on many occasions, we all agree that there is at present strong pressure towards increasing the standard of living throughout the world, as exemplified, of course, by the FAO policy, and furthermore strong pressure towards the development of resources in the less-developed areas, as illustrated by President Truman's "Point Four" and the response which this approach has received in the Economic and Social Council and elsewhere.

The effect of such an increase in the standard of living and of the opening up of new developments in various parts of the world will, of course, lead to a very greatly increased demand for the renewable and nonrenewable resources of the world.

Sir Harold has mentioned the very excellent paper of Pehrson on the mineral side. A glance at the final table, as far as minerals are concerned, shows us that if the standard of the world were raised to that of the United States, our potential iron ore would be used up in 75 years, our copper in 5 years, our lead in 4 years, and our zinc in 6 years. Mr. Hall's paper on the forestry side indicates that if the backward countries of the world used forest products at the rate of the United States, the situation would here too be critical. I know that many of us who are in this country as foreigners realize immediately that if the whole world produced newspapers the size of the Sunday editions in this country, depletion of the world's forests would become an immediate and very serious problem.

I do not think for a moment that any of these schemes are likely to raise the world's demand for raw materials to that of the United States in any foreseeable future. In fact, in the present world situation and with our present political and economic organization, the world could not afford it. Changes may well take place which will alter that circumstance. But that, again, is for the future.

Nevertheless, although we cannot envisage the demands for raw materials and other resources being increased by forty times, or ten times, or even twice, the tendency—and it is a tendency which will probably accelerate—is for a great increase in the demand from all parts of the world, and particularly from the less-developed areas, for a considerably higher proportion of resources; and this demand will in itself change the economic situation so that a number of the materials and the processes which have been discussed in the papers presented today may well enter the picture as extremely important factors.

I am therefore saying these few words as a plea that work be continued and intensified on these subjects. The more we know about these resources, I think, the better position will we be in to put them to use when economic circumstances change and they become possible and desirable. As the previous speaker said, they may become desirable through changing financial circumstances in times of depression or through other circumstances quite apart from the over-all economic position. I therefore feel sure that such work should be continued, and furthermore that its economic assessment should be done in parallel, and stage by stage, so that quick use may be made of all these regenerative resources, whether traditional or otherwise, when the economic circumstances permit and favour them.

The CHAIRMAN: I call on Mr. Raushenbush of the Preparatory Committee.

Mr. RAUSHENBUSH: Like all the rest of you, I listened with a great deal of interest to what Sir Harold Hartley and Mr. King and others had to say, and I wondered how many of you got the same impression of today's meeting that Mr. Goodrich had.

The speakers today were cautious, as scientists always are; they do not, in their own papers, lead anybody to see quite what they are saying. But if it is correct that Mr. Woodward, who is a technical man in his field and a specialist of high repute, brought himself, in his modest English way, to say that the results might be very remarkable, then, in a much simpler American way, I am going to take a gamble—not a complete gamble, but a good one—that the results are going to be something very extraordinary indeed.

Here we have the algae process and the fat synthesis process and the opportunity to get more land by obtaining certain products from trees instead of from plants—in other words, using our cotton land, not only in this country but perhaps throughout the world, for wood products.

Those three things all deal with food. They all deal with the questions that have intrigued the American imagination so much in the last few months, the questions concerning a population that may be encroaching upon food supply. If you take a layman's translation of what all these scientists together have said—and I did not get all of Mr. Lundin's figures—you have a real challenge to the thesis that has been put forth that the people are going to live at a coolie wage and a coolie standard of living in the very near future.

In connexion with what Sir Harold Hartley and Mr. King said about taking these things *pari passu* and in due measure, and so forth, I should like to take up just two points. First, these things deal with food. They are not completely analogous to the over-use of minerals which might occur and which Mr. Pehrson talked about the other day. They have to do with the question of whether a population that is now 2 billion, and is going to be 3 billion in fifty years, is or is not going to eat adequately.

In that kind of situation, I would try to amend Mr. King's suggestion that the scientists should go forward in due course and due manner, and in the light of all economic considerations, with a statement or suggestion that they go just a little bit faster. The scientists are going to have a big job here with these promises—and nothing more than promises—that the speakers have given us today, in order to get just a little bit ahead of hunger. In view of the bill that the world pays whenever there is instability, it could pay a very considerable bill—it is a good business proposition—to avoid the kind of instability that comes when some people starve and other people do not starve. That difference, which confronts us in many parts of the world today and in many parts of this country, is a not inconsiderable difference, whether you look at it in sociological terms or in purely financial terms or in that peculiar twilight atmosphere that the gentleman from Purdue University, Mr. Erselcuk, was trying to persuade us exists between the financial and economic.

I should like, then, to summarize, very roughly and in layman's form, what I learned from this meeting. What is implicit in it, I think—and Mr. Woodward and Mr. Lundin and Mr. Hall may want to raise objections to this—is the most hopeful challenge for people who are hungry throughout the world. It is so hopeful—it deals solely with hunger and the improvement of standards of living through better diets—that it might be worth the consideration of the world to put a good many more of their teams of experts on matters that are now dragging along perhaps a little more slowly than they might.

Mr. WOODWARD: I think that perhaps we have achieved something if we have got men like Mr. Stephen Raushenbush and his economist colleagues to realize what we pseudo-modest technical chemists are doing. I am making a point of meeting as many of them as I can in the corridors after this meeting because for some time I and my professional colleagues have been trying to do such things as making sausage-skins from seaweed and the like and apparently we are all wrong in our perspective. I heard the other day of a man who had succeeded in making edible protein from sheep's wool. That is only one stage, I am sure, from making wool from mutton. It is high time, I submit, that the economists teamed up with us in the development of the many new fields we have been discussing here.

I should like to point to three things which have been said before but which to me, as a chemist, seem to be essential in developing these techniques we have been talking about. We certainly require a factual survey; the minerals people are far ahead of the agricultural technicians. They have facts and figures. I think it is right to say that with the exception of forestry there is no competent survey in the world of agricultural commodities and by-products, with the sole exception of one in the United States carried out ten years ago. That, I submit, is essential and of immediate importance, and must be carried out by scientists and chemists.

Secondly, we must do more and more in spreading the technical "know-how", by means of discussion, articles, and by bringing people to such laboratories as that headed by Dr. Hilbert.

The third, and most fundamental point of all, is to have the necessary mechanical equipment in the parts of the world where the development of these processes is required. Without that, all this talk is entirely in vain.

The CHAIRMAN: I call on Mr. King Hubbert of the Shell Oil Company, Houston, Texas.

Mr. HUBBERT: There have been certain not quite expressed currents of thought running through these meetings, particularly the plenary meetings, for the last several days. It has taken several forms. Yesterday, at the Mineral Session the criteria for determining whether or not certain low-grade minerals should be extracted were discussed, and the central theme was whether or not it was profitable to do so. This afternoon, we have had Mr. Hall's very excellent technological exposition. We have just heard what can be done with various products, and we have heard a word of caution that "economic factors" must also be taken into account. Since this concept of "economic factors" has been brought into the discussion I should like to inquire what we mean by it. What do we mean when we say that a given operation cannot be carried out because the cost will be prohibitive?

In that connexion, I should like particularly to call your attention to two totally different kinds of costs—costs which have nothing whatever to do with each other. In all kinds of physical operations—I use the word "physical" to include the whole general domain of matter and energy—one type of cost of any process is its physical cost. I can illustrate this very simply by saying that the cost of driving an automobile is the gasoline which is burned and which, so far as energy is concerned, leaves the earth. That is strictly and irretrievable cost. The other type of cost is the monetary cost of the gasoline. This involves the exchange of tokens or paper between two individuals, and after the gasoline has all gone, the tokens are still with us, so far as the national economy is concerned. The only thing we lost in the deal was the gasoline, not the tokens.

It happens that the dictates of these two different types of accounting often are contradictory. The dollar accounting sometimes says that we cannot do a given thing, and the physical accounting says we can and we should. That is the essential contradiction which seems to me to be running all through these various problems. Yesterday the problem was brought into focus in the case of gold mining, and there is no better example. This is an operation which is physically unjustifiable because it is an absolute waste of resources for no useful purpose, yet it enjoys every sanction of monetary accounting. Going further, it is noteworthy that physical accounting so far has been given precedence over monetary accounting only in times of war.

I mention this because I do not believe the distinction has been sufficiently appreciated. Food, biological products, minerals and energy resources are all physical entities and their utilization comprises a complex of physical processes upon which the well-being of humanity depends. Hence if socially desirable and physically practicable operations are forbidden by the dictates of monetary accounting, I think we should at least be aware of what is causing the obstruction.

The CHAIRMAN: In drawing this meeting to a close may I again, on your behalf, express the appreciation we all feel to those who presented formal papers this afternoon? May I also say that I am pleased that my earlier remarks of a slightly conservative economic kind acted as an adequate stalking horse. The response from some of those who took part in the general discussion gave the kind of encouragement most scientists like to have.

Mr. Hall suggested that we should not measure the things we have been discussing in the way conventional economists and business men are inclined to measure them, and he added that faith and courage and the need to enrich ourselves is something which transcends some of the dry rules of academic economics. Mr. Raushenbush put the matter even more forcibly when he said that the scientist should get a little ahead of the hunger which threatens. We should perhaps remember that practically every one of the steps by which new commodities and resources have in the past been created has been subject to the same type of comment which this discussion has so forcibly rejected. It was, for example, completely autarchic to develop the rayon industry in Germany in the Thirties; but that rayon industry, once developed, has gone ahead and has added economically and substantially to the total amount of fabric available in the world.

The last speaker has differentiated well between social cost and monetary cost, between—if one puts it in different terms—the value of an operation and the cost of operation. That is something which we ought always to bear in mind. I do think, however, that while research for new resources should surge ahead, we should not forget the economic difficulties which now beset the world. We have to distinguish clearly between our urgent short-term economic problems and the longer-term matters we have been considering. With Mr. Hall, I feel that some new form of international credit organization will prove necessary if even a fraction of the various possibilities that have been touched upon today are to be fully exploited in the years to come—years which may slip by so quickly that the problems we have been discussing are going to appear more and more urgent and, if we are not careful, probably more and more insoluble in terms of the time available.

Methods of Resource Appraisal

Thursday Afternoon, 25 August 1949

Chairman:

Emmanuel DE MARTONNE, Member of the *Académie des Sciences de l'Institut de France,* Honorary President, International Geographic Union

Contributed Papers:

Mineral Discovery
Fernand BLONDEL, *Ingénieur en chef des mines,* Paris, France

Resource Surveys
Robert H. RANDALL, Bureau of the Budget, Executive Office of the President of the U.S.A.

Statistical Control in the Conservation and Utilization of Resources
W. A. SHEWHART, Bell Telephone Laboratories, Murray Hill, N. J., U.S.A.

The Place of Experimental Investigations in the Planning of Resource Utilization
F. YATES, Rothamsted Experimental Station, Harpenden, Herts, England

Statistical Tools in Resource Appraisal and Utilization
P. C. MAHALANOBIS, Indian Statistical Institute, Calcutta, Statistical Adviser to the Cabinet, Government of India

Discussion:

Messrs. HARRISON, E. DE VRIES

Programme Director:

Carter GOODRICH

Programme Officer:

ALFRED J. VAN TASSEL

Mr. Randall's paper was presented by M. A. C. Simonpietri, Secretary, Commission on Cartography, Pan-American Institute of Geography and History.

The CHAIRMAN:[a] The main object of our meeting today is to define methods which will enable us to attain a somewhat better knowledge of the resources at our disposal and of means by which we may so husband and use them as to prevent their exhaustion.

I should point out that some aspects of the problem were studied at a recent United Nations meeting of experts on cartography, where the co-ordination of the cartographical services of specialized agencies and international organizations was considered. The report of the Committee of Experts has been distributed and some additional copies will be available at the end of the meeting to anyone interested.

During today's meeting we shall have the great pleasure and privilege of hearing at least four or five papers, first those of Professor Fernand Blondel and Mr. Robert Randall and then those of Dr. Mahalanobis, Dr. Shewhart and Professor Frank Yates.

Mr. Fernand Blondel is, as you know, Director of the *Bureau d'Etudes géologiques et minières coloniales* (Bureau of Geological and Mining Studies for Colonial Territories). It is a great pleasure to welcome him among us. His speech will be of great interest to everyone and will be followed with pleasure and profit.

[a] The Chairman spoke in French.

To list all Mr. Blondel's claims to our attention would take far too long. I will confine myself to reminding you that he has been president of the *Société géologique de France* (Geological Society of France) and of the *Société française de minéralogie* (Mineralogical Society of France) and that he is a member of the *Académie des Sciences coloniales* (Academy of Colonial Sciences). Many foreign distinctions have also been conferred upon him. Today, by reason of his constant journeys and his many contacts, he might be described as an essential cog in a scientific machine, which, like a cinema projector, brings before us a picture of the development of science and its contribution to the field with which we are concerned.

Mr. BLONDEL *delivered the following paper:*

Mineral Discovery[1]

F. BLONDEL

In his brilliant communication of 18 August, Mr. H. L. Keenleyside examined the general problem of minerals, placing particular stress on the following questions:

1. The future expansion of demand for minerals resulting from the increase in world population and the universal desire for improved standards of living;

2. The satisfaction of this demand by greater yield from the production and utilization of the minerals extracted from deposits at present being operated;

3. The discovery of new deposits by intensified exploration with a view to increasing the number of deposits for operation.

The first two questions were examined in greater detail at the plenary meeting of 23 August. Today I propose to deal with the last question, namely, exploration. I shall not dwell on technical matters, but shall simply point out the direction in which methods have evolved. I shall deal at rather greater length with the results obtainable from exploration, since it is these results which are most likely to interest the whole Conference, assembled at a plenary meeting.

THE EVOLUTION OF MINERAL PROSPECTING

Has there been any progress in the methods of mining exploration? In what direction? May we anticipate further progress in these methods? These are the first questions I should like to examine.

Exploring for minerals is as old as man; even primitive man, searching for special flints for his stone tools, was a prospector, like his successors who, a little later, discovered the more or less stanniferous copper ores which made possible the manufacture of bronze. We can easily guess the method used by our distant ancestors, since it is basically that still used, consisting simply in searching the region in question and examining stones by splitting them so as to obtain a section less affected by superficial agents. The geologist's primary tool is still his hammer, which doubtless differs little from the prehistoric prospector's club.

[1] Original text: French.

In the course of the centuries data accumulated, and gradually certain associations more frequent than others were noted. When, at the end of the eighteenth and the beginning of the nineteenth centuries, geology little by little deciphered the constitution of the earth's crust, it became possible to formulate certain of these associations in terms of the new science. Nevertheless, the search for minerals has to this day remained an extremely personal and largely incommunicable process.

To the public, both the picturesque old-time prospector, with his mule and his camping equipment, and the more modern expert who travels by air and is backed by very large petrographic and chemical laboratories, are still sorcerers, magicians. The expert, if you prefer a more dignified term, is like a doctor, diagnosing the deposits under examination. The diagnosis is assisted by the results of laboratory analysis, but its essential precondition is still a degree of knowledge and personal experience which can be acquired only after a great deal of time, travel and—luck.

This situation—I was about to say this picture taken from a child's fairy-tale—is being progressively transformed by two factors, namely, the systematic and collective organization of research and the use of geophysical exploration. Let me say a few words about both these.

The results obtained by an isolated prospector penetrating into a new region are clearly largely at the mercy of chance, or luck. But this study of regions still virtually untouched is the task with which we are faced for the future, if we are to discover new deposits which are not merely extensions of deposits already known. To place one's trust in a benevolent fortune would be extremely naive, and as reliable as buying tickets in a lottery. Consequently the idea has gradually gained ground—particularly in little-explored countries such as Africa—of organizing systematic reconnaissance, leaving as little as possible to chance. It would take me too far afield and necessitate technical details out of place at this meeting to describe how such systematic reconnaissance should be conducted or go into its cost and the assistance which it can and must receive from general geology and the geology of mineral deposits. Suffice it to say that such reconnaissance has already been carried out in Africa, and has led to the discovery of a number of extremely interesting deposits, including manganese and diamonds in the Gold Coast, gold, tin and diamonds in the Belgian Congo, diamonds and gold in French Equatorial Africa and iron and tin in French West Africa. In the French overseas possessions, particularly Africa, this method is now well established, and is applied to the extent made possible by available credits.

For the drawback of this method is its high cost, caused by the enormous extent of the territories requiring exploration; moreover results are so uncertain that practically no private undertaking has yet assumed the risk, and but for a few rare exceptions such systematic exploration has been undertaken by public or semi-public bodies. But the funds available to such bodies are not always as large or as regular as is desirable for such work.

In this connexion, I should like to make a comment outside the scope of mining exploration. The time has now arrived when, if the problems of exploiting new resources are to be solved, large-scale works, the profitability of which cannot be mathematically demonstrated in advance, must be undertaken. If we demand evidence of their profitability as an absolute condition, most of them will have to be abandoned. In many cases an act of faith is required; or, if a more down-to-earth expression is preferred, the profitability of such schemes must be considered as a matter for the distant future and as a by-product of their operation. It was on the basis of such an act of a faith and such a view of the future that the States of Western Europe piece by piece constructed their internal organization. When, several centuries ago, the French road system was laid down, no computation was made of their future profitability, and to take an example from more recent times, it would be easy to show that J. de Lesseps' estimates of the profitability of the Suez Canal were based on inexact hypotheses, and that the success of the Canal has been due to factors which de Lesseps did not even dream of, notably the tremendous expansion of steam navigation. This is equally true of mining exploration in the still under-developed countries. It will be understood, however, that such considerations can be entertained only by public bodies on a national or international scale and it is clear, I think, that one of the things we have to do before such systematic reconnaissance can be developed is to create such bodies and supply them with funds which are not required to bring immediate returns.

To return to the technical problem of exploration, it will be noted that the trend has been to devise methods which reduce cost by restricting the areas to be searched systematically.

One of these methods—and the most effective—is the utilization, referred to above, of data provided by general geology. The mineralization of a region is merely an episode in its geological history, and one of the tasks of applied geology is to endeavour to bring out relationships of this kind. Some of the very simple ones are classical; for example the fact that tin is found only in regions of acid granites. Save in a few special cases, progress along these lines has hitherto been rather timid. Nevertheless, I have been trying to show for many years that a great deal more progress can be made if we abandon the too simple idea of a rigid relationship between general geology and mineralization, and instead look for relationships, based on probability: "contingent" relationships, as they are called in this technique. Then proceeding simply from our knowledge of general geology, we can make forecasts which, by limiting the field of investigation, will go a long way towards showing the direction exploration should take. Thus both I and other French geologists have been able by applying these methods to forecast the presence in untouched regions of Africa of gold, iron and tin deposits which have in fact been detected on exploration of the regions indicated. This fact is sufficiently uncommon to merit particular mention.

Knowledge of the general geology of the country to be explored is therefore essential. To learn this general geology we can continue to apply old methods—which again consist in searching the terrain, hammer in hand—but we can and must also take advantage of the new processes known as "geophysical processes", the general principle of which consists in drawing up a map of a particular physical factor, such as gravity, magnetism, electrical resistance etc. Such factors clearly change in accordance with the nature of the rocks composing the earth's crust, and their geographical variation, if properly interpreted, may therefore give us the geological map.

These geophysical processes—and particularly the most recent method, geophysical survey from aircraft—enable us to discharge very successfully the laborious task of the geologist who, still on foot and still, like his ancient ancestor, armed with his hammer, strives to detect the surface rocks and, by a process of extension, imagine those underneath. To the extent that mining discovery can be guided by geology, geophysics is a truly marvellous auxiliary. This is particularly true of petroleum, but might, following the studies to which I have referred above, apply to many more substances.

Geophysics, however, is not magic; its use in the direct discovery of mineral deposits is quite exceptional, and even for general geology it is merely an auxiliary technique—no doubt an extremely useful one, but one which in itself alone is insufficient and does not replace the direct study of the terrain. In any event, no miner worthy of the name will consider that he has demonstrated the presence of a deposit unless he has really touched it and penetrated into its very mass by veritable workings, in particular borings. In mining exploration blind faith is not enough; we must really see with our own eyes, touch with our fingers and analyse samples in our laboratories.

What we have said goes to show that while mining exploration has become more effective and, particularly, more rapid, its principles have not, generally speaking, changed. Its tools have been improved, but they remain tools, and for the moment no new principle likely to revolutionize mineral discovery is in sight.

Yet it is such mining exploration, so recently out of its infancy, which has given us the deposits which at present supply all our mining resources. Thus, failing to see in what way its principles can be modified, we are tempted to increase its effectiveness by adding to the number of trained geologists and prospectors, geophysical prospecting teams, air surveys and research laboratories; largely, in short, by increasing the total cost of exploration, particularly through the medium of the specialized and, in a sense, disinterested bodies of which I spoke a few moments ago.

What can we anticipate from this great expansion of mining exploration? Thus stated, the question is too vague, and no reasonable reply can be given. I lay particular stress on this point: it is because the question is generally put in this indefinite form (or in some similar manner) that we obtain extremely divergent answers, according to the views of the person interrogated, who generally tacitly supplements the data of the problem in such a way as to give it a definite sense.

Mining exploration does not seek to draw up an academic inventory of the composition of the earth's crust; or, if it does, any results which it may obtain interest specialists only, and not industrialists, economists and the general public. What these ask of exploration is to produce exploitable deposits, i.e., concentrations of mineral substances capable of supplying products which can be actually sold and utilized. The boundary between workable and non-workable deposits is not traced by physical, chemical and geological conditions, but by the economic conditions prevailing for the time being, which exploration must merely accept without discussion. When, for example, Hermann Goering decided to work German deposits containing less than 25 per cent of iron, he thereby lowered the limit at which mining exploration would normally have ceased.

But who can say what the economic conditions affecting mineral products will be tomorrow? Will prices be similar to present prices? Or will consumers of mineral products be prepared, under the pressure of ever-increasing demand, to pay much higher prices than those now in force? This is an open question, to which very different answers may be given; in any event, it is an economic, and not a technical, question. Yet it clearly dominates the entire problem of exploration.

It must be added at once that the same problem may be formulated differently, but with equal uncertainty as to the reply. From the standpoint of the limits to the discovery of workable deposits it is immaterial whether mineral substances obtain higher prices or whether their cost of extraction is reduced; in both cases new deposits not at present workable are opened for exploitation. But who can say what the future cost of mining exploitation will be? At present, of course, the cost of labour, which may serve as a measuring rod for the prices of various products, constitutes a considerable proportion of the costs of extraction; but another element of cost, one which is considerable even today and may become preponderant in the future, is energy consumption. If, in the future, energy can be supplied cheap, at prices much lower than those now in force, very considerable developments will be possible in the mechanization of ore exploitation and treatment, and extraction costs will be correspondingly reduced.

Consideration might similarly be given to other economic factors, for example the price of long-distance transport. What has been said should suffice to make it clear that no forecast can be made as to the possible results of developments in exploration, without specifying at the same time the economic conditions in which such exploration is presumed to be undertaken. I must therefore divide my reply to this question into two parts:

1. The possible results of exploration in economic conditions similar to those now prevailing;

2. More or less hypothetical estimates of the results of exploration under different economic conditions.

THE POSSIBLE RESULTS OF EXPLORATION IN ECONOMIC CONDITIONS SIMILAR TO THOSE NOW PREVAILING

If we refuse to play the inspired prophet, and if we place our feet firmly on the ground and content ourselves with forecasting the development of mining exploration in economic conditions similar to those now in existence, i.e., understanding what is likely to happen in the coming fifteen or twenty years, the reply to this question is at once simple and definite:

It is extremely improbable that the mining industry as a whole—with the possible exception of petroleum exploitation—will be subject to changes of any considerable extent in the near future.

To put the matter differently—and subject again, to the possible exception of petroleum—there is reason to believe that whatever developments may take place in mining exploration, no deposit will be found of sufficient size to change the present order of magnitude of production. This may appear a pessimistic statement, but I believe it would be supported by everyone qualified to give an opinion.

In any event, it is not an unwarranted statement, being based on two facts:

1. It is extremely rare for any deposit (or group of deposits in a single area) to produce a yield so large that its presence or absence appreciably affects the order of magnitude of world production. The most striking case is probably that of Witwatersrand, in South Africa, the exploitation of which toward the end of the last century completely changed the situation in the gold industry. But examples of this kind can be counted on the fingers, and what is entirely typical is that in spite of all the very considerable exploration carried out in the last fifty years, they have remained unique of their kind. Such deposits or districts are, as it were, "monstrosities" of mineral concentration, regarded with a sort of righteous horror and outside the common rule. They are unparalleled.

2. On the other hand, the greater part of present-day mining production comes from deposits which have been known, at least in the form of indices, for several decades. In a very interesting communication on Australia, Mr. H. G. Raggatt points out that 80 per cent of existing Australian production comes from deposits detected before 1900. Not long ago Mr. Feiss remarked to me that the copper deposits of the Katanga-Northern Rhodesia zone, which probably constitute yet another mineral

monstrosity, were detected by Livingstone—i.e., before 1870. Even in the Union of Soviet Socialist Republics, where sensational discoveries are frequently vaunted, it is customarily pointed out that the great sources of production specified—on the infrequent occasions when they are specified—derive from deposits already described in the classical treatises dating back to before the 1914 war.

Of course I do not wish to imply that no mining discovery has been made for the last twenty or thirty years. Many examples to the contrary could be cited; for example—to deal with the American Continent alone—the various deposits worked in the provinces of Ontario and Quebec. But recent discoveries have not in themselves been large enough to affect the general situation to any great extent; they have made their contribution, sometimes a considerable one, to total production, but have not changed its order of magnitude.

The reason for these facts will, of course, be readily understood. As I pointed out above, deposits have hitherto been discovered by tracking down the points where they show themselves on the earth's surface, or, in the technical language of prospecting, by tracing their "outcrops." Other things being equal, the greatest deposits will clearly have the largest outcrops, and discovery will therefore most likely begin with such great deposits. Those remaining to be discovered are deposits of medium or small size, which may doubtless be important for local economy but have no serious effect on world economy.

But of course, again, the foregoing remarks need some qualification. I began by stating the case with considerable exaggeration in order to make my point quite clear. Certain finer distinctions must now be introduced into this rather crude picture.

I cannot, of course, go into all the details, but shall confine myself to citing a number of specific cases which will illustrate the reservations which must be made.

The main exception to the above generalization, as I remarked at the outset, is petroleum. In this case a forecast almost the reverse of the general rule may be made without great risk of error. It is extremely likely that in the fairly near future discovery will be made of new petroliferous districts which will appreciably alter the present situation. The very recent case of the discoveries in Alberta, Canada, is a very suggestive specific case. Regions likely to produce similar discoveries could almost be pointed out on the map; they are the rather flat, sedimentary zones situated at the foot of the tertiary chains; and while the petroleum fields of the United States, Canada and the Middle East answering this definition have already been detected, there are many other similar regions of the world which have not yet been adequately explored by modern methods. I am convinced that under the pressure of necessity and the stimulus of the successful results obtained elsewhere, such exploration will shortly be undertaken—say in the coming ten or fifteen years—and that it will radically transform the world supply of petroleum.

It may be asked why petroleum is an exception to the general rule. The reason, essentially, is its liquid or semi-liquid state which is the cause why petroleum is found concentrated under conditions very different from those of other minerals and in particular is the cause why the large deposits of petroleum do not touch the earth's surface—but for which fact they would by now, in the course of geological time, have either exhausted themselves or become oxidized as bitumen. (I must add at once that there are a few apparent exceptions to this rule, but I am unable to dwell on them here.) Consequently, the reasons for which the large deposits of minerals have generally already been discovered do not apply to petroleum, and in addition, the potential reserves, which are invisible from the surface, have only been detected recently thanks to the perfecting of sensitive methods of geophysical exploration.

It may be possible that certain substances or types of deposits are subject to conditions rather similar to those applying to petroleum. This may, for example, apply to copper, the outcrops of which are not usually very apparent, owing to the fact that the salts of copper are readily soluble and rapidly disappear on the surface of the soil. Thus, perhaps, though it is relatively unlikely, some very large deposits of copper may not yet have been detected.

Similarly, but for different reasons, it may be that certain large mineral deposits of various kinds are not visible on the surface of the soil, particularly in regions such as Canada, where the rocks are covered by a glacial layer concealing the subsoil. This, however, does not leave us entirely at a loss, and the study of glacial alluvia often leads to interesting results, as is the case in the tropical regions, where the layer of laterite plays an analogous, though essentially different, role to that of the northern glacial layer. Moreover it is not out of the question to anticipate that the perfecting of geophysical methods will enable us to overcome this obstacle and to "see" below this superficial layer. The research at present being carried out in this field entitles us to entertain serious hopes.

I repeat, however, that apart from petroleum there is no great likelihood of any deposits so large as to alter world production being discovered in the near future. Further discoveries, whether of new deposits or of extensions of old deposits, will simply have the effect of enabling us to maintain approximately the present state of affairs.

LONG-TERM PROSPECTS

Is our mineral world, then, a restricted world, frozen, as it were, at its present state of development? Is the extraordinary rise in mining production during the last fifty years about to slow down gradually and stop at about its present level? This question is bound to cause great anxiety, since if this is so, all hope of raising the standards of living of the under-developed nations must be regarded as illusory.

I should prefer not to end on so pessimistic a note, but it must be confessed that to go beyond this point I shall have to launch into speculation more in keeping with romance than with science.

Nevertheless, it seems to be certain that the present situation is an unstable one. Not only for more lofty altruistic reasons, but in their own interests pure and simple, the nations possessing a high standard of life cannot possibly lock themselves up in their ivory tower and close their eyes to the poverty of three-quarters of humanity, whatever its cause. From the standpoint of the consumption of minerals, we are faced, if we wish to improve this situation, with the following dilemma:

(*a*) Either total production will remain at approximately its present level, and the richer countries will be obliged to agree to a deterioration of their own standards of life in order to improve those of the poorer peoples; or

(*b*) Total production will be very considerably increased. It is self-evident that the rich nations will do everything in their power to evade the first term of the dilemma, and consequently large new deposits will have to be detected by exploration. But, as I have just been repeating, perhaps with excessive insistence, such discoveries will not be possible unless the economic conditions of mine working change, either through a rise in the relative price of mineral products, or through a reduction of extraction costs.

It is very unlikely that the first solution, that of a relative increase in the price of mineral products, will be acceptable. In his communication which received such great attention Dr. Clark on the contrary insisted on the necessity of a relative rise in food prices if agricultural production is to be brought up to the level of human needs. These two standpoints are diametrically opposed.

The only possible solution, therefore, is a reduction in the cost of extraction and processing which would make it possible to utilize deposits much poorer than those at present being operated. Thus the problem is referred back by the prospector to the mining operator.

No doubt the mining operator will continue, as in the last thirty years, to make appreciable progress by means of improved technique and more intensive and economic processes, such as flotation. I do not believe, however, that such progress will to any great extent change the basic facts of the problem.

I think it more probable, as I stated above, that the most likely prospect is an enormous increase in the supply of cheap energy, replacing labour, the cost of which is inevitably a constant factor in this problem.

Thus we can, if we care to indulge in dreams, allow ourselves to be carried away by the prospect of very cheap sources of energy of solar, atomic or as yet unknown origin. It must be said that at the moment all this is still very vague. But when all doors are closed save one, and the key of that door, though we do not yet possess it, may, we are justified in hoping, be discovered in the future, it would be unreasonable not to say that this may perhaps provide an escape from the difficulties in which we find ourselves imprisoned at present.

Must we then allow ourselves to be carried away by enthusiasm, and describe the vision, once this door is opened, of a new, sunny world where material life will be happier and more joyful for the peoples now disinherited? Is this a utopia, or merely a healthy stimulus?

I leave it to others to decide. As for mining exploration, that is merely the servant of the mining industry. In the words of the popular old French proverb, "The prettiest girl in the world can only give what she's got". Exploration can offer mining only the deposits which mining is prepared to accept. If the mining industry is too hard to please, the gifts offered by exploration will be limited; if, at some time in the future, the mining industry is prepared to accept humbler and less lavish gifts, exploration will be able to find them, and find them in abundance.

Let us develop mining exploration by providing it with the necessary funds, but let us not expect miracles; the miracle, if miracle there must be, is to be sought in the direction of mining technique and energy production.

The CHAIRMAN: Gentlemen, you have just heard a discourse which can only be described as masterly. It gives a picture, painted by the most expert of hands, of the situation in regard to the mining research essential to raising the standard of living of the peoples generally referred to as "under-developed"; peoples whose present state, if prolonged in a descending curve might bring about a tragic situation in the most civilized of countries.

We are going to have an opportunity of hearing another very interesting contribution to the problem just discussed. That opportunity we shall owe to Mr. Randall, whose work lays particular emphasis on the cartographical and geographical aspects of a survey which, among others, involves mineralogical research.

For some years past, Mr. Randall has gained wide experience in the United Nations Committee of Experts on Cartography, of which he acted as Chairman. He is also an indispensable staff member of the United States Bureau of the Budget. Thus he is possessed of very considerable information, some idea of which we may gain from the paper which he has been kind enough to write for us. Unfortunately, Mr. Randall has been unable to come in person, but he worked in close co-operation with Mr. Simonpietri, who has been good enough to take his place and will put forward facts and aspects of the problem which Mr. Randall would have given us if he had been able to come.

Mr. SIMONPIETRI *delivered the following paper:*

Resource Surveys

ROBERT H. RANDALL

ABSTRACT

The paper begins by pointing out that resource surveys must precede resource appraisal. The paper discusses (1) definition, (2) methods of finance, (3) technical methods. It defines resource surveys as those which give facts on (1) topography, (2) geology, (3) soils, (4) hydrology, (5) vegetation, (6) animal life. It refers to the United Nations document, "Coordination of Cartographic Services of Specialized Agencies and International Organizations" (E/1322, 18 May 1949), for defintion of cartography which includes resource surveys. It emphasizes need of collaborating between scientists who make resource surveys and officials of agencies responsible for carrying out large developmental and improvement projects. It recommends that scientists think in terms of the contribution their resource surveys can make to such projects. It gives examples of how, and how not, to present argument. It stresses the great need of resource surveys, referring to the world situation and one area in the Unites States. It gives the order of procedure as (1) resource surveys, (2) resource appraisal, (3) planning of improvement projects based upon appraisal, (4) building or otherwise affectuating projects planned. It warns that there are no miraculous shortcuts in making resource surveys for appraisal. It insists that resource appraisal cannot be done by "treasure hunting," but requires systematic inventory procedure. The paper closes with a quotation from the United Nations document cited, which calls for extension of the maxim, "know thyself," from man to his planet.

Although the title to be inferred from the program indicates that I should discuss "Methods of Resource Appraisal—Resource Surveys," I have taken the liberty of titling these remarks "Resource Surveys." I do this because I should like to begin by stressing the fact that *the surveys come first,* logically and chronologically. You have to know what resources you have, before you can evaluate and appraise them. Appraisal is, of course, a necessary part of the process of conservation and utilization of resources, which is the general subject of this Conference. But before there can be an appraisal there must be a fact-finding stage. The surveys for producing the required facts are properly termed "resource surveys."

The program title also seems to me to suggest that some emphasis be placed upon the techniques of resource surveys. Important as these are, the first consideration in any program for conservation, utilization and development of resources is that adequate information concerning them be made available, by whatever scientific method. This, in turn, raises the question of how such surveys may be provided. And, of course, the root of this is, how are they to be financed? How do public officials, at all levels of government, persuade disbursing authorities to appropriate the money necessary?

A logical order for my remarks then would seem to be (1) to define what is meant by resource surveys, (2) discuss practical means for their financing, and (3) describe the scientific techniques by which they may be carried out. For reasons which I shall present later, I shall not deal with the third point in detail, rather placing chief emphasis on the second.

Taking up the first point, what is meant by resource surveys, I should like to say that, although all of us realize that man himself is certainly not the least of our planet's resources, and that the purpose of all of our efforts toward proper conservation and use of resources is that they may be turned to maximum human benefit, I consider it convenient for our discussion here to limit ourselves to consideration of resource surveys of non-human, or what might be called "objective" resources. These surveys may be defined as being those investigations which are necessary to identify, locate, and record the existence, character, and extent or quantity of such resources. In general terms, these investigations may be classified as surveys concerned with (1) topography, which provides a knowledge of the earth's surface, and is the basis upon which all other resource surveys are made; (2) geology; (3) soils; (4) hydrology; (5) vegetation; (6) animal life, including insects, fishes, etc.

The foregoing resource surveys are inventories. As such the facts that they present may be expressed in various ways—by language, by numbers, and by maps. Since it is important not only to record the existence, character, and extent of these necessary resource facts, but also their location, considered both in terms of absolute position and in relationships to other factors of geographic interest, maps afford the best means. Increased appreciation of maps as a medium for these purposes has led to the use of the general term "cartography" to cover resource surveys.

It is of interest in this connection to note that the Secretary-General of the United Nations has recently prepared a report on "Coordination of Cartographic Services of Specialized Agencies and International Organizations" (E/1322, 18 May 1949). This report was made in response to a resolution introduced by the Delegation of Brazil at a meeting of the Economic and Social Council, February 19, 1948, and is being presented to the Council at its meetings in Geneva, July-August of this year. The Committee of Experts called in by the Secretary-General to assist in the report's preparation begins its statement by saying, "Cartography is considered as the science of preparing all types of maps and charts, and includes every operation from original surveys to final printing of copies. The types of maps and charts included are: (1) topographic maps;[1] (2) geologic maps, soil maps, vegetation maps, cadastral maps, hydrologic maps, hydrographic charts, and aeronautical charts; all of which are prepared upon a topographic map base; and (3) office-compiled maps showing the location, extent, and character of physical, economic and social phenomena."

From the above quotation it may be seen that a principal purpose of this report was to deal with resource

[1] Geodetic surveys are the first step in topographic mapping. See supplement, "Schedule of Resource Surveys."

surveys. For this reason, the comments and conclusions of the experts who prepared it are of further interest in our discussion here. Two of the principal points which we deal with—the definition of what is meant by resource surveys, and the discussion of practical means for their financing—are treated in full by the experts. Our third point, scientific techniques, is not dealt with in detail, attention rather being directed toward the organization by which the United Nations and the Member Governments could be effective in expediting cartographic progress.

Accepting the definitions of resource surveys as being substantially what I have given here, and as constituting a large and important part of what the report quoted considers to be included in the field of cartography, it is in order to turn our attention to the means by which resource surveys can be provided. This, as I have indicated, amounts to a discussion of practical means for their financing. In turn, this requires us to consider what arguments may be expected to carry weight with disbursing authorities.

To focus attention on the arguments which will appear valid to disbursing authorities seems to me to be entirely realistic. Technical and scientific groups do well to direct their attention to scientific methods, and to the scientific management of their own researches and investigations. All this is important to progress. It is, however, a mistake to attempt to justify scientific programs, such as resource surveys, solely on the basis of their value as seen by those who make them. To illustrate what I mean, I should like to give two hypothetical examples, one indicative of how *not* to go about raising money for technical surveys, and the other giving a clue as to a more promising approach.

Let us suppose that the aerial photographers in any nation, for example the United States, meeting together in their scientific and technical meetings have become concerned over the national lack of progress in their field. They are aware that (1) the United States is not completely covered by aerial photographs; (2) at the present rate of progress it will take a hundred years to finish the job; (3) for both general and specific reasons, it ought to be finished in five years. This being the situation, they conceive it to be their duty to do something about it. Therefore, after due deliberation, they produce a report saying that it is important to complete aerial photography of the Nation within five years, for the following reasons: (*a*) Completing the aerial photography of the United States will be a wonderful thing because it will advance the science of aerial photography; (*b*) such a program will provide aerial photographers with a very necessary tool, so that they will be able to render better service in the future; (*c*) the photographs will provide cultural values; (*d*) the photographs will serve some military purposes.

At this point it will, of course, occur to us that arguments such as the foregoing ought to be considered in the light of the audience to which they are to be addressed. Who constitutes this audience? The Congress of the United States. So let us analyze what this hypothetical report means to Members of the Congress. This, in turn, requires us to consider the position of these gentlemen in the matter.

Members of the Congress are interested in the welfare of the specific areas they represent, and of the total national territory. They are approached upon all conceivable kinds of problems, by their constituents, by representatives of the Executive Branch of the Government, by officials of State and local governments in their areas, and by persons and pressure groups from outside of their areas. By and large, most Members would like to be reelected. And they know, on the most elementary kind of common-sense logic, that they will be returned to office by doing those things which their constituents understand and which they believe will result in something of value to them. So the arguments put forward by the scientific group, in this case the aerial photographic experts, have to be examined with these facts in mind. These questions arise: How many of the constituents of the typical Member of Congress are going to understand and appreciate the necessity of their representative voting for funds to advance the science of aerial photography? What percentage of his constituents do the aerial photographers constitute? Do the cultural values to be derived from aerial photography provide a sufficient appeal to induce large numbers of the electorate to vote for his re-election?

This leaves just about one of the four arguments advanced by the photographers which can be understood by the Member's constituents. That is, of course, the military value. And here we have argument which, while it perhaps makes sense to the voter, may even arouse his antagonism. Maybe most of the voters are thinking that at the time this matter is proposed the Nation should not spend so much on military matters!

So the whole project falls through. The amount of money might be, let us say, 5 million dollars, and therefore perhaps not a great item in the national budget, when extended over the period proposed. But funds for the million dollars for the first year are never appropriated. Not that Members of Congress are against it—perhaps they will even appropriate five or ten thousand dollars for it, if sufficinetly importuned, but by those in the Executive Branch of the Government who they know are earnestly and honestly concerned in starting the job. But, in general terms, the cause is lost. Arguing for aerial photographs *on the basis of their need as aerial photographs* has simply been futile.

Now let us take this same situation and present it with a different emphasis. It happens that one of the important projects for national improvement being considered at the time the photographers are preparing their report is an agricultural improvement program. The photographers know about this program. Of course they also know that aerial photography will be needed for it, and is indeed absolutely essential to its success. Recognizing this, surely they will see the opportunity for supplying the technical services they can render. How should they proceed?

They should begin, not by talking to each other and persuading their colleagues in the profession who need no persuasion, but by talking to those responsible for the agricultural program, who really need the service that they can render for the specific program in mind. And, of course, it will not be important to present to these officials the arguments of (*a*) the advantages to the science of aerial photography, (*b*) the advantages of providing a tool to aerial photographers, (*c*) cultural benefits, and (*d*) military values. All they want to know is, *just how will photography help in the agricultural program?*

It is not too much to suppose that the officials of the Department of Agriculture of the United States Goverment, charged with the carrying out of the proposed program of agricultural improvement, will understand the advantages of aerial photography in that connection. The five million dollar estimate for photography is a minor cost in a program that will directly concern the national welfare and will run into millions, and perhaps eventually billions, of dollars. So department officials include the cost of aerial photography *as a part of the total cost of the agricultural program.* They go before the Congress and explain to the Members just what they propose—the measures to be undertaken for soil conservation, the procedures they want to put into effect for better agricultural practices and for better farm income. At no time do they stress the need of aerial photography in itself. Their position is that, of course the photography is necessary. It is incidental to the whole project. Nobody hides the fact that five million dollars for aerial photography is in the total estimated cost of the program, but nobody makes any particular point of it.

And so, in our hypothetical case, the photographic scientists get the money needed to complete the aerial photography of the Nation. The departmental officials feel very gratified about this. Members of Congress are, to the extent they have thought about it at all, entirely approving. And the four values which the photographers themselves originally saw in the job may now be realized!

The point that I wish to make is that logical presentation and argument *from the viewpoint of scientists and technicians* may be largely futile when addressed to the authorities that are expected to appropriate the funds necessary. Technical people should attempt to see their proposals in the light of the consumer's interest. In a practical sense the consumers in our second hypothetical case were first the officials of the Department of Agriculture, second Members of Congress, and third the voters.

In general terms it may be said that resource surveys will be provided, in the sense that the money for their accomplishment will be appropriated, for one or more of the following three reasons. One of these is reliance upon logic—logic, that is, as appreciated and presented by the scientific and professional persons and groups who are concerned in performing the service in question. Another is because there is an immediate and visible penalty attached for *not* having the information needed. A third is because the survey is a necessary step in a program which has popular or political appeal, although completely incidental to it.

In the foregoing two hypothetical cases we find illustrations of the technicians' appeal to logic, and of the inclusion of survey as an incidental part of an easily understood program which has political significance. The other case, that of an immediate and recognizable penalty for lack of information which resource surveys supply, perhaps deserves some attention.

When the Committee of Experts advising the Secretary-General of the United Nations in the preparation of the report already referred to, considered the broad question of cartography, they listed two kinds of maps or charts which, because of their well-recognized penalty aspect, ordinarily require no argument on the part of the technical personnel preparing them. The Committee pointed out that in respect to hydrographic charts, which are really topographic maps of the submerged land surface of coastal and oceanic areas, there is a direct connection between a proper supply of such charts and marine insurance rates. If information of this sort is not available in proper quality and quantity, as an aid to navigation and as a part of proper provision for safety at sea, marine insurance rates go up. Therefore the commercial interests involved may be expected to support this sort of cartographic activity, and will argue in Congress for the necessary appropriations. A similiar condition prevails in the case of aeronautical charts. A proper supply of these is necessary for passenger safety. Passenger safety is reflected in patronage. The aviation industry therefore may be counted upon to support appropriations for the charts necessary for civil aviation.

Only one of these, the nautical charts, comes within a strict definition of resource surveys. I mention both of them here, however, to bring out what I have called the "penalty" argument. In respect to both of these kinds of surveys, the penalty for not having the information is soon felt and entirely appreciated. When the commercial interests concerned are properly served by an adequate supply of such information, profits go up. But in respect to topographic maps, and geological investigations, and hydrologic and other resource surveys, the penalty, though real, is not so easily seen and understood. I should like to expand on this situation just a bit.

In a certain locality—and this is *not* a hypothetical case—there stands a concrete dam. It was designed and constructed to store water for irrigation and power development. It has never stored any significant amount of water, for the reason, that the water just doesn't get to the dam. It sinks into the ground, and comes out below the dam. What happened? Why did this project—and it is but one instance of a great many real but perhaps less conspicuous demonstrations of project failure—ever turn out this way? The answer is that the authorities in charge did not insist upon a thorough geological investigation of the reservoir site. The dam took some little time, probably several years, to construct. By the time that its failure was demonstrated, it is quite possible that some of the officials originally responsible—perhaps all—were out of office. In the case of the commercial operators' interest in nautical charts and in aeronautical charts, not only are the economic penalties caused by the lack of these quick in becoming visible, but usually the persons responsible are still in a position to get the blame. This points to a recommendation which I should like to make in respect to this whole question of resource surveys.

Let me precede this recommendation by a little further discussion. First I should like to make the flat statement that the principal blame for the present lack of the basic information which is obtained by resource surveys is not to be charged to public administrative officials, including disbursing authorities, or to the voting public. Most of it lies clearly with the professional and scientific contingent which makes the surveys. In a situation where the penalties for their lack do not immediately appear, those responsible for the making of such surveys in all our governments and in all scientific associations are really to blame. They should protect public officials against the very real and inevitable penalties resulting from inadequate or too tardy information upon our resources.

My recommendation is, therefore, that those of us who as scientists and technicians carry out resource surveys should (1) realize our responsibility, to the end that we may both be effective in providing them and in protecting the public and Government officials from the losses incurred by their lack; and (2) that we should studiously cultivate the practice of thinking in terms, not of our own professional ideas and problems, but *of the uses to which our surveys are to be put.* What I am trying to say is that we must school ourselves to think in terms of the consumer's interest, and not merely in terms of our own ideas and inclinations as producers of the needed services.

Thus far in this consideration of ways and means to finance resource surveys I have offered two examples, indicative, I think, of the need for the scientists who produce resource surveys to make their argument for the need of their services *in terms which the users can understand and value.* I have also called attention to the fact, as I see it, that the scientists in this field have a principal duty to protect the public and public officials from the results of going ahead with large projects involving resource use without the necessary fact basis. Let me now draw further attention to the necessity of this protection by giving some figures as to the lack of resource information with which we are now everywhere confronted.

In the report on cartography mentioned, the experts point out that, in respect to topographic mapping, less than 2 per cent of the land areas of the world are mapped on scales of 1:25,000 or larger, essential as such maps are in themselves for planning, development, and administration, and as the basis for all other resource surveys. It is further stated that only about 25 per cent of the world's land area is now covered by even the reconnaissance type of map, on such scales as 1:250,000.

Lest the foregoing figures be interpreted to mean that, while the deserts and other less habitable regions of the world are unmapped, adequate maps do exist in the more favorable, better developed portions, I should like to refer to one of the great river basins of the United States.

In this area, comprising about one-half million square miles, there are at present plans for construction amounting to more than five billion dollars in projects for reclamation, river improvement and flood control, soil conservation, etc. Yet if we consider only four elements of what we might agree is a proper schedule of resource surveys, namely topographic mapping, geological surveys, soil surveys, and hydrologic surveys, it is a fact that only about 10 per cent of the required information in these categories now exists in this area. Startling as this statement is, there is no question as to its accuracy. The status of topographic mapping, geological mapping, and soil mapping can be measured in each case, and it is perfectly easy to determine just what is available. The situation in respect to hydrologic data, on surface water and on ground water, can be determined within realistic limits in terms of percentage of adequacy. In these four categories of fundamentally needed basic data not more than 10 per cent exists in the aggregate; and, as a matter of fact, the present coverage or adequacy in each category is very close to that figure.

That this is a monstrously wrong situation hardly needs to be said. What we are concerned with here is, how may it be remedied? Again, I should like to say that I think the way to improvement is through the surveyors—topographic, geologic, soil, hydrologic. They should do some realistic thinking, accept their share of the blame for conditions that now exist, and work with the construction engineers and the agriculturalists and others who are in charge of improvement programs for which their survey services need to be performed.

How is this to be done? As for this I can, of course, offer only general comment. No pattern would be universally applicable, in all places, times, and conditions. Perhaps, however, it may be helpful to refer briefly to United States practice in these matters. Obviously, as can be inferred from the foregoing reference to a particular United States area and from the further observation that only about 25 per cent of the territory of the United States is now covered by modern topographic maps, no one can accuse the United States of boasting about progress.

It is, however, fair to say that, in the operations of the United States Government, there is growing up an increasing understanding as to the necessity of obtaining resource surveys before resources may be appraised and projects designed and constructed for their conservation and best use. It may also be said that those agencies in the Government whose business it is to make the different surveys in the resource schedule are progressively more successful in thinking in terms of their services *as a part of the process of improvement,* and not simply as matters of scientific and professional interest to themselves. The resultant effect of these two factors is being felt in Congressional appropriation practices.

To illustrate this, let us consider topographic mapping, and, more specifically, such mapping in the particular area of United States territory above referred to. The agency of the United States Government which is principally responsible for this sort of mapping receives Federal funds in this and other areas from two main sources. The first of these is from appropriations made by the Congress directly to it, for the specific purpose of topographic mapping, on the recognized principle that for the general welfare and improvement of any area, such maps are essential. The second source is money appropriated by the Congress *to the agencies having large improvement programs in the area in question.* Funds of this latter category are procured by the agencies concerned, as a part of the cost of planning and constructing the improvements with which they are charged. They are then immediately transferred to the topographic mapping agency. A quite similar situation prevails in respect to the other three principal resource surveys—geology, soils, and hydrology. Not only in this area but throughout the United States, the practice of financing resource surveys as a part of the total cost of large developments and improvements is increasing. This requires real understanding and close collaboration as between the surveyors and those who direct the so-called "action agencies", who actually put improvement plans into operation.

Turning to the third point in this discussion, techniques of resource surveys, it will not be appropriate, of course, to present these in much detail. Many volumes have been written on this subject, and the literature is constantly increasing. In the recent United Nations report on cartography, the experts included a "Study on Modern Cartographic Methods," prepared by the Pan American Institute of Geography and History. This gave a general account of the current methods employed in each type of resource survey, and mentioned recent scientific developments that seemed worthy of note. It also included a bibliography of the principal publications now available. Perhaps it will be sufficient here for me to refer to this study and to this bibliography, and to the material given in the "Schedule of Resource Surveys," which I have prepared as a supplement to these remarks, and which may be available in published form.

One thing does, however, need to be said here, in respect to technical methods. That is that, despite the advances in such things as aerial photography, electronic aids for measurement of distances, recently developed methods for making observations from the air on such matters as gravity, magnetism, and the like, there is no magic way to make the careful inventories of the kind which are already standard practice in each of the categories of resource surveys. Complete resource surveys of the total area concerned are always requisite. These start with topographic maps, and upon this basis are produced the geologic investigations, the soil surveys, and the hydrologic and other surveys necessary. The topographic maps are made largely from aerial photographs, but they are still based upon measurements made on the ground, and still require labor and time. The methods of aerial photography, and of geophysical "prospecting" from the air, also have large application to geological surveying. But again careful work upon the ground is essential. The same is true for the other categories.

It should also be emphasized that the method of surveying for the appraisal of resources is that of inventory, and not "treasure hunting". Whether the purpose of the survey is to discover and to study lands appropriate for agricultural development, or to determine the existence and extent of mineral deposits, or whatever purpose, the economical as well as the scientific method is to proceed by making first *a systematic general coverage of the total area under consideration,* making the general surveys, of course, only to specifications of such detail and accuracy as are necesary for inventory purposes. The next step is that of more intensive surveys and investigations of the smaller areas in which resources of whatever category have been located in the inventory process. In such of these areas as appear to be potentially profitable, an exhaustive study and appraisal should then be made. This is the pattern of proper resource surveying. The "treasure hunt" method, whether looking for new areas for settlement or for deposits of precious metals, is, because of its accidental character, always less desirable than systematic inventory procedure.

At the beginning of this discussion I made the obvious statement that appraisal of resources can only be undertaken after resource surveys had been made available, this on the self-evident premise that you have to know the existence, and something about the character and extent, of resources before you can appraise them. Following this I have invited your attention to practical ways and means by which the necessary public money for resource surveys can be forthcoming. This was followed by some illustration of the desperate need for resource surveys throughout the world, and a plea that those who make such surveys orient their thinking in such a way as to collaborate effectively with the public officials who are responsible for the developmental and improvement programs which should result from the sort of appraisal of resources which the surveys make possible. My last point has been that resource surveying should be accomplished by the inventory process, and not by "treasure hunting" procedure. All that I have said may perhaps be summed up in the following terms: For the scientific conservation, utilization and development of resources, the order of procedure is (1) resource surveys, (2) resource appraisal, (3) planning for the improvements that can be and should be made upon the basis of the appraisal, (4) constructing or otherwise bringing into completion the improvements indicated.

I should like now to close these remarks by urging that all of us, citizens of member nations of United Nations and of the world, bend our efforts toward following out the procedure which is recommended herein. At every opportunity we should caution public officials, in national governments or in the operations of United Nations and its Specialized Agencies, against slighting or even ignoring the absolute necessity of resource surveys before proceeding with plans for proposed improvement. It is not scientific and it is not feasible from any standpoint to inaugurate plans and to build the structures and to make the installations called for in proposed improvement projects, just by sending in so-called "experts" to walk around over the ground, or to have them base their recommendations upon the casual information which is all that aerial photography will now yield. It is a completely unjustifiable gamble with the lives and the welfare of the people now living in, or proposed to be brought into, any area to proceed toward proposed improvement without an adequate knowledge of resource facts and the true possibilities for human betterment that can result from their proper consideration. There is no such thing as an "expert" in resource appraisal, in any field of resource development, being able to find the facts and make the judgments that are required of him, just by traveling over or through an area. He must have the facts which only the maps conveying the results of resource surveys can give.

In the *United Nations Bulletin,* of July 1, 1949, appears a quotation from the report of the cartographic experts to which I have already referred several times. Since it expresses the philosophy which is basic in all that I have said in this discussion. I should like to repeat it here.

"'Know thyself' is recognized as the basic precept for individual understanding and consequent improvement. In quite similar fashion, basic and ever-available knowledge of the physical facts of man's planet are equally necessary. 'Things' have value only in the context of their possibilities for human use and enjoyment. In the conduct of the United Nations as a world organization, we feel it to be the duty of those who are concerned with social matters to see to it that the promotion and the building and bringing into existence of material things and arrangements of things is based upon the knowledge of man's environment that is essential to success."

APPENDIX

SCHEDULE OF RESOURCE SURVEYS

As has been stated in the foregoing paper, the proper procedure for the scientific conservation, utilization and development of resources is, first, to make an inventory of the physical facts concerning resources; next, to evaluate and appraise these facts in order to determine the feasibility of future development; then, to plan the improvements that can be and should be made upon the basis of this appraisal; and, finally, to proceed to construct or otherwise bring into being the improvements indicated. Emphasis has been placed, and rightly, upon the importance of getting the facts first, as to what resources are available, before attempting to appraise such resources or proceeding with plans for their development.

The schedule of surveys necessary for the appraisal and development of resources includes surveys and maps in the following categories:

Topography, Geology, Soils, Hydrology, Vegetation, and Animal Life.

The foregoing may be said to include the principal categories of information essential to resource development. Under topography, of course, there should be included geodesy. For while godetic surveys are not in a true sense resource surveys, they do constitute a necessary and very important step in the making of topographic maps, and provide valuable basic control for much of the engineering work that will be necessary in the later phases of resource development, such as the surveys required for construction operations, for acquisition of land, and for highway locations. Another class of survey information should be listed as supplementing the schedule, namely cadastral maps. These show the occupation of the earth's surface in public and in private property holdings. While they cannot always be said to be an absolute necessity for resource appraisal, they are uniformly required for the subsequent operations of resource conservation and utilization.

The sequence in which the different surveys should be undertaken deserves consideration. It is obvious that topographic maps come first, since these are the basis upon which most of the other information sought is to be collected and presented. Even before the actual work of compiling the topographic map, but classified here as a part of its construction, comes the geodetic survey, which provides a frame-work of points whose longitude and latitude and elevation above sea level are accurately determined.

In general, geologic surveys will follow the topographic mapping. An adequate knowledge of geology, for example, is of great advantage in making soil surveys. It is also essential in hydrologic surveys and studies, especially those involving underground water resources. Geologic maps, therefore, should ideally be available before surveys of soils and of water resources are undertaken. Similarly, while it cannot be said that soil maps and hydrologic maps must necessarily be constructed before surveys of vegetation and animal life may be made, the advantages of having them on and as an aid to assembling the information needed in these categories is apparent.

Normally the surveys listed in the schedule are made in several stages. The first of these is a systematic *general coverage* of the total area under consideration. For this the specification as to amount of detail to be shown and the requisite accuracy should only be such as will provide information which will disclose the existence, location, and character of resources in particular areas within the total. The general coverage stage is then followed by a more *specific* fact-gathering in the areas discovered in the general coverage. Frequently, this stage is followed by an *intensive* survey, involving more detailed information, occasioned by the need of additional data for intensive appraisal and study.

The foregoing procedures, in regard to the desirable sequence of resource surveys and the logical stages in which each should be carried out, are to be considered as general statements. They are usually applicable for surveys of virgin areas, where, to all intents and purposes, nothing is known. They also apply as general recommendations for resource surveying in areas already occupied, and developed in some respects and to some degree. Even in these two cases—the substantially unknown and the partially developed areas—they must be presented with some explanation and even qualification.

Discussing the procedure to be followed in virgin territories, it should be said that before the first stage recommended here, that of general coverage, there will inevitably be required a preliminary examination. This is not so much a stage of surveying, in the sense used here, as it is of exploration, or even discovery. Certainly in the 75 per cent of the world's land area that is thus far without maps even upon such small scales as 1:250,000, a preliminary examination of the area under consideration will be necessary before the inventory stage can be begun.

Here we clearly meet the necessity of approaching the problem of resource conservation and utilization from the viewpoint of total and balanced consideration. If, for example, the preliminary step of examination of any area be approached entirely from the standpoint of the development of agricultural resources, it is obvious that those charged with making the examination would first discard mountainous, desert, and similar areas from their consideration. In so doing, of course, they would automatically rule out areas which would probably be the most potentially valuable from the standpoint of mineral and other resources. The examination of virgin or largely underdeveloped areas should, therefore, be undertaken only from the most comprehensive and balanced viewpoint. Emphasis and concentration on areas potentially profitable for the study of possibilities for the development of one category of resources will commonly operate to exclude consideration of other resource opportunities.

In the examination process, recourse will first be had to whatever map or aerial photographic information exists. Maps on the approximate scale of 1:250,000 will, of course, be valuable wherever they are available. Maps on the million scale, to the specifications of the International Millionth Map of the World, are to be found in some areas, notably in Central and South

America. All the land areas of the world are covered by the one-million scale aeronautical charts of the United States Air Force. These, being a relatively new series, vary in value, depending upon the amount of aerial photography or other reliable information existing in various parts of the world.

For resource surveys of partially developed areas, it is obvious that the recommendations given here as to sequence and stage can, and should, be applied as a general guide, but should in nowise operate to place undue restrictions upon the carrying out of such surveys under the varying conditions that will be met in widely differing situations.

In the specifications which follow it will be noted that most of the surveys follow a three-stage pattern. Usually these are generally analogous to the general coverage, specific, and intensive stages, as presented here. Where they are not, no attempt has, of course, been made to force the terminology normally used in each of the surveys into exact agreement with that used here in the effort to simplify the discussion of each and all of the surveys.

Two other matters perhaps need to be considered before proceeding to brief descriptions, or specifications, of the principal resource surveys. The first of these concerns terminology, especially the use of the term "reconnaissance." The second is related to the proper place of aerial photography.

In this connection, the term "reconnaissance" needs particular attention. This has been used to indicate anything from the most generalized and sketchy inspection to a process of systematic coverage which nearly approaches the general coverage stage described here. The dangers of too loose a use of this term are apparent, and for that reason use of the words "examination" and "general coverage" seems preferable for general discussion. As applied to a specific stage of a particular survey, however, the term "reconnaissance" may properly be used.

It should also be said that "preliminary examination" is intended to indicate the process of general investigation of an undeveloped area with a view to planning the first survey stage of general coverage (or, less preferably, "reconnaissance") of *all* potential resources, not just the search for one.

As mentioned earlier, in the main body of this discussion, while aerial photography is a tremendously valuable tool in the process of resource surveying, there is a danger that such photography may sometimes be used in an attempt to have it replace some of the ground surveys and observations that are always necessary.

It may be said that there are three proper uses of aerial photography. First, it is a principal means of constructing topographic maps, on all scales, and these are the necessary precedent to and the backbone of all other resource surveys. Second, in areas where photography is already available but topographic maps have not yet been made, the photographs will naturally be used until more adequate information is obtained. This applies especially, perhaps, to the examination process, where such a situation is quite usual. Third, aerial photographs are always valuable tools to complement and supplement the use of topographic maps. Sometimes they are employed in this manner to enable geologists, soil scientists and others to improve and to speed up their field work. They are also valuable in some instances in the office work of compiling the maps which result from resource surveys. And, of course, photography has large utility in the process of resource appraisal, after resource surveys are completed.

The following brief specifications, descriptive of the various resource surveys, are based principally upon current practices in the United States. They have been prepared in collaboration with the following Federal officials: Dr. Carleton P. Barnes, Chief Analyst, Division of Soil Survey, and Mr. R. D. Garver, Director, Forest Survey, Forest Service, of the Department of Agriculture; Mr. H. M. Bannerman, Assistant Chief Geologist, Geological Survey, Mr. Gerald FitzGerald, Chief Topographic Engineer, Geological Survey, and Mr. C. G. Paulsen, Chief Hydraulic Engineer, Geological Survey, of the Department of the Interior; and Mr. Earl G. Harrington, Chief, Division of Engineering, Bureau of Land Management, Department of the Interior.

TOPOGRAPHY

Topographic maps are so well known as to require no detailed description. Also they are universally recognized as being one of the first requirements for any extensive resource survey. In general, topographic maps portray (1) relief, the physical features of the earth's surface; (2) drainage, by which is meant streams, marshes, lakes, oceans, etc.; (3) culture, or man-made features such as roads, railroads, buildings, boundaries and other similar items. Topographic maps without contours, and which convey little or no information on relief, are often referred to as "planimetric" maps.

For the purpose of a comprehensive study of resources of large regions, map requirements may be considered under four phase groupings: preliminary examination, general coverage, specific coverage and intensive surveys. Characteristic differences of the maps for the various phases are principally those of the amount of detail shown rather than subject matter. Suggested groups, broadly specified, are as follows:

Preliminary Examination. For use in the preliminary examination of an area, topographic maps of any sort and on any scales are employed. Mention has already been made of the International Millionth Scale Map, and the United States aeronautical charts to the same scale. Maps on the approximate scale of 1:250,000 are of value in inspection, wherever they exist. Maps on about this scale, and sometimes on the scale of 1:125,000, are useful after the inspection process, as will be noted hereafter.

General Coverage. These maps should be general purpose maps, for systematic large-area coverage. The scale of such maps should be adequate to permit showing relevant details for a general inventory of the area. In the United States, publication scales are normally in one of two ranges: approximately 1 inch to 1 mile, and approximately 1 inch to one-half mile. Exact scales for the mile range may be 1:63,360, 62,500, or 50,000, the latter being for restricted military use. The sheets cover 15 minutes of latitude and longitude. The half-mile range scales may be 1:31,680, 24,000 or 20,000 and 25,000 for military editions, and each sheet covers 7½ minutes.

Specific Coverage. Maps of this group should also be of a general purpose type but at scales larger than Group 2. Scales should be adequate to show the details required for specific examination of potential resources revealed by the general coverage and also adequate for preliminary planning of construction projects. Maps in this group are usually on publication scales varying from 1:31,680 to 1:12,000.

Intensive Surveys. Maps in this group cover a broad field of requirements ranging from a detailed investigation of a limited area to large scale plans for a construction project. These are usually published on scales of 1:12,000 or larger.

In the United States maps of the last three groups are made in accordance with these standard accuracy specifications:

Horizontal accuracy shall be such that not more than 10 per cent of all points tested shall be in error by more than 1/50th inch on maps published at scales smaller than 1:20,000, or by more than 1/30th inch on maps published at scales 1:20,000 or larger.

Vertical accuracy requires that not more than 10 percent of the elevations tested shall be in error more than one-half of the contour interval.

Maps are tested for compliance with these specifications and those found to comply are so labelled.

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GEOLOGY

Geologic maps are designed to show the distribution, the boundaries and the character of the various kinds of rock (both surface and bedrock) and their structural relations to one another. From a practical standpoint they serve five major purposes.

1. They provide basic subsurface information needed for design and economical development of both public and private construction, particularly heavy construction such as waterworks, highways, and airports.

2. They are the only basic guides in the search for mineral and mineral fuel resources, and in the appraisal of their size, position in space, and mineralogical character.

3. They contribute fundamental data needed to implement the appraisal of water resources, both surface and underground.

4. They provide the basis for land classification.

5. They provide information on the kind and chemical composition of rock formations and lay the groundwork for facilitating the mapping of soils.

The *general coverage* stage, in terms of geologic mapping, requires adequate topographic maps as a base upon which to plot the geology, and aerial photography to serve as guide to the terrain and to provide certain kinds of supplementary information useful to the geologist. In addition, and most important, "on the ground" examinations must be made by widely experienced geologists. The scale of mapping that should be adopted in this stage depends on the nature of the terrain and the status of existing data. The operation should produce a map with adequate control and accuracy to provide:

1. Regional configuration of the land forms;

2. The gross patterns of the rocks involved, and the geologic framework;

3. An appraisal of what types of mineral resources are likely to be present, and a guide to the more critical areas, structurally and mineralogically;

4. Guides for establishment of stream gauging and hydrologic surveys;

5. Information useful in appraisal of the agricultural potentialities.

Specific coverage calls for geologic mapping of selected key areas; the scale of mapping depending upon the complexity of the rock structures and the nature of the resources sought, but the scale should not be less than 1:62,500. Here, too, adequate topographic maps and aerial photos are required as working tools. In this stage, rock outcrops must be mapped by "on the ground" examination, in sufficient detail to trace geologic formations, establish accurate geologic sections, and determine the subsurface structure with a reasonable degree of assurance. Operations of this order should produce:

1. An accurate geologic map, adequate to interpret the geologic history of the area;

2. The basic information required to forecast the probable potentials of the area from the standpoint of mineral resources, i.e., as to whether under existing economic and technologic conditions it warrants more detailed examination and exploration;

3. Adequate geologic data to permit a forecast of the engineering conditions likely to be encountered;

4. A guide to the critical areas, i.e., those likely to contain mineral or fuel resources, and those deserving of, or suitable for, water development;

5. A map showing nature of the soil materials in the engineering sense, and the effect on the ground water supply and hydrologic runoff;

6. A map showing sources of engineering and constructional materials available within the area examined;

7. Geologic information needed for soil science studies, and water development programs.

Intensive geologic surveys call for geologic mapping at scales varying according to the specific purpose, but generally from 1:1200 to 1:200 or greater. Such surveys are usually restricted to target areas such as those containing economic mineral deposits or construction sites. The work calls for a detailed topographic base, complete "on the ground" coverage of rock outcrops to determine the precise location of formation boundaries, and geophysical surveys to supplement the work of the geologist. The operation should provide:

1. A satisfactory base from which to plan exploratory engineering operations such as drilling and other subsurface operations;

2. An accurate picture of the rock structure so as to enable accurate forecast of subsurface conditions;

3. An adequate geologic map to serve as a base for soil science, construction engineering, or hydrological studies;

4. The details of the rock structure, and mineral variations needed to serve as guides to specific mineral deposits, and/or oil and gas traps;

5. An economic appraisal of the mineral resources potentialities in terms of amounts and approximate grades likely to be present.

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SOIL SURVEYS

Soil mapping and classification in the United States has been done at several different levels of generalization, depending on the character of area covered and its agricultural potentialities, and upon the need for general information on soil distribution in advance of detailed surveys. These levels may be roughly divided into three categories—reconnaissance, semi-detailed and detailed, which correspond approximately to the stages "systematic general coverage," "specific fact gathering," and "intensive surveys" referred to earlier in this paper.

In those portions of the United States that have been long known in general terms, and are for the most part already occupied in varying intensities, the order of soil surveys has been (1) reconnaissance surveys, (2) semi-detailed surveys, and (3) detailed surveys, but much of the country has not had and has not required surveys at all three of these levels of generalization.

RECONNAISSANCE (BROAD GENERAL COVERAGE) SURVEYS

The general distribution of soils in most of the agriculturally promising parts of the country has been disclosed by widespread coverage of detailed and semi-detailed surveys. Reconnaissance surveys are therefore now of utility primarily in areas of low agricultural potentialities, such as arid grazing areas, and steep, or mountainous areas. Generally speaking, they are made on topographic base maps at scales of 1:125,000 to 1:250,000. Publication is usually on the same scales.

Under present procedure, mapping categories consist of soil associations. These are geographical associations of soils occurring repeatedly in similar geographic patterns. It is obviously not possible to map individual kinds of soils at these scales. Areas of such soil associations are characterized in terms of the soil types making up the association. The component soils are described, and the approximate percentage of each in the association is estimated. This procedure provides information more accurate and less misleading than the eariler practice of characterizing the mapping units of reconnaissance surveys solely in terms of the predominant soil type or series. The composition of the areas is determined on the basis of detailed surveys of small sample areas within them. Association area potentialities are predicted from a study of the characteristics of the associated soils, as disclosed by the survey of sample areas, and by study of any data available on experience in using the soils.

SEMI-DETAILED SURVEYS (MORE SPECIFIC STAGE)

These are now made chiefly in semi-arid grazing areas and relatively low-producing dry farming areas. Vertical aerial photographs and topographic maps are used in the field placement of boundaries. Topographic maps are used in compiling base for publication, which is usually on a scale of 1:62,500.

Soil characteristics are examined and soils classified according to the procedures described hereafter for detailed surveys.

Distinctly different areas of mapping units, established at the start of the survey after inspection of the soils of the area, are mapped if they are larger than about 12 acres. The range of characteristics to be allowed in the categories used in mapping are determined in such a manner as to differentiate categories that are significant in their effect on the predominant kinds of land use. Since, in areas to be covered with semi-detailed surveys, extensive uses of land such as grazing will prevail, the range of characteristics permitted within a category will generally be broader than in detailed surveys. For example, a range of slope of from 3 to 15 per cent might be permitted within a category here, whereas in an area suitable for cultivation, narrower ranges of slopes would need to be recognized. Similarly, a category might have a range of soil texture that included both loams and silt loams, undifferentiated, whereas in detailed surveys these textures would be distinguished in the mapping categories. Areas in which the individual categories are not mappable, because the publication scale is too small to show individual bodies, will be mapped as complexes or associations of the individual categories.

Semi-detailed surveys are published in county units. Where the county contains important irrigated areas of intensive farming, these are covered by detailed surveys requiring separate larger scale publication as specified for detailed surveys. Irrigated areas of 5 square miles or less occurring within an area being covered by a semi-detailed survey, are generally surveyed in detail, but the soils are shown on the published maps subject to such consolidation or grouping of soil types as are imposed by the scale of the map. Steep mountainous areas, or other areas clearly unsuitable for crops or grazing, are generally covered in the manner described under reconnaissance surveys, and included on the same map as the areas covered by semi-detailed surveys.

DETAILED SURVEYS

These are required in humid farming and irrigated areas. Field mapping is done on vertical aerial photographs of scales varying from 1:20,000 to 1:7,920. Topographic maps are used in compiling base for publication on scales from 1:31,680 to 1:15,840.

Soils are generally examined to a depth of 5 feet,[2] and characteristics of the soil observed within this depth generally determine the classification unit into which specific soil areas are put.

Characteristics of each distinct layer or horizon in the soil are examined. The characteristics of the layers, including their color, texture, structure, consistency, thickness, reaction, stoniness and presence of injurious quantities of salts, along with surface slope, degree of erosion, incidence of high water table, and the parent material from which the soil developed, determine the category in which a soil is placed in mapping. Soils having approximately the same sequence of layers with similar characteristics, developed from similar parent material, are considered one type of soil.

A range of characteristics defines each soil type, and each area within which the soil characteristics fall within the limits of this range is shown on the map as belonging to a specific soil type. The soil types are named according to the nation-wide standard system of soil nomenclature used by the Soil Survey. In this the first word is a place name, e.g., "Ontario", selected to represent all of that group or series of soils that are nearly similar in the kind, thickness, and arrangement of layers in the soil section or profile. Subsequent words describe the textural class of the surface soil, e.g., "fine sandy loam". Thus, "Ontario fine sandy loam" constitutes the name of a soil type. Within each soil type, differences in surface slope or configuration, of significance to agriculture, are shown on the soil map as subdivisions of the type, called phases. For example, those areas of Ontario fine sandy loam having slopes ranging between 3 and 8 per cent are designated "undulating phase, 3-8 per cent slopes"; and those having slope from 8 to 15 per cent are designated "rolling phase, 8-15 per cent slopes". Soil types that have suffered truncation by erosion are mapped as eroded phase or severely eroded phase, according to the extent of truncation.

Samples of each of the layers of soil at particular points are collected and anlayzed to determine mechanical composition (percent of sand, silt and clay), content of particular plant nutrients, reaction, and content and kind of soluble salts (in areas where these are a problem). The results are correlated with characteristics observable in the field, to help achieve consistency in mapping, and to help characterize the kinds of soil as mapped. The samples are also compared with samples of previously mapped soils to help insure consistency in classification and nomenclature.

At this level of detail, all areas of distinctly different kinds of soil larger than about 3 acres[3] are shown on the map; except that in areas of steep, mountainous land, extremely stony or rocky land, tidal marsh, or other areas clearly having little or no agricultural potentiality, the geographic details of soil differences are not mapped out. Such areas are mapped in more general categories, such as steep, stony land, tidal marsh, etc. Rock outcrops, sink holes, short steep escarpments, deep gullies, wet spots and other features that are in striking contrast to the surrounding soils are shown by symbol when they occupy less than about 3 acres.

When the soils occur in an intimately associated pattern in which the individual bodies of the different kinds are usually less than 3 acres, and consequently are impossible to show individually on maps of these scales, soil complexes are mapped. For example, the term "Clairon silt loam-Webster silty clay loam" represents a complex of two soil types occurring in individual bodies too small to show on the map.

When the soils have been classified and mapped, a study is made of crop experience on the principal kinds, to ascertain production possibilities. Production experience from farms and experiment stations, both in the county surveyed and in other areas where they occur, are analyzed. Crop yields are studied in relation to rotations, fertilization and other management practices on each soil, and predictions are made of the expectable average yield over a period of years of each important crop on each soil under two or more systems of management, including (a) the management system most commonly followed and (b) on a system that appears to give generally the highest production consistent with soil maintenance. Ratings of the soils according to their general desirability for agriculture are developed, on the bases of the predicted yields of individual crops

[2] The feasibility of irrigation may be affected by layers at greater depth than five feet. Since the cost of making deep borings is so great, it is not practical to make them throughout the country generally. The more practical procedure is to supplement the usual basic soil survey with deep borings in areas for which the availability of an irrigation water supply has been determined, and then only in those parts of the areas where the soils—aside from the question of the effect of deep strata—are favorable for irrigation.

[3] This is a general figure. Smaller areas of soils very markedly in contrast to those surrounding them may be mapped out, whereas larger areas differing only slightly from those surrounding them may not.

and pasture. The text includes detailed descriptions of the soils, and recommendations for their use and management.

The maps and explanatory texts are usually published in units covering one county, except in parts of the West, where counties are large and have their arable land concentrated in particular areas. Here the units may cover special areas other than counties.

PROCEDURE IN UNDEVELOPED REGIONS

For virgin territory, such as large parts of Alaska or of the tropics, a procedure is needed that will rapidly delineate the broad areas of different character to permit eliminating those of very low potentialities from time-consuming study and, on the other hand, provide quickly some detailed information needed by agricultural planners and farm advisors without waiting for completion of the detailed survey. The order of procedure is somewhat different than has been the practice in the United States heretofore.

The first step in the procedure is to compile a first approximation of a soil association area map of the region from all existing data on soils, and on the principal soil-forming factors of the environment—climate, vegetation, relief, and geology, including notes of travelers. This might correspond roughly to the "preliminary examination" stage referred to earlier. Aerial photographs should be used, provided each kind of pattern shown on the picture is examined on the ground to avoid misinterpretation. This map would be made on scales of 1:125,000 on up to 1:500,000 and would not be published.

The second step is that of making detailed soil surveys of representative sample areas of from 500 to 5000 hectares within each soil association area, except those clearly unsuited to agriculture, such as rugged mountains, or tundra. Mapping in the sample areas should be in the full detail described for detailed surveys.

In making the classification maps for the sample areas, laboratory facilities should be available, and also facilities for field experiments. Each mapping unit is carefully defined, and the best possible predictions are made of its potentialities. These are made from evidence afforded by farm experience or field experiments on the soil itself. Lacking this, they are made from evidence afforded by experience on similar soils with similar climates in other parts of the world.

For each sample area a soil key is developed, showing how the local soil types—defined and named—may be recognized. Clearly, if this is not done, subsequent mapping will flounder for lack of an adequate classification.

The third step is to make a second approximation of the soil association map, using what has been learned in the sample areas to define and describe the different soil association areas in terms of the individual soils in them, and to make predictions of their potentialities. Also, the boundaries of the soil association areas can be revised at this stage, now that their soil patterns and characteristics have been defined from study of the representative samples. The revision of boundaries may be accomplished by systematic travel, somewhat in the fashion generally understood by the term "reconnaissance," and the revised map might be thought of as an equivalent in level of generalization to that referred to under "general coverage."

A fourth step, not strictly a part of survey procedure, but essential to the success of subsequent detailed or semi-detailed surveys, is that of holding field schools in each sample area to teach soil surveyors and agricultural advisors how to identify the soils in unsurveyed parts of the area.

The fifth step is to proceed with progressive soil surveys, detailed or semi-detailed, according to the nature and potentialities of the area, and timed according to agricultural programs of settlement and development.

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HYDROLOGY

Fresh water is distinct from other mineral resources in that it is a renewable resource. It is a product of the operation of the ever-changing hydrologic cycle, with vagaries of occurrence that are associated with those of other meteorologic and climatic phenomena. Therefore, the approach to surveys for the appraisal of the water resources of a basin or area is necessarily influenced by the constantly fluctuating characteristics of water and the fact that such characteristics often are adequately defined or revealed for development purposes only after observations and measurements extending over a period of years. It should be understood that operational requirements may necessitate a continuing accounting of the water supply and the associated factors of the hydrologic cycle.

An adequate evaluation of these resources for development purposes can be achieved through a schedule of investigations which has three major parts or phases: (1) general investigations, (2) observational network and (3) intensive investigations. The first and third phases are typically of the project type, with the rate of progress dependent upon the manpower and other facilities available. The second phase, the observational network, differs from the other two in that a certain length of time—frequently many years—is required to produce the required data. Because these data from phase two are a prerequisite for certain surveys under both phases one and three, it is fortunate that a skeleton observational network—though entirely inadequate to meet present needs—is already established throughout the United States.

1. *General investigations.* The general investigation is a particularly essential step in the planning stages of water development programs in any basin or area. Water data and other pertinent information already collected are brought together, reviewed, correlated and interpreted. Deficiencies in hydrologic records are determined, and steps taken to begin observations under phase two. Following is an outline indicating types of work in this phase:

1. Reconnaissance of regional surface and underground hydrology and geology.
2. Surveys to locate new, and to check locations of existing, observations and measurement stations on streams.
   (*a*) Miscellaneous measurements on ungauged streams to determine general character.
   (*b*) Information on past floods.
   (*c*) Miscellaneous chemical and sediment water samples and temperatures.
3. Reconnaissance of representative wells and springs in major aquifers.
4. Reservoir surveys.
   (*a*) Stage and volume records on existing reservoirs.
   (*b*) Reservoir and power site prospecting.
5. Approximate evaluation of major aquifers.
   (*a*) Test borings where necessary.
   (*b*) Pumping tests to determine hydraulic properties.
6. Reconnaissance of water-use data, pumpage and diversions.
7. Correlation of data to determine general characteristics of streams and ground-water aquifers.
8. Publication of data and findings.

2. *Observational Network.* This includes all base stations and locations at which measurements or observations are made on a continuing basis, by which the various characteristics of ground and surface water are identified and developed. The data from this network are used directly by many Federal, State and private agencies. Unlike the first and third categories, which are project activities, the network is accomplished by means of a continuing program; that is, regardless of the funds and manpower applied, the characteristics developed from the network stations require continuous observations over a period of years. Therefore, the station network must be anticipated years ahead of specific projects, in order that such projects may be assured of adequate preliminary data.

Continuous (daily) and periodic observations of the following data outline this phase.

1. Surface waters.
   (*a*) Water discharge.
   (*b*) Stage only.
   (*c*) Sediment discharge.
   (*d*) Chemical quality.
   (*e*) Temperature.
2. Ground waters.
   (*a*) Discharge.
   (*b*) Water levels.
   (*c*) Chemical quality.
   (*d*) Temperature.

3. *Intensive Investigations.* Comprehensive investigations may be divided into two categories: (1) comprehensive evaluations of the water resources of large areas or of drainage basins, and (2) intensive investigations of small or local areas in which specific developments are proposed. The comprehensive evaluations of the water resources of large areas are dependent upon the data and the analyses obtained in the reconnaissance and observational programs, and can be undertaken as soon as enough data are available from the observational programs to permit their execution. Such comprehensive evaluations are of much value to all action agencies concerned with development and control of water resources. Much of the work done in the comprehensive evaluation would constitute a re-analysis of data on a broad scale and covering broad areas, with special emphasis on the correlation of all the phases of the hydrologic cycle of those areas. The careful preparation of reports is an integral part of the work.

Intensive investigations are also most successfully accomplished in areas where the various basic characteristics are known from the reconnaissance and network programs. This is the type of investigation that usually can be accomplished fairly readily after a project is proposed in order to provide for detailed planning, design, and operation, *if the base network data have been previously fairly completely developed.* The following outline lists some of the typical types of work involved in such investigations:

1. Analyses of steam-flow data.
   (*a*) Short-term gauging stations at project sites.
   (*b*) Extension and completion of past records to cover critical periods.
   (*c*) Compilation of all available records.
   (*d*) Flood surveys, computations of flood discharge, unit hydrograph analyses, channel storage and related flood properties of drainage basin.
   (*e*) Drought surveys.
2. Detailed inventories of wells and springs.
   (*a*) Well logs.
   (*b*) Water-level observations.
   (*c*) Yields (past and present).
   (*d*) Temperature.
   (*e*) Types of well construction, explorations for leaks, hydraulic and mechanical efficiencies.
3. Reservoir surveys.
   (*a*) Collection and analyses of existing records of stage and volume.
   (*b*) Determination of rates of sedimentation.
   (*c*) Determinations of evaporation loss.
   (*d*) Collection and surveys of area-capacity data.
   (*e*) Studies of adequacy for water supply or water conservation.
4. Evaluation of aquifers.
   (*a*) Numerous and detailed pumping tests to determine hydraulic properties with test borings where necessary.
   (*b*) Laboratory analyses of water-bearing material.
   (*c*) Natural recharge and discharge.
   (*d*) Artificial recharge, methods of accomplishing.
   (*e*) Geophysical surveys.
5. Detailed studies of chemical and physical properties of water in relation to proposed uses.
   (*a*) Use of water in industry and agriculture.

(*b*) Pollution of streams and aquifers.
(*c*) Salt-water contamination.
(*d*) Water erosion and sedimentation.

6. Detailed and classified surveys of water uses.
   (*a*) Well pumpage, artesian flow, and diversions from surface streams.
   (*b*) Kinds of water use: irrigated acreage; domestic, per capita; industrial, per unit of product; hydroelectric power development.
   (*c*) Wastage of water.
   (*d*) Estimate of potential uses and development.
   (*e*) New undeveloped sources of supply.
7. Correlations of all data to form complete picture of water in local area-recharge, movement, discharge, chemical properties, floods, and the many associated factors.
8. Preparation and publication of reports.

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VEGETATION

Studies of vegetation in the United States are usually made in successive steps, each succeeding one becoming more intensive and usually supplementing previous work. As used here, vegetation means the natural plant growth that is found on all kinds of forest and range land.

1. *General coverage:* Preparatory to studies of wild land, such as parts of Alaska and possibly some sections of western United States, all available references are normally first reviewed followed by an extensive examination of the area by air and on the ground. This provides the beginning of a work program foundation consisting of basic generalized information on the topography of the area, forest and range types, accessibility, parts to be omitted such as barren mountain tops or other nonproductive tracts and possibly agricultural valleys. It is also essential background for developing procedures to inventory such areas.

Most of the United States, however, is sufficiently well known so that much of the above step can be omitted. Under such condition, surveys usually proceed as follows: 2. *specific coverage surveys,* and 3. *intensive* or *detailed surveys.* Step 2 generally covers large areas and is basic to the formulation of both public and private policies for effective and rational use and management of land suitable for forest and range purposes. The third step covers smaller areas down to 100 acres or less in extent and is used for detailed development and management plans.

For such surveys topographic maps are essential, and aerial photographs are very desirable. Topographic maps, however, need not show contours, although such information is generally useful. Resource surveys normally do not prepare such maps but rely on mapping agencies for them. In subsequent operations of resources, conservation and utilization, relief information usually is a requisite.

2. *Specific coverage surveys:* Such surveys commonly include all wild forest and range land. For forest land, the different tree associations, called forest types, and usually named after the major species in each, are delineated on planimetric maps either from aerial photographs or ground mapping. The total acreage of forest land is usually obtained either by determining the percent forested by dot counts on aerial photographs, then applying the factor to the total land area, or by planimetering the forested areas delineated on the maps. The kind, size, and volume of the timber is obtained by examination and measurements of the trees on a predetermined number of sample plots ¼ acre in size. These are randomly located on the land in accordance with the requirements of the stratified nature of the forest which is made up of saw timber, pole timber, seedlings, and saplings, and nonstocked areas. The total volume is obtained by blowing up these samples.

Aerial photographs on a scale of 1:15840 are preferred. Twenty-two generalized forest types are used for large areas and often are shown on maps with a scale of 1:2,500,000. The sampling error of accuracy for forest area is placed at 3 percent per million acres, and for timber volume at 3 to 10 percent varying by regions per one billion cubic feet.

The major factual items obtained by the Forest Survey consist of the extent, location, and condition of forest land, the species, quantity and quality of the timber on these lands, the current annual growth of the timber, and the amount that is cut and destroyed by insects, fire, and disease yearly. Periodic resurveys are required to keep the information up-to-date on account of the dynamic nature of forests.

The results of these forest surveys are compiled in statistical and analytical reports, including forest type maps for each state and groups of counties within the state having similar characteristics.

Range surveys determine for the forage resource what the forest survey does for timber and are carried out in much the same manner. Such surveys are systematic inventories of the amount and grazing value of grass, weeds, and browse occurring on range lands. They form the basis for planning the management and use of range lands.

The maps and aerial photographs used are on about the same scale as for forest surveys. Field mappers often use planimetric maps with corresponding aerial photographs to supplement them. Range forage types are identified, delineated on maps, and the grazing capacity for each estimated. A compilation of such information is an essential part of a grazing management plan.

3. *Intensive and detailed surveys:* Such surveys are required for small areas of wild land varying in size from possibly less than a section, up to several townships. Aerial photographs on scales no smaller than 1:15840 and planimetric maps from 1:31680 to 1:7920 are preferred. They are used to get the basic information needed in both forest and range management plans, in research and, if practicable, are superimposed over extensively surveyed areas, using the existing information to the fullest extent. Examples are: plans for logging and cutting cycles on timber sales; rotation grazing on controlled areas, recreational development and wildlife management. The results are also used in experimental designs for research in both forest and range projects.

A fourth type of vegetation mapping or survey is illustrated by the government publication, *The Natural Vegetation of the U. S., 1924,* by H. L. Shantz and Raphael Zon. This may be called an ecological study of the natural vegetation. The object of the investigation is covered by this sentence from the publication: "The natural vegetation is the expression of environment, it is the integration of all climatic and soil factors, past as well as present, and, therefore, if it can be distinctly and clearly indicated, provides often a better basis for classification of environments than any one factor or set of factors."

The report is replete with plant succession discussion, illustrated by a vegetation type map.

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ANIMAL LIFE

Surveys for resource of this category can hardly be dealt with in brief and summary form, as is possible with those previously described. This is true for two major reasons.

In the first place, the kinds of animal life that constitute valuable resources for human use are legion. Such resources include creatures living on land, in water, and in the air. Further, man's interest in animal life is not limited to those species that are adapted to his use or enjoyment. He is also concerned with those which, because of their capacity for interference or destruction, are obstacles to his way of life and livelihood. Because of the variety of forms and of the conditions under which they live, the methods of surveying which must be employed to locate, identify and record them are correspondingly various.

Secondly, animal life is distinguished from other resources by its mobility. This factor makes location and quantitative reporting difficult. Examples are the finding of schools of edible sea-fish, and the counting of wild birds and game animals.

The impracticability of summary treatment of animal life surveys, and the consequent failure to treat the subject here, by no means implies that this is a field that is not important or one in which technical advances are not being made. On the contrary, the necessity of knowing and of profiting by the proper use, conservation, and control of such sources is daily becoming more evident. It is also true that notable progress in scientific method is being made. To give but one example, reference is made to the increasing practice of locating and even identifying sea-fish by electrosonic devices originally (and currently) used in making soundings of depth measurements for nautical chart-making purposes.

CADASTRAL MAPS

Cadastral surveys in general create, re-establish, mark and define boundaries of tracts of land. Such surveys, unlike scientific surveys of an informative character which may be amended with changing conditions or because they are not executed according to the standards now required for accuracy, cannot be ignored, repudiated, altered, or corrected, and the boundaries created or re-established cannot be changed so long as they control rights vested in the lands affected.

The official record of a cadastral survey ordinarily consists of a drawing or map and a written description of the field work. The drawing represents the lines surveyed showing the direction and length of each of such lines; the boundaries, description and area of the parcel of land; and, as far as practicable, a delineation of the topography of the region; including a representation of the culture and improvements within the limits of the survey.

The vast net-work created by cadastral surveys in any area in any country may be used for control in connection with the general and specific mapping programs. Such a comprehensive network provides a basis for accurate map compilation.

The basic methods used in cadastral surveying are similar in most countries; that is, each individual tract of land is marked on the ground and a description and area are given in each instance. However, different methods have been adopted by the countries concerning the size, configuration, and description of the lands disposed of or administered by those countries. For example, in the United States of America the rectangular system of surveys of the public lands was adopted in 1786 and marked the important transition from the procedure that prevailed in the greater part of the Colonial States where the land grants and all tracts were defined by irregular metes and bounds, each depending more or less on the description of the adjoining tract known by name or survey number and mostly without common geographic location other than by reference to some well-known natural object.

The CHAIRMAN: We have just heard a second very lucid and interesting discourse, but time is flying and we still have three reports to hear.

To save time, we will open the discussion of the first two papers at once. If possible, comments should either bring out the exceptional interest of the two papers or else raise some point especially deserving of discussion.

Mr. HARRISON: After listening to the very interesting papers we have just heard, there are one or two observations about resource surveys that I think are in keeping with modern thinking and which are of particular importance from the point of view of FAO.

Naturally, that Organization is vitally interested in doing everything it can to promote the surveying and inventorying of resources in many different parts of the world, all with the very practical object of achieving those conditions under which the resources that are available can be used, and used in the near future, for improving the living conditions of the people to whom they belong.

In Dr. Randall's paper, reference was made near the end to the desirabiilty that those who make surveys should collaborate with public officials. I should like to suggest that those who make the surveys, and those at an even higher level who are responsible for having them made, might with great advantage collaborate with each other.

There are remarkable opportunities, especially where extensive programmes are being undertaken on the basis of aerial photography, mapping and interpretation of aerial photographs, for serving many purposes with a single basic survey.

In the past it has sometimes happened that large programmes of aerial photography have been undertaken for some specific purpose and they served that purpose well, but they proved to be quite unsuitable for some other purpose. It is possible to use the photographs from a single aerial survey for very many purposes providing adequate planning is done in advance.

Among those who will use aerial surveys are: the topographic mapper, engineers planning hydro-electric developments, foresters, people developing agricultural programmes—and the list could be extended considerably. On the engineering side they will be used by road builders, railroad builders, people planning power lines, on so forth.

A good many of these separate operations demand certain characteristics in aerial photographs, and it may be that if the photos are taken for a single purpose the emphasis given to particular characteristics desired will make them unsuitable for another purpose. Experience has shown that if a multiple purpose survey is envisaged in the first place and if all those concerned can get together, it is generally possible to arrive at compromises with respect to such matters as scale, wide-angle lens or standard lens, type of picture to be taken, type of film to be used, etc. There are enormous opportunities for economy in that direction. That is something which in my Organization we believe to be of great importance to those who are planning resource development in countries known as, for lack of a better name, under-developed countries.

There is one principle that might be mentioned with respect to inventory, and that is the possibility at an early stage in the work of varying the intensity of the examination being made. It certainly is desirable to obtain a preliminary idea of the resources of a country or a region, but it is quite possible to get that preliminary idea over the whole area and to limit intensive work to those most accessible areas in which practical development is likely to take place in the near future, leaving the more remote areas for more detailed, more time-consuming and more expensive treatment later on.

There is one other thought which was put before the United Nations Committee of Experts on Cartography and I should like to repeat it here. The map-maker in general believes that there are certain limitations of accuracy, certain desirable standards of accuracy, on which insistence must be placed. In a general way that is correct; it is not open to argument. If a standard series of topographic maps is being made for a country, then a certain standard of precision, and so forth, must be laid down. But there are cases in the world—and I know of specific cases—where the urgency for some sort of a map to be used as a basis for immediate resource development is so great that it is justifiable to make preliminary maps although the geodetic and other controls would not ordinarily be considered satisfactory in their existing stage.

The need for the resources themselves may be so great that the time simply is not available to put in a sufficient network of control points, desirable as that may be from the mapping point of view. This is thoroughly understood, and, as I say, I have in mind one or two practical programmes that are now going on in this field. At a later stage the ground will be gone over again, the necessary control points will be properly established, and thoroughly satisfactory maps will be made. In the meantime temporary maps made largely from air photographs are proving very satisfactory for practical source development, and I think that that is a tendency which may increase in many parts of the world—merely as a temporary expedient but as a way of meeting a very real and urgent problem.

The CHAIRMAN: I would like at this time to call on Dr. Walter A. Shewhart of the Bell Telephone Laboratories, U.S.A., who is one of the outstanding leaders in the application of statistics to industrial problems.

Mr. SHEWHART *delivered the following paper:*

Statistical Control in the Conservation and Utilization of Resources

WALTER A. SHEWHART

ABSTRACT

The basic contribution of statistics to the science of control is an improved scientific method in which each of the three steps, hypothesis, experiment, and test of hypothesis, is modified to take account of the fact that valid inference can never be more than probable. The use of this method in analyzing the way men and equipment act together in an organization to determine what changes, if any, need to be made in order that the organization may come closer to attaining its objective, has already proved an effective means in many industries for conserving natural resources and human effort in the mass production of goods of standard quality.

The urge to control our environment to suit ourselves is as old as the human race. In fact, this urge largely differentiates man from other animals. However, the act or method of control has shown a marked development down through the ages—first instinctively guided by trial and error, later supplemented by appeal to the supernatural, then gradually modified in accord with the developing climate of scientific ideas. Our object here is to trace in bold outline some of the modifications brought about in the act of control through the introduction and use of statistical concepts.

GROWING NEED FOR STATISTICAL CONTROL

A basic problem in control is that of devising an operation of using raw materials at our disposal that, if carried out, will give a thing that is useful in satisfying some human want. It is desirable to differentiate between two kinds of factors that must be taken into account. Over one, man has little or no control, as, for example, the weather; he must be content with trying to make valid predictions. Likewise no industrial organization has much control over a large number of factors such as fluctuations and trends in human wants, available supplies of raw materials, economic and business conditions, labor supply, the laws and mores of the people, the growth of population, and international relations. In fact, it is alleged in some quarters that human affairs of this character are essentially unpredictable and beyond the reach of research and experimentation, thus falling outside the scope of scientific inquiry. In marked contrast are those factors in the field of the natural sciences where it is possible to make reproducible experiments; where it is assumed that phenomena obey laws that can be discovered through scientific inquiry; and where it is assumed that valid prediction is possible.

A man of practical affairs must take into account both types of factors. The fact that he has learned through sad experience that it is not yet possible to forecast with certainty the future trend of social and economic phenomena has not deterred him from trying to make such forecasts. Experience has taught him that his short-term forecasts based upon social, economic, and business data are better than no forecasts at all. The subject of statistics had its origin in the attempt to satisfy this need of the man of practical affairs for factual information upon which to base such forecasts.

For example, when the Royal Statistical Society of London was founded a little over a century ago, its stated objective was "to collect, arrange, digest, and publish facts illustrating the condition and prosperity of society in its material, social, and moral relations." Even today in many quarters the statistician is thought of as one engaged in the collection, tabulation, and reduction of data, particularly of a financial and economic character. Gradually there grew up a statistical methodology "adapted to the elucidation of quantitative data affected by a multiplicity of causes." It grew up as something apart from scientific method—in fact, it grew up to serve the need of the practical man in fields which many scientists would claim are beyond the pale of scientific inquiry.

Turning our attention to fields in which scientific inquiry is admittedly possible, we find that the scientist has not only accepted the fact that the only kind of *observable* constancy is statistical but he has also found it necessary to go further and develop statistical theories to account for the many *conceptual* properties of the particles of modern physics. Although the basis of the scientific process is often taken as the reproducible experiment, it has long been realized that the outcome of the repetition of such an experiment can only be predicted within limits upon the basis of probability theory. Measurement itself is a fundamental operation of this character and the theory of errors was developed by Gauss more than a century ago to take account of the statistical nature of repetitive measurements.

Even so, however, the pure scientists in these fields have paid little attention to the methods of the statistician as such. True enough, natural scientists have long computed probable errors but by and large these errors have been used only in perfunctory manner. For example, a great physicist, the late Lord Rayleigh, once said that error theory was something to read up on and then forget. Within the past quarter century, however, the applied scientist at least has begun to take cognizance of the statistician and his ways. Why, you may ask, has this change come about? The answer is not hard to find. The applied scientist has run head on into certain types of problems in his attempt to control the variability in the results of repetitive operations and to disentangle and measure the effects of different causes of variation upon some variable that he wishes to control.

Obviously the manufacturing process may be thought of as a repetitive operation analogous in many ways to the repetitive experiment and measurement in science. We may conceive of the manufacturing process as an operation that may be repeated again and again, and thus capable of producing an indefinitely long sequence of physical objects. Such processes are often refined to the state that the repetitions are made under presumably the same essential conditions. Even so, we find that the qualities of the objects thus produced vary from piece to piece in much the same way that a sequence of repetitive measurements of the pure scientist may vary.

For example, consider the production of a protective fuse designed to blow within a given interval of time when subjected to a specified load. Obviously all fuses cannot be tested because the test itself is destructive; yet one or more persons may lose their lives or at least there may be large property damage if a fuse fails to blow within the specified limits. Here it becomes vitally important to be able to make valid probability predictions within specified limits. Whereas in the field of error theory the scientist usually *assumes* that a sequence of observed values made under essentially the same conditions will approximately obey the normal law of error, the production man early found that such assumptions were not valid in his field. The operation of statistical control was introduced about a quarter of a century ago to help the practical man detect the presence of assignable causes of variability in his production process that had to be taken into account before valid prediction was possible.

Even where the inspection test is not destructive, it is often found that a small percentage of product made under presumably the same essential conditions will fall outside of the tolerance limits and usually must either be scrapped or reconditioned. This adds to the cost of production. Here again it often becomes of great importance to study the causes of variability in the process with a view to reducing the percentage of product falling outside of tolerance limits. Oftentimes, it is also important to close up on the tolerance limits in order to effect certain economies, on the one hand, and to attain a more desirable product on the other.

For these reasons, if no others, it is important from the viewpoint of conservation and utilization of raw materials in manufacture to detect the presence of assignable causes of variation in the repetitive act of manufacturing. Another reason stems from the work of R. A. Fisher on the design of experiment as introduced in the field of agricultural experimentation. The classical ideal of experimentation is to keep all of the independent variables constant except one. Fisher was the first to point out the advantages to be gained by including in the same experiment as many as possible of the factors whose effects are to be determined. Not only does this provide greater efficiency and provide measures of the variability attributable to each of the different factors; it also provides a means of determining the extent to which the factors themselves *interact*.

To illustrate, let us consider once again a manufacturing operation. In the development of a complicated manufacturing process of modern industry many operational steps are involved and these are sources of causes of variation in the final product. In the industrial research underlying the development of such a process, it is often highly desirable to be able to determine the contribution of each of these steps to the over-all variability. Moreover, in any such process it is almost certain that the interaction between the effects of some of the factors will be of great importance. Fisher's theory of the design of experiment sets forth the principles for efficient experimentation in such instances. This is particularly true in the development of processes of production of such items as thermionic devices, varistors, thermistors, and transistors, to mention only a few coming out of recent advances in modern physics and chemistry.

STATISTICAL CONTROL

The theory of statistical control is concerned with the development of a scientific method of making the most efficient use of raw materials in the production of things to satisfy human wants; a scientific method that takes into account the fact that inferences can only be probable; a method that will help us to obtain maximum validity in the field of prediction and that will provide a rational routine for minimizing variability in the repetitive act of production through the detection and removal of assignable causes of variation. The theory of control as here conceived must take into account all steps in the act of control including the determination of human wants, the selection of raw materials, and the more formalized steps of industrial research, development, design, specification, production, and inspection.

For our present purpose we may think of scientific method as involving three important steps:

1. The adoption of an hypothesis and the development of a formal theory for making valid predictions provided the hypothesis is true.

2. Experimentation to provide the data with which to test the hypothesis.

3. Development of ways and means of using the data in testing the hypothesis.

The fundamental role of statistics is that of modifying each of these three steps. Statistical method is one in which we start with statistical hypotheses, make use of statistically designed experiments, and apply statistical tests of the hypotheses. Such a view no longer conceives of statistical method as something apart from scientific method but rather as an improved scientific method.

Turning our attention to the production of manufactured goods, it is customary to consider three fundamental steps in the act of control, namely, (1) the specification of the physical and chemical properties of the thing wanted, (2) production, and (3) inspection. From the viewpoint of statistical control theory, these three steps are analogous to the three steps in scientific method. Based upon industrial research and development, the engineer or applied scientist comes out with the design of something that is presumably wanted. In order for the parts of such a design to function, it is necessary that they be controlled within specified tolerance limits. Such limits, however, cannot be drawn out of the air but must conform to the limitations imposed by lack of homogeneity of raw materials and chance causes of variation in the production process.

As a preliminary step in arriving at such specifications, it has long been the practice in industry to build and try out tool-made models. In many instances, it has been found necessary to go even further and to make use of what is customarily known as a pilot plant production. From the viewpoint of statistical control, it is highly desirable in these stages to make use of statistical control theory and techniques, first in weeding out assignable causes of variability and then in making estimates of tolerance limits based upon the rational use of probability theory. It is particularly desirable at this stage to make use of available criteria for statistical control and also the statistical design of experiment in determining the effects of different factors and their interactions.

This use of statistical control procedures becomes a very important tool in setting up specifications that may reasonably be expected to be satisfactory from the viewpoint of mass production. Even so, it is usually found that when such specifications are used under the necessary conditions of mass production, additional assignable causes of variation come into play. Fundamentally, therefore, the specification is of the nature of the best possible hypothesis to be tried out in the second step, production. The third step, inspection, was originally conceived as a screening. From the viewpoint of statistical control, however, it is much more than this: it can really be made a crucial step in testing the hypothesis implied in a specification.

CONTRIBUTIONS OF STATISTICAL CONTROL

In a recent article in the *Wall Street Journal,* it is estimated that the potential annual savings to American industry through the contribution of statistical control within the fields of production and inspection alone is of the order of magnitude of two or three billion dollars. There are several corporations that have reported actual annual savings running above a million dollars. However, so far as I know, no corporation has as yet explored the full possibilities of effecting savings at all steps in the over-all problem of control as set forth in this paper. There are six ways in which the advantages to date have been most felt.

1. *Reduce the amount of inspection:* At each stage in the process of attaining a state of statistical control of a production operation from the sampling of raw materials to the production of the finished piecepart, statistical theory has made possible the establishment of efficient sampling plans that screen at minimum cost the output of each operation so as to meet previously specified tolerance requirements with economically balanced consumer and producer risks.

2. *Minimize the number of rejections and hence the quantity of scrap:* By helping the engineer to detect the presence of assignable causes of variation so that these may be discovered and removed, statistical control techniques help to reduce variability of quality and hence the number of rejections. This is not only important from the viewpoint of reducing costs but also nationally and internationally important from the viewpoint of conserving available quantities of scarce materials.

3. *Maximize quality assurance:* As assignable causes of variation are detected and removed, the quality of a given product approaches a state of statistical control for which the assurance that the quality of a piece of product will meet its tolerance requirements is a maximum. This fact is of particular importance for goods that cannot be given 100 per cent inspection because of the destructive nature of the inspection test.

4. *Increase output of goods of standard quality:* This advantage is of particular importance in times of both war and peace when production does not come up to the levels required within a given nation or group of nations. At such times, savings in dollars alone does not adequately measure the importance of the contribution of increased production.

5. *Increase employee satisfaction:* Through the application of statistical control techniques, it becomes feasible to detect whether or not excessive variability in the quality of output has been occasioned by some physical factor or by some human factor. In many instances, the operator of a machine has taken great interest in the results of applying such techniques because it assures him that he will not be penalized for low production when the cause is either in materials or machines. Statistical control techniques are also useful in detecting and helping to eliminate assignable causes of variability in many kinds of human effort thus helping the operator to maximize his efficiency.

6. *Minimize tolerance range:* The operation of statistical control provides an experimental technique for minimizing tolerance ranges. Such an operation makes possible the most efficient use of limited quantities of raw materials and provides the maximum degree of refinement attainable by any production process. Both strategically and commercially, industrial groups and even nations often need the maximum assurance of quality and the minimum tolerance ranges that can be obtained from the elimination of assignable causes, not only in pursuit of the arts of peace but also in time of war. For example, the attainment of maximum control may extend the potential carrying capacities of ships both in the air and on the sea.

THE FUTURE OF STATISTICAL CONTROL

The primary concern of this conference is stated to be the "practical application of science to resource management and human use". Management in this sense may be defined as the art and science of organizing and directing human effort in the *control* of our environment for the benefit of man. The broad function of the theory and practice of statistical control is to provide management with an adequate scientific statistical method for collecting the best possible quantitative information and drawing valid probable inferences therefrom in regard to the operations under its control.

Even assuming that a perfect methodology for effecting control were at hand, there would still remain the really stupendous problem of organizing human effort in the use of this methodology. Consider, for example, a large industrial organization such as the Bell System. More than 100,000 different kinds of piece-parts are required in the physical system to make it possible for one subscriber to talk to any other in the system. Many of these parts have an annual production running into the millions. The human effort required in the production of these parts is provided by thousands of employees. No one group of employers is solely responsible for control—instead each employee plays a part. The maximum advantages of statistical control come about only when every employee is in possession of the "know-how" adequate for his job. For this reason many corporations have provided in-company "short-courses" attended in some instances by all employees concerned from the vice-presidents down. The know-how gotten across in this way may be adequate training for the majority of the employees but far more advanced training is essential for others responsible for the more complicated control operations. The customary organizational set-up for developing and using company standards of quality as a guide in production and inspection became a logical means of developing and coordinating the statistical control efforts of those engaged within a company in production and inspection.

There remains, however, the problem of controlling the quality of incoming raw and fabricated telephone materials. Some idea of the magnitude of this problem in any large industry can be gleaned from the fact that in a typical post-war year something like 65,000 tons of raw steel, more than 109,000 tons of copper, more than 121,000 tons of lead, 6,700 tons of cable paper, 6,500 tons of wood pulp for cable insulation, 7,400,000 lb. of cotton yarn, and 1,990,000 lb. of acetate rayon yarn were purchased by the Bell System. These are just a few of the thousands of items purchased from thousands of suppliers. Such supplies come from every state in the Union and from many foreign countries—literally from the four corners of the earth. The practice of buying in accord with specified standards of quality subject to rigid inspection makes possible a thorough job of screening to insure maintenance of standards of quality. However, to the extent that outside suppliers adopt statistical control procedures, there accrues a reduction in the amount of inspection required and in the amount of material rejected as substandard, both of which are reflected in savings. Moreover, the use of such procedures gives maximum assurance that quality standards are being maintained even in those instances where 100 per cent inspection could not be carried out because of the destructive nature of the test.

Industrial groups in many countries have long appreciated the mutual advantage of common standards of quality to all engaged in trade one with another. For this reason, national standardizing bodies have been established in many countries since the turn of the century and an international standardizing organization has been set up since World War II. Some of these organizations were among the first to appreciate the mutual desirability of extending the use of statistical control procedures throughout industry. In fact, the American Standards Association at the request of the war department, developed certain standards of quality control by statistical techniques that were used extensively here and in England, Canada and Australia to attain the advantages of statistical control in war production. More recently, the Indian Standards Institution has republished these as tentative standards to be used in the development of her industries. By and large, statistical quality control has gained a toe-hold in industry within several nations largely through existing organizations devoted to standardization. To date we have only begun to reap the benefits of the movement started in this way.

However, before any appreciable percentage of the potential contribution of statistical control in industry can be reached, it is necessary that applied scientists, engineers, and others engaged in research, development, design, and specification avail themselves of the latest developments in the theory and practice of the science of control. Ground has already been broken by way of organizing effort to explore the possibilities in this direction. In several large scientific and engineering societies, committees have been organized to develop the application of statistical control procedures in their specialized fields. An American Society for Quality Control has also recently been organized and now has a membership of approximately 3,000 members. Such groups can be relied upon to extend the fields of application.

It is, however, to the universities and colleges that industry must look for leadership in the development of new and improved statistical hypotheses or models, improved methods of applying statistics in the design of complicated experimentation, and new and more powerful statistical tests of statistical hypotheses, all of which constitute the basic foundation of statistical control theory. We must also rely upon engineering schools to develop the *art,* as well as the science of statistical control which goes beyond statistical theory *per se* as I have tried to imply in what has gone before.

Any prognostication about the future of statistical control would not be complete without a comment on that toughest of all problems, the establishment of the goal of control in terms of that which will give the greatest satisfaction of human wants to the ultimate user. This implies, among other things, the need to make valid prediction of trends in the non-controllable natural and social factors and of how these will tend to modify and shape his future wants. This involves, among other things, the study of individual and group patterns of motivation and preference and then an attempt to determine how to make valid predictions about future trends in a user's behaviour in terms of available knowledge of his present preferences in relation to prevailing economic and social conditions.

One ray of hope from the viewpoint of this aspect of control has shown above the horizon—I refer to the development in the past few years of a theory of prediction based upon the introduction of new statistical models of so-called stochastic processes. To date the psychologist, economist, and social scientist has not been prone to base much hope on the use of probability theory. This tendency is partly attributable to the fact that their concept of probability was limited to that of a random repetitive process in which the successive observations are independent. It is obviously possible, however, to develop statistical models for which the successive observations are not independent. Such models have proved their usefulness in such diverse fields as the study of stellar phenomena, cosmic rays, and the theory of communication. Attempts have been and are being made in several quarters to develop similar models applicable in the field of economics. How the continuing theoretical developments in this direction will affect the control theory of the future no one knows—that they will modify our present views of control theory is, however, almost a certainty.

Finally a word about the ultimate user whose wants are to be satisfied. In the last analysis, a nation can be great in science only to the extent that the population has an inkling of the objectives, methods, and limitations of scientific work. Unfavorable reaction is sooner or later bound to result from any disposition to regard science as a form of magic. In some quarters there has been a tendency to emphasize the "fact" that applied science has reached a stage where it was possible to buy and sell in accord with exact engineering specifications of quality. In fact, I recently read the following advice in a publication distributed widely among the consuming public: "Buy as your Uncle Sam does, in accord with exact specifications of quality". The implication is that at least in some instances specifications can be written that specify unequivocally an object of trade. This is like advertising the magic of science. It is not possible to specify the quality of the simplest thing in a absolute manner. But even if it were, it would not be possible to determine with *certainty* that the object had the specified quality. In the last analysis, scientific method can only lead to a probable inference. The public should not be led to expect the impossible from scientific control. Its full support, requisite for achieving the greatest success in the scientific control of our environment, can only come when it is acquainted with the limitations of science imposed by the fact that valid inference can never be more than probable.

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The CHAIRMAN: Mr. F. Yates of the Rothamsted Experimental Station in England was invited to prepare a paper for this meeting. In his absence the following paper has been circulated among the conferees.

Mr. YATES' *paper follows:*

The Place of Experimental Investigations in the Planning of Resource Utilization

F. YATES

ABSTRACT

Experimental investigations are of use not only in fundamental scientific research, but also in the technological research required to establish "scientific know-how". It is this latter type of experiment which is of particular value in planning resource utilization.

Technological experiments introduce new problems of experimental design, and their efficiency has been very greatly increased during recent years by the development of this subject. They constitute a new and still developing technique of which the possibilities are as yet imperfectly realized.

The paper outlines the considerations governing the planning of technological experiments for resource utilization and discusses their relation to surveys and other forms of observation. The problems encountered in agricultural development are specially considered. Questions that arise are the degree to which experiments should attempt to mirror practical conditions, how far a problem can be broken down into component parts for experimental purposes, the degree of replication that is required in space and time, the place of large-scale pilot experiments, allocation of resources to the different problems, and the timing of experimental work in relation to other work required in planning for resource utilization.

Plans for the conservation and utilization of resources must have a sound scientific foundation, but this in itself will not guarantee success. They must also be correct in their technological details—the "scientific know-how" required for their execution. In addition, therefore, to utilizing existing scientific knowledge, and if necessary extending it, we must carry out technological research into the best methods of applying this knowledge under the particular conditions existing in the areas concerned.

Technological research requires experiments which differ somewhat from those used in scientific research. In pure scientific research the objective is the elucidation of the underlying laws governing the phenomena under investigation. In technological research the underlying laws have to be supplemented and extended by empirical working rules. The conditions under which the experiments required to establish these empirical rules are carried out must be much closer to those actually existing than is the case with the experiments of pure scientific research.

There is, of course, no absolute division between the type of experiment used in pure scientific research and that used in technological research. There are in fact all degrees; in particular, experiments which are primarily concerned with empirical questions may well bring to light facts which suggest further fields of pure scientific inquiry. Conversely, pure scientific experiments may sometimes reveal empirical facts which, though inexplicable in terms of the scientific theory of the time, are of considerable practical importance.

EXPERIMENTAL DESIGN

Technological experiments have introduced many new statistical problems, broadly classified under the heading of experimental design, with which the pure scientist, particularly one trained in the physical sciences, is frequently unfamiliar. One reason why statistics enters into the design of such experiments is that the experimental material, particularly if it is biological, is inherently variable, so that comparisons and quantitative estimates based on the behaviour of single units are subject to errors which are large, relative to the effects that it is desired to measure, and are consequently unreliable. We must therefore have a means of ensuring that the errors introduced into the experimental results are sufficiently small, and that moreover the actual accuracy of the results is ascertainable, even when there is no exact prior knowledge of the variability of the material. These ends are attained by the twin principles of *randomization* and *replication,* coupled with the imposition of any restrictions which appear likely to increase the accuracy and which are compatible with these principles.

A further device which is of considerable importance in technological experiments is that known as *factorial design.* In a factorial experiment the effects of a number of factors (treatments, varieties, etc.) are simultaneously investigated, by including all combinations of various levels or variants of the different factors. The advantages of factorial design are considerable. Firstly, a number of factors can be investigated in the same experiment, and this leads to economy of experimental effort and material. Secondly, the experiment will provide an indication of whether the response to one factor is affected by variation in one or more of the other factors. Thirdly, the results are obtained on a wider inductive basis, and in so far as the effects of one factor are not substantially affected by variation of other factors the response to this factor averaged over all variants of the other factors provides a satisfactory measure of the general response to the factor.

Factorial design is of particular importance in technological experiments, since it is often necessary to repeat an experiment a number of times so as to obtain a reasonable sample of the conditions affecting the results. Thus in agriculture fertilizer responses and varietal differences are affected by meteorological conditions, soil type etc., and experiments must therefore be carried out over a number of years and at a number of different locations. Only moderate accuracy is required in any one experiment. If each factor had to be investigated separately this would lead to a very extensive experimental programme, but by the use of factorial design comprehensive results of adequate accuracy can be obtained with a reasonable amount of experimental work.

HOW REALISTIC SHOULD EXPERIMENTS BE?

There is often a conflict of views between the scientist and the practical man as to how far experiments should attempt to mirror practical conditions. The scientist will claim on the basis of his laboratory experience that no progress can be made unless the variability of his experimental material is so reduced that experimental errors are small relative to the effects he is investigating. The practical man, on the other hand, will claim that the conclusions reached by such methods are not applicable to practical conditions and that only trials which strictly reproduce the practical set-up have any relevance or interest.

There is truth in both these contentions, and part of the art of planning experimental investigations consists in striking the optimal balance between them. In agriculture, for example, it is comparatively easy to obtain precise results by growing plants in pots under carefully controlled conditions. Agricultural literature, however, is full of erroneous conclusions that have been reached by this method of experimentation. On the other hand, there are many examples of "practical" experiments on large unreplicated plots or whole fields which have given equally misleading conclusions, or have completely failed to give any conclusions, owing to their inherent inaccuracy and defects in design.

In certain types of investigation there is little difficulty in reproducing practical conditions sufficiently closely, but in the more complex type of problem the fully "practical" experiment is often of little value.

As an example we may consider a problem which is of considerable importance at the present time in British agriculture, namely the estimation of the comparative value of the use of ley-arable rotations instead of permanent pasture and permanent arable. Here we are involved in long-term questions of the maintenance of fertility, control of plant and animal diseases, weeds, etc. In the case of pasture there is the additional difficulty of measuring the grazing value. The severely "practical" test of the relative merits of the two systems of agriculture will consist of setting up the two systems side by side on different fields (or even dividing a whole farm into two parts). Such a test gets us nowhere. Quite apart from the lack of replication and consequent large and uncertain experimental errors, uncontrolled variations in farm management of the two systems are likely to introduce large differences which are not really inherent in the systems. Moreover, an adequate number of variants of the two systems—which may vitally affect their relative merits—cannot be properly investigated. There is therefore no alternative but to break down the whole complex of factors into separate parts, which can then be investigated experimentally and reintegrated. Such experimental investigations will in any case require small plots, and these in turn lead to artificial conditions of grazing etc.

There is, of course, the chance that the sub-division of a problem in this way will result in some vital factor being overlooked, with the result that the final reintegration is incorrect. Nevertheless this is a risk which must be taken, though as a check, pilot-stage investigations of what appear to be the best systems may be set up. These may be quantitative, so as to provide estimates of the differences between the chosen systems under large-scale conditions, thereby checking the estimates from the small-scale experiments; alternatively, they may be qualitative, designed to see if the systems work smoothly in practice and whether there are any unexpected troubles, such as those arising from a plant or animal disease.

SURVEYS AND EXPERIMENTS SHOULD BE COMPLEMENTARY

The main function of surveys is to provide basic information on the existing state of affairs, and on any changes that are taking place, either naturally, or as a consequence of some plan that has been put into operation. In addition to their main function it is sometimes claimed that surveys can act as a substitute for experiments, and can in fact determine the quantitative effects of different factors under practical conditions more economically and more effectively than can experiments. Thus it is frequently suggested that the responses of the various crops to fertilizers can be ascertained by a survey of the yields of fields with and without fertilizers. This is a fallacy and a dangerous one. In the case of fertilizers, for example, there is no reason to believe that fields with and without fertilizers are comparable in other respects. In particular, fertilizers are likely to be more extensively used by the better farmers, who may be expected also to carry out other agricultural operations more effectively, use better varieties, etc., and may also farm better land. Conversely, fertilizers may be more extensively used on poorer land because its requirements are believed to be higher. Even if known differences are allowed for as far as possible there is no guarantee that there are not further unknown or unassessed differences which will vitiate the comparisons.

Nevertheless surveys, although no substitute for experiment, may provide a useful indication of the factors that are likely to be worth experimental investigation. If, for example, after eliminating disturbing factors as far as possible, variety A is found to yield consistently more than variety B on one soil type, and consistently less on another soil type, there is at least *prima facie* evidence that a genuine difference of this kind exists. Conversely, factors which from survey results appear to produce little effect can be placed low on the list of priorities for experiment, unless there are other reasons for believing they are of importance.

Surveys can also, under certain circumstances, provide information more quickly than can experiments. Certain points, such as the rate at which land becomes exhausted under continuous cropping after being reclaimed from bush, from their very nature take a long time to investigate experimentally, and in such cases surveys can give information which, though it lacks the certainty of that derived from properly planned experimental investigations, can form a useful, if provisional, basis for action.

Surveys and experiments should therefore be regarded as complementary. Surveys should be used to provide the basic background information, and to give partial information on the effects of factors that do not easily lend themselves to experiment, but factors which can reasonably be made the subject of experiment should be so tested. Only by experiment can results be obtained in which full confidence can be placed.

PROBLEMS ENCOUNTERED IN AGRICULTURAL DEVELOPMENT

The development of areas which are agriculturally backward, though by no means the only problem of resource utilization, provides a good illustration of the potentialities and limitations of experimental investigations, and is also of wide-spread importance and general interest. We will therefore consider it in a little more detail so as to see the way in which experimental investigations fit into the whole programme of development.

In considering the development of an area about which little is known, the main questions that have to be answered, on the crop side, are:

1. What is the rainfall of the area, and how is it distributed?

2. What are the characteristics of the soils, and what is the location and extent of the different soil types?

3. What system of agriculture shall be followed, i.e. what should be the balance between crops and livestock and between arable and grass?

4. What are the best crops to grow?

5. What fertilizers are required for the proper growth of these crops?

6. What cultivation methods, crop rotations, etc. are required in order to conserve fertility and prevent erosion?

7. If rainfall is scanty, what is likely to be the increase in the yields of crops by irrigation?

8. Are utilizable water-supplies available for irrigation?

9. What are the most suitable varieties of the given crops and to what extent can they be improved by further plant-breeding work?

10. What plant diseases and pests are likely to occur and to what extent are measures of control available?

A similar set of problems, covering breeds, diseases, feeding, etc. will arise in connexion with livestock.

The answers to a number of these questions can be, and indeed must be, obtained by direct observation and surveys. Thus meteorological data can only be obtained by setting up suitable meteorological stations. If immediate action is required and adequate meteorological data are not available, a study of existing vegetation may give a rough indication of the quantity and distribution of rainfall. A survey of the existing vegetation, coupled with a soil survey, can also give valuable basic material which may in itself serve to divide the country into more or less homogeneous regions, each of which can be treated as a whole. Similarly a study of the existing crops and their yields will indicate at least some of the cropping possibilities of the area, and will at the same time bring to light some of the problems that require solution. Consideration of the agriculture of similar areas in other parts of the world may also suggest improvements such as the introduction of new crops, and new varieties of existing crops.

When all this has been done, however, there remain a large number of questions which cannot be resolved without actual experimental work. More specifically, answers to all the questions 3 to 7, 9 and 10, if they are to be reliable, must be derived in whole or in part from experimental investigations. Thus the crops and varieties which are best suited to local conditions can only be determined with certainty by local trials. Such trials will be far more efficient if they take the form of properly planned experiments, carried out at an adequate number of sites, and continued for a sufficient number of years, rather than haphazard and uncoordinated trials and exchange of information by farmers. Similarly only experiments can show what fertilizers are required and in what quantities and types, and here again properly planned and coordinated trials will enable a reliable body of knowledge to be built up much more quickly.

Long term questions such as the maintenance and improvement of soil fertility, prevention of erosion etc., cannot normally wait on the verdict of experiments before any recommendations are made. Yet they are vitally important questions, which require continuous experiments over a number of years if they are to be answered correctly, and it is important, therefore, to put experiments of this kind in hand at the earliest possible moment.

ALLOCATION OF RESOURCES AND TIMING

Since the resources available for experimental investigations and scientific research generally are usually very limited, particularly in undeveloped countries, the experimental programmes must be drawn up with the greatest care, having regard to:

1. The importance of the problems to the agriculture of the area.

2. The probability that the experimental work will contribute effectively to their solution.

3. The length of time that is likely to elapse before worth-while results accrue.

The fact that a long time is likely to elapse before results are available does not necessarily mean that no work should be undertaken on a problem, but it does imply that such work as is undertaken should be of a more general nature than might be advisable if an immediate solution were likely to emerge. A correct balance must be struck between technological research on *ad hoc* and immediate problems, and more fundamental scientific research. At the outset most research will be of the technological type on *ad hoc* problems, the fund of established scientific knowledge being drawn on to provide the scientific background. Provision should be made at the outset, however, for more fundamental research, and it should also be arranged that there is close contact between those working on fundamental research and those working on *ad hoc* problems, since each type of investigation is a continuing stimulus to the other.

The timing of experimental work in relation to other work required in planning for the development of resources is also of considerable importance. Most experimental investigations can be conducted more efficiently if they are carried out at a fairly slow tempo over a considerable period of time. In particular, investigation of agricultural problems is necessarily a slow process. Under normal circumstances only one experimental crop can be grown in the course of a year. Experiments investigating long-term changes of fertility and the effects of treatments on perennial crops are still more time-consuming, as is plant-breeding work. Experiments must be replicated in different years, in order to obtain an adequate sample of meteorological conditions, and in different places in order to obtain an adequate sample of soil conditions, etc. Thus even simple fertilizer and variety trials have to be carried out over a number of years before any firm conclusions can be drawn.

These considerations indicate that experimental work should be begun on an adequate scale at the earliest possible moment. It is, however, of little value to start experiments until some idea can be formed of what problems really require experimental investigation. This frequently demands that a good deal of survey work be undertaken first.

In agriculture, however, there are a few basic problems—in particular, trials of different varieties of both new and established crops, and fertilizer trials—which will usually repay experimental investigation, even before the necessary surveys have been carried out. It is sometimes objected that there is little purpose in making fertilizer trials in an undeveloped and backward country when there is no immediate prospect of ensuring an adequate supply of fertilizers, even if substantial responses are shown. This, I think, is a mistake, since without basic knowledge on fertilizer responses it is impossible to form any judgment of the value of the returns that may be expected if fertilizers are imported, or if local fertilizer industries are established.

Apart from a few problems such as fertilizers and varieties whose experimental investigation is relatively simple, the ideal order of development is undoubtedly to commence with surveys of resources and conditions etc. so that the problems most needing experimental investigation can be ascertained. Secondly, to initiate both field experiments and basic scientific research, which should together give fairly clear indications of the agricultural potentialities of the area and the best way of developing and utilizing them. There will follow a period of active planning coupled with large-scale or "pilot" experiments in which large plots or separate fields are used to test a few of the most promising methods, so that any practical difficulties not brought out by the small-scale experiments may be revealed. These pilot investigations will also serve as demonstrations to the agricultural advisers and ordinary farmers. The conclusions may then be applied to full-scale agricultural operations, which should be kept under observation by means of survey techniques and operational research.

The above may be regarded as the ideal order of events if time is not pressing. In practice, time almost always is pressing and it is thus a matter of judgment to decide between the conflicting needs of the situation. There will usually be an urgent demand to get schemes under way, while at the same time there is the ever-present necessity of avoiding costly mistakes.

In such circumstances it is customary to call in eminent scientists to give their advice. The scientists will be confronted with a demand that practical plans should be made for an immediate start. They may well be aware that much of the basic information that they require is lacking, and that if only investigational work had been begun a few years earlier it would have been possible to obtain this information. Under such circumstances judgments are bound to be partly a matter of temperament. The least that the scientist can do, therefore, both for his own protection and to safeguard the reputation of science, is to emphasize the extent to which the conclusions reached and the advice given are subject to uncertainty through lack of precise knowledge, and to demand as an essential condition of the development being undertaken that provision should be made for surveys and experimental investigations to be put in hand, so as to ascertain how far and in what way the initial steps should be modified.

The East African Groundnut Scheme provides a good example of the difficulties which are likely to arise when large-scale development work is undertaken without an adequate basis of survey and experimental investigation. The difficulties which have been encountered in this scheme are well-known and need not be discussed here. The scheme, however, is noteworthy in that, apart from the initial mistake, if mistake it be, of starting the scheme without adequate preparation, a very extensive and vigorous programme of surveys and experimental investigations was instituted from the outset. There appears to be little doubt that this work will in due course produce a sound scheme. In justification of the precipitate commencement it may be claimed that had the opportunity of commencing large-scale work not been taken, nothing would have been done, and that many of the difficulties encountered were in fact on the administrative and agricultural engineering side and that the only way of discovering and resolving these difficulties was to undertake large-scale operations.

THE NEW TECHNIQUE

From the above discussion it will be seen that organized experimental investigation of technological problems constitutes what is essentially a new technique, of which the possibilities are as yet imperfectly realized. Equally the technique itself is capable of much further development. It is still unduly influenced by the tradition of the experimental techniques of pure scientific research, with their emphasis on the need to isolate factors and investigate them one at a time, and to work on only the most uniform experimental material.

This new technique, together with the techniques of operational research, are serving to bridge the gap between science and practice. It is a frequent criticism of our use of science that it takes ten, twenty or fifty years for a scientific discovery to be applied in practice. The fault, however, has not by any means lain entirely with the practical man. Many of the scientific discoveries emerging from laboratories, though basically sound, have overlooked points which have made them inapplicable under practical conditions. The proper testing out of new discoveries should be regarded as an essential prerequisite for modifications of existing practices.

It must also be recognized that the science of experimental design, which is the basis of the technique of technological experimentation, is not entirely simple. Just as it is frequently claimed that statistics consists of common sense plus ability to add two and two, so it is thought that any scientist can design effective experiments without prior training or study of the subject. I can only state from my experience of experiments that are actually laid down and carried out, particularly in technological investigations, that this is not so.

On the other hand the planning of experimental investigations should not be solely the province of the expert in experimental design. As in so much of modern scientific work, what is required is cooperation—here between the expert in experimental design and the scientists who are involved in the problems under investigation.

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The CHAIRMAN: This discussion could doubtless be continued indefinitely, for a debate which is slow in getting under way often ends by developing and leading a considerable number of speakers to make their contribution. Unfortunately, time presses. I therefore propose that we should ask Professor Mahalanobis of the Indian Institute of Statistics at Calcutta to read his paper at once. He is a great authority on statistical methods, which he has applied to problems of physics and even of agriculture, and will certainly give us very interesting information on the topic.

Mr. MAHALANOBIS *delivered the following paper:*

Statistical Tools in Resource Appraisal and Utilization

P. C. MAHALANOBIS

I am glad to have the opportunity to speak at this Conference. As time is short, I shall only try to put across briefly a few leading ideas.

I have come here to sell statistics to resource engineers and economists. I hope you will find me an honest broker. Two grounds on which I plead for statistics, I may mention at the outset. First, we are bold enough to claim that the statistical method supplies the real foundation of inductive logic or inductive inference in all scientific reasoning. Secondly, at a more concrete level, the aim of the statistical method is to secure the maximum economy of cost in the appraisal, utilization and conservation of resources.

First, the abstract aspect. In deductive logic, one starts with certain premises from which the conclusions inevitably follow. The counterpart in modern thought is pure mathematics which Bertrand Russell, the mathematician and logician, defined as the class of all propositions of the form "P implies Q". That is, if P, then Q must follow. There is complete formal certainty of the deductive conclusions; but we must not enquire what P and Q are, or whether they are real in any mundane sense at all. This is pure mathematics.

Classical physics was based on a deterministic logic. An invariable sequence of cause and effect is in many ways similar to the formal-deductive process in pure mathematics. The classical method is to isolate one factor at a time and write down the equations of motion of a single particle. Prediction becomes, in principle, absolutely certain. Following, step by step, by mathematical reasoning what happens to the particle, it is possible to predict the future. Newton in his great treatise on the principles of natural philosophy adopted this mathematical form. The construction of a rational model of the whole universe was, no doubt, a great triumph.

However, when one has to deal with not one, or two, but three, or more, particles, the equations of motion become unmanageable, and the next step in the history of the physico-chemical sciences was the study of not one single but an aggregate of particles or molecules. This led to the kinetic theory of gases and thermodynamics. The object now was not to ascertain with complete certainty the motion of each single particle separately, but to investigate the collective properties of a large number of particles taken together. Again there were great triumphs of theoretical conclusions corroborated by experiments. A parallel development led to the emergence of the concept of entropy; and the principle of increase of entropy was recognized as nothing but the increasing degree of randomness of the physical universe. The growing complexity within the field of the physico-chemical sciences thus led to the gradual replacement of the deterministic-mathematical model by the probabilistic-statistical view.

A further shift to a statistical model occurred with the development of statistical and quantum mechanics culminating in the enunciation of the uncertainty principle by Heisenberg which denied the possibility of absolutely certain knowledge of both the position and the motion of a particle at any given instant. This deliberately sets a limit on the deterministic chain by openly admitting the existence of residual uncertainty. In the physical sciences, the whole foundation thus changes and becomes fundamentally of a probabilistic or statistical nature.

At this stage, I ought to mention the concept of the random sample which supplies the theoretical foundation of modern statistics. The tossing of a coin supplies a simple example. It is quite impossible to predict anything about a single toss of a single coin, that is, whether it will turn up head or tail. However, if the coin is tossed a large number of times, it is practically (but never absolutely) certain that heads and tails would turn up approximately in equal numbers. The expectation of such roughly equal frequency of heads and tails essentially refers to the whole set of throws, that is, the prediction belongs not to any single individual throw but to a group or assemblage of throws taken together. Secondly, the relative proportion of heads and tails will inevitably fluctuate from one throw to another so that it is never possible, even in principle, to make any absolutely certain prediction. And yet, although prediction is never absolutely certain, it is possible to estimate the limits of uncertainty.

The position is similar in the case of physical observations and measurements. However careful the observer may be, even the simplest measurements, for example, of the length of a rod, when repeated, have been always found to vary. The average of a number of repeated measurements usually becomes more and more steady as the number of measurements is increased. The deviation from the average, i.e., the "error" of each individual measurement is sometimes positive and sometimes negative, and behaves like heads and tails in the tossing of a coin. Fluctuations or variations are thus essential features of all measurements. This is true not only in the physical but also in the biological and social sciences.

This is the crucial point. All knowledge in physical, biological and social sciences is ultimately based on measurements and observations. Every set of measurements is characterized by variation. In fact each set of measurements constitutes only one out of many possible similar sets. Also, the totality of all possible sets constitutes the "population" or "universe" under study. Each set of measurements is thus essentially a sample of the "universe". In order to reach valid conclusions about the population or the universe, it is necessary that the sample should be representative of the universe. In statistical language, the condition for such representativeness is supplied by the fundamental concept of randomness.

The aim of statistical theory is thus to reach general conclusions about the population or the universe on the basis of the sample. And, as all scientific knowledge is based on "samples" of observations and measurements, statistical theory supplies the only valid method of making inductive inferences.

So much for the statistical method in the abstract. I may now make a rapid survey of the scope of the statistical method in the concrete. We may try to construct a mental map, and start by representing pure mathematics by a geometrical point at the centre. A small circle round the centre can represent classical physics in which the form is mathematical but knowledge is, in fact, based on measurements and subject to errors of observation, and hence amenable to statistical treatment.

A second larger circle may represent the wider field of kinetic theory of gases, thermodynamics, and statistical mechanics. In this region of physico-chemical sciences, the factors of variation are often amenable to a large degree of control and the classical method of isolating and studying one single factor at a time is usually available.

We next come to the field of biological (and social) sciences which can be represented by a third larger circle. In 1900, Karl Pearson coined the word "biometry" for the methods appropriate to this region. It is no longer possible to isolate and study one single factor at a time. For example, in agricultural experiments to compare the yield of different varieties of a crop, there are innumerable factors which cannot possibly be isolated such as the fluctuation of soil fertility from one plot to another, root competition, the influence of weather conditions, etc. An altogether new approach became necessary, and was made by R. A. Fisher, just about a quarter of a century ago, in the development of the design of experiments and the analysis of variance. He explained quite clearly:

"No aphorism is more frequently repeated in connexion with field trials than that we must ask Nature few questions, or, ideally, one question at a time. The writer is convinced that this view is wholly mistaken. Nature, he suggests, will best respond to a logical and carefully thought out questionnaire; indeed, if we ask her a single question, she will often refuse to answer a single question, she will often refuse to answer until some other topic has been discussed."(1)[1]

Fluctuations and variations are known to be large and complex. The object now is not to eliminate them, but to allow them scope to come into play in a balanced fashion so that valid inferences may be drawn from the experimental observations(2). Variations are themselves of great importance, and can be used as yardsticks. In fact, once we succeed in measuring the chance variations, it is possible to reach valid conclusions with statistical and probabilistic rigour (but not with mathematical certainty).

Experience has shown the great advantages of the statistical design of experiments in economy of effort and time, and in adaptability not only in agricultural field trials but in technological experiments and resource appraisal of all kinds. For example, suppose we wish to study different methods of treating wood for its better preservation. There are many factors of variation, temperature, humidity, pressure, the use of different chemical agents, etc. The strategy of the statistical method here is to design the experiment in such a way that we may measure the effect of the different factors operating at the same time. Large developments have occurred during the last two decades, and biometrics are finding increasingly fruitful applications in biology and genetics; agriculture and forestry; education and psychology; and the medical and social sciences.

Variations always occur in the process of manufacture. You can not turn out two screws or two rods absolutely identical in size or other specifications. The problem is to maintain the quality (or output) of the manufactured articles within permissible limits of variation. My friend, Dr. W. A. Shewhart, who has spoken on the subject, tackled this problem in the Bell Telephone System. So long as the fluctuations remain stable, production is under statistical control. This was used by Shewhart to develop the method of control charts(3). When fluctuations go beyond the control limits, there is clear indication of change in the conditions of production which is usually of great diagnostic value(4). "Statistical Quality Control" and allied methods created a kind of revolution in the efficiency of production in the USA. during the war. In fact, I have been assured, and the evidence is there, that the large-scale war effort of this country could not have been possible without the help of such statistical methods.

The industrial system does not consist entirely of machines. The human factor is also there, and is a source of large variations. Here also logic indicates, and experience has shown, that statistical methods can be used most effectively in operational research and investigations dealing with the physical, psychological, and social conditions of work.

I may now come to another region, that of sampling surveys, which we may demarcate by drawing a fourth circle in our diagram. Factors of variation are now even more complex, and are not subject to experimental control. This is the field where traditionally the method of the exhaustive census has been used for a long time. In recent years, during the last 10 or 12 years, there have been important developments in the use of the sampling method.

The driving motive in the first instance was economy. The United States of America can afford to conduct an agricultural census which would aim at enumerating every single farm. But in a country like India this is simply unthinkable. In India, it was the overwhelming need of economy which led to the use of sampling methods. In crop production, for example, the experience in India has shown beyond dispute that one can get results with a margin of error not exceeding 2 per cent at a cost of one-tenth or even one-twentieth of the cost of an attempted complete enumeration. Dr. Harrison has referred to the efforts now being made by the FAO to organize a world-wide agricultural census in 1950 or 1951. In many countries, the only possible line of advance will be by the use of the sampling method.

Speed is another important factor. In a sample survey, both the field work and the tabulation of the data can be finished very quickly. In a complete count, the results are usually available when they have already become out of date or when the interest or the possibility of practical applications is mostly gone.

The advantage is not merely in lower costs or greater speed, but what is most remarkable, a sample survey when properly conducted has been usually found to be more accurate than an attempted complete count. The reason is very simple. In a sample survey, only two or three hundred workers are often quite enough against perhaps fifteen or twenty thousand required for a complete count. It is naturally possible to have better trained and more experienced investigators, better inspection, and all-round better quality of work in sample surveys so that we can get much better results. This has been the experience in India, in the USA., and also in the USSR, as far as I could gather from my colleagues on the UN Statistical Commission.

The sampling method has another great advantage. In a sample survey, it is always possible to calculate valid estimates of the margin of uncertainty. With a proper design, it is also possible to estimate (and hence often eliminate) fluctuations arising from investigator bias and other causes. In fact, the survey can almost always be arranged in a way to supply a direct measure of its over-all reliability. For example, consider an area, possibly a whole country, over which a sample survey is being conducted to ascertain, say, crop acreage. It is possible to throw a set of random points on the map and make a physical inspection of the crops at these points. Suppose these points are marked in green on the map, and suppose just one per cent of the land is investigated

[1]Numbers within parentheses refer to items in the bibliography.

in this way. We then get a result based on what we may call the green sample. We can at the same time, throw at random another set of points which we may mark in red on the map and which cover just another one per cent of the land. The green and the red points are like two inter-penetrating clouds, and from each we get an independent estimate. The two estimates are not identical, but if they are in good agreement, we may reasonably conclude that we have got something which is objective.

From each sample, it is also possible to estimate a valid measure of the margin of error, and compare the difference between the two sample results with the margin of error of the difference. Such a comparison would show immediately whether or not the sampling was done under conditions of statistical control. In principle, the sampling method thus has within itself the possibility of ascertaining its own margin of error and hence assessing its own reliability. In a complete count, on the other hand, if any items are missed, or other mistakes are made, we can never know; that is, the margin of uncertainty is completely unknown.

Again, in a sample survey it is not only possible to ascertain the level of precision, but it is also possible to prepare the design of the survey in such a way that the desired precision can be attained at a minimum cost(5).

I have briefly indicated the advantages of statistical sampling. I should also mention that the three methods, the design of experiments, statistical quality control, and sampling surveys are inter-related and supplementary, and used in combination, can lead to great economy and efficiency in the survey of resources, not merely in the sense of cartography, but in the appraisal of the quality of the material, and also how one can control the utilization and hence the conservation of available resources. Statistical sampling (together with statistical experimentation and statistical control) is in fact finding increasing use in such diverse fields as agriculture, demography, commerce and industry, and economic and social studies of all kinds(6).

I may now turn to still another field which we may demarcate by drawing a fifth circle in our diagram. This is the area of free observations in which factors of variation are neither amenable to control, nor to experimentation, and are not even subject to sample surveys. The only thing to do is to undertake a patient collection of observations, and a painstaking investigation of possible statistical connexions between different factors of variation. Although experimentation is not possible, when significant relationships are discovered, it is possible to make predictions and compare such predictions with subsequent observations. This is the field in which statistical correlations and the analysis of time series have been used with great success, for example, in economic and business statistics, the study of weather and river records, or mortality data.

I may give one or two examples. Consider the control of floods. In India, in the province of Orissa, there was a catastrophic flood in the Brahmani river in 1926. The question arose whether the bed of the river had changed. A committee of expert engineers, after a careful study, reached the conclusion that the bed of the river had been raised by about 4 feet. In order to give the same protection from floods, the engineers recommended that flood embankments should be raised by at least 4 feet at a cost of many millions of rupees. This was the conclusion reached by ordinary methods of appraisal; but a fundamental difficulty was that you cannot directly measure the level of the river bed as you cannot have any bench marks.

An entirely different approach was, however, possible with the help of statistical methods. Detailed analysis revealed a close correlation between the rainfall in the catchment and the height of the river. The statistical evidence showed that heavy rainfall in the upper reaches of the river had caused the very high flood (which appeared to the engineers to be of a catastrophic kind). Purely on a statistical basis, the advice could be given with confidence that there was nothing wrong with the river, and it was not necessary to spend millions of rupees to raise the height of the embankments. I gave that advice in 1930. If a mistake had been made, catastrophic floods would have occurred and swept away large portions of the country during the last 20 years(7). This was a practical demonstration that statistics could save a lot of money; and in India, saving 40 or 50 million dollars was not a negligible affair.

I may give another example of a more abstract nature. The motion of the moon gives rise to tides in the sea and the rivers. The motion of the moon must, of course, also cause a tidal effect on the earth's atmosphere. That is, due to the motion of the moon, the pressure of the atmosphere would undergo a cyclic change, and also the temperature (due to adiabatic heating up). The effect is naturally very small. Actual calculations show, for example, that the temperature would rise and fall with an amplitude at certain places of .008°C, that is, less than one-hundredth of a degree, due to the lunar tide. The amplitude of the cyclical change of barometric pressure in certain places would be less than one-thousandth part of an inch. Variations in temperature and pressure from hour to hour or from day to day are enormously larger in comparison. Yet if one has a long series of records, these gross variations, although enormously large, would cancel out and the effect of the lunar tide should be capable of being ascertained by purely statistical methods. This is exactly what Professor Sydney Chapman, F.R.S., of the University of Oxford and his associate workers have done. They have shown by the detailed statistical analysis of a long series of records extending over 50 or 60 years that the gross variations cancel out, and the observed effects of the lunar tide on the earth's atmosphere agree satisfactorily with the calculated values(8). This is a striking example of the great power of the method of correlation analysis.

In this brief review, my aim has been to indicate the wide scope for the use of statistical methods in science and technology. At the abstract level, the aim of statistical theory is to reach general conclusions (about the "universe") from a knowledge of the particular (i.e. the "sample"). At the concrete level, the aim is to collect relevant information (or extract such information from available data) with a view to choose, on a probability basis, the "best" out of two or more possible programmes of action. The statistical method thus supplies, both in theory and in practice, the true logic for making decisions on a scientific and objective basis.

At one end, in classical physics, it is often possible to isolate and study one factor at a time, and the statistical method consists primarily in the adjustment of observations with the help of the classical theory of errors. With more complex systems, the degree of control decreases, and the statistics of assemblages becomes more important as in the kinetic theory of gases, thermodynamics, and statistical mechanics. In the field of biometry, factors of variation become still more important and are inextricably mixed up and cannot possibly be studied in isolation. The strategy changes, and the aim becomes to study more than one factor at the same time with the help of appropriate designs of experiments, analysis of variance, and statistical correlation. A further extension is the use of control charts, and the methods of statistical quality control. Beyond this lies another wide field in which the most fruitful line of advance is by the use of sampling surveys (9). The degree of control is small, but predictions on the basis of statistical sampling are still possible and capable of being corroborated or refuted by subsequent observations. Finally, there is the field of free observations where conclusions can be drawn (and predictions, subject to verification, can be made), only on the basis of detailed statistical correlation and analysis.

Over the whole field, the statistical method supplies the basis of uncertain inference (as distinguished from the absolutely certain deductions of formal logic and mathematics). The margin of uncertainty in statistical inference, in principle, is ascertainable; and its magnitude depends on the degree of control to which the factors of variation are amenable and on the available quantity of information. The use of statistical method can be, therefore, commended with confidence to all persons interested in resource appraisal, utilization, and conservation.

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Mr. De Vries: I would first like to make a small remark on the introduction of Professor Mahalanobis from India. Our experience shows the value of what he said of observations and trying to make correlations and results from those observations when they are made in the right way. In agriculture especially there are so many factors which work together, and experiments are very difficult and costly. I think that these developments can be worked out more fully in the future, and we need more international cooperation in this respect.

My second remark is with regard to the whole idea of this Conference. When statistics are made, they should be comparable internationally. When statistics in the various countries are on a different basis, they lose much of their value. I think one of the conclusions of this Conference should be that the statistical tools used in the appraisal of resources in the world can be sharpened by making them on the same basis all over the world.

In the papers submitted to the Conference, the Secretary-General for this Conference said that unfortunately there were not enough figures in the field of resource appraisal to present to this Conference a review of the world's resources. My question is: Could the United Nations, or any body of the United Nations or any scientific body, go on with the work on statistics which so far has been done but unfortunately is not sufficiently complete to be presented to this Conference? Are there any ideas in the Secretariat that the work can be done, and if so, how can the nations and scientists work together to attain better and sharper statistical tools?

The Chairman: As there are no other speakers, I shall adjourn the meeting.

The Adaptation of Resource Programmes

Friday Afternoon, 26 August 1949

Chairman:

Egbert DE VRIES, Counsellor for Economic Affairs to the Ministry of Overseas Territories, The Hague, Netherlands

Contributed Papers:

Economic Considerations in Conservation and Development
Stephen RAUSHENBUSH, Washington, D.C.

Application of Simple Conservation and Utilization Practices
B. A. KEEN, F.R.S., Director, East African Agriculture and Forestry Research Organization, Nairobi, Kenya

Organizing Rural People for the Proper Use and Conservation of Natural Resources
M. M. COADY, Director, Extension Department, St. Francis Xavier University, Antigonish, Nova Scotia, Canada

Application of Simple Conservation and Land-Use Practices in China
J. Lossing BUCK, Chief, Land-Use Branch, Agriculture Division, Food and Agriculture Organization of the United Nations

Invited Discussant:

Economic Considerations in Conservation and Development
John D. BLACK, Harvard University, Cambridge, Mass., U.S.A.

Discussion:

Mr. COPPOCK

Programme Director:

Carter GOODRICH

Programme Officer:

Herbert SCHIMMEL

Mr. Keen's paper was presented by Mr. G. F. Clay, Agricultural Adviser to the Secretary of State for the Colonies, London, England.

The CHAIRMAN: I declare open the tenth plenary meeting of the United Nations Scientific Conference on the Conservation and Utilization of Resources.

The subject of this afternoon's plenary meeting is "The Adaptation of Resource Programmes". I think that means the adaptation of resource programmes to human needs, to the development of human society. The sociological and economic problems have come up in this Conference many times, when we spoke about more technical subjects. This afternoon is the time when the programme gives us full opportunity to discuss the implications of conservation and waste upon the development of human society. I think that we all want a rapid development without waste. It is very difficult, as we have already seen, to reconcile conservation and development.

We are very glad to have a number of able speakers for this afternoon. The programme falls into two large parts, the first being the assessment of conservation programmes, in a global way, and the second the application of simple conservation and utilization practices in different parts of the world. That brings the solution to the problem we have before us today more to the practical field where it has been worked out recently, or, in the case of China, for some thousands of years.

I am very glad to introduce to you now—although I need not introduce him to you, but would merely ask him to come to the rostrum—Dr. Stephen Raushenbush of the Preparatory Committee, who has already contributed so much to this Conference. He will speak to us about economic considerations in conservation and development.

Mr. RAUSHENBUSH *delivered the following paper:*

Economic Considerations in Conservation and Development

STEPHEN RAUSHENBUSH

I. ALTERNATIVE RESOURCE USES

The determination of efficient use, and the rate of use, of resources is the essential problem in any discussion of resource utilization or conservation. That is a concept which changes with time and social climate, as well as with price and the consequent cost-benefit relationships.

The impact of this problem can be seen quickly on an international scale by a mention of the resource allocations which may have to be made in view of the increasing world population in the under-developed areas. We may take Asia, Africa, South and Central America as a group for statistical purposes. It seems clear that, given food, the present population of 1,625 million may increase by the year 2000 to 2,936 million at present growth rates. That would mean 1,311 million new people at the end of the next 50 years.[1]

The outside world would not think for a moment of doing this, but if this new population were to be fed by the rest of the world, over these 50 years, a meagre ration of ½ kilogramme of rice per day, the expense would be more than $83,000 million.[2] They would starve the moment aid was interrupted. They would have no means of paying for the food.

A more possible alternative would be to aid those new peoples to establish sufficient land so that they could eat about as much as the present people, but no better. That is a poor diet. That would require over 394 million new hectares,[3] operated at the efficiency of the present land. At $75 of original investment per hectare (about $30 per acre)[4] the original investment of resources would amount to about $29,500 million during the fifty-year period. On top of that, a soil conservation investment in present lands of over $8,000 million would be necessary. The total investment would be close to $38,000 million. The people would still eat very poorly, and would still have no new means of servicing or repaying the investment.

A third alternative resource allocation would be that of helping these growing peoples, old and new, to feed themselves on a level of 2,800-3,000 calories. The land presently in use would have to be increased greatly in productivity to make this possible, and a possible limit of 450 million hectares of new land in this group of continents[5] would have to be opened up also. The application of new seeds, insect and disease control, and technique of cultivation, as well as fertilizer, would all have to be made. At $77 per hectare, or its equivalent in increased productivity, the original investment might be in the neighbourhood of $73,000 million over the period. The productivity of old and new land would have to be increased by an almost unbelievable 41 per cent over the present efficiency.[6] As a result of all this, the old and new people would eat much better than before. They would still have no new means of repaying the investment.

A fourth alternative use of resources would be that of channelling savings in and outside the area in question into industrialization. Basically, income goes up with the increase in the proportion of the population engaged

[1]Given 1,625,000,000 people in those areas at the beginning of 1951. The rate of increase is taken at 1.19 per cent, based on data from W. S. Thompson in *Population Problems,* for 34 nations, on which data on industrialization was also available. The total in the year 2000 would then be 2,935.8 million; the increase 1,310.8 million.

[2]The estimate is based on 30,500 million food-years over the 50 year period. The estimate for delivered rice is $15.00 per metric ton, or $.015 per kilogramme. One-half kilogramme for one food-year of 365 days would then cost $2.73. The total cost would be $83,265 million.

[3]1,311 million additional people each requiring 0.301 hectare *per capita* (0.746 acre). The basic figures taken for 1950 were 0.26 hectare *per capita* for Asia, 0.46 hectare for Central and South America, and 0.5 hectare for Africa. The total land available and used in 1951 was taken as 492,300,000 hectares (1,216 million acres).

[4]The figure of $75 per hectare ($30.36 per acre) was derived from the author's study, *Our Conservation Job* (United States 1949), in which $25 per acre is found to be the cost of adequate soil conservation work on wasted land in the United States

[5]Charles E. Kellogg, *Food: Problems and Prospects,* United States, 1949.

[6]See Table 2.

in non-agricultural activities. Education and urbanization are by-products of that increase and all three together have the effect of lowering the rate of population. For a change of 10 per cent in non-agricultural population the net rate of increase seems to go down by 1.2 persons per 1,000.[7] So one of the slow but positive results of this fourth alternative would be a gradual decrease in the rate of population growth in these areas.

If it were found desirable to shift population to industry and commerce by reducing the population engaged in agriculture from 76 per cent to 50 per cent, to do so while the population was growing and within fifty years, an investment of $4,000 million annually from foreign sources and $5,000 million from domestic sources annually would do it by the year 2000.[8] Apparently the over-all income could be increased by 161 per cent—an increase of $262,000 million (from $162,500 million) at the end of the period.[9] The *per capita* income could go from $100 to $156 (see Table 1). Interest and amortization on the investment at 6 per cent and the financing would not go over 6.7 per cent during the period, and could be paid. The population would be 215 million less at the end of the period than it would probably be without such industrialization.

Here, in fairly simple form, we have a significant illustration of the effects of quite different resource uses and resource investments. The estimates are necessarily rough, but they give some picture of the order of magnitude that is involved in the choices. The most efficient use of resources is the one which most closely approximates the final goal which we find desirable.

II. CONSERVATION IN A COMPETITIVE ECONOMY

One of the first questions which conservationists throughout the world ask us is, "How does it happen that the United States, one of the richest of the countries, has done so badly with its conservation job?" This question carries implications that less fortunate countries can obviously not afford such a luxury as conservation. The answer is that "this country could have afforded conservation at almost every period in its history, but chose rapid development instead, and refused until recently to face the problem of future shortages." The answer leads us right into a major difficulty of conservation economics.

A more complete explanation is that we, like any other nation with open frontiers, low resource-values but high capital and labour costs, left our resource future to the mercy of the price system in a competitive economy, and now find ourselves with a depleted resource base as a result. The price system does not emphasize future values as much as present values. The large cyclical price movements that we have experienced over the past one hundred and forty years made it plain to the resource owner, at least once every decade, that future values were uncertain.

This uncertainty about returns has hindered voluntary conservation greatly in this country. Conservation even with a possible 15 per cent increase in soil productivity must have seemed too risky. Even if the resource owner had been able to borrow for soil conservation purposes at only 6 per cent (much lower than the 140 year average) and pay off in ten years, he would have taken a loss about three out of ten times. The cotton grower would have found only one decade out of the hundred and forty years in which there was no year of loss, and the owners of wheat and corn lands fared little better. (I have illustrated this by Charts 2, 3, and 4 entitled Sample Conservation Investments for corn, wheat and cotton).[10] Between 1910 and 1935 there was no five-year period in which the cotton grower could be sure that the price he would receive for a year's crop would be greater than his cost of production. (Chart 5).[11]

But the possibility of loss three out of ten times is far too great to induce a farmer to invest his own savings or a bank to loan on the risk. The situation would have been quite different if conservation loans at 3 per cent had been available. The price risks of the business and weather cycles would have been canceled out to a large extent. The years of loss would have been cut from 42 to 20 for corn. Similiarly, investment in forest conser-

[7]Trend of natural increase based on per cent of industrialization: 33 nations from Colin Clark, *Conditions of Economic Progress*, (London), and Louis H. Bean, *International Industrialization and Per Capita Income*, (New York). Where X is the per cent of the population in non-agricultural occupations, Y=36.55—.25 XX for birthrates, and 21.83—.131 X for death rates. The trend of net increase shows a drop of 0.12 per cent for every 1 per cent shift from agricultural occupations into non-agricultural.

[8]The investment per person in non-agricultural occupations was taken at $1,200, and represents an average between industrial, commercial and service occupations (see FAO report of June 1949 on *Investment Requirements*, where $1,000 is used). The use of $4,000 million annually from foreign sources is arbitrary and follows the FAO report. The amount of domestic investment is the difference between the total sum required to transfer 1 per cent of the population out of agricultural labour every 2 years ($1,200 times the increase in non-agricultural labour force) and 2 X $4,000 million. The sub-totals are $200,000 million from foreign sources and $249,000 million from domestic sources, a total of $449,000 million for 50 years.

[9]The increase in *per capita* income was taken from the trend curve in Chart 1, based on 11 nations with 25 to 50 per cent industrialization in 1924-35, and incomes under $300 (US dollars 1948) on which data were available from Clark and Bean (footnote 7). The curve is log y=1.594644+.0167749x. The annual income was based on the population at the beginning of 1951 (1,625 millions). The slope of investment on income is 2.43.

[10]The method used in Charts 2 (Wheat), 3 (Corn), and 4 (Cotton), was that of taking a hypothetical borrowing in each year of the value of 10 bushels of wheat or corn, and 100 pounds of cotton at the then current prices for the purposes of soil conservation. An increase in production of 1.5 bushels of wheat or corn for each year of a ten-year period for each 10 bushels' investment resulted in an increase of 15 bushels over the ten-year period, from which the loan has to be repaid with interest at 6 per cent. The average annual payment to service and retire the loan was 13,5868 per cent. The average ten-year price was then calculated in order to find the average return on these 15 bushels resulting from conservation. Production costs are held stable. The solid line on the charts represents the requirements in current dollars of the loan with interest in ten years. The broken line represents the average price received for 15 bushels.

For cotton the investment taken was the current value of 100 pounds and the total additional return was 150 pounds.

These sample charts indicate the extent of risk in past conservation work due to variable prices. The wheat farmer would have found 10 decades out of 14 in which there were some years in which his investment would not have repaid itself in ten years; the corn and cotton farmers would have found 13 out of 14 decades. The years in which actual loss on the investment would have been incurred were:

Cotton	41 out of 140	29.2%
Corn	42 out of 139	30.2% (6%); 14.4% (3%)
Wheat	36 out of 131	27.5%

[11]Chart 5 shows that the varying production cotton costs from 1910 to 1946 (U. S. Department of Agriculture figures) actually made the risk for the American cotton grower greater than indicated in Chart 4. Before the Government support programs of the 1930's and 1940's he stood to lose in 11 years out of 35.

vation shows even a larger degree of risk. Put in one way, in our earlier history the investor would never have been able to pay off a 6 per cent loan by marketing in the tenth year, with accumulated interest, unless his trees had grown beyond all known rates. In our later history he might have done so in only 10 years out of 33. Put in another way, in 64 per cent of the cases he would have needed a growth-rate of from 5 to over 10 per cent each year in order to break even see Chart 6).[12]

Note that it is not evident from these studies that high resource prices bring conservation and low ones bring exploitation. All that they indicate is that over a 140-year period (1800-1940) the risk of low prices in the future has been too great to warrant a resource owner to invest much high-priced capital. The increased price of land did not warrant it generally. Also, since 1900 the ratio of land values to labour costs has been declining.

The general theory is that high resource values do, in fact, allow for more conservation than low values, and I agree with it if the important qualification is added that practically no sharp drops in return (lower prices, higher costs) are to be expected in the future. This is a guarantee which no competitive economies have been able to perfect—although we may yet do so, and are moving in that direction.

Meanwhile we have been living through many generations in which both high and low prices brought exploitation and wasteful resource use. That has been true of farm land, forests, oil wells, and coal mines. In time of recession, forest owners found that they had to log cheaply and plentifully to meet competition and their debt charges. In boom time, they also found they had to cut heavily, this time to recoup their losses in depressions and to provide a reserve against future depressions, and also to match high labour costs with lower unit overhead. Similarly our oil wells were over-pumped during depressions and booms alike until a production limit was imposed, which had conservation effects. Land was worked in much the same way. Coal seams, at least in small mines, suffered some of the same destruction, with fine impartiality between periods of high and low prices.

To state as an economic theory the difficulty inherent in conservation: The conflict between the present and the future which is symbolized by conservation (increased present costs, delayed returns) is never settled against the present by the present owner, and the future enters the market as a bargaining force only in the case of shortages evident beyond question. Only the government is the guardian of the interests of the future, and while those interests are large, they are not always powerful in the peculiar competition which makes up the governing process.

This is simply another way of saying that under any high interest arrangements rapid exploitation is more profitable to the resource owner than postponement and conservation, and that only a certainty of future returns and low interest rates (a riskless situation) will make conservation an attractive business affair, in competition with other business possibilities. If it were clear to the resource owner that the present value of the future return to be obtained after conservation work would assuredly be enough to cover costs and profits, the fact that the ultimate profit was somewhat remote in time would not deter conservation investment. It could be liquidated at any time. It would have sufficient value at any time. But this certainty of increasing values has not existed. The risks have been too great, in relation to the cost of capital, to justify the conservation.

Now we have to deal with the results of this process. The failure of the price system to act as a conservation force can also be seen in our waste of natural gas in oil fields through flaring. Until recently we lost as much energy that way annually as the whole TVA system produced. The cost of channelling and processing that oil-field gas was higher than the market value of other nearby natural gas. Its use did not pay. Although little doubt exists about the future higher value of this wasted energy, the price system has provided no mechanism to protect that future. Similarly in our use of growingly scarce petroleum for steam-raising, and the fact that the production of oil from coal is presently unprofitable and consequently has not been developed, we can see the lack of any desirable mechanism for equating future needs and social costs with present practices. There is no national policy that will protect future resource users from future scarcity prices by an expenditure that will eliminate present wastefulness.

Some picture of the magnitude of the sums involved is given by the price-fixing experience in the last two wars in this country. In the First World War the Government paid the marginal price for all basic production. In the Second World War it paid one price for the bulk of its needs, and subsidized marginal oil, copper and other producers. The price administrator has told me that he estimated the saving at $50,000 million over a four-year war period. Lack of national policy in peace-time to avoid future shortages will result in consumer payments of marginal prices and similar sums as a matter of course. The United Kingdom is now investing 4 per cent of its national income in the health conservation of its human resources. Most of this is investment rather than maintenance, and a relatively small resultant increase in national productivity would justify it economically.

We are now, however, in a position where two factors may be basically changing the whole conservation picture. First, not only in this country, but in other areas, low-cost governmental credit is about at the rate that the growth-rate of trees requires for profitable use of such credit, and crop and pasture land can do a little better than repay loans with delayed and accumulated interest at present costs of capital.

We are only beginning to recognize the possibilities of

[12]Chart 6 shows hypothetical investments in forests, each year at current prices, of a sum equal to the value of 1,000 board feet of lumber in that year plus accumulated interest at 6 per cent (the broken line). It also shows the mill price of 1,000 board feet in the tenth year after the investment (the solid line). The difference between the two lines represents the amount of growth that is needed in the forest to make good the investment. The forest would have to grow at the following rates, for the investment to pay off at such a rate of interest, ten years after the loan was made:

0.0-2.5%	15 years	35.8%	5.1- 7.5%	22 years	64.2%
2.6-5.0%	14 years		7.6-10.0%	26 years	
			Over 10	4 years	

such low-cost credit for conservation work. In many under-developed areas credit now costs 15 per cent or more, and that in itself is enough to stop most conservation work before it gets started. It has so operated. In the United States about a hundred and thirty years were required for credit on farm-improvement loans to drop from 12 per cent to 5 per cent. That was the period of great exploitation.

Second, the increasing population of the world, coupled with a reasonable certainty of industrialization in the under-developed areas, increases the possibility of high land-values and resource-values. The effort of the scientists represented here to increase productivity and to make possible the opening up of new land areas will not, I believe, reduce the anticipated demand for food to the point of decreasing land values, in the key areas of increasing population and new industrialization. Over the next fifty years or more, raw material prices will probably be moving upward generally. There is a better chance than ever before that the uncertainty about prices, which was discussed earlier as a major cause for conservation failure, will grow less, and even sharply less. It would take an international organization with some wide financial powers, to carry over the probable short-term dips in such a rising level, but that difficulty is not insoluble.

This combination, I believe, represents a new opportunity for conservationists in competitive (internally uncontrolled) economies to achieve their conservation purposes. It should be examined and used. In the United States, I, for one, have attempted to make the combination between these two trends by proposing a National Resources Corporation to loan at low-cost government rates (2½ per cent for forests, 3½ per cent for soil conservation) to private resource owners, with a sharing of any windfall profits (60 per cent to the owner, 40 per cent to the investor) due to the upward price movements in resources which are anticipated. The suggestion was that loans of $18,000 million would pretty well complete practically all of our needed soil and forest conservation, and that these loans could be repaid within fifty years, after allowing moratoriums for development and hardship periods. Better combinations of these two new factors can doubtless be made for other areas by conservationists.

During the depression of the 1930's the United States Government undertook to aid farmers through conservation payments of various types. The achievement was considerable, and is being discussed in the morning meetings. There is a considerable movement toward forest credit. Yet total reliance on the government as the agent, trustee and paymaster for the future is undesirable. This is not an expression of a philosophy, but a comment on effectiveness. We have in the United States adequate and visible evidence that other social demands may push aside and make impossible an adequate conservation job. Countries with more rapidly increasing population and limited land areas will also find that the rapid growth of demands on their treasuries for social insurance, education, and health will make it highly desirable for them to move in the direction of well-planned credit to resource owners in order to obtain good conservation practices, instead of moving toward subsidies from their treasuries. Conservation encounters another difficulty in a competitive economy: It becomes more possible as competition decreases. The large lumber or pulp company or the large industrialized farm whose owners have the power to get markets and have some capital reserves, can do more to obtain sustained yield, and to effect soil and forest conservation than the small resource owner without capital. Our Forest Service figures show that this pattern is being followed quite uniformly.

The type of society that is wanted by man enters into the conservation picture here, just as it did in examples I gave earlier (section I) of resource allocations needed to feed poorly or well, and to industrialize, the under-developed areas. If, for example, the power of large capital groupings is to be feared, and small, independent men are to be held at a premium, then obviously means must be found to make it possible for the latter to match the former in access to capital. If the banking system can recognize that conservation investments do not follow the pattern of mercantile loans, but require developmental and hardship periods, without capital payments, it could even up the existing inequality which equates large ownership more nearly (although still very unsatisfactorily) with conservation than small ownership. If the banking system trips over its cultural lag, it would be efficient for the government to help equalize the situation by loans to resource owners in a twofold national interest.

It should also be pointed out that the risks of the market and of conservation effort alike fall most heavily on the tenant in any competitive system. The soil he rents was not, in the past at least, protected through the landlord's efforts, for reasons given earlier. The pressure on the tenant was to "mine the soil" and make what he could while he was there. And the soil grew steadily poorer. The tenant could not win. The uncertainty of price and market gave him no security in his tenure of the land. Other competitors could take his place any year. In cotton, for example (Chart 5), growers did not get back their production costs in 11 years out of 35 between 1910 and 1945. So the tenant had no incentive to invest his labour in land he might lose at any time, and would probably never own. This situation changed somewhat with the war years of the past decade. But clearly soil conservation and a stable land base cannot be obtained in a competitive economy if there is no obligation on the landowner to keep his land in good shape. I hope the handling of this tenant problem by some other nations with a record better than ours, will be discussed.

There may be no other efficient and rapid way to obtain the sound land and forest base the nation needs than for the national government, as the only guardian of the future, to force the level of competition up a notch in slightly higher costs and prices by requiring a minimum of good conservation practices from all land and forest owners. A loan programme of the type suggested could ease the burden of that requirement, or it might possibly be adequate by itself if it appeared to a sufficient number of resource owners that the future price trend was clearly upward.

This discussion of the difficulties of conservation in a competitive economy carries no implication that there is always better use of resources in a non-competitive economy. If this nation at its foundation had decided to hold on to all its natural resources instead of giving them away, it would now probably have enough revenues to meet a $42,000 million budget without taxation or borrowing. However, it would not have been as industrially developed as it is or as able to aid in the fight against Fascism as it was, and there probably would be no United Nations today. Or if this nation had closed down its frontier until land across the border became so valuable that good conservation would have been obtained on that land, and then opened only a small piece of new land, we would have had excellent conservation across 3,000 miles instead of our sorry history of resource exploitation.[13] However, we would today still be a small nation.

Conservation and development, the future and the present, are certainly in some conflict. Given a certain point of demand, however, it is demonstrable, I believe, that the visible social cost of scarcity can far exceed the present cost of conservation, with consequently increased production. Scarcities in lumber and oil cost the people of this country $1,500 million annually in increases above other price levels during 1947 and 1948, and the prospect of any such shortage situation in the future would justify economically considerable present sacrifices.[14] If my belief about the general upward movement of raw material prices is correct, many underdeveloped countries will find that the return they can expect from conservation investment will be easily justified in economic terms by the time the increased production results from the conservation. There may, in this present and prospective situation, be less conflict between present and future than other nations have experienced in the past.

III. CONSERVATION AND PEACE

There is some belief that when people press too heavily on resources, nations will find it preferable to attempt to take new land by warfare than to attempt to adjust themselves by reducing their populations. Conservation is therefore considered to be an alternative to war because conserved land will yield more food and fibre, ease the pressure, and consequently help hold that balance called peace. Certainly ancient history is full of accounts of nomads fighting for greener pastures, and of Romans fighting and levying food tributes abroad at a time when their own soil was deteriorating badly.

This belief, however, requires restatement in view of the industrial structure of the modern world. Perhaps the basic fact in conservation over the past century is the transformation of soil in many areas from a localized foundation for an independent way of life into a part of a national and then of an international economy. The growing world population demands exportable production, and most of that demand was met. In the process the owners of farmland became subject to the dislocations of an international trade system and remote weather conditions. In the industrialization process many nations became dependent on food imports.

In the recent World War, Germany, Japan and Italy all attempted to conquer new land areas. The first two countries had good conservation practices. Italy had done less. All three offset their conservation efforts somewhat by encouraging more population pressure. There has been an attempt in recent years to explain the role of these nations in the last World War by pointing out that the essential economic characteristics of Germany and Japan, at least, were not those dealing with conservation, but those that came from their requirement for food imports from abroad. Their rulers saw the need for markets for industrial products to pay for that food. They wanted security for those markets. This was something which the tight economic world of the 1930's certainly did not give them or anyone else. There was then no unity of agriculture and industry possible that transcended national sovereignties. There is not yet. These nations, the argument runs, fought for security of markets rather than for land. Therefore, until all industrial, food-importing nations are certain of industrial markets, wars are bound to recur, and the food-importing industrial nations are going to be the ones that start them.[15]

There is obviously much more to the picture of resource use and peace than this. Italy's historic chief export crop was human labour (persons who were also purchasers of Italian specialties) in return for remittances and customers. In the early 1920's this export was heavily curtailed when other nations stopped immigration. This was a greater economic blow than any struck at defeated Germany after the First World War. This external measure accelerated the internal unbalance in Italy's resource situation, helped in creating dictatorship, and was then used to make war for land-and-immigration-opportunity seem the lesser evil to the people.

In Germany, it was the prolonged use of land, fuel and mineral resources in combination with a dictatorial State which drove that nation to its several attempts at the conquest of Europe. During one hundred years German industry had become a fighting branch of the State, and natural resources had been devoted to objectives which made the State strong instead of those which would make the people prosperous. Protective measures, applied against Russian and American wheat as a war insurance, cut off the opportunities for foreign sales of German industrial products. In turn, protection of industry brought cartels, high domestic prices and regulation of production, and the dumping of goods abroad to destroy competition. Together, these factors created an over-specialization in heavy industries instead of a development of the finishing industries which could have allowed for a higher living standard, more imports and closer ties with world markets. The terms of trade went sharply adverse between 1933 and 1937 as they did in Italy and Japan.[16] The survival of this top-heavy unbalanced economy began to seem dependent upon conquest or miracles, or both. The basic pattern of re-

[13]This illustration was first used by L. C. Gray in an article in the *Quarterly Journal of Economics*, May 1913.

[14]See *Our Conservation Job* (1949), Public Affairs Institute, Washington, D.C., by the present writer.

[15]See Arthur P. Chew, *Plowshares Into Swords*, New York, 1948, and Frank A. Pearson and Floyd A. Harper, *The World's Hunger*, New York, 1945.

[16]See Colin Clark, *Conditions of Economic Progress*, London, 1940, page 256.

Terms of Trade (1927=100)

	1933	*1937*	*Adverse change*
Germany	139.2	114.3	24.9
Italy	97.0	67.7	29.3
Japan	81.9	60.5	21.4
United States	137.8	128.9	8.9
France	118.9	113.7	5.2
United Kingdom	122.3	107.3	15.0

source use is still unstable.[17] Enormous technological progress was accompanied by a conscientious disavowal by the professionally trained specialists of concern in the national use of resources over and above their own specialties, and this irresponsibility was an outstanding contribution to disaster.

Without accepting the full implications of the argument that secure access to food and other raw materials through secure foreign markets for industrial goods is the *sine qua non* of peace, it can be concluded that food-importing, population-heavy nations which attempt autarchic arrangements will necessarily have limited choices of action in the long run. It can also be pointed out that under-developed nations might well couple their industrialization programmes with agricultural developments so that the point of future panic over foreign markets for the industrial goods they may need to sell in order to buy future food, will be postponed as far in time as possible. The Food and Agriculture Organization has, to its credit, constantly insisted on very adequate agricultural development, to go hand-in-hand with new industry. In this way, some obvious mismanagement of resources that will run afoul of the still uncertain field of world trade may be avoided.

To restate this, a national pattern of resource use can be directed either toward world interchange of products, and peace, or toward autarchy and war; and conservation is an important part of any nation's resource pattern.

IV. FACTORS IN ECONOMIC GROWTH—UNDER-DEVELOPED AREAS

In this field we are dealing with the demonstrably provable proposition that the shift of a percentage of the population from primary to secondary and tertiary occupations can increase income. (See section I).

It would be helpful if we could reach a common agreement on the necessary combination of dynamic factors that is essential for successful industrialization of the under-developed areas. I should like to name and have you consider, several factors in such a combination, with full awareness that the mathematicians have not gone very far in their work on the peculiar organized complexity that is involved in such industrial development.

1. We may start with access to technology and education, both fields being ably represented here. Let us say first that education must carry at least one concept about wealth and income in advance of successful development: That increased wealth and income result only from increased production by men and machinery—not from merchandizing or speculation in themselves. This concept should, naturally, carry with it an understanding of wealth as productive power rather than as an accumulation of tokens. The capability of obtaining a national plant that can produce things is far more significant for a nation's future than an accumulation of token wealth.

2. Second, there must be access to capital at low cost. The significance of this factor for conservation has been developed earlier (section II). For industries using something less than the world's most accessible and low cost supplies as basic raw materials, this is an essential. Low cost capital, however, requires and involves a minimum of risks, a minimum of failures, and therefore a maximum of intelligent advance programming. It requires a minimum of governmental instability. In ordinary circumstances, it would be desirable to have a large part of the capital made up of shares rather than debt, to allow a fair amount of "get-going" time for a new industry. But the holders of common shares should not, in return for the delay in receiving their reward, be allowed to get into a position of forcing an inefficient production and distribution system on the new industry.

3. Third, the widest possible use of that universal tool, electric energy, should be made. Next to low cost capital, it seems to be the most dynamic factor in industrial development. If it is really low-cost energy, and can be marketed nearly at cost (instead of being used as a profit-source itself on a restricted use—high cost basis), it can create many industrial opportunities, many comforts, new ways of doing things. It takes away some of the cost burden of transportation. It breaks down the isolation of communities separated by mountains. Many industries in which the energy cost is a large part of the total cost of production, are basic to both industrial and agricultural development.[18] Low-grade ores acquire marketable value when they can be processed by low-cost energy. From the large energy-using electro-metallurgical and chemical industries, a whole series of fabricating plants can, in turn, be developed.

Industrial development is not furthered when energy costs 40 cents per kilowatt-hour as in some places in Central America. There labour costs are only half that much per hour. The ratio is adverse, 2:1. In Canada and the United States, the industrial ratio is nearer 1:50 (2 cents per kilowatt-hour, 100 cents per man-hour), and in the electro-metallurgical plants it is nearer 1:1000 (2/10 cents per kilowatt-hour and 200 cents per man-hour).

Just as the use of local petroleum resources for household fuel can save the land from erosion around the big cities where the charcoal-burners have carried on their inefficient devastation for centuries, the use of hydroelectric power can conserve local wood-use for higher purposes and save foreign exchange otherwise used for fuel imports. Almost every great movement forward of physical progress has been coupled with a substitution of a new kind of energy for an old one, from the invention of the wheel onward. If and when atomic energy becomes available, perhaps at 1½ to 2 cents per kilowatt-hour, a considerable number of fuel-less, power-less areas will be able to introduce irrigation pumping and mineral developments that are now impossible.

4. To obtain development there must also be increasing consumption. Consequently there must be a conscious insistence on a reversal of the present practice in many areas of a small production-volume and high unit-prices. The development of the low-unit markup and the mass market, within the widest possible tariff-free area, alone allows for mass-production methods, their efficiencies,

[17] See A. J. P. Taylor, *Course of German History*, London, 1945; also J. H. Clapham, *Economic Development of France and Germany*, Cambridge, 1921.

[18] Energy cost as percentage of the cost of production is:

	Per cent		*Per cent*
Aluminum	20	Cement[a]	15-26
Chlorine-caustic soda	10	Brick	20
Phosphate fertilizer	33	Flat glass	7-10
Chemical nitrogen	22	Iron and steel	12

[a] With coal costing $2 to $6 per net ton.

their increase of *per capita* and national income. The monopolistic factor, agent and enterprise are doing their nation a disservice in insisting on the old colonial way of doing business. The great innovation of North American industry is less its celebrated technological progress than its revolutionary discovery that the greatest total profit-volume can be obtained through low prices and small profits per unit. However, North American industry had the advantage of a large tariff-free area in which to achieve this invention. Similarly, there must be a conscious effort to keep a wide distribution of all income so that savings will not be excessive, and in turn to force a continuous high level of investment in order to maintain a high income level. An approach to equality of income tends to establish a high national level without requiring excessively heavy investments, which are hardly obtainable in areas without large present accumulations of capital.[19] This is only another way of saying that there has to be growth for any economic or political system to survive.

Industrial growth always has to carry the burden of some cultural-economic lag. Just as our southern States obtained Negro slaves because they were profitable in the development of cotton and tobacco, and then found that the presence of the slaves determined the future economic growth of the South for many decades, so any continuation of the past practices of the importing agent or monopolist, under which high profits are obtained on small sales of imported or local goods, can hold back industrial development considerably. In the capital city of a certain great nation light and power are now being shut off nightly in different neighbourhoods because the power-plant owners will not let cheaper hydroelectric power come into competition with their old plant. A nation-wide transmission system is blocked. Refrigeration and home-cooling are blocked. It is demonstrable that the retirement of these owners on an annuity equal to their present profits, and the introduction of cheaper energy, would be rapidly paid for from the increased national income.

In this connexion, it should be pointed out that there can readily be a hampering confusion about what are the creative forces of industrialization and what are the results. Capital investment and technology are certainly among the former. Social security is one of the possible results. It is not a cause. If demands for an immediate carbon copy of all the social security progress of the past fifty years in the highly industrialized areas are asserted in an economy that has no surplus, or inadequate surplus, for investment, the development process can not only be retarded, but prevented from starting at all.

Certainly one of the first beneficiaries of industrialization should and would be the labour groups in the underdeveloped areas. Higher consumption levels on their part are as necessary for development as higher investment levels. The terms of trade have operated against these areas for many years. The value of manufactured goods which they were able to obtain for a given quantity of raw materials may have declined by as much as 40 per cent over the past two generations. Partly because of this fact, these areas are not industrialized. They have supported a higher living standard in the industrialized areas. The latter have not supported such a standard in the poorer parts of the world.[20] Now it will take both higher raw material prices (which I expect) and much more than the past rate of investment from the industrial areas to restore, let alone improve, the older relationship. Through a fairly free saving and investment process the labour group in these areas can gain far more in twenty years than by an attempt to secure everything they want and need before their nation's economy can afford it.

[19]See Colin Clark, *op. cit.*, chapter XV.

[20]See H. W. Singer in *Social Research*, March 1949, New York.

5. Careful timing and single-agency responsibility for industrial and resource development are equally important, and necessarily go together.

There is usually little chance that loans for roads, harbours, power plants and railroads can pay their costs unless and until industry, improved agriculture, and trade are there to use them. A basic task is to have them all come together at about the same time, so that industry can use and pay for public works as soon as the latter are ready. Another obligation is to take all the elements of resource development and conservation into consideration in every development project. This realization of the essential unity of resource use and conservation is a fairly recent achievement. Now we all accept the idea that to build dams without providing soil and forest conservation work is to waste energy, capital and resources.

We have made all these mistakes and some others in the United States. In the Missouri basin where $6,000 million will be spent, we proceeded without any assurance that the farmers in the semi-humid areas would want to pay high costs for water. We planned the whole water job without counting soil conservation costs until after the river-plan was frozen and the dams begun. We had only vague hopes about navigation possibilities, and calculated social benefits from navigation without counting in the losses that the railroads and their shippers outside the area would thereby suffer. We are still not certain whether there will be enough water for both navigation and irrigation, and are uncertain about both power costs per unit and the power revenues, since both these other interests create an irregular river flow. In the process, we have developed the unfortunate concept of the "residual dependent variable" under which hydroelectric power pays whatever the farmers choose not to pay, and that fact may yet vitiate the full value of much hydro-power development in our West. The Missouri is not a single-agency development. It is the result of a competition between several existing, separate-function agencies racing to prevent single-agency operations.[21] In earlier days, irrigation projects were started in such rough shape that one or two generations of farmers were forced into bankruptcy before the land could be worked profitably. These are mistakes few nations can afford to duplicate.

6. A conscious coupling of agricultural expansion and conservation with industrial development is needed for the dual purpose of supplying industrial workers with food and removing some of the pressure toward new foreign markets for industrial exports as an indirect source of food.

[21]See *Report on Natural Resources of the Commission on Organization of the Executive Branch of the Government* (Hoover Commission) and Appendix. 1949. Also *The Big Missouri*, Public Affairs Institute (1948).

7. Finally, and perhaps the most important factor in the necessary combination for successful industrial growth, is the size of the effort. In one sentence: Given proper programming and timing, the effort will be more successful if it is big from the very start.

Income, it seems, increases with industrialization at an accelerated rate rather than at a flat rate. The faster that the occupation-shift to industry is made, the earlier can the rewards of better living be reaped, and the greater they are.[22] In turn, the greater and earlier are the potential savings for needed further investment. This is the simple common sense of the situation—the more people who are made able to buy goods, the better are the chances for more industries, whose workers can, in turn, buy from others. That there should be no lag between the basic, necessary public-works investments in roads, power-plants and harbours, and the industrial investment has been said before. Hides and shoes; brick, cement, and housing; cotton gins, mills and shirt factories; iron-working and farm implements —whatever industrial groupings are possible in the particular area, should all be brought into operation as nearly as possible with the completion of the public works they will use. This is not possible where roads are needed to open up new resources, but it should be a general, guiding requirement.

This thought stresses the importance of fabrication and many smaller industries rather than the concentration of investment on any one or two big and costly plants. It is there, rather than in basic heavy-materials production, that large employment opportunities can be created. Available investment should be allocated accordingly. A large reduction plant for aluminum that will use all the electric power a region can produce is far less valuable in increasing employment and income in the area than a smaller reduction plant plus a surrounding fabricating industry. Similarly, industries that are purely extractive are less valuable in the industrialization process than others.

It is advisable to start big, and inadvisable to start small, for another reason. A small start may only give an upward push to population without really bringing into operation the combined pressures of education, urbanization, industrialization and income that have to be relied upon in the long run to bring population into balance with resources. So the responsible government will soon find itself, income-wise, about where it was before the small start was made. A nation with growing population, and without a readily expandible plant has to run fast to stay where it is, and much faster to get ahead.

To sum up, the task is not simply that of transferring population into industry to increase wealth, but to make that transfer under a grouping of conditions which can produce the most effective use of the resources. That combination must include at least (1) access to technology, education, and particularly understanding about productivity, (2) access to low-cost capital, (3) widespread use of low-cost energy, (4) low-unit-cost, large-scale production, without excessive claims for security at the start, (5) careful timing, programming and single-agency operation, 6) adequate agricultural development and conservation in partnership with industrial growth, and (7) a really adequate large-scale effort at the start of the conversion process.

Under such a grouping of dynamic factors, a most hopeful, exciting, and significant chapter of human history should open up for the peoples of these areas.

[22]Chart 1 indicates the extent of this acceleration. It is to be compared with the main curve in L. H. Bean, *op. cit.*

Shift in agriculture

	Per cent	*Increase in income*
Bean:	From 70 to 60	From $60 to $100 or $40 (1924-34
Bean:	From 60 to 50	From $100 to $155 or $55 dollars)
Chart 1:	From 70 to 60	From $125 to $184 or $59 (1948
Chart 1:	From 60 to 50	From $184 to $271 or $87 dollars)

Dr. Bean's curve is based on China, India, Japan, Chile, Australia, Argentina. Chart 1 is based on Finland, Hungary, Japan, Latvia, Estonia, Poland, Bulgaria, Romania, Lithuania, India, China.

Table 1. Asia, Africa, South America and Central America: Projected Population, Industrialization and Income, 1951-2000

Year	*Per cent in non-agricultural occupations end of year* (1)	*Per capita income[a] from Chart 1[b]* $ (2)	*Rate of population increase per cent* (3)	*Total population (end of year) (millions)* (4)	*Total average income[a] ($1,000 millions)* (5)	*Cumulative investment ($1,000 millions)* (6)	*Debt Service[a] at 6.34443 per cent ($1,000 millions)* (7)	*Per cent of income required for debt service* (8)	*Per capita income[c]* $ (9)
1951	25	103.30	1.18	1644	167.86	9.6	0.61	.04	102.10
55	27	111.60	1.15	1722	181.35	34.8	2.21	1.2	105.30
60	29	120.60	1.12	1821	195.97	64.9	4.12	2.1	107.60
65	32	135.40	1.09	1930	220.02	107.4	6.82	3.1	114.00
70	34	146.20	1.07	2036	237.57	143.0	9.07	3.8	116.70
75	37	164.20	1.03	2145	266.82	191.2	12.13	4.5	124.40
80	39	177.30	1.01	2256	288.11	232.4	14.77	5.1	127.70
85	42	199.20	0.97	2369	327.70	287.4	18.23	5.6	136.60
90	44	215.10	0.94	2485	349.54	334.2	21.2	6.1	140.65
95	47	241.60	0.91	2602	392.60	396.0	25.1	6.4	150.90
2000	49	261.00	0.89	2721	424.12	448.6	28.46	6.7	155.90

[a]U.S. dollars 1948.
[b]Stationary population.
[c]Growing population.

Table 2. Productivity Requirement

Year	*Population (millions)*	*Total land requirement Present efficiency at .4532 hectares (million hectares)*	*Availability of land (million hectares)*	*Required increase in productivity on available land (per cent)*
1955	1724	781	781	
1960	1829	829	829	
1970	2059	933	933	
1971	2083	944	942	
1975	2184	990	942	5.1
1980	2317	1050	942	11.4
1985	2458	1114	942	18.2
1990	2608	1182	942	25.4
1995	2767	1254	942	33.1
2000	2936	1330	942	41.1

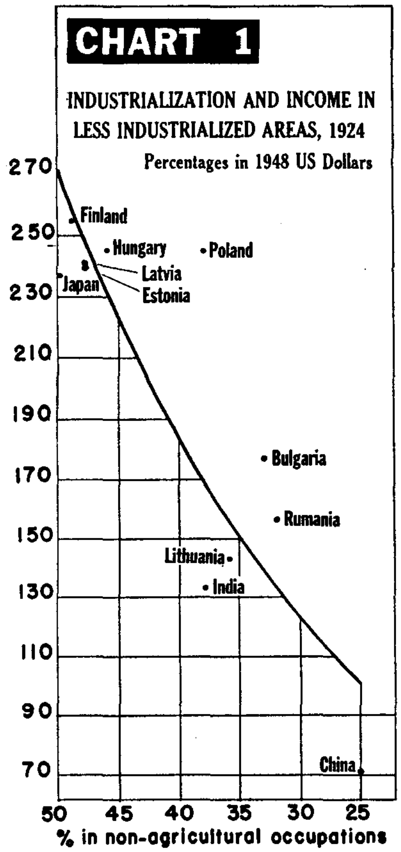


CHART 1
INDUSTRIALIZATION AND INCOME IN LESS INDUSTRIALIZED AREAS, 1924
Percentages in 1948 US Dollars
270
250
230
210
190
170
150
130
110
90
70
Finland
Hungary
Poland
Latvia
Estonia
Japan
Bulgaria
Rumania
Lithuania
India
China
50 45 40 35 30 25
% in non-agricultural occupations

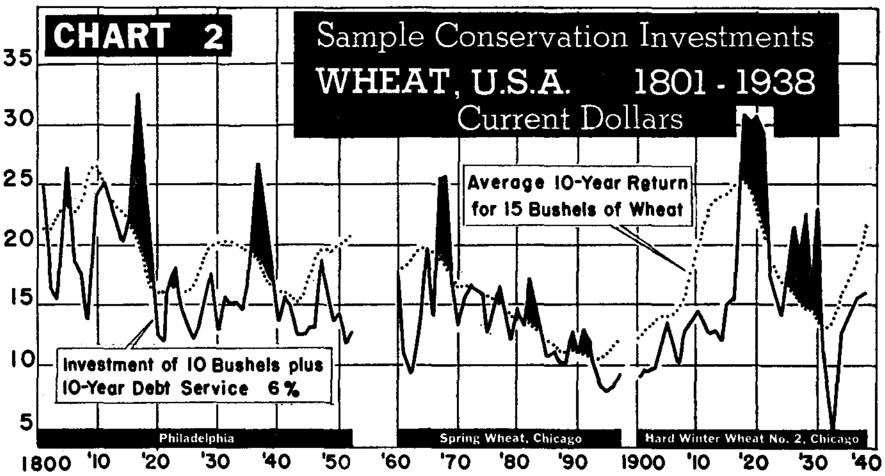
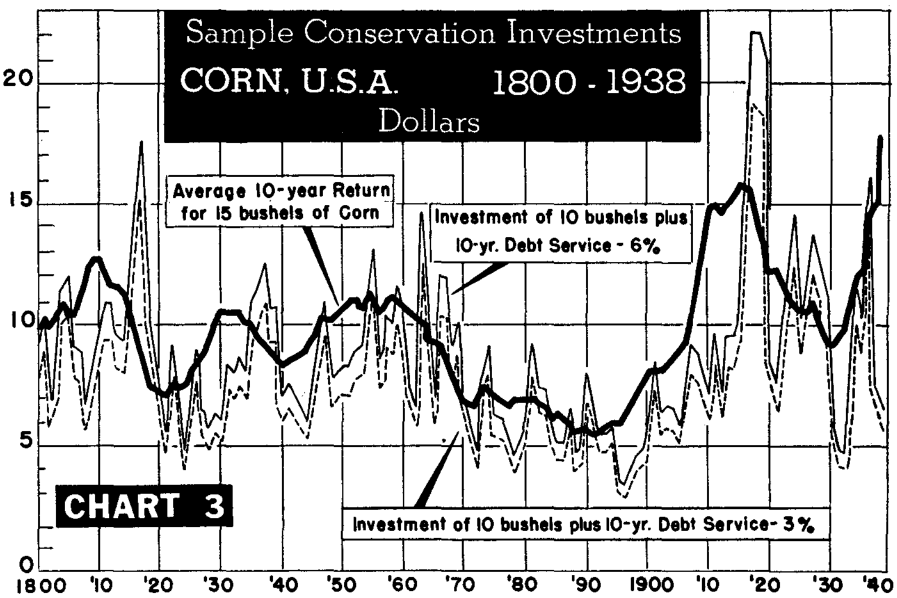


CHART 2
Sample Conservation Investments
WHEAT, U.S.A. 1801 - 1938
Current Dollars
35
30
25
20
15
10
5
Average 10-Year Return for 15 Bushels of Wheat
Investment of 10 Bushels plus 10-Year Debt Service 6 %
Philadelphia
Spring Wheat, Chicago
Hard Winter Wheat No. 2, Chicago
1800 '10 '20 '30 '40 '50 '60 '70 '80 '90 1900 '10 '20 '30 '40


Sample Conservation Investments
CORN, U.S.A. 1800 - 1938
Dollars
20
15
10
5
0
Average 10-year Return for 15 bushels of Corn
Investment of 10 bushels plus 10-yr. Debt Service - 6%
CHART 3
Investment of 10 bushels plus 10-yr. Debt Service - 3%
1800 '10 '20 '30 '40 '50 '60 '70 '80 '90 1900 '10 '20 '30 '40

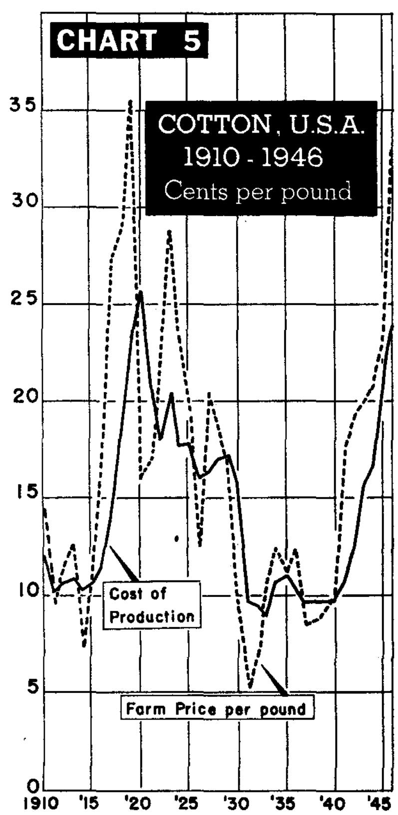


CHART 5
COTTON, U.S.A.
1910 - 1946
Cents per pound
35
30
25
20
15
10
5
0
Cost of Production
Farm Price per pound
1910 '15 '20 '25 '30 '35 '40 '45

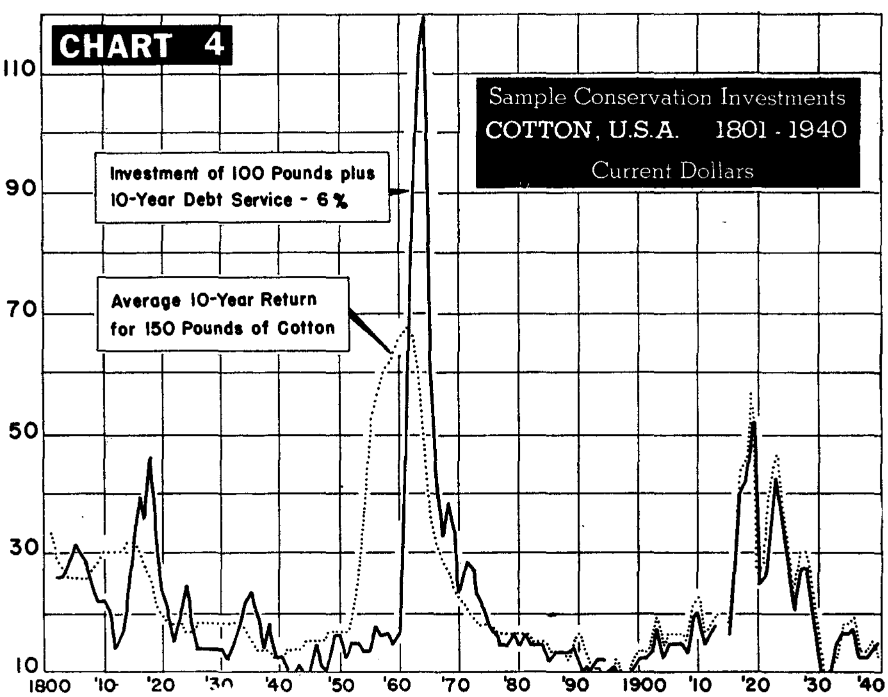
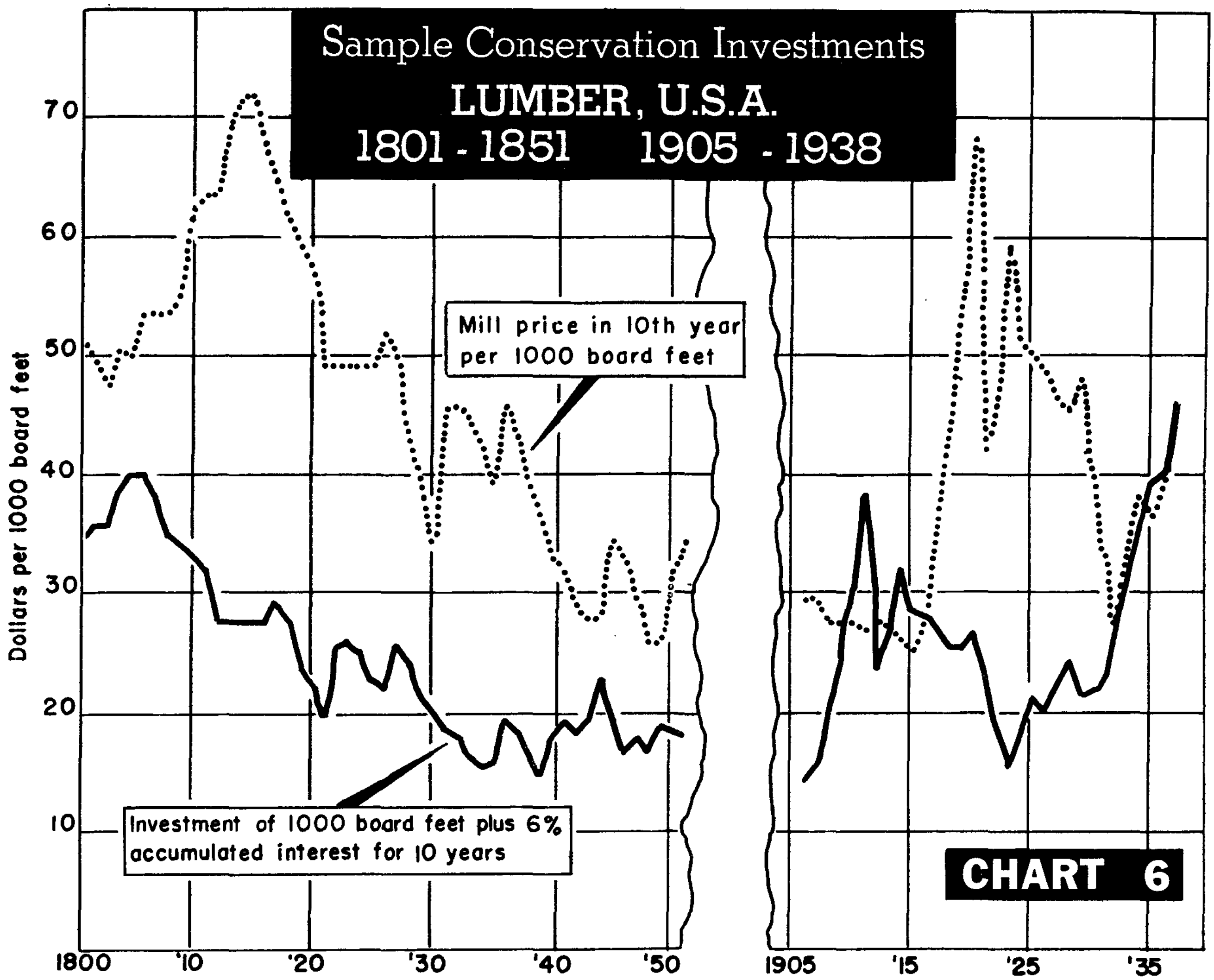


CHART 4
Sample Conservation Investments
COTTON, U.S.A. 1801 - 1940
Current Dollars
110
90
70
50
30
10
Investment of 100 Pounds plus 10-Year Debt Service - 6 %
Average 10-Year Return for 150 Pounds of Cotton
1800 '10 '20 '30 '40 '50 '60 '70 '80 '90 1900 '10 '20 '30 '40



The CHAIRMAN: I wish to thank Dr. Raushenbush very much for his inspiring speech which, I think, gave us a synthesis of the aims of this Conference. I am sure that after that speech there will be a long discussion, and I am very glad that I can invite Professor John D. Black, of Harvard University, who will be the first discussant.

Mr. BLACK: I can feel only grateful to this Conference for asking me to come here and discuss Dr. Raushenbush's paper. Otherwise, in the strenuous life which some of us have to live, I would never have taken time to read his excellent paper as carefully as it deserves, or to do a certain kind of thinking on the subject of conservation and development that I, and most of the rest of us at this Conference, very much need to do.

I find myself, after doing this thinking, taking no major exception to Dr. Raushenbush's paper, especially to its final summary in seven points on the conditions of economic progress. But I do find a need for some clarifying, supplementing, and even a little qualifying. The principal thing I am going to do is take advantage of this occasion to say some things relating to conservation that very much need to be said, and that neither Dr. Raushenbush nor anyone else has said thus far at any sessions of this Conference that I have attended.

In this connexion, I must confess at the outset some difficulty over language. Dr. Raushenbush uses some important terms in different senses than I do. What he calls exploitation, I would call mal-exploitation or over-exploitation. Exploitation of resources of itself is a normal process and not evil in any sense. Likewise for depletion. You will find the prefixes "mal" or "over" attached to exploitation and depletion in what follows except in direct quotations from Dr. Raushenbush's paper. There is a possible similar confusion even in his use of the term conservation.

The phase of Dr. Raushenbush's paper that most needs supplementation is its population phase. I shall therefore begin with his statement of four alternatives for his under-developed parts of the world, Asia, Africa, and South and Central America, with its present population of 1,625 million, and, *given food,* of prospective 2,936 million in the year 2000. What Dr. Raushenbush has here done is in effect to analyse the food problem of the world in terms of *two worlds.* Most of those who discuss population and resources these days do it in terms of *one world,* as if, as I have been saying over and over for emphasis in the last two years—as if the population of the earth were one vast drove of hogs feeding out of a common trough. It is surely better to talk about this problem in terms of two worlds, rather than one, but still there is much danger that we shall be led astray by it. We are neither *one* world nor *two* so far as food production and use are concerned—and this is equally true for most other resources—but instead a complex of social aggregates of varied types and descriptions, and we must do our thinking in terms of this complex if we are to be realistic or even truthful.

Some of you may say that I am denying the objectives of the United Nations when I speak thus. If you do, I can only say that you are just another of those muddle-headed persons who plague all serious undertakings in world collaboration. The Hot Springs Conference that gave birth to the FAO stated very clearly the sound basic principles involved. After proclaiming its objective of food enough for all peoples, the Hot Springs Conference then said that the attainment of this goal was an undertaking for each nation, that each nation must work out its own adjustment of food and population; and then it added: The several nations can, however, attain this goal much sooner if they help each other. It is this helping of each other which should be the programme of the FAO.

This Hot Springs statement was in terms of *nations* as social aggregates. They are, for some purposes, but for resource-use purposes some other aggregates may easily be more significant. To illustrate, for purposes of food-resource analysis, the several different groups of nations who stand in the relation of exchanging food for other products with each other are important social aggregates, and in the main these groups work out within themselves their own particular adjustments of population and food supply. To be sure, they may supply some types of food to other aggregates, but no large amounts of them.

To make this point clear, so far as food is concerned, the aggregates to which the United States and India belong are different aggregates, and no large movement of food from the United States to India is in prospect, for the simple reason that India cannot buy such foods, and as Dr. Raushenbush fully realizes, the United States is not going to ship much free food to India; and hence what happens to the adjustment of food supply and population in India will have no large effect on food production, prices and consumption in the United States.

If nations as such *are* to be differentiated in any way for purposes of food-resource analysis, by all odds the most significant basis is the relation between population increase and increase in food supply in each country. If the supplies of food and of other consumer goods are increasing faster than the population, levels of living are rising. One calculation has been made to the effect that 40 per cent of the peoples of the earth are living in countries where levels of living have been rising importantly in the present century. A recent analysis (Colin Clark's) indicates that this estimate is much too low if we accept *small* increases. The history of civilization will, in the future as in the past two centuries especially, be a history of more peoples being added to this forty or larger per cent, whatever it is. The prime objective of the United Nations is to accelerate the rate of this addition.

If the foregoing is the true picture of modern history, to discuss the food problem of the world in terms of percentage annual increases in world totals is the worst kind of confusion. I shall have to add, Dr. Raushenbush, that the offence is only a little less when you put Asia, Africa and South and Central America all in one total.

And the food-resource-population problem, and other related resource problems of these three continents, are not going to be resolved, in any sense of the word, by or for, the peoples in these continents as one group, and to analyse four alternatives for them as one group is more confusing than helpful.

The second major respect in which I wish to clarify Dr. Raushenbush's paper has to do with his treatment of the *risk* factor in part II. The risk which he describes as all-important in checking conservation is that which arises in the swings from booms to depressions in our economic system. I do not deny their considerable influence; but far more important as a check is another kind of risk, that for some reason I do not sense he avoids calling by name anywhere in his paper. It is the risk that the remaining *virgin* supplies of these resources will keep the price down to a level that will not compensate him for his investment in a more intensive use of resources. Frequently associated with this is the risk that new technology will increase or cheapen the supply.

The timber situation in the United States illustrates the foregoing simply. In spite of all of the very free exploitation of the forests of the United States, the stumpage prices of a large majority of the types and grades of timber in the United States are still kept so low, by timber that grew without benefit of any management. that only very circumspectly most timberland owners dare venture more than simple extensive woodland management practices. Most of our virgin timber areas have been cut over, it is true, but large virgin resources of other species, particularly hardwoods, remain after the first logging; and natural reproduction following cutting has added still more. The major retarding factor in adoption of woodland management practices in this country from the Lakes states east is a sufficient demand for the timber that needs to be cut out as the first step toward sustained yield management.

One of the main ideas that I obtained from the discussion of the petroleum situation on Monday is that the industry may well lag in its discovery operations because of the fear that new oil fields will break the market. I have heard it rumoured that some of our state governments have a similar fear, and are even doing something about it.

So far as agriculture is concerned, this country is still in a large way drawing from virgin resources of plant nutrients, and will continue to do so for a long time, and the same is true of large areas in other lands, and this helps to keep prices of agricultural products so low that farmers in these and other areas dare not risk more intensive forms of use. When they do, they are likely to choose what is usually the cheapest form of intensification, namely using commercial fertilizer.

Dr. Raushenbush makes bold to predict generally rising prices of agricultural and other raw material products over the next fifty years. I boldly predict that he is dead wrong so far as agriculture is concerned—except in a few countries that may possibly develop their manufacturing faster than their agriculture. I do expect land values to rise, however, because technological advances will increase net returns even with no rise in prices.

Of course Dr. Raushenbush is right that making credit available, under suitable repayment terms, at 3 per cent interest, instead of inappropriate terms of 5 per cent interest, will make a tremendous difference in what investments in more intensive land or other resource use can be ventured with reasonable safety. One of the important developments which the United Nations and its member organizations can sponsor to great advantage is this kind of credit. He is right that governments can properly take a hand in this if private credit agencies do not sense their opportunities.

But a strong warning needs to go with this, to the effect that credit of this sort could be over-extended with very great ease. To illustrate for agriculture in this country: if no more than half, or even a third, of the farmers in the United States borrowed what they would need to put their farms on what our farm planners consider an efficient and productive basis, the agricultural surpluses of this country would double.

Dr. Raushenbush has presented to you in bold outlines the failure of competition to give us proper conservation in this country. No one who knows my work as an economist would ever describe me as one who has hesitated to criticize the workings of competition. But I shall have to say that it has worked much less "badly" in conservation than he indicates. I shall even venture to say that if the professional conservationists of this country, and of many other countries, were given a free hand to say how our farm lands should be used, and what practices should be applied to them, and the kind of credit and other aids to implement their ideas, they would not do as well as our competitive system has done.

There is in the balancing of present and future uses an optimum that represents the best long-run return. I am willing to concede that probably we have over-exploited our food resources in this country and by so doing, reduced by a little the food part of this long-run optimum. But I am not sure of it. I am more sure that if the professional conservationists had been running the show, they would have come out farther away from the optimum than we now are, but on the other side of it. *And mistakes on one side are as serious as on the other—neither can ever be unmade.*

Now as for our other resources, I am in no position to have a judgment—especially for mineral resources. But before we are sure that we have over-exploited our resources as a whole, we must ask ourselves two questions and answer them definitively: The first is: Is our present level of living lower than it otherwise would have been because we have used our resources too fast? The second question is: Are future levels of living going to be lower than the present because we have used our resources too fast? Dr. Raushenbush apparently answers "yes" to both of these questions. Otherwise he would not be speaking of us as "having lived through many generations in which both high and low prices have brought exploitation and wasteful use of resources," or saying that as a result of having "left our resources future to the mercy of a competitive economy", we now "find ourselves with a depleted resources base". Speaking as an economist who arrives at answers as calmly and objectively as possible, and chooses his words carefully, I shall have to say that in nothing that I have read on the subject have I found definitive proof that the answer is "yes" to either of these questions.

If you ask instead the question: Could we have used our resources more efficiently so that levels of living and of work would be higher than they now are, we can very safely answer "yes". We can safely go further and say that the long-run optimum which we are seeking can be made into a higher optimum if we can find more efficient ways of using our natural and human resources combined than we now have, and then get these ways practised. It is this that is the sole objective of true conservation. It is of course, also the objective of society's utilization of resources. This Conference has been called a conference on conservation *and* utilization. It was practical wisdom to put both words in the title. But in effect the two terms bring us out at the same place.

When we come to the last section of Dr. Raushenbush's paper, I must agree fully with him as to the need of developing agriculture along with industry in an under-developed country. Such explorations as I, and my former student, P. K. Chang, whose recent book on industrialization of an agricultural country I hope many of you have had a chance to read, have been able to make, indicate that in general, agricultural revolution has accompanied industrial revolution and has kept pace with it. It happens, however, that at the particular period in history that the so-called "Industrial Revolution" was taking place in Western Europe, a new continent, or two, was being settled, which provided a place where manufactured products could be used to buy food, and in consequence Great Britain, Belgium and some other countries acquired populations far larger than they could feed with their own agriculture. But the situation that made this possible no longer exists in the world. From now on, the countries that industrialize will have to find most of the markets for their manufactured goods in their own countries or countries close by. Japan, I think, marked the turning point in history in this respect. But Japan is now faced with a problem of more industry than market. We are all keenly aware that this is true in part of Western Europe. We have no right to blame these countries for their present over-large industrial populations. It was world conditions that caused them. Instead, we should help them in any way that we can. And most of such countries have their population increase under such control that we can really help them by accepting emigrants from them, and in many cases help ourselves at the same time. At least, many of the undeveloped countries can.

But although in the past, agricultural and industrial development have usually come together, this does not mean that this will take place inevitably in all the undeveloped countries. The United Nations and the FAO do need to watch the evolution in these countries carefully from this point of view.

A final word on population. Dr. Raushenbush began with it and so have I. Much more important in determining the level of the long-run optimum which we have been discussing, than any levels of efficiency of use of natural resources, is the number of persons who must be fed, clothed and housed at the optimum. The range among countries in *per capita* real income and level of living can be as wide as 1 to 20 because of population differences alone. No doubt there were good reasons for leaving population off the programme of the Conference. But *to leave it out of our thinking* is almost like playing Goethe's Faust without the villain.

The CHAIRMAN: I wish to express our appreciation for Dr. Black's excellent contribution to our discussion. The two addresses that have been made are now open for general discussion by the conferees.

In order not to waste time, I shall take the opportunity to say a few words myself, and I hope I shall be followed by other speakers. I am most grateful to the two speakers, Dr. Raushenbush and Dr. Black. When listening to Dr. Raushenbush, I had the same idea that Dr. Black had, that to bring together the over-populated countries of Asia and the less-densely populated countries of Africa and Latin America simplifies the problem too much. I think that, without any doubt, there is a very vast field for the development of agriculture, mining and industry in Africa and Latin America. The problem there will be how to get the people to these countries, and which nationals would be able to and willing to go to work in the tropical regions. Probably the population of Africa itself will not be able to fill the whole continent in reasonable time, but for Asia I think the problem is quite different, and for India, China and Indonesia, and especially for Java where there are old civilizations and over-dense populations, I think the factor brought into the discussion by Professor Black on the availability of virgin resources is very important. With the technology that was at hand in these countries, they have used up most of the virgin resources, and so the problem is one of better use of existing resources. That does not apply, I think, to mining or to more modernized industry, but it fully applies to agriculture.

In these countries, the first and main problem must be the living standards of the people with regard to food. We have been talking about this a great deal at this Conference, and rather optimistically. Especially when we see the possibilities of synthetic fat and semi-synthetic fat from micro-organisms, one might say one can industrialize food production so that there is no danger of real hunger in the world. But I think the quality of the food is more important. Protein and vitamins are important, but one does not get that from synthetic fats, and from carbohydrates in general. They are very easy to produce, and the production of sugar, of starch and of other carbohydrates can be increased very largely.

For me, this Conference brought out two things which I think are very important. There is a possibility to catch much more fish and there is a possibility to grow food yeast. Now let us see what we can do with these two resources of protein and vitamins. It would be possible to double the annual consumption of fish, which is now 6 kilogrammes *per capita* for about one billion people who have a lack of proteins. That would mean 6 million tons of fish. The fishery people here say that that is possible. That is 30 per cent of the present sea fisheries, and that can be attained, and probably attained by comparatively small investments.

With reference to food yeast, a man can eat ten or 11 grammes a day, that is, 4 kilogrammes a year, without bad results. Again, 4 kilogrammes of yeast means 4 million tons of food yeast for a billion people. That is possible. It is quite an industry, and it will ask for large investments, but can be developed by minerals and cheap molasses or other starch or sugar food for the yeast.

These are two measures which are within our reach now, and they will give 10 grammes a day of valuable protein to one billion people in the world. I think that if we go beyond these figures, the difficulty of feeding the increasing population is large, but here is something which can be done and which is not very expensive. It is a problem on which the nations and the governments ought to work together to see whether, with the very difficult population problems, something could be achieved. I put this before you.

The CHAIRMAN: I call on Mr. Coppock of the Preparatory Committee.

Mr. COPPOCK: I should like to ask Dr. Raushenbush whether there is not an air of unreality about his proposal and about the seven points setting forth the conditions of economic development. They all stress the widespread use of energy, large scale production, and so on. The less-developed areas of the world are in many cases small countries where the national state is the dominant controlling force—which Dr. Black has emphasized—more or less directly making the country a discreet social aggregate. Now, I wonder, if the national state system is as strong as it seems to be and if Dr. Raushenbush's words mean what they seem to mean, how would he combine the conditions of large-scale operation with the other and apparently contradictory conditions imposed by the fragmentation of the world into so many national state systems?

Mr. RAUSHENBUSH: Mr. Coppock's point is a very important one. He has said that my paper insists that it is a condition of economic progress that each country or each area carries out its development in the way to get the greatest efficiency, that is, on a large scale. He asked: Is that possible in many areas which are small and where the markets are small? I think you will find in my paper, if you read it carefully, a statement that it is in the fabrication rather than in a few big units of high-cost chemical or steel plants that the advantages of both employment and wealth are found. I would answer his question by saying that if we stay on the small nation basis, it is almost impossible for a small nation to have a plant that itself competes with the materials it could buy outside, if it had the exchange to pay for them.

However, this does not vitiate my point that it is desirable for that small country—or large country—to have as efficient a large-scale plant as it can possibly have. And it would be even desirable and necessary—desirable anyhow—for it to consider marketing in overlapping political areas. For instance, in Central America, in which I have travelled and worked, and am interested in, it would make far more sense, I would think, for the five Central American Republics to do this planning, not only for power but for their fabricating, together. It would make a lot more sense, and it would get the utmost of large-scale advantage in distribution.

Those areas will never be as large as in a country like Russia or the United States where the tariff free market is very large. But these nations should get the most area they can. I do not know whether that quite covers your point, but that would be my answer to it.

I should like to speak a little bit to Professor Black's points, because I think they are of more than immediate importance. I was happy to have him spend some of his time on this paper; but I am sorry that he and the Chairman got into a kind of confusion about my "two worlds". If I were creating two worlds, I would not think of creating those two worlds. The only reason I brought them into being was for statistical purposes, to give a picture of the order of magnitude as to what certain things would cost. The whole point of the first part of my paper was alternative methods of resource application. I was not trying to find a smooth way of distributing the world's food resources. Apparently, since it hits both Professor Black and the Chairman the same way, it was a mistake to try that. But I find no quarrel with the criticism there. It was done for statistical purposes and not for creating any new idea of world food distribution better than that which the FAO is doing. I did not have time to do that in my idle moments. But I did find something a little disturbing in Professor Black's comments about need, because having said that two worlds are bad, he went on to say that one world was worse, and came back to the idea that these various nations would have to take care of their own food supply pretty much in their own terms.

Well, I do think that there is some major point of difference between us there. We are thinking of the living over the next fifty years, together in this world, where great masses of the population, as you all know, in the under-developed countries, have tasted a little more good of life than they ever have before, and where the demands are going to be large. I do not see where the food-rich countries and the food-poor countries are going to go in their own separate ways quite as easily as I read into Professor Black's remarks. This, I think, is a major disagreement. That came up again in his last words, that people in countries with an income disparity of 20 to 1 could live happily together. We have disparity in this country between our southern states and northern states of about 7 to 1. It does not lead for any particular happiness and could lead to some friction.

The second point, I think, was a misunderstanding, pure and simple. I gave elaborate charts, over a hundred and forty years, for several conservation areas, showing that the price of the product was not always sufficiently high to cover the farmers' costs, and they would have lost through conservation on a high interest basis. There were also a few figures for cost basis for cotton, and the few years available for 1910 and 1940. Those prices were the very result of all the worries about future supplies, new supplies coming in, and all of that. They are all involved in that. I would be happy to label them also as a risk. But I assumed that the price showed all those things, and expressed the risk.

We have a second major disagreement on rising prices. I think that the demand of labour around the world, the growing scarcity that the scientists—most of them here, not all of them, but most of them—feel exist in many of our raw materials, the increasing demand of industrializing nations, old and new, is going to drive prices up for fifty years.

With respect to the statement of whether conservation planners could have done better, Professor Black and I have a somewhat more identical position about that than he indicated. I pointed out that if our conservation planners had gotten hold of this country, back when it was started, we would be able to live on the income without taxes. We could have had a forty-two billion dollar budget without taxes, but, as I said, we would have been a very small nation. And again, I said there would be the question of opening up our frontiers only on the condition of getting excellent conservation and land prices. I think that our agreement is better than our public statement on that, that we probably agree that we could have done things more efficiently in the past.

I take it that one of the reasons why you are all here at this Conference is because there is some real worry about whether we are going to do as efficiently, with what we have left, for the future. Anybody, whether in a controlled economy or a non-controlled economy, could have over-exploited this country and had this type of civilization. We did well by it. Other people might have done equally well by it. That is still not quite the question. The question is whether increasing prices of oil are necessary, whether increasing prices of lumber and all other resources are necessary to the degree we get them in every shortage period, as we got them in 1946, 1947 and 1948. I think that we can be seriously concerned about that for the future, and use our minds a little bit to figure out whether there are not better ways than the present and past ways which we have used, to handle them. The question is not whether the conservation planners would have done it better than anybody in the past. I myself think we would have been a very different nation.

Another point, and the last one which Dr. Black has spoken about, concerns many of you here, I think, very seriously, and I do not think I shall comment on it. I just think I will call it to your attention. He said that the industrialization around the world was now such that most of the under-developed countries could not expect an export market for their products. I think that deserves a considerable debate on its own at this point or some other point, because if that is correct, then industrialization of the under-developed areas must take a very different form. I think we should be glad that somebody has stated that idea at this Conference—and somebody with Professor Black's authority; because if that is true—that they are not only going to be able to export a little but, by and large, practically nothing—then the type of development they plan for their own countries and their need for joining together, not only with linked-up water systems, but their joining their economies in order to get as large a market as possible, goes all the way across the board, and not only in Central America. Then it will have to be done in the Near East, and in all of Europe. I think that is worth some discussion.

The CHAIRMAN: Time is running out fast and we still have a very important second part of our meeting. In fact, the time is about over now for the first part, but there is still an opportunity for people who would like to contribute to these most important points that have been raised.

If there are no remarks now, there may be some after we have heard the following three speakers. They are about conservation and utilization practices in different countries. The first paper we have before us is from Dr. Keen, the Director of the East African Agriculture and Forest Research Organization. We regret that he is not with us, but his paper will be presented by Dr. Clay, Agriculture Adviser to the Secretary of State for the Colonies in London.

Mr. CLAY *delivered the following paper prepared by Dr. B. A. Keen:*

Application of Simple Conservation and Utilization Practice

B. A. KEEN

ABSTRACT

An examination is made of the reasons for the difficulties of introducing improvements into the backward agricultural systems, including the indifference or even resistance of the peasants to self-evident improvements. Stress is laid on the importance of the economic factor because, the simpler the rural organization, the more involved, and yet less obvious, are its economic problems. Three traditional systems are discussed involving respectively, village or communal land ownership, fragmentation by inheritance, and the native African system, where ownership in our sense hardly exists. It is shown how the rights and customs arising from these systems have created almost insuperable obstacles to the introduction of improvements, no matter how obvious their advantages may be. The rights and customs are so ingrained in the social system that there is no practical way of removing them, short of an agrarian revolution. But they can be circumvented, and thus left in harmless operation. The device is essentially that of the public utility corporation in which is vested the responsibility for the proper use, although not necessarily the ownership, of the land. The arrangement is exceedingly flexible, applying equally to the Sudan Plantations Syndicate that operates 400,000 hectares, and to the simplest form of group farming.

The documents defining the purpose of this Conference have, very wisely, stressed these fundamental points: (1) The development of a single, and apparently simple, improvement in land utilization may involve many sciences; for example, terracing in soil conservation raises problems not only for the engineer, but for soil physicists and chemists, and hydrologist as well. (2) Conversely, a single development has usually to be combined with others if it is to have any practical use; thus, work on improved breeds of cattle must be accompanied by investigations on better fodder crops and on improving the agronomy of existing ones, because better cattle require better quality food. (3) All developments must be on a sound economic basis; this may seem, as indeed it is, a truism. And yet it is so often ignored, and much money, effort and enthusiasm are wasted in introducing some improvement that is bound to be dropped once the artificial incentive is withdrawn. Therefore, this paper deals mainly with the economic and the associated sociological difficulties inherent in the peasant or family-farm systems of agriculture, and the obstacles thus created, to the introduction of technical improvements. It does not deal in any detail with the numerous small-scale improvements in land use and in rural developments, but selects typical ones to illustrate the main theme.

In the large-scale plantation type of agriculture in the tropics, and in the modern mechanized systems of the industrialized countries, the mistake of thinking that agriculture is solely a "way of life" and not an industry is now rare. But the farther we go down the scale towards the peasant family-farm the more easily are the economic factors overlooked. There seem to be two main reasons. Firstly, the peasant-farming life is the happy hunting ground of those nostalgic people who, enjoying all the amenities of modern civilization, have their eyes fixed on an imaginary past. They look back to the time of a happy, contented, and healthy rural community that was ruthlessly uprooted by the change from communal ownership to individual freehold land, and then destroyed by the Industrial Revolution. But that Arcadia never existed, as every serious student of social history knows. The second reason why economic factors are often overlooked is the paradoxical one that the simpler the farming system the more involved, and yet, the less obvious, are its economic problems. One simple illustration may be given. It is self-evident that little progress can be made in the more primitive peasant communities until all the children have at any rate the rudiments of education. The resistance by parents to compulsory child education may be, and often is, expressed in terms of conservatism and suspicion; but the real reason is that child and woman labour is an economic foundation of peasant-farming systems. An essential economic difference between primitive agriculture and all other forms is that its working capital is humans, not money. Economic factors pervade the whole community structure. Trevelyan puts it with epigrammatic simplicity: "the social scene grows out of economic conditions to much the same extent that political events in their turn grow out of social conditions".

The inescapable conclusion is that any attempts to improve peasant agricultural practices within the framework of that system must fall strictly within the economic limitations which, in this type of farming, are themselves at a low level. Progress must therefore be slow, even imperceptible, and will usually be more than offset by an increase in the population. There is the further difficulty that many land-use procedures and many land customs, often amounting to taboos, exist in the social structure of the more primitive peoples. Many of them are so wrapped up in obscurities of the forgotten past that they cannot now be explained even by those who practise them, and can only be elucidated by patient anthropological research. This has always to be borne in mind by those whose duty it is to try to raise peasant agricultural standards, because it often explains the exasperating indifference or even refusal to adopt improvements whose self-evident value is freely admitted by the peasants themselves.

The land-use and land-inheritance aspects of these social structures can be broadly divided into three types. The first springs from community or village ownership of the land and the right of the individual cultivator to a fair share of both the good and bad land. This found expression in strip cultivation, each man being allocated each season, a number of these strips scattered over the area. It was for many hundreds of years the standard practice in Western Europe until the ancient three-field system of which it was an integral part, was replaced by enclosures. In the Middle East it exists today, noticeably in the broad plain of north-east Syria where strips only two to three metres wide but a kilometre or more in length can be seen.

The second type arises from individual ownership of land which is divided equally among the heirs. This leads to successive fragmentation until an owner possesses a number of scattered pieces each surrounded by fields belonging to others. It is found today in the countries formerly part of the Turkish Empire, and in India, where it reaches its extreme form. Thus in Bengal, in spite of the food requirements of the teeming population, at least three per cent of the area is permanently out of cultivation because it consists of boundary ridges and of excessively minute plots.

The third type of land custom is found over much of Africa. It is too nebulous to be summarized, because it is a vague but complicated joint responsibility of the living and of ancestral spirits, that expresses itself mainly in rights of land usage and not land ownership. In fact, in our sense of the word, ownership, even community ownership, does not exist.

Within the framework of these traditional customs even simple and obvious improvements meet with difficulties. No discussion of the thorny problem of individual versus community ownership is necessary before reaching agreement that the farm within a ring-fence, and under a unified direction, provides far better and easier opportunities for improvement than any of the three traditional systems just mentioned.

In the case of the three-field system with strip farming it is impossible, in practice, to grow a different crop from one's neighbours, or to attempt systematic improvement of animals which, even if they are individually owned, have nevertheless to range in communal herds. Nor can terracing and contour ploughing be introduced on sloping erodable lands, because, to ensure equal treatment for each member, the strips must run up and down the slope in spite of the fact that cultivation in that direction invites erosion.

In the case of the system of fragmented ownership similar difficulties arise, which are intensified when the fragmented inheritance extends also to the water rights, as in Cyprus, and even to trees of economic value, as for example, to date palms in the Northern Province of the Sudan.

The biggest problem in the traditional system of Africa is, of course, that the absence of a sense of land ownership, even by the community, to say nothing of the individual, necessarily also means the absence of any sense of responsibility for the well-being of the soil. Although the inculcation of this idea is a slow process, the system has one advantage, in that the institution of remedial and conservation practices is not beset by the obstacles that exist in the strip-farming and fragmentation systems.

It will be apparent from what has already been said, that in the strip and fragmentation systems the form of land ownership and the customs arising from and dictated by it are the crux of the problem of improvement. But the form of ownership is so deeply rooted in the social system that its removal except by the brusque process of an agrarian revolution, is impracticable.

However, it can be—and, indeed, has been—circumvented. An excellent example—one that ought to be far more widely known—is the Sudan Plantations Syndicate that operates on the area of 400,000 hectares in the Sudan Gezira. The land grew formerly only rain-grown dura. It is now under irrigation, with cotton as its cash crop, and it produces from a fraction of the same area more dura than the whole area previously did and a fodder crop is also included. The tenant farmers make a comfortable, indeed a prosperous living, and in addition the Sudan Government revenue has greatly benefited from the higher tax receipts that this thriving area produces. This remarkable achievement was based on a concessionary lease to the Syndicate from the Sudan Government, who leased the area in the first place from the owners who, with their assured and steady rental, are at least as well off as before. The Syndicate divided the area into farms whose boundaries bear no relation to the original ones, because they are fixed by the requirements of the irrigation system. The farms are let to tenants, and first choice is given to the original owners and their relatives. The lease is designed to give all the essential advantages and incentives of private ownership, without the power of sub-leasing. The Syndicate undertakes many services for the tenants, including the work of power cultivation needed in this heavy soil, and markets the cotton.

But the most significant feature is that the death of one of the landowners no longer has its former consequences. The rental is divided among the heirs; so too is the land, but this is merely a division on paper, without any effect whatever on the operations of the Syndicate and their tenants. The traditional and ingrained custom continues, therefore, unaltered, but shorn of its harmful and restrictive effects.

There are other examples from the Middle East of this type of organization. They have been fully described by the writer in a published report on Middle East agricultural development and need not be further discussed here. They include two other schemes in the Sudan, the Jewish settlements in Palestine and the Italian colonization schemes in Libya. These schemes differ widely in their origins, methods, aims and ideals. But the outstanding fact is that they all possess one feature in common: they have got round the biggest obstacle to progress, namely, the throttling effect of the existing form of land ownership and its associated customs.

The device they have employed for this purpose is one in which the responsibility for the proper use of the land is vested in a corporate body on the public utility corporation model. There need be no rigidity in the form of the corporation. It can be a development body set up by the government, or a private company with statutory obligations. It can work on indigenous or foreign capital or both. It can be a co-operative society of farmers themselves. It can own the land, or lease it. In fact, its constitution can vary within wide limits to suit the conditions and the stage of social emergence of the people, provided that it is also vested with the authority for ensuring the proper use of land by attaching suitable conditions to its own sub-leases and to capital loans.

The general principle is, therefore, so flexible that it applies equally to a vast undertaking like the Sudan Plantations Syndicate and to the simple conception of group farming by African cultivators. In the writer's opinion it is certainly the quickest, and perhaps the only, way of opening the door to technical improvements in backward agricultural systems. It is inconceivable, for example, that the ancient three-field system could have been adapted to the four-course rotation which, with its new crops—turnips and clover—greatly raised both animal and crop outputs besides building up soil fertility. But, with Enclosures, the new crop rotation was adopted without difficulty. No one would suggest that the Enclosure movement was based on the ethics of a public utility corporation but it did share its essential features: it provided incentives and reward for personal efforts; it facilitated the introduction of technical improvements; above all it simplified and focused the responsibility for the proper use of the land.

The stress rightly laid in this Conference on the complicated interrelations of even simple improvements gives special point to the advantages of the public utility corporation procedure. This body can take an over-all view. It can integrate the social, economic and technical aspects of the various improvements to be introduced. Thus, the Sudan Plantations Syndicate deals as one problem, with matters as diverse as the highly-skilled business of marketing the cotton, the introduction of new varieties, the development of the best crop rotation (which was one of their biggest technological problems), the development of village amenities and the supply of consumer goods to enable the tenants to make the best social use of their improved financial position.

Again, any improvements based on the use of water resources probably defeat their own ends if done on an *ad hoc* basis instead of taking the catchment area as the unit. Thus, the water supply for the town and industries of Haifa in Palestine was causing concern some years ago because of the increased use of irrigation water by the Jewish settlements. To take another example from earlier history, the highly fertile Fen District of England consisted of isolated and precarious patches of reclamation until a new drainage system was introduced which dealt with the area as a whole and not piecemeal as hitherto.

It is significant to the main theme of this paper that the idea of a unified consideration of the conservation and utilization of resources, which is inherent in the public utility corporation method, has already been applied, on its own merits. Thus in the native areas of East Africa and elsewhere, both district and provincial teams are functioning, consisting of government officers resident in the area. The chairman is the local District or Provincial Commissioner, and the members are the local officers of the Agricultural, Veterinary and Forest, Permanent Works Departments, etc. This body is able to assess the impact on the other departments of an improvement advocated by one, and to keep the various separate aspects of development in step. It should be noted, however, that this arrangement would have limited application in countries where rights and usages of land ownership exist, as in the strip cultivation and fragmented inheritance systems. In those cases the assumption by a public utility corporation of the essential rights that bar progress is necessary. It is mainly because land ownership scarcely exists in most of native Africa, that the district teams can do useful work in the conservation and improvement of land resources. But there would still seem to be a case for instituting some form of public utility corporation both for providing the statutory powers required for the inauguration and operation of certain kinds of development, as well as for creating an impartial body in which land rights can be reposed, before the otherwise inevitable growth of vested interests leads to problems analogous to those already described for the strip and fragmented ownership systems.

The writer's personal conviction, arising from some considerable study of rural improvement problems under varied agricultural and land-use systems in many countries, is that the difficulty with the backward agricultural systems lies not so much in finding suitable technical improvements. These already exist in quantity, they are being constantly added to by scientific research, and many of them have already produced highly beneficial results elsewhere. The real difficulty is to introduce them, for their cutting-edge becomes blunted by the hard core of rights and customs that exists in, and is, indeed, synonymous with, the backward agricultural systems. The public utility corporation conception provides the means by which this resistance can be rendered harmless in its operation.

Bibliography

A fuller development of the points made in this paper will be found in the following three publications:

C. K. Meek, *Land Law & Customs in the Colonies,* London, Oxford University Press, 1946, 337 pages.

B. A. Keen, *The Agricultural Development of the Middle East,* London, H. M. Stationery Office, 1946, 126 pages.

G. M. Trevelyan, *English Social History,* London, Longmans, Green & Co. 1942, (U.S.A.), 1944 (G.B.), 628 pages.

The CHAIRMAN: I wish to thank Mr. Clay for the presentation of the paper of Dr. Keen, and for the big contribution which he himself made to that paper. We have now heard about the development of rural people in British colonies, and I am glad now to introduce Dr. Coady, Director of the Extension Department, St. Francis Xavier University, Antigonish, Nova Scotia, who will speak about the development of rural people in another part of the world, in Canada.

Mr. COADY *delivered the following paper:*

Organizing Rural People for the Proper Use and Conservation of Natural Resources

M. M. COADY

ABSTRACT

Ignorance and lack of ownership on the part of the people explain their misuse of natural resources. Profit-making and power seeking as a primary motive in the developing of resources has been another cause for the misuse of natural resources. Correcting this situation will give us the clue to the proper use and conservation of resources. The general answer is enlightenment. This calls for the universal mobilization of people for adult education. The technique of effectively doing this is demonstrated in the adult education of the three eastern Provinces of Canada; Nova Scotia, Prince Edward Island and New Brunswick. The basis of this programme is the discussion circle. Common people in all the vocational groups, farming, fishing, lumbering, mining and common people everywhere, have been organized during the last twenty years for continuous adult learning. Their thinking issues in individual and group economic action. This group action is economic co-operation. About 60 per cent of the people of Eastern Canada are now operating co-operative activities in the four main fields of economic action—money and credit, marketing and processing, merchandizing and the field of services. These activities condition the people to take a greater interest in their society and supply the dynamics for the scientific use and conservation of their natural resources.

A proper appraisal of the nature of Man and his relation to the universe will give us the clue for a programme for the proper use and conservation of natural resources. It is in the very nature of things that the earth and the fulness thereof is for Man. Natural resources, therefore, fulfill their purpose when they minister to human life on this earth. This is their manifest destiny, so to speak. Proper use and not abuse is, therefore, the rational and hence, scientific way of exploring and developing Nature. This should immediately dictate to us the wisdom of, first, consuming at the rate of "holding out" in those things such as minerals, that are exhausted with use and cannot be replaced, and second, replenishing wherever possible the materials that are destroyed by use. This is the positive side of the picture and lays the foundation for the proper use and conservation of the resources of the earth.

The negative side of the picture is even more illuminating. The story of Man's misuse of and failure to conserve his natural heritage should also guide him in arriving at a scientific procedure for the future. Past performance should be terrifying to us all; the correction of the sins of the past will give the blue-prints for the future. If we get clearly in mind the reasons why Man abused, rather than used, the natural resources of the earth, we have the answer we are looking for.

REASONS FOR PAST BEHAVIOUR

There are three evident reasons that explain our misuse of natural resources in the past.

(1) The first is just plain ignorance on the part of the human race. Man did not know how to treat the earth; he did not know how to farm; he was ignorant of the fundamental sciences of biology, chemistry and physics. Many parts of the earth that were at one time fertile and have long since become deserts are testimony to his stupidity. This is particularly true of the Old World, and according to many authorities, the inhabitants of the New World are travelling the same road faster than was ever done in the past. There are people who think that North America, if we keep on going as we are, may be largely a desert in a hundred years.

(2) The second reason for the sins of the past is that the great masses of the people lacked interest in the conservation of natural resources. This was due to the fact that they lacked ownership. Tenancy, share-cropping, the emergence of a rural proletariat, and the landlordism that is still so widespread, have all tended to make the masses of the world's people feel that they have no stake in the world. The good earth was not theirs and why should they care?

(3) The third reason for the misuse of natural resources is the false motives behind those who, in the main, explored and developed the natural resources of the earth. This was not to develop food, fibre, and materials for the physical and social life of the people of the earth, but rather to amass wealth and gain power over their fellows. No scientific development of natural resources is possible under the dynamics of such a motive; greed will drive out reason. The power-mad and profit-seeking individual has only a short span of life on this earth. He is going to "make the most of it" while he can. It is too much to expect that he will think of the good of future generations. Like bad boys, these power-mad individuals will cut down every last tree in the world, dig out all the precious metals of the earth, and destroy all the fish in the sea, to add to the glory of their passing day. These profit-seeking individuals must be restrained so that they will not plunder and destroy what was intended for all the people. The motives will have to be changed; a new philosophy of production for use will have to replace as a primary

motive production for profit and power. This will come about automatically as the people gain ownership and democratic control of their affairs.

The most difficult phase of this problem is to find a formula by which the undeveloped masses of the world's people, who have heretofore never had any interest, ownership or control of the good things of the earth, may be capable of the task. The problem, in a word, is to find a programme that will bring the undeveloped people of the earth up the road of progress to the point where they can own and control the earth—their earth —and become "masters of their own destiny."

ADULT EDUCATION

The first phase of the plan to carry into action these principles is, as is almost self-evident, a programme of adult education. If there is a better and more scientific way of using natural resources, then the people should know about it. But this cannot be left to the slow process of elementary and secondary education. These, of course, are necessary; a people must have schooling to make progress in keeping with these principles. Formal education in the schools, however, is not enough and never was enough. The short-cut to human progress is to mobilize the adults of the world for continuous learning—even if they now have little education.

The people—the common people—must progress "under their own steam", so to speak. We cannot help along the road to progress by handing out doles or treating them as inferiors or grown-up babies. We have to release the energies that are in them, and look forward to the day when they will be able to take over the affairs of their own life. This is the scientific way. It is in the end the quickest way although to some this may not be apparent.

We must, therefore, find a technique of adult education that is practical, inexpensive, widely applicable, and capable of fanning out into the higher levels of culture. It would be a great mistake to think that such a programme can be solely academic. Such a procedure would be to ignore completely the nature of Man. Common people—in fact all people—must parallel their learning with action. The action can best be found in the social and particularly in the economic field. Action in the economic field is twofold. It can be individual economic action, or group economic action. Individual efficiency in the economic field is highly desirable, and goes a long way to produce a good society, but individual action alone will not solve the economic problems facing the people. Economic group action, or what is called economic co-operation, is also required and offers the greater possibility.

The complete formula, therefore, for the progress of the undeveloped peoples of the earth is spiritual enlivenment and mental enlightenment accompanied by group economic action. This is the double-barrelled programme for human progress and for the right use and conservation of natural resources which I propose as the requisite formula for our day. Not only does this programme result in material and economic betterment, and hence a higher standard of living, but it lays the foundation for human development in the cultural and spiritual fields. It conditions the people to the point where they are able to manipulate the other social forces, and to rise to a high level of civilization.

THE ANTIGONISH MOVEMENT

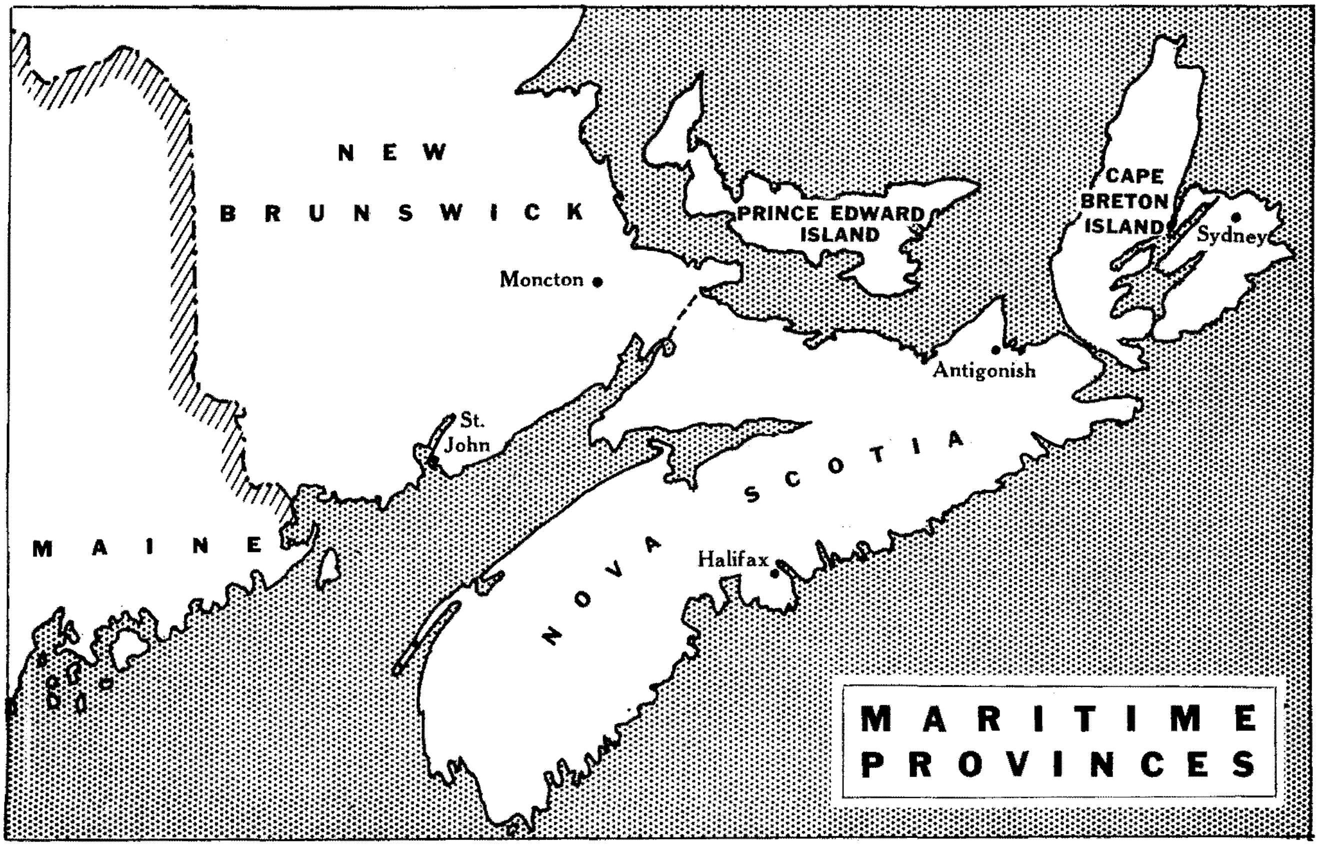
To say that the double-barrelled formula of adult education and economic co-operation is the plan by which common rural people can be brought along the road to progress is still too academic and abstract. It must be applied in the concrete. The education of the people of a given nation—especially if this is a large nation—and hence the education of the people of the world, must be tackled by regions or zones. It is well known that people in a given zone have common economic, social and political problems, and common characteristics. This supplies a natural unit for education purposes. The zone should be large enough to be significant, and small enough to be manageable. Educational action on a national scale comes from federation of the zones. Federation of national movements gives us a programme on an international scale.

The Antigonish Movement, an adult education movement of the type outlined above, which is carried on by the Extension Department of the University of St. Francis Xavier, Antigonish, Nova Scotia, is an illustration of the workability of such a programme. This movement is carried on in the three Eastern Canadian Provinces of Nova Scotia, New Brunswick, and Prince Edward Island, an area of about 53,000 square miles—approximately the size of England or the State of New York. This area has a population of 1,250,000. It has all the vocational groups and problems of a modern rural and industrial State. There are 40,000 fishermen scattered in villages on 8,000 miles of coastline; 13,000 coal miners; 5,000 steel workers in Nova Scotia; and various other types of industrial workers. More than half the people are engaged in mixed farming. The people are of four principal racial origins and are of many religious faiths. This area, the Maritime Provinces of Canada, is therefore, on account of the variety of its natural resources, and the diversity of racial origins and religious beliefs of its peoples, probably one of the best social laboratories in the Americas.

Twenty years ago, the Extension Department of St. Francis Xavier University began to mobilize the people of this region for continuous adult learning. Almost from the start efforts were made to get the thinking of the people to issue in economic action, especially economic group action, or economic co-operation. The movement first started among the farmers and fishermen and then spread to the coal miners and steel workers, and finally to all groups in the country. At the present time there are about 100,000 enrolled in this educational and economic movement. This is not quite 100,000 families, but it means that about 60 per cent of the families in this area are engaged in the activities promoted by the movement.

EDUCATIONAL TECHNIQUES

The fundamental technique of the Antigonish adult education movement is the study group or discussion circle. In the case of illiterate people, it was first necessary to teach reading and writing, and this was done in many cases. But even with totally illiterate people, it is not impossible to apply this technique. Leaders who are already possessed of an education can be used to transmit knowledge to even the illiterate portion of the population. A good deal of work for economic betterment can be carried out in this way. The programme, of



course, calls for ultimate literacy if it is to work effectively.

The first step in mobilizing a people for this kind of adult learning is to call them together in mass meetings. Competent leaders talk to them about the value of knowledge, and the necessity of economic and social action. The people are then divided into small groups which are to meet at least once a week. There would be monthly meetings of the groups of a given area to compare notes on success and failure of the work. This phase of the programme calls for the co-operation of local leaders; clergymen, school teachers, social workers, or other community leaders. The necessity for schools for leaders becomes apparent early in such a programme —leaders both in the techniques of education and techniques of economic co-operation.

The third phase is the holding of local, regional and general conferences. These conferences, to which representatives from every community go, supply the inspiration for further activity.

The next stage is to produce simple literature that can be used by these people. Then comes the question of supplying books and pamphlets; and finally libraries come into the picture.

The newest development in the twenty-years experience of Antigonish is the use of radio. The Extension Department of the University has easy access to a radio station which gives ample time without charge for broadcasting material. The workers in this programme have been organizing "listening-in" groups. The broadcast is once a week. The material is sent out in advance to the listening groups. Then a panel of three discusses the topic over the air for half an hour. The listening group turns itself into a discussion circle and mulls over the material under discussion. Supplementary reading is indicated for further study on the topic; this gives a chance for individual study and more mature consideration of the material.

It is important that the material discussion in the first few years should be of intense interest to the people in question. Generally speaking interest can be aroused by touching on the material, economic, and social phases of life in the area.

ECONOMIC ACTIVITIES

Finance—credit unions: The first and simplest field of economic co-operation is in the field of money. The common people are urged to mobilize their financial resources, however meagre they may be, in what is known as "credit unions" or "co-operative savings" institutions. This promotes thrift among the people; gives them a sense of responsibility, and affords the necessary credit facilities for carrying on economic operations in other fields. This short-term credit system, which has operated for the past hundred years in many parts of the earth, can be expanded into the field of intermediate and long-term credit.

There are 451 of these credit unions in Eastern Canada alone. From Eastern Canada, where this movement started in 1933, it spread to all parts of Canada, outside of Quebec where it was introduced in 1900 for the first time in North America by Alphonse Desjardins.

There is something significant about the sudden spread of this movement in a country as large as Canada. It augurs well for the future of democracy. It proves that common people, even the uneducated and so-called "dumb demos," are capable of quickly grasping an idea. Judging from this favourable reaction, it might not take so long, after all, to make a better world.

Processing and marketing: The activities by which rural peoples get their living are an important—if not the most important—phase of the economics of rural life. Group action or economic co-operation in production, processing and marketing, is necessary for the proper economic development of rural peoples. As a matter of fact, there can be no scientific marketing except centralized marketing. This calls for co-operation. Individual activity in these fields is impossible in the modern industrialized world. The people must either co-operate or perish.

Modern machinery is too expensive for the little operator to own personally; he either must give way to corporation farming and forget the business of marketing, and be forced as a consequence to live on a low self-sustaining subsistence level, or join with his fellows to own and operate co-operatively the instruments of processing and marketing. There are more than economic reasons for this. Experience teaches that there will be as many types and qualities of products among fishermen and farmers as there are individual producers. Only through co-operation, in which all products are pooled and graded and processed, can we get uniformity and volume to meet the requirements of our day.

Co-operative marketing is equally important in the use and conservation of natural resources. Once a rural people have set up a complete unit for the handling and processing of all their commodities for the markets of the world, then they are forced to the scientific use of raw materials and their conservation. This is for the simple reason that they have their money invested in their own plants. These plants will be useless to them if they run out of raw materials. Then too, the wider vision that comes to the people who have already achieved this measure of industrial progress will dictate a scientific procedure with regard to the use and conservation of natural resources. It is to their own best interest to get a living out of the least possible production. This is possible because they get everything out of these economic operations. They are no longer, in other words, just mere primary producers. They are now taking a hand in the nobler work of following their products to the ultimate consumer. This dignifies themselves in their own eyes and gives them a new sense of responsibility.

There is another real sense in which this procedure is vital to the proper use and conservation of natural resources. Rural people will not be long engaged in this type of activity before they realize the absolute necessity of a wide scientific knowledge of land, plants, animals, and the processes by which they are made available to the consumers of the world. It is impossible that we can long conserve our fisheries, forests or lands, if the great bulk of the human race have only an indirect interest in doing so. On the other hand, it is almost certain that the sense of responsibility that comes from ownership, and the ability to use the products of the earth for the elevation of the great masses of the people will make them the jealous guardians of Mother Earth. We are finding in Eastern Canada, especially with the fishermen, that as the people take over the co-operative development of the fisheries, there is no need for a great police force to prevent poaching and other undesirable practices of former days. This would seem to indicate that if we give the people a chance to call the earth their own, everything else will take care of itself.

Experience in Eastern Canada has shown that these theories can be easily translated into practice. All groups of primary producers — farmers, fishermen, miners, lumbermen — are capable under proper educational organization to organize themselves into productive units. The nature of the business undertaken will decide the extent of the territory served by these business units. Farmers, for example, in this modern age can set up dairy plants which will manufacture butter, ice cream, cheese etc., for the people over a comparatively large area.

What is said of farming is true also of lumbering. Co-operative sawmills and plants that season and manufacture lumber can serve an area of similar size. Co-operative fish plants vary with the kind of fish processed. Generally speaking, one important port can be the nucleus of several little ones within a ten-mile radius. This, of course, depends on the nature of the sea coast and the distribution of the people.

These individual, local plants are federated for marketing purposes into central organizations that cover the whole zone. Such marketing institutions can be federated with similar institutions in other parts of the world, and thus people all over the earth can enter into a programme of mutual self-help. The universalizing of this movement might easily lay the material basis for universal peace and good will.

Consumer co-operative business: A fundamental principle of the Antigonish Movement is that action in the processing and marketing field is not alone enough to build up rural life. This must be paralleled by co-operative action in the consumer field. As a matter of fact, it would be difficult if not impossible to sustain continued high-class activity in processing and marketing if business in the field of consumer and vocational goods is to be done by business agencies whose primary motive is profit making.

How the fisherman gets his rope, twine, nets and gear, and his boat; how he gets his clothes, his food, his consumer goods; is just as important as how and where he sells his fish. The same thing is true of the farmer and lumberman. The kind of scientific production and marketing we have outlined above is not likely ever to start, or if it is begun, will it long remain a successful business if the people, especially in the earlier stages of their development, are exposed to the wiles and intrigue of private profit business. They will revert back to the old feudalism, in which the setting of prices is a one-sided affair. The merchant thus has a lien on the products of the primary producer before they are even produced. Generally speaking, this type of business keeps the primary producers in perpetual debt. There never can be real scientific procedure in this kind of a feudalistic set-up. Therefore, how people do their business has a direct bearing on the use and conservation of natural resources.

The field of services: To complete the programme by which the rural peoples of the earth can become self-respecting citizens, we must have group action in the field of services. This is particularly true in the field of housing, health, hospitalization and medicine. A people who lack the ambition or the ability to organize themselves to obtain proper diet and hygienic living cannot rise to any high standard of living or build a decent civilization. An organized effort to know about these services, as a general rule, will result in their attainment.

CAN IT BE DONE?

The story of the Antigonish Movement gives the well-founded hope that people everywhere in the world are capable of carrying out these economic activities. The fishermen, farmers and coal miners of Eastern Canada in many cases were very poor and of limited education, but their achievements are encouraging. They organized 451 credit unions having memberships of 90,000, and assets of $10 million, and carry on a sizeable insurance business. They have 210 retail stores, which in 1948 had a sales volume of $17 million. These stores are serviced by a wholesale and three affiliates which had a turnover of $10 million. The central marketing association of the fishermen had a business of $3,500,000. A very great variety of marketing organizations, fish processing plants, creameries, sawmills, and a number of service institutions are scattered throughout the entire country.

Morrell, a fishing-farming community of 300 families in Prince Edward Island, has an egg-grading station, a frost-proof potato storage, a modern creamery, a theatre, an outdoor skating rink, a $50,000 credit union, and a co-operative store with a turnover of $550,000.

Shippegan, a fishing-farming community of 415 families, in ten years has built up a credit union of over $200,000, a co-operative business of $400,000, a great variety of co-operative fish plants, a marketing organization, and during the past two years has spent over $1 million on a new high school and other educational developments.

The stories of scores of other communities could be cited to show that simple people are capable of great achievements through economic co-operation. Organized in this way they are capable of immediately putting into action whatever is best for the use and conservation of natural resources. Such education and organization would seem to be a necessary step in the development of people everywhere on the earth.

CONDITIONING FOR A BETTER WORLD

The answer, therefore, to the problem of the right use of natural resources is enlightenment, scientific knowledge, and education. This is achieved primarily by the mobilization of the people for continuous adult learning. By such a programme we chase away ignorance from the earth, and put knowledge in its place. This must be followed by social and economic action that will lift the people to new levels of life. The joy of living will make them jealous of their natural resources, their earth; they will have a vested interest in Mother Earth and will fight to defend it.

There is something else just as important. Such an uplift of the people will drive out exaggerated nationalism and tend to kill international jealousies. The people of one part of the earth, under such an enlightened programme, will realize that the things that they have in abundance really, in all decency, should be made available to those that have not; they will rejoice, and will not be jealous of the fact that some other nation is blessed with natural resources that they do not have. In a really friendly world, built up by such activity on the part of the people, they will come to the conclusions that, after all, the resources of any part of the earth are in a sense the resources of all the people. True, the people of a given nation will own and control the products within their own territories, but let us hope that the day can truly come when a Swiss can say with real truth that he is proud of his diamonds in South Africa, his oil and rubber in the East Indies, his cotton in the United States, and his fruit in the tropical countries. We hope further that the time will come when all people will look upon these things as their own, because they really are the products of their earth, which under an enlightened programme of education and economic development will really some day become One World.

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APPENDIX A

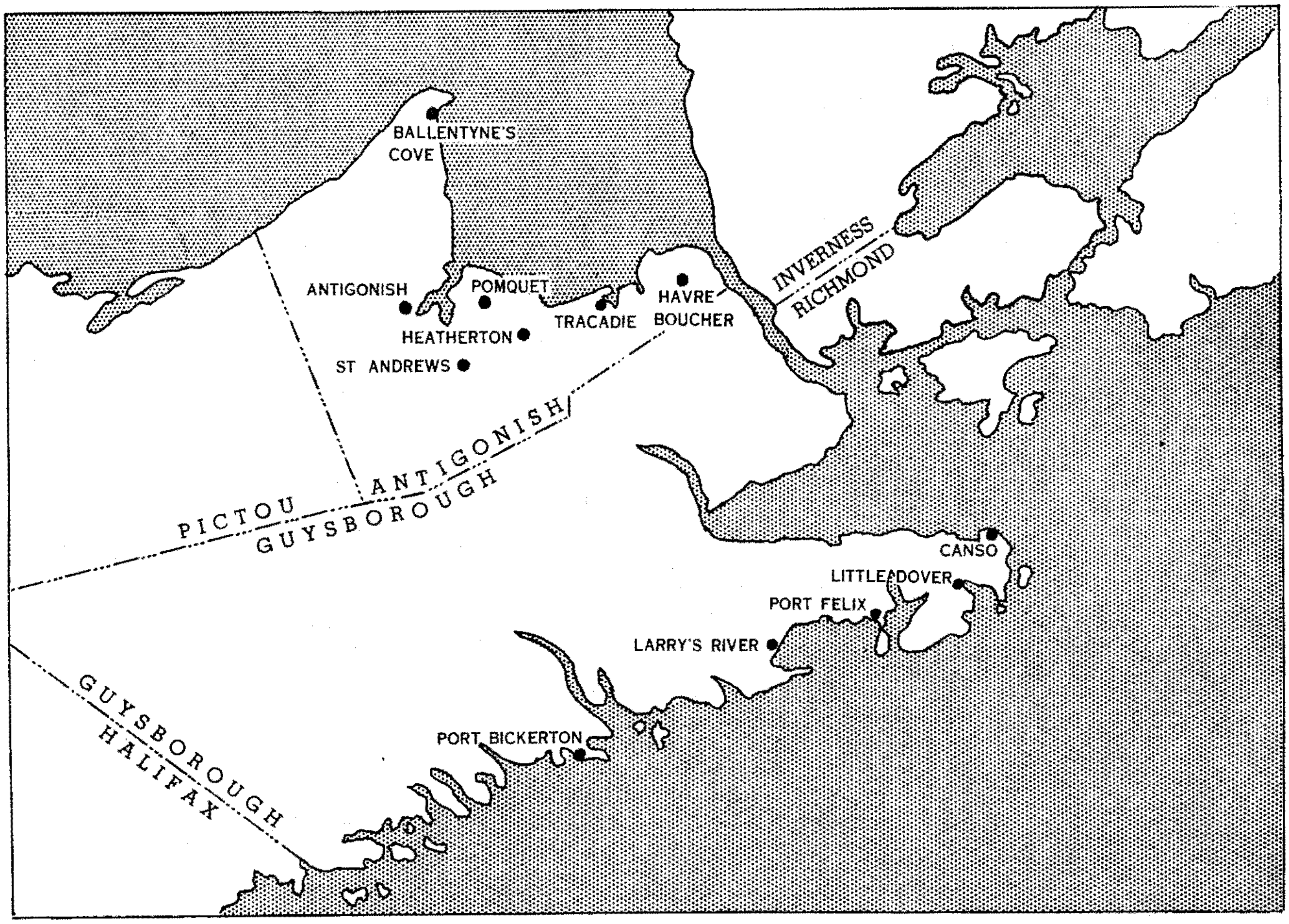
EASTERN CO-OP SERVICES PLAN

Regional Co-operative Wholesale, Antigonish, Guysboro Counties

LOCAL

Introduction: A sound co-operative development is built from the bottom up, not from the top down. First, individuals organize in local societies to do collectively what they can't do working separately; then these groups unite with others in the area to form larger regional societies to furnish wider services common to all; then these wholesales combine with others to do a still broader job, and so on to the field of international co-operation. But the whole structure finally rests on individual persons who must understand the system and control it democratically. In this region there are certain things that the people in each local community will have to do by themselves, and then this collection of strong locals will unite to build a regional wholesale, Eastern Co-operative Services, to carry on a larger marketing, processing and merchandizing service for the whole area.

The consumer approach: In this region, particularly in Guysboro County, too much attention has been given to the producer organizations as compared with consumer stores. The producer organization is, of course,



important; but only by linking it completely with the Consumer Co-operative can the farmer or fisherman get full benefit from the organization. It would appear that many fishermen have not seen this, and in the last few years in Guysboro private-profit stores have swallowed up much of the increased earnings from the fishing industry. In Canso, for example, only half the members of Eastern Co-operative Fisheries are members of the co-operative store. Besides losing much of the fishermen's money spent for groceries and home supplies, the co-operative is handling only a dribble of the fishing supplies. (The Canso member of the committee estimated the volume of fishing supplies for Canso alone to be about $35,000 or $40,000, and this is as much as the total volume of business in the co-operative store at present.) It would seem, therefore, that the emphasis in the future must be on the development of the Consumer Co-operative end of the programme in every locality.

Organization: This committee feels that the most effective way this can be done is to have the producer and consumer organization under single management. Sometimes this cannot be arranged—as in the case of a fishery organization which covers a much wider territory than can be served by a store. In such places, smaller consumer stores should be set up to serve the members locally.

Strong management is important. A good store manager could carry out the duties of general manager over store and fish plant both. In addition to uniting the producer and consumer ends, this would get clear of the seasonal problem of hiring a fish plant manager for part of the year. To start with, e.g., in Canso, the bookkeeping for both organizations could be done under the one roof, in the store, and this could serve as a connecting link between the fishermen and the store and provide the first step to unification.

The local job: Before a strong region can be built, each local society has a job to do on the community level. Sufficient capital has to be invested to build both local and wholesale facilities, trucks and processing plants, and in the case of certain fishing centres, smaller cold storage plants as described below.

REGIONAL

Regional affiliation: At the present time, (September 1946), Eastern Co-operative Services is owned by five co-operative stores: People's (Antigonish), Pomquet, St. Andrew's, Heatherton and Tracadie. They have invested about $40,000 to provide the present facilities of the wholesale. But wholesale and marketing facilities are extended to other co-operatives besides these five, and it is only proper that all organizations in the region become affiliated and help to build up the capital necessary for the expansion outlined below. The capital investment for a local society for membership in the wholesale is $5.00 per member, of which $1.00 per member may be paid at the start and the rest built up over a period of time. Of course, $5.00 a member cannot build the plant needed by Eastern Co-operative Services.

There are about 1,600 members of co-operatives in the region and at $5.00 per member this would yield about $8,000. But "Eastern" will need a plant and new buildings requiring at least $115,000 of new capital in the next few years. This matter of finance is discussed later.

Note: By 10 December 1947, five additional organizations had joined Eastern Co-operative Services: St. George's Co-operative, Canso Co-operative, Little Dover Co-operative, Fort Felix Co-operative, Ideal Co-operative.

Cold Storage: The co-operative development of this region in the future will depend largely upon cold storage facilities. The suggested plan includes the erection of a large central plant at Antigonish and three smaller plants at Canso, Larry's River and Port Beckerton.

The three small plants would provide storage for bait, limited quantities of fish between shipments to Antigonish, store supplies, blueberries (Larry's River), and farm products brought into Guysboro. The large plant at Antigonish would provide space for all the farm products from Eastern Co-operative Services requiring refrigeration. It would also be the main holding plant for fish from the Guysboro groups, which would be stored here on rail siding to be shipped on order from U. M. F.

Exchange of products: With these plants and the necessary trucks, one can imagine a great exchange of farm products and fish between Antigonish and Guysboro. To the various points in Guysboro would go milk, eggs, vegetables, poultry, meat etc., and when possible they could be picked up from farming areas in Guysboro itself for consumption in fishing centres. In addition, trucks would carry store supplies, flour and feed etc., from the wholesale in Antigonish. On returning trucks would come fish to be stored in the main cold storage awaiting shipment to consumer outlets in Antigonish, Pictou and other points in Nova Scotia, as well as the Upper Canadian market or elsewhere.

FINANCING THE PLAN

Introduction: In presenting this plan to the people of the region, emphasis should be placed on the fact that our farmers and fishermen have never invested in the business side of their occupations to any extent as compared with their investment in the production end. Farmers who have built up an investment of as much as $10,000 in a farm and equipment in order to produce, may have as little as $10 or $25 invested in the business which is going to market and take care of their products. Fishermen, too, have neglected the business end of their vocation by not putting enough money in it. A fisherman's boat and gear may be worth as much as $2,000 or $3,000, but at the same time he may have only $40 or $50 in his fish plant. But his co-operative organization is as much a part of his calling as his boat or engine, and he can't get the full returns from his work unless he takes investment in his organization as seriously as he takes investment in equipment.

New money needed: Going over the whole area and taking into consideration the new local and regional plants needed by co-operatives in these counties, the committee estimates that at least $179,000 will be needed to bring about this development. This is money that members of all co-operatives combined will have to invest in their organizations to provide the facilities required for these services. These facilities include the four cold storage plants; a new creamery, hatchery, warehouse and abattoir for Eastern Co-operative Services, the new co-operative stores in the region; and additional capital needed by present locals in the area. (In the case of the cold-storage plants, 30 per cent of the money required may be obtained by grants from the Federal Government and 50 per cent on loan from the Provincial Government.) Of the total, $115,000 is needed for the regional wholesale; and the remainder, $64,000, for the local societies.

This may seem like a great deal of money; but when divided among the 1,625 members of co-operatives in the region and spread over a period of three to five years, it becomes a very small amount for the individual member. The over-all average is $110 per member, which becomes $22 per year on a five-year basis. This is probably much less than the yearly dividend which many members get from the co-operative. But this is the average. In places like St. Andrew's, which is already well capitalized, the individual investment is only a pittance; but in Larry's River and Canso for instance, which are under-capitalized and also need a local investment for the cold storage plants, individual members will have to invest around $140 each to build up their own local organizations and contribute to the central development as well. But even $140 or $150 means only $30 yearly for five years.

Using the credit union: We must not lose sight of the part the credit union can play in this development. In fact, this plan might help a great deal to revive interest in credit union work in some communities. Credit union borrowing may be done in two ways: either by the society or the individual member. If, for example, your co-operative store needs $3,000 of new capital to carry on, it may seem easy to borrow the whole amount directly from the credit union; but a much sounder and safer way is to have a hundred members each borrow $30 individually from the credit union, invest it in the store, and then pay back the money to the credit union over several months.

EDUCATION

This committee recommends that the plan outlined above be given to all our co-operative members in the region for special study during the coming months. It is not complete and no doubt requires revision in certain details, but at least it should be studied with a view to the future of the co-operative movement in this region.

We propose to give it first to boards of directors and managers all over the area, then discuss it at a regional rally to be held at some central place this fall, and finally have it studied by the members at large, including young people, so that the people will have a vision of the co-operative structure they are building.

FIVE YEAR PLAN
LOAN CAPITAL SUBSCRIPTION

Name . . . .

Address . . . .

Patron number . . . .

. . . . Co-operative Society Ltd.

I hereby subscribe for (number) Loan Units (of $5.00 each) in the above named Co-operative society. I agree to have the subscribed amount paid up not later than . . . . 19. . . .

This amount is to be paid by one or more of the following methods as indicated.

(1) Cash in full.

(2) Cash payment in part and balance in instalments of $.....

(3) Deductions from produce.

(4) Any other means.

(5) Charge on store account.

Dated .... 194..

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Signed

CHAIRMAN: I thank Dr. Coady for the vision he has given us of the work he has achieved. We all know that he is the inspiring force behind the movement, and we wish him all good luck with the programmes of the movement and hope that it will be followed in many other places in the world.

We now have to go to another part of the world—China—and I am glad to be able to introduce Professor Lossing Buck, who has spent so many years there and will now give us details of the ways and means by which the Chinese nation has managed to have its conservation practised through many centuries.

Mr. BUCK *delivered the following paper:*

Application of Simple Conservation and Land-Use Practices in China

J. LOSSING BUCK

ABSTRACT

Simple conservation practices have been applied for centuries in China. They are based on a need for conservation and good use of land. The Chinese know the importance of water to crop production and irrigate nearly one half of the total cultivated area; a large proportion of this irrigation is in humid regions where rice is grown. Diversion of streams is the greatest source of water. Large diversion projects such as the irrigation development of the Chengtu Plain in Szechwan Province were constructed about 2,000 years ago by the use of simple methods and basic hydraulic principles.

Wide-scale terracing of several types is prevalent. Farm manures and night soil provide most of the plant nutrients added to the soil. Crop rotations are an important factor in conservation. In a country-wide land-use survey, farmers reported 546 cropping systems, many of which embody good rotation principles, including the use of legumes.

The useful practices found in China are worthy of study and trial by other countries.

China is often cited as a horrible example of soil erosion. Let us this afternoon consider the other side of the picture—China as an example of simple conservation and good soil-use practices applied for centuries over a great area of that country's farmlands. For China is an old country. Its lands have been used for thousands of years. Some land has been badly used and seriously exploited. But there is another aspect—the invention and application of good practices, practices having the greatness of simplicity, which have been used for thousands of years over millions of hectares in China. These simple practices are those which every farmer or farm community can use with local resources. They are based on a need for conservation and good use of land, a knowledge of their usefulness and a desire to make them a part of the farming system. They are as much a part of Chinese farming as knowing how to plant seeds at their proper depth.

The greatest Chinese conception of conservation is the need for and importance of water to crop production. Chinese use water in farming to a greater extent than any other people with a similar-sized territory. Land-use surveys indicate that 46 per cent of China's cultivated area is irrigated, and, strange as it may seem, the largest proportion of this irrigation is in the humid regions. To grow rice you must have water. With sufficient water, the Chinese find that rice provides greater food production per unit of land than any other crop. For this reason, rice is the chief crop in the humid regions where water, soil and climate are favourable. The source of this water varies in different areas. Aside from direct rainfall on the fields, water is obtained from the diversion of streams, from canals connected with streams and rivers, from lagoons, from excavated ponds, and in West China from collecting rain water in rice fields through the non-growing period by refraining from planting winter crops such as wheat and broad beans.

Diversion of streams is the greatest source of water. Small-scale stream diversions account for a much greater irrigation area than large-scale diversions. Individual farmers and communities in many parts of China divert water from mountain streams along mountains and hillsides. Canals are a typical means of water utilization in the lower Yangtze delta area, near Shanghai, where water is made available to farms by a network of canals dug by hand centuries ago. Some of the fields can be irrigated by gravity flow, but pumping is usually necessary. The traditional wooden pump made by local carpenters consists of a wooden trough with an endless chain of wooden slats moving over a cogwheel of wood. It is propelled by handles for hand pumping or by pedals for foot pumping and ranges in size from a one-man pump to a six- or eight-man pump. Similar types of pumps are also propelled by a water buffalo or by a windmill.

These pumps are used mostly for low lifts of several feet. For this purpose they have been found more efficient than centrifugal pumps. However, man and animal power are often insufficient to pump the amount of water needed by the crop at certain times. For this reason internal combustion engines have come into use as a source of power for pumping. Farmers have attached belt wheels to their wooden pumps and contractors owning engines put them on boats and ply the canals, irrigating the farmers' crops at so much per unit of land. This kind of mechanization, combining traditional with modern equipment, indicates possibilities for other conservation operations.

The canals are also a convenient farm-to-market transportation network throughout the Yangtze delta. Instead of using farm carts, these farmers use farm boats to transport produce from the fields to the farmstead and for taking fertilizer to the fields.

Locally the canalized area is known as the "water road" area; it is greatly favoured for farming and travelling as compared with the adjacent rolling lands, known as the "dry road" area. The distinction is also reflected in higher values of land and higher rates of taxes for the "water land" than for "dry land". Where "water land" and "dry land" are close together, farmers try to have both kinds of land in order to distribute risk and assure income. Difference in productivity of land is one of the reasons for fragmented holdings in China.

Although the diversion of small streams is the most important source of irrigated water, some large diversion projects also illustrate the use of simple methods. The outstanding irrigation development of the Chengtu Plain in Szechwan Province is an example of a three-hundred-thousand-hectare project for the diversion of water by use of simple methods. The Chengtu Plain had been already settled for centuries and it suffered periodically from droughts and famines. The situation was so serious that a man named Li Bing conceived the idea of diverting water from the Min River to the plain by cutting a channel through a small ridge and distributing the water by irrigation channels throughout the plain. Modern hydraulic engineers credit Li Bing with having known every principle of hydraulics. As a result of his work, famines were banished forever from the plain.

Destruction of canals by the flood waters of the Min River is prevented by maintaining the proper height of the diversion channel banks just below the intake, as spillways into forked branches of the river. Li Bing insured proper maintenance of the diversion channel by burying a large piece of iron in the channel bed at a depth to which debris had to be cleaned out each year. I saw this iron during one of the annual clearances of the diversion channel. Moreover, the banks of the diversion channel are protected by what is commonly known as bamboo sausages, consisting of long containers woven from local bamboo and filled with large cobblestones. Maintenance is carried out each year by a labour assessment from each county on the plain, plus a water charge per unit of land. The system has been in operation for 2,000 years. It was built and is maintained without any modern equipment. Modern Chinese engineers who consider that they can improve the system find scepticism and opposition from farmers and local officials who fear that tinkering with a system which has operated satisfactorily for so many centuries might cause disaster.

The cost of the system is light in comparison with its advantages. The water charges are low and the assessment of labour each winter is not a heavy burden because it occurs during the time when farmers have little other work.

Although the chief purpose of the Chengtu Plain project was irrigation, the canal water is also used for water power to grind grain and to hull and polish rice. Big irrigation wheels propelled by the flow of water are sometimes used to lift water to higher land. Foot and hand pumps are prevalent wherever water cannot be taken to the fields by gravity. Portions of the canals are used for transportation, but no system of canal locks was developed for an over-all water transportation system throughout the plain—an omission in Li Bing's planning for the use of Min River water.

Another large irrigation project, also constructed about 2,000 years ago, is in a dry unsettled area at Ninghsia, North China, where water was diverted from the Yellow River. Little or no attention was given to the appropriate size of farms for settlers or to drainage to control the salinity of soils. Much of the farmland is now suffering from salinity, which reduces crop yields or prevents crop growth altogether. Land-use surveys show that these farmers have a lower standard of living than farmers in many other areas. By comparison the Chengtu Plain is a paradise, chiefly because it has good soils and a more adequate size of farm makes possible better standards of living.

On rolling lands out of reach of canals and streams, ponds are dug to catch rain-water run-off from the surrounding area. To make certain of obtaining all possible water, minute diversion channels are dug on the higher lands leading to the ponds. Irrigation from these ponds is by gravity to the lower fields and by pumping to nearby higher fields.

Efficient use of all these irrigation waters is a prime concern of Chinese farmers. Stone masonry is used to protect canal banks and to make locks and spillways. Seepage in farm irrigation ditches is minimized by puddling the soil in the bottom and sides of the ditches. The water is applied by flooding, furrowing and spreading.

Extensive dyking is a simple form of water control to prevent flooding of crop land. The whole Yangtze Flood Plain inside the main river dykes is a complete network of dykes built and maintained by village communities. During the flood season farm villagers take turns patrolling the dykes and sounding a gong whenever a break is discovered. This dyking system works well except for occasional peak floods. For instance, during the Great Flood of 1931, which inundated the lands of some 25 million farmers, practically every dyke was overtopped with flood waters. A similar flood occurred some 70 years previously. However, these and minor floods are not without their benefits. Farmers claim the silt enriches their land each time it is flooded. But dyking of a flood plain delays the geological process of building it higher. One might consider that, geologically speaking, the flood plain has been settled too soon.

In the wheat and millet areas of North China irrigation occurs on about 15 per cent of the cultivated area.

In the Great Plains portion it is largely from dug wells with a Persian wheel type of pump. In Northwest China it is chiefly from diversion of small streams. Modern knowledge of deep well drilling will undoubtedly result in a development of deep well irrigation in the Great Plain of North China, where geologists have indicated there are large underground water supplies. A great deal of Northwest China is so rough that extensive irrigation is impossible, but the Chinese have met the situation with a large amount of terracing: stone-faced terraces and bench terraces to hold as much water as possible.

In some areas of Shansi Province, these terraces are graded and sloped toward the mountain to hold rainfall. At the centre of each terrace is a carefully constructed stone-faced spillway to carry off any excess water.

In the rice region terracing is even more extensive, because rice fields must be level to hold water. This leveling with plough, shovels and a special pronged iron leveller drawn by a water buffalo is one of the greatest aids to the conservation of both land and water.

On the eastern slopes of West China's mountains, the diversion of excess water from croplands is engineered as well as anywhere in the world. There I have seen diversion channels on steep slopes leading into a main stone-lined channel and well protected with erosion-control grasses.

Special types of conservation are found also in limited areas. In the Province of Honan good soil buried during floods with sand and gravel from the Yellow River is retrieved during the winter months with simple implements by turning under the top debris and bringing the good soil to the surface. Conservation in the dry area of Northwest China may also extend to such laborious methods as the carrying of pebbles from stream beds to fields as a mulch to absorb and hold moisture in the soil.

The tremendous engineering feat of levelling rice fields, terracing fields on mountainsides in both the rice regions of South China and in the drier regions of North China, and bench terracing on less steep slopes, has taken place on nearly two thirds of the cultivated area of China. And it was done with human and animal labour by means of simple tools like the shovel, the plough, the levelling harrow and the hand-laying of stonework. The need and the desire for the conservation and full use of land and water have been so great that thousands of small informal community organizations and millions of enterprising individual farmers did it without any national or provincial conservation commissions and without mechanized equipment. They did this work during slack seasons. By this means they enlarged the size of their farm business without increasing the area of the farm. Even so, the job is far from complete.

But the application of known methods is being extended and demonstrated in the modern version at Tien Shui, Kansu Province, Northwest China by personnel with up-to-date training. The Tien Shui Soil and Water Conservation Station was established in 1941 to study the conservation problems of the area and to determine through experimentation the practices best adapted to the area. The site chosen is typical of the vast region of the upper Yellow River watershed; methods found practical in Tien Shui should be applicable over a much wider area. The technical personnel at the station consists of a civil engineer, a meteorologist, an agronomist and foresters.

A recent report of the station's work illustrates successful practices, combining local resources and methods with knowledge obtained through modern training. It has been found that the planting of willow, black locust, hybrid poplar, tamarix, sweet clover and alfalfa on previously non-productive areas has been effective in controlling erosion and in building up soils of small flood plains through siltation. An additional advantage is gained because the woody plants provide urgently needed fuel and the sweet clover and alfalfa furnish fodder for livestock. By confining the river channel within dykes, the flat areas outside the dykes have been reclaimed through siltation by flood water allowed to pass through gates in the main channel dykes. Some of these new areas are already growing good crops. These additional lands make it possible to relocate farmers now cultivating steep mountain slopes and to provide permanent vegetative cover for the badly eroded slopes. Improvements have also been made in types of bench terraces. On the more sloping terraces, contour cultivation and improved crop rotations have been introduced. It is claimed that all the water that falls on the demonstration fields is absorbed by the soil. If similar results could be obtained over the whole of the upper Yellow River shed area, the amount of silt carried by the Yellow River would be reduced and floods would be minimized.

The conservation picture in China does not end with man's modification of land and his control and use of water. Strictly agronomic practices also hold an important place. Production, storage and use of farm manures is a great source of plant nutrients. While the American farmer on small eastern farms has the saying, "raising hogs is like putting money in the savings bank, the profit is interest only", the Chinese farmer says, "raising hogs gives only a profit of manure for the land". Few appreciate that farms in China have a density of animal population greater than farms in a similar-sized country such as the United States. Although a large proportion of these animals are for draft purposes, still they provide for a moderate rate of application of manure to the land. These farm manures, as well as human excreta, are the chief factors in maintenance of soil fertility. It is estimated that night soil itself supplies 15 per cent of the plant nutrients in China, whereas in most countries it is wasted. Additional potash requirements are largely met by the ashes from crop by-products of stalks and straw, which supply most of the fuel of China. Still further plant nutrients and organic matter are obtained in Central and South China by digging muck out of canals, lagoons and ponds during the winter season and applying it to the fields as fertilizer.

In the rice region the growing of legume, *Astragalus,* for ploughing under or for cutting and composting with night soil is an excellent practice and an important source of organic matter. Other organic matter for rice fields in some areas is supplemented by cutting grass and weeds from nearby rolling hill lands and working this organic matter into the soils of the flooded fields.

The rotation of crops throughout China, the use of green manure crops in certain areas and the extensive use of legume crops play an important function in maintaining soil fertility. In a land-use survey of 17,000 farms in 22 provinces, farmers reported 546 cropping systems. These crop rotations follow the essentials in providing for shallow and deep-rooted crops, cultivated crops and leguminous crops.

In North China many localities have as many as 12 to 15 different crops fitted into the various rotations. This diversification lessens the risk of crop failure, utilizes plant nutrients efficiently, maintains soil conditions, distributes income over a larger part of the year, and provides good labour distribution.

Excellent control of weeds in these rotation systems is prevalent for maximum use of moisture and plant nutrients for growing crops. Weeds are seldom allowed to go to seed in the cropped fields of China. Not only are row crops cultivated several times, but all cereal crops are hoed once or twice during the growing season. The importance of cultivation is illustrated by the saying:

If you hoe cotton three times,
It will be white as snow;
If you hoe rice three times,
The swelling grains will burst the husks.

The farmers' understanding of rotation is evident from sayings in the countryside such as:

Planting millet after buckwheat
Will cause the farmer's wife to weep.
Planting millet after millet
And you will end by weeping.

The planting of non-glutinous proso-millet and beans together,
Will equal the joy of the nephew at meeting his uncle;
But the planting of non-glutinous proso-millet and millet together
Will cause them both to weep.

Some examples of good rotations may be cited. In the southern portion of the wheat area of North China, where two crops a year are grown, rotations such as the following are used:

Three years of winter wheat followed each year during the summer by soy beans, and in the fourth year, kaoliang as the cultivated crop and the only crop of the year.

Winter wheat followed by millet during the summer and in the second year, winter wheat and field peas planted together followed by a summer crop of sesamum.

On poorer land the legumes form an important feature of the rotation. First year: winter wheat and field peas planted together followed by a summer crop of soybeans. Second year: winter wheat followed by a summer crop of mung beans. Third year: winter barley followed by soybeans.

In the rice area, typical examples are four years of winter wheat followed each summer by rice, and the fifth year *Astragalus sinensis* as a winter green-manure crop followed by rice. Another four-year rotation consists of two years of winter wheat followed by rice, and two years of *Astragalus sinensis* followed by rice. On low land, a typical example is broad beans in winter followed by rice and, in the second year, winter wheat followed by rice.

Many of the crop rotations used in China are unknown elsewhere. Some of them could very well be tried in other countries.

Extensive use of water, control of soil erosion, fertility maintenance, crop rotations and control of weeds account for China's continuing high crop yields. But these yields can be further increased with plant breeding, control of insects and diseases, a still greater use and control of water, more soil conservation, improved pasture management and more extensive use of chemical fertilizers.

So, although China is remembered by many as the horrible example of soil erosion, it has much that is not so well publicized which other countries can learn with profit. Professional people have been finding out for years that not all of China's lessons for the world have yet been learned.

The CHAIRMAN: I wish to thank Dr. Lossing Buck very much for his description of his experiences in China, experiences which, I think, are a revelation to many of us. I think that the time is near when we have reluctantly to break up our meeting. Already we have gone a little beyond the normal time, but I hope I shall be permitted to sum up what we have heard this afternoon.

We have reviewed from many sides the same problem: How can humanity in the future go through a rapid pace of development without too much waste of its natural resources? Countries like China have succeeded in this in their own circumstances for centuries. Now the conditions in the world are changed because we have a system of transportation and movement of goods and movement of capital all over the world. This global aspect of a utilization of the natural resources is the big problem that confronts us in the twentieth century.

I think all the speakers this afternoon were unanimous in this respect, that we have before us a tremendous task, but they all came to the conclusion that it can be done. The increase of population is a big danger if and when the nations and the peoples forget the lessons of the past, and if they do not want to co-operate in villages, in larger groups, in nations and on a global scale internationally. I think it came out very forcibly this afternoon that we have to have that co-operation and that we have to work together. Also, I think it has come out that while humans are consumers of natural resources, they are in this field not only a liability but an asset as well. We all are born with a mouth with which to eat and with hands with which to work but, more than that, with brains and hearts and minds with which to co-operate.

What we have heard from the three parts in this one world, if I may say so, from Africa, from Canada and from China, represents more or less the three types of worlds which exist now. At least we see that in all these three parts of the world there are village communities and it is through the village communities and organizations in one form or another, and by the close co-operation of these people, by education, by pilot farms, by co-operatives or by any other means that they work together. But it all boils down to the same hard facts; we all will have to work together to make the achievement of our task possible.

Dr. Raushenbush asks for capital at low cost.

Professor Black asks for capital on wise terms. Dr. Clay asks for capital, capital, capital. They all agree on this. And it comes out, I think, in these terms of Professor Black, that if we use the natural resources in a wise way, then the optimum income, the optimum consumption, the optimum production will be higher than if we refuse to do that. That means capital investment; that means present labour, present work, present possibility of consumption placed as an investment in the future. I think the result of this afternoon's meeting may be that humanity has the right and has the duty and the possibility of having faith in the future, and that we may invest in the future, because we believe that it can be done, if we do it in the right way.

I wish to announce that the background papers for next Tuesday's meeting, dealing with conservation and education, will be distributed at the door. And for those members who wish to discuss the general prospect further, I might add that we have now dealt primarily with agricultural problems and that is only one side. The other side is industry. The same subject which was discussed this afternoon will be seen, more from the industrial side, at the plenary meeting on Monday afternoon.

Assessing Resources in Relation to Industrialization Plans

Monday Afternoon, 29 August 1949

Chairman:

Raymond DREUX, Commercial Counsellor, French Embassy, Washington, D.C.

Contributed Papers:

Special Problems in Industrialization
John ABBINK, Consultant on the Foreign Technical Assistance Programme, United States Mission to the United Nations

Special Problems in Assessing Resources in Relation to Industrialization Plans of Less-Developed Countries
Roberto VERGARA, *Corporación de Fomento de la Producción,* Chile

Industrial Development in Venezuela
Pedro Ignacio AGUERREVERE, Consulting Geologist, Caracas, Venezuela

Special Problems in Assessing Philippine Resources in Relation to its Industrialization Plans
Filemon C. RODRÍGUEZ, National Research Council of the Philippines

Discussion:

Messrs. EL BANNA, RODRÍGUEZ ARIAS, AGUILAR, KARPOV, VAN TASSEL, ROELSE, REYNA-DROUET, BLOCH

Programme Director:

Carter GOODRICH

Programme Officer:

ALFRED J. VAN TASSEL

The CHAIRMAN: [a]First of all I have to express regrets on behalf of Mr. Rossin, Secretary-General of the *Office de la recherche scientifique coloniale,* who, having been detained in Paris and prevented from coming to the United States, has been denied the pleasure of presiding at this meeting today.

Before we start on the agenda, I have a technical announcement to make. In order that everyone may have the maximum facilities for taking part in the discussion, portable microphones have been installed. The microphones on the central table are also at your disposal throughout the discussion. Anyone who wishes to take part in the debate is requested to come to the table.

Our subject for today is extremely important because of its economic repercussions. At a time when the American Government, by yet another generous initiative, has announced to the world what has been called "point four", it is obviously most important that the technical experts who have gathered together for this assembly should express their opinions as to the best method of ensuring, within the framework of industrialization plans, the most rational possible use of the existing natural resources.

You have already had proof of the high qualifications of the experts who have spoken during the preceding meetings. You will certainly not be disappointed this afternoon, for our various colleagues who are going to speak to you have all had occasion, in the course of their present or former functions, to deal personally and directly with the important problem on our agenda.

I shall not delay any longer your pleasure in hearing them, and I shall first give the floor to Mr. John Abbink, Consultant on the Foreign Technical Assistance Programme to the United States Mission to the United Nations. Mr. Abbink recently participated as co-president in the Brazil-United States Technical Commission, a very important mission which carried out a comprehensive study on the conditions of economic development in Brazil.

Mr. ABBINK *delivered the following paper:*

[a]The chairman spoke in French.

Special Problems in Industrialization

JOHN ABBINK

In presenting this brief comment on Special Problems in Industrialization, I should like to make it clear that it is not to be taken as representing official opinion of the United States Government. What I shall say is based primarily upon personal observation and experience in various aspects of the problem of economic advancement in underdeveloped areas of the world, and upon conclusions reached after a recent intensive study in one such area in the Western Hemisphere.

Actually, no country on the globe has attained economic maturity—or ever will, if there is to be continued progress. Millions throughout the world are convinced that in some respects the United States is truly a promised land—that it has reached the acme of material well-being—a feeling which the people of the United States fortunately do not share. It is doubtful that the total of the budgets for the presently projected plans—however starry-eyed — of all of the underdeveloped countries would greatly exceed the amounts that must be spent during the next few years, through private and public agencies, to maintain and expand the economy of the United States. One item alone—the rehabilitation and improvement in this country of highways, neglected during the war period—will require the expenditure of an estimated $45 billions over the next five years.

I was startled during one of the sessions of the Havana conference which was drafting a Charter for the proposed International Trade Organization, to hear one of the delegates suggest that the United States might well assist the rest of the world in attaining economic equality before planning to further its own material progress. No expression that I have ever heard or read illustrates more clearly the misconception that exists in many minds as to the nature of the problem of economic development throughout the world. It is part and parcel of the subversive doctrine that the world needs, not to produce more but to divide what has been produced in the past; as though a tinier share to each individual in an increasing world population would create a Utopia; a fallacy that has been exploded many times in many countries, and is even now being bitterly disproven in unhappy Britain.

The most difficult single problem which faces leaders in underdeveloped countries is that of convincing their peoples that economic progress comes from within; that it cannot be imposed from without, or even greatly advanced unless there exists a wide-spread desire for national improvement so strong that the necessary temporary sacrifices will seem worth while to all who will be affected. The longing for economic progress seems universal; the question our generation must resolve is how to inspire those who yearn to accomplishment.

Almost without exception, the countries which are most vigorous in their demands for assistance from without in attaining what they call "economic development," emphasize manufacturing as the activity that they wish to promote. Perhaps this was inevitable, because the scarcities brought about by concentration on armament during the war years and immediately prior to the opening of hostilities, seriously affected those areas whose economies were devoted largely to the production of foodstuffs and raw materials.

But—again almost without exception—few of these countries are ready for the degree of industrialization to which they seem to aspire. The provision of physical plant and machinery is usually not an insurmountable difficulty compared with the other problems that immediately arise. It is a fair statement that industrialization may easily create more problems than it solves. Let me give you an example.

Recently I had a long conversation with the representative of a group of small manufacturers in a country which is anxious for economic development. This group would like to expand its operations, and estimated that the provision of $600 millions in modern machinery would meet its requirements. This would mean the investment of at least $1 billion when the necessary shops and buildings were erected. As we discussed the proposal, it became evident that not only must the machinery be imported, but skilled labor and management engineers as well would be required from abroad for a period of years, and more seriously, practically all of the estimated 100,000 operatives who would be needed must be recruited from agricultural regions where labor was already scarce. Coal for heat processing was expensive and poor in quality. Besides, the local demand for products which would come from the new machinery was insufficient to insure capacity operation for more than a few weeks each year, and a large export market would need to be developed in the face of competition from manufacturers in other countries who have had long experience in supplying the world's wants.

This last difficulty was waved aside with the suggestion that the United States should be prepared to take any surplus which developed, whether there was a demand in this country for such products or not, and even though the prices under circumstances as I have described them might be far higher than those of comparable products obtainable elsewhere. In other words, the United States, they felt, should provide the machinery on a long term loan basis, install and operate it for a period of years until local technicians were capable of taking over, and be prepared to absorb any production not saleable elsewhere.

The representative of this group of manufacturers was naive enough—or stupid enough—to insist that the proposal was a reasonable one, and that the United States "owed" it to his associates—an implied obligation that was never explained—to give it serious consideration.

These manufacturers failed to understand that industrialization does not necessarily mean economic development, that undue emphasis in one part of a nation's economy may disproportionately harm another, or others, and that the concentration of industry in various parts of the world is due much more emphatically to natural factors, such as the location of resources, than to man-made considerations or desires. The Ruhr, the Midlands of Britain or the industrial belt in the United States could not have prospered had nature not been kind.

The first concern of any government which proposes a program of industrialization must be its people. Would they benefit in real measure, or would they merely be transferring their energies from one activity to another, without eventual benefit, or even at the danger of an ultimate lowering of their standard of living? Is there surplus population whose energies can be led into manufacturing activities, or would transfer of those now raising crops into manufacturing result in less food production? To undertake industrialization at the risk of hungry stomachs, or in the face of rising imports of food staples readily produced locally would be *uneconomic* development. Is the general level of health such that a body of workers can be made available which will be able to stand the strain of industrial pursuits? What standards of education have the prospective operatives attained? Manufacturing pursuits cannot be successful where what is known as "common labor" only is available. More than half of the operatives must in time be capable of varying degrees of skill, for which some educational background is a pre-requisite. Above all, is there wide-spread determination for the attainment of a better life and the willingness to sacrifice for it, or only the wistful yearning, of which I spoke earlier, and which often translates itself into dangerous envy?

These are considerations which any nation must weigh through its leaders before embarking on an extensive industrialization program.

The development of the most valuable natural resource in any country—its people—needs greater emphasis and more study in every program for economic advancement. Where it has had the attention it requires, it becomes readily apparent that the pattern of industrialization which has been successful in one area will not suit conditions elsewhere; that each country has advantages and disadvantages which must be taken into account, and that to disregard them in a reckless determination to industrialize at whatever cost, may easily result in economic retrogression, rather than advance; in political upheaval instead of progress.

Many of the countries now projecting industrial development will find other problems soon facing them, less fundamental, perhaps, but still difficult to resolve. The type of banking laws and the system of credit regulation in an area hitherto largely devoted to agriculture, the production of bulk raw materials, and ordinary commercial interchange, will be found to be inadequate in a community of growing industrialization. Interest rates in such countries usually are high, far higher than can be absorbed into the cost structure of competitive manufactured products.

Local capital markets rarely exist in these areas and to promote industrialization, even to a limited degree, entirely or largely on borrowed foreign funds would be hazardous in the extreme even if they could be obtained. Many proponents of industrialization in underdeveloped countries do not realize that success will consist not of a few large, spectacular operations, but of the secondary plants which arise to use the products of the primary industries. These smaller plants must be financed locally to a large extent, and they will not prosper unless a local capital market exists, or can be developed. Liquid funds in most underdeveloped countries are devoted much more readily to speculative ventures or commercial transactions where there is promise of a quick return, than to industrial processing where returns are calculated in years, rather than in weeks. Unless the shares of secondary industries particularly are readily saleable and widely distributed, the outlook for industrial development is bleak.

The attractiveness of industrial shares to individual investors probably will depend to a considerable extent on the fiscal policies which their governments adopt. As in banking, so in tax legislation, systems which have grown in most underdeveloped countries will not be suitable for the encouragement of industry. Physically the manufacturing establishment presents an easy target for the tax collector, but its continued successful operation will depend upon enlightened fiscal administration which takes into account requirements for reserve funds that must be accumulated without fear of confiscation through ill-advised taxation, merely because they loom large in a financial statement.

To stress so obvious a necessity as adequate transportation for a growing industrial area may seem superfluous, yet it is a fact that this facility is often overlooked in development plans. Establishment or rehabilitation of railway systems for movement of bulk freight, and of highways for express traffic, is a costly procedure the world over, but an absolute essential for industrialization growth. Recent studies indicate that in at least one under-developed country, fully one-third of badly needed agricultural produce is wasted because transport and storage facilities are inadequate, and that national distribution of locally manufactured products would be almost impossible excepting at prohibitive cost.

Last, but not by any means of least importance, is the problem of providing markets for the greatly increased world production which is in the offing. I have listened to, and in some cases examined, the development plans of a considerable number of countries. In none of them has there been much evidence of sales planning. Most of the planners assume that markets exist for the production they project. Britain has increased her national output by about 40 per cent in the past 10 years, but finds sales increasingly difficult to make, partly because of high prices but more specifically because her producers have paid too little attention to market demands. People will not buy just anything merely because someone makes it. If England with her many years of experience in quality production finds the going hard today, how much more difficult will it be for a newcomer in the industrial field.

Practically every country which is projecting development plans counts on the United States to absorb any surplus that may appear, and most of them invoke imprecations on United States tariff laws, in spite of the fact that tariffs here are only about half on the average what they were twenty years ago, a condition that does not apply to any other country of which I know. The truth is that if the energy devoted to condemnation of tariff policy were devoted to study of market demands in the United States, much greater sales would follow.

I have cited some of the special problems I see ahead in industrialization in underdeveloped countries not because I wish to discourage vigorous progress, but rather to warn against immature planning. Many countries look to the United States for help in financing their undertakings, and I have no hesitancy in asserting that their proposals will be measured here against all of the criteria I have outlined, much too briefly, perhaps. President Truman's Point Four program was widely hailed throughout the world because it contained a reference to financing. Actually it stressed much more emphatically the need for planning such as I have suggested here. The people of the United States have proven that they are willing to help to the limit of their abilities, but they will be little inclined to provide funds merely because some country wants them. There is too great need at home for capital.

During the past year I have had the privilege of working closely with a group of leaders in Brazil as Co-Chairman of the Brazil-United States Technical Commission. After six months of study, this joint commission made a report which was remarkable in that the conclusions reached were unanimous. In a few words, the report stresses the need for balanced development in which all segments of the economy participate and from which all will benefit. The document was not particularly pleasing to those who are interested chiefly in manufacturing, but even they were forced finally to admit its logic. If the recommendations made in the report are carried out, I am confident that Brazil will be one of the most prosperous nations in the world long before the twenty-first century dawns.

The urge for development is one hopeful facet of an otherwise dreary world scene. Those of you who are helping to plan it, and to condition your countries for its impact, have opportunities which have come to very few humans in the past. It is not too much to say that you are in very truth the architects of the future! In closing, I should like to repeat one thought that I expressed early in my remarks. The people of the United States have come to the conviction that "the most difficult single problem which faces leaders in underdeveloped countries is that of convincing their peoples that economic progress comes from within; that it cannot be imposed from without, or even greatly advanced unless there exists a wide-spread desire for national improvement so strong that the necessary temporary sacrifices will seem worth while to all who will be affected. The longing for economic progress seems universal; the question our generation must resolve is how to inspire those who yearn to accomplishment."

The CHAIRMAN: We wish to thank Mr. John Abbink for the remarkable exposé he has just given us.

I do not doubt but that the conviction with which he has developed his arguments will, when we embark on the discussion, arouse some opposition that should give rise to interesting debates.

However, despite the pleasure we should feel in having the advantage of Mr. Abbink's presence for that discussion, as our four subjects for this afternoon are all of a similar nature, we thought it would be preferable to await the end of the papers before opening the general discussion.

I shall therefore give the floor now to Mr. Roberto Vergara, our colleague from Chile.

Mr. Vergara is at once an economist, a mathematician and an administrator. He has all the qualifications for giving us an extremely interesting talk, especially since he has fulfilled high functions in Chile, in the official agency for studying and promoting the development of that country.

Mr. VERGARA *delivered the following paper:*

Special Problems in Assessing Resources in Relation to Industrialization Plans of Less-Developed Countries

ROBERTO VERGARA

ABSTRACT

The advance in economic growth of the world community of nations is paced by ever greater attention being paid to the problems faced by under-developed countries. The economic sectors of industry, agriculture and public utilities must be considered from the standpoint of balanced growth by countries attempting, both with their own assets and with the help of outside aid, to raise their standards of living and to promote economic and social stability within their borders. Balanced change in the field of industrialization of a whole nation for these sectors presents continuing problems to be continuously met. These problems cover a vast horizon of subjects summed up in the word "resources". A country's resources are not only her streams and sod, trees and mines, capital and savings, but above all, the people of the nation. A people must be considered the very first resource in any undertaking into industrialization. The structure of business and of government, the financial and political situation, and willingness or ability to carry forth programmes of development are the foundations of plans and statistics. In Chile, the development programme has been carried forth with an eye to combining plans with practicalities. Projects chosen first were ones with greatest justification from the standpoint of competitive costs, market outlets, capital availability, and managerial and technical know-how, plus the intangible of over-all feasibility in the light of world conditions and administrative competence. Whether in the field of relating hydro-electric power resources to those of coal and petroleum requirements and supplies, or in assessing forest resources as related to industrial growth, or in raising farm output and productivity to an efficient and satisfying level, all must be considered as part of an integrated and interdependent organism. Finally, although the development of specific commodities or particular services required for balanced growth may differ for various countries, the basic problem of assessing resources in relation to industrialization plans emerges in a similar pattern for the whole community of less developed countries. Essentially the pattern is one of programme and progress, based on flexible policy and action constantly geared to current conditions and realities.

GENERAL

In a day when the economic stability of continents is clouded with uncertainty, action and accomplishment are themselves goals difficult to reach in the process of converting resources into living standards. For under-developed countries, the frontiers of industry are being pushed forward. This push is being accomplished both by private, local and foreign investment, and by government action.

It is true that the various problems faced by under-developed regions in their attempts to industrialize, mostly grow out of conditions existing in the particular country. However, considering the many specific problems of resource assessment for the community of under-developed countries, a basic pattern emerges which is more or less common to them all. Such items as lack of capital, need for technical surveys, absence of technological and managerial experience, under-developed transportation and public utilities systems, unco-operativeness and instability of political régimes, and the difficulty of welding together the various groups and interests of a country into the development programme, all contribute to the problems to be met by the under-developed area. But, while it may be interesting to approach such problems on an overall basis, it is more feasible to outline them as they have been experienced and met by one country and organization; that is, one with which I, of course, have had particular experience, the Chilean Development Corporation, or Fomento, as it will be called here.

Fomento was chartered to raise the standard of living and stabilize the economy of Chile. It was instructed to do this simply by the directive to conduct studies and put such studies into action. A challenge was offered, even granting that funds were provided for; and even though its administrative personnel were chosen from the chief business, technical, labour and government groups of the country. Fomento walked into the grown-up world without benefit of precedent. Hers was the instinctive admonition of doing first things first and by virtue of hard work and common sense rather than with programmes and theories alone. With the passage of time, and with the actual placing into operation of initial projects, more attention may now be devoted to the filling out of a complete programme. However, from the day of Fomento's first project to its now developing rational plan of exploiting resources, the problem of assessing these resources in relation to existing plans has inevitably been a problem which was met and solved in manner conscious or otherwise.

The first projects of Fomento were ones for which production costs and markets were easily proven after initial surveys. Without question, the hydro-electric power projects of Fomento represent the most significant programme of resource development for Chile, both in terms of immediate living standards and of long-term growth. The power programme is of major importance in the problem of assessing Chile's resources. For it is related to her limited coal reserves, which are required for purposes even more basic than those of fuel; whereas the hydro-electric power potential is almost limitless by comparison.

Perhaps a more dramatic, even if smaller, example typifying Fomento's work, is that of the copper processing industry. For years Chile had not only been the world's largest exporter of copper, but had also derived most of her consumption of such copper products as wire, sheet and tube, from the very countries to whom she exported the raw material. Thus the copper processing plant in Santiago, one of the first set up by Fomento with the aid of Export-Import Bank funds, serves as a kind of standard bearer to the functions which Fomento continues to perform.

The first hurdle of resource assessment has been presented, namely the question of competitive cost of output in relation to justifiable size of market. In addition to costs and markets, which can be judged better through market surveys and technical studies, a very basic problem must be met which is not easy to define. It is the complex of social, economic and political life of a country or of an industry at the time that the indicated development is desired to be carried out. In the case of agriculture, for example, statistics may prove beyond the shadow of a doubt that certain products and certain projects are justified from the market, cost and soil point of view; but even though that project is being carried out considering all technical facts, problems such as type and tenure of land distribution and ownership must be weighed before effective action can be undertaken. For it must be remembered that the past history and current status of a population are fully as much a part of resources as the soil they till.

Once, however, clearing has been made with interested parties, surveys and studies themselves are the first problem to be met. A really effective survey can only fit into the budget of a small country if there is a fair assurance that the cost can be later borne and considered as part of the capital of the project. It is of meaning that the present Point Four Programme of the United States is immediately concerned with the cost of surveys to be later used in carrying out such projects. In the initial years of Fomento, such prior aid for making studies was not forthcoming. It had to rely on its own funds, with perhaps at best an agreement in principle that such survey costs would be borne later once the project had been justified and initiated.

Another basic problem, after choosing the most rewarding projects from the standpoint of costs, markets and reserves, was a rough estimate of which proposals had priority in the branches of the country's economy; that is, whether manufacturing, agriculture or public utilities.

The problem of resources as applied to specific projects and fields of endeavour may be made in a four sector approach. These include first, the sector of industry, mining and fuels; second, agriculture, fisheries and forests; third, transportation and public utilities; and last, the all-embracing field of government and finance.

INDUSTRIALIZATION, MINING AND FUELS

Resource assessment in the sector of industry and mining operations may be examined in several aspects. These spring from whether the industry is a new one or an existing one, and whether a raw material or a finished product is involved. Fomento's development of the steel industry is significant. During and prior to the war, Chile's needs for semi-manufactured steel were imported, mostly from the United States and European countries. This was despite the country's possessing iron ore reserves, some of which have supplied one United States company for many years; and that Chile's output of coal has supported her existing level of industry and transportation.

Compañia de Acero del Pacífico, as this steel mill is named, is now under construction and will be in operation early in 1950. But many of the problems which were faced and met while this plant was in the discussion stage are pointedly related to our problem at this meeting. First arose the quality and quantity of reserves, both of coal and of iron ore. Considerable discussion centred upon both of these items during the initial stages of discussion on the Mill. Briefly, however, the basic questions arising were first, grades of coal to be used for the coking process, and second, the extent of iron ore reserves as related both to the length of life of the plant itself and to the Chilean steel market. Another item of interest in regard to the steel mill was the matter of disposal of by-products, particularly that of coke oven gas.

The importance of properly assessing raw material resources can be hardly better shown for any other aspect of industry than for petroleum, especially if one considers loan policies of the development institution. Not only is petroleum development related to the general problem of conserving coal resources for those purposes where hydro power or internal combustion engines are not applicable, but in order to assess petroleum reserves properly, funds must first be provided to carry on adequately exploratory well and drill work. Rough estimates must be made of reserves, even to determine whether or not reserves exist. For petroleum, the cost of reserve determination and exploration is thus largely the cost of production, assuming that reserves are struck. Uncertainty of return on investment in the oil industry has caused reluctance of loan institutions in granting development credits. Partly for this and bearing in mind the past company-state relations in this industry, Fomento, as an agency of the Government of Chile, is the party which has responsibility for exploiting oil resources. To date most of the funds, constituted largely by foreign exchange, spent by Fomento in oil-well development have justified the investment in this field. Another distinct possibility is that of a refinery within the country to convert seen reserves of crude oil on wells already capped for later production.

Turning now to basic existing industries, rational development of the country's resources required that raw materials already in production continue to be developed. Copper and nitrates are the star primary goods of the nation. Existing copper reserves in Chile are roughly 25 million short tons, copper content. This compares with annual production of between 350,000 to 400,000 tons per year. Of equal bearing in regard to copper resources, is that some deposits in the above reserves recently began to be exhausted. Sulphide type ores in the chief mining centre of the country thereby remained, but without the needed refining equipment. As a result, Chile Exploration Company, a subsidiary of Anaconda Copper Company which works its largest mine at Chuquicamata, approved in 1948 a plan to invest $US130 million in the construction of a new plant to extract copper from the major remaining deposits of sulphide ores.

Existing manufacturing industries have received their share of attention in the development programme. Perhaps the most important of these in the economy of Chile is that of textiles and fibres. In the case of cotton, both by means of government loans several years ago and through continuing expansions by means of private investment, both spindle and loom capacity of Chile have been increased to a point where the country is now largely self sufficient in the production of cotton yarn and cotton fabric.

Beginning to supplant consumer-goods fibres is the fibre rayon. In a period of less than ten years, Chile has expanded her production of rayon filament yarn to the point where the domestic market for rayon goods is now filled almost entirely with the output of filament and of spun yarn produced in spinning and staple fibre plants in Chile. However, the rayon woodpulp required in the manufacture of the rayon yarn and staple fibre still must be imported from such outside countries as Canada, Sweden or the United States. It is true that production of paper woodpulp is a project now under way because of the known application of present industrial techniques to existing timber land in Chile. Although present forest tracts in Chile are largely of the hardwood variety, there are nevertheless plantations of coniferous pine in southern and central provinces, which in the future, it is expected, may reduce Chile's dependence on outside sources for her consumption of rayon wood pulp.

Wool, hemp and flax are also of interest in fibre development and their expansion has been furthered by direct investment policies of Corporacion de Fomento by means of loans encouraging both greater processing and farm production.

These, then, are some of the more basic projects which have been undertaken by Chile in recent years. It is also fair to say that the outcome has not always been as desired. This may have been due to inadequate managerial background, lack of experience in a particular field, or use of inefficient equipment in carrying out particular projects. Such industries as cement manufacture and moving-picture making, for example, have not entirely proved satisfactory, contrary to the case of most other projects so begun. These disappointments, however, have been lessons for the future. They are part of the sum of experience against which the larger programme may be carried forward.

AGRICULTURE, FISH AND FORESTS

In terms of number employed, agriculture is the largest single economic pursuit in Chile. But from the standpoint of output and productivity, Chile's farm methods and land yields are backward when compared with other more advanced areas of the world and even with non-agricultural occupations within Chile itself.

Fomento, with the technical and administrative operation of other agencies of the Government of Chile, has almost since its inception ten years ago been making steady progress in its efforts at agricultural improvement. These efforts were chiefly in the field of mechanization, but to some extent in such other outlets as fertilizer manufacture, irrigation development and rural electrification. Now that the more significant of the industrialization projects have been launched, attention must of necessity be directed in greater measure towards the farm sector of the Chilean economy. For though farms support two-fifths of Chile's population, they receive less than one-fifth of her national income. This is due to antiquated practices on the land, poor use of available water and arable land, and in no small measure to lack of farm capital in certain areas.

There are several more basic problems of resource assessment in agriculture and food, including soil management, water supply control, crop and livestock planning, fishery development, and forest programming.

For the soil, a programme of research and action is to be established. This would involve the making of adequate soil surveys to indicate present productivity and depletion as well as possibilities of further crop use; setting up requirements for different types of fertilizer to be used in different areas; determining what drainage improvements are necessary in each area; or what improved soil management practice is in order, such as contour ploughing or terracing. All of these are to be directed to indicate whether they ought to be applied to presently cultivated areas, or whether building of entirely new projects of land clearing and reclamation, mechanization and irrigation is to be undertaken. In the latter respect it is of note that in many of Chile's areas, particularly along the coastal cordillera of the central section and even in the interior of certain of the southern provinces, severe soil erosion has in many instances removed top soil or depleted the soil of needed compounds, reducing crop yields in certain counties; action must be taken to counteract these soil depletions.

The problem of water availability and control of supply is one of the basic ones of resource management in Chile. It affects not merely the régime of irrigation and agriculture, but also the supply of water for hydroelectric power, industrial consumption and consumers' use. Only about 20 per cent of the gross agricultural area of the country is under irrigation. But much of the total agricultural land is uncultivated every year either by virtue of its being turned over to grazing on uncultivated grassland, or due to incomplete utilization of cultivated areas where cattle-grazing is carried on. Thus it may very well be that as much as 50 per cent of the cultivated area of Chile is irrigated to some degree. It is therefore understandable that in the central valley of the country, the agricultural and industrial heart of Chile, the régime of water supply is of basic importance to the continued economic life of the whole land. The flow of streams must be regulated to obtain maximum possible agricultural and consumer use. It must consider other factors—adaptability of soils and availability of transportation. Charting of stream flows is thus needed not merely for efficient current consumption, but also for the proper planning of future irrigation and industrial projects.

The application of resource assessment to the programme of selection of areas devoted to crops and livestock is a particularly involved one. Consideration must be given not merely to the physical inventory of the country as it may allow various products to be grown or produced. There must also be taken into account such diverse factors as markets and consumption patterns, export and import trends and possibilities, and factors which are neither technical nor even on the strict economic plane in their implication. The latter would include distribution and ownership of land, and the consequent political and even social bearing that this situation has upon plans for agricultural development. The factor of selection of specific products to be produced or expanded, in the case of an irrigation or other agricultural project, just as in the case of an industrial plant, depends initially upon competitive costs of production and upon a justified market. For example, there can be no question, based not only upon common market knowledge but upon studies of *per capita* consumption of nutrients, that calcium bearing milk, Vitamin A rich green vegetables, and ascorbic acid-laden fruits, have all a ready domestic market in Chile. Even in the case of meat, a protein food, existence of a widespread market is undeniable. For all of these, however, future expansions must likewise take into account foreseen costs of output. These costs are based upon present construction and future operation charges for irrigation, mechanization and land management projects. Also to be weighed in advance are matters of land and project administration, and processing and distribution of products.

An issue in the question of agricultural areas and consumption has recently been revived both in a strictly popular manner and even on a more professional plane by various authorities in the field of population study. It is the problem of land, food and population. There is no question but that problems of soil deficiencies and erosion, fertilizer requirements and crop yields, and other non-human elements of Chile's farm assets, when balanced against population, increases in numbers and general health and work efficiency, present a long and even short-term problem which may not and is not being ignored. The whole complex of activities of Fomento and of other government agencies of Chile are in one sense or another directed towards the solution of these conditions.

Fish and timber offer two of the vastest possible fields of new industrialization among Chile's replaceable resources. To a great extent, also, these two items present problems similar to one another as far as development organization is concerned. For there can be no question but that both the forest and marine reserves in this southwestern strip of South America are among the largest though as yet relatively untapped economic treasures of that continent. The problem here is not even one of assessment, inasmuch as technical missions have made complete surveys for both these products over five years ago. These missions were staffed by experts of the United States Government and of Fomento. Their reports showed beyond question both the possible range of development as well as recommendations for specific projects. The real problems are not physical but human. They are twofold: first, availability of capital, both foreign exchange and local currency; and second, availability of adequate technical personnel and managerial ability.

With respect to sawmill operations, from the viewpoint of the Government, forest conservation, fire control, and efficient exploitation of timber resources are foremost problems. The technical mission which explored Chile's wood possibilities found that a considerable proportion of the timber cut annually in the country fails to be replaced due either to limited forest range practices or to wasteful methods of cutting. The problem has yet to be adequately solved by the appearance of a working programme of forest development for the country.

Of additional interest in respect to sawmill operations is first, the programme which Fomento at present is sponsoring for the development of several large sawmills. These are to replace partially the great numbers of small and inefficient portable sawmills operating over the vast forest tracts of southern Chile and in some central areas as well.

Of additional importance in this field is the recently proposed programme of "selective cutting". By this system, large forested areas of limited boundaries would be managed so as to cut the oldest trees only. This would replace the present practice of indiscriminate cutting of trees of all ages in a smaller area but with the necessity of later replanting. Also, the method of "selective cutting," though entailing greater road costs, preserves the forest forever.

In the case of fish, the conservation problem does not compare with that of timber. The study made by the U.S. Survey Mission to Chile indicated area boundaries and annual catch possibilities for the various species of fish available in her waters. Therefore, locations and capacities of canning and other processing plants projected for this industry are contingent upon the raw material supplies available as well as upon anticipated market demands.

In both the case of fish and forests, the export market has been analysed to give further indication of the significance of the local resources. Moreover, plans for processing plants have also taken into consideration secondary products made from these materials. In the case of wood, for example, wood pulp and paper plants, a wood preservation factory and other cellulose and by-products are being planned; while in the case of fish, plants for the extraction of feeds, fertilizers and oils are also contemplated and in some cases under construction.

TRANSPORTATION AND PUBLIC UTILITIES

The industrial and agricultural progress of a country can advance no more quickly than its output of power and consumption of fuel, and the extent of transportation facilities. It is the expansion in hydro-electric power capacity which can be said to be by far one of the greatest contributors to Chile's future growth. Endesa, the Fomento network of hydro-generating plants and sub-stations, added to the existing coal and developing petroleum resources of the country, has since the inception of Fomento been leading the way to a richer life in Chile.

Surveys which have already been made on streams having hydro-electric potential in the various parts of Chile indicate that if this programme of construction can be carried out in its entirety, Chile may eventually produce over ten times its present power capacity even considering all existing projects plus those under construction. As already mentioned, initial impetus to the hydro programme was based upon the fact of limited reserves of coal. Since the latter fuel will be required in primary measure for manufacture of steel and in transportation, initiation of both the hydro-electric programme and that of petroleum exploration and refining are basic tenets of resources assessment in the country.

It is well to speak of Chile's railway development at the same time as her power development is considered. Chilean State Railways owns and operates over 90 per cent of the country's total railway mileage. In addition to its programme of expansion in rolling stock and power units, it has sponsored such subsidiary developments as refrigeration, storage and tourist facilities. But most important of all its past and contemplated improvements is the further conversion of many miles of right-of-way to an electrified system. Thus, dovetailing expansion in its transportation system into the development of electric power capacity is a basic example of rational procedure and the utilization of national resources.

GOVERNMENT AND FINANCE

In concluding a discussion of resources and industry plans of less-developed countries, we must link together with specific projects the administration and managerial problems of government. The primary concern here is one of human relationships and even historical setting rather than technical data. It is the basic policy of Corporacion de Fomento to separate its chief function of planning, engineering, and project operation from the non-technical, although important field of political relations; still, it would be naive to assume that rights and interests of parties and groups in a modern State are unrelated to the plans and activities of government organizations representing that State. The problems implied may take many forms: stabilizing of foreign exchange operations and reserves; shaping balance of payments policy for the country; control of internal money and investment policy; obtaining support for and development of specific industrial projects; relationships towards such external loan institutions as Export-Import Bank or International Bank; or conducting of foreign debt negotiations whose purpose it is to maintain the credit standing of the country. In all these, concerted action and policy by responsible government agencies is required at all times. Moreover, policies which stem from intended paths to be taken by farm and factory projects must be geared to current happenings in the sphere of international investment. The happening may be a new policy of the Executive Branch of the United States Government—the force of the recent Point Four Programme is beginning to be felt in legislative halls of far-off lands; the happening may relate to a policy based on flotation of securities by the International Bank; or even conclusions reached in studies of specific Commissions of the United Nations. All must be assessed for their proper weight and meaning in the development of a growing country. The end purpose is to assure that goals commonly agreed upon are being approached with realism and a measure of common sense.

The CHAIRMAN: Mr. Vergara, I thank you very warmly for your exposé, which was imbued with the profound knowledge acquired in the discharge of your duties.

We shall now ask Mr. Pedro Ignacio Aguerrevere from Venezuela to be kind enough to let us also share the benefit of his experience.

Mr. Aguerrevere was until quite recently the Venezuelan Minister of Economic Development. He is consequently particularly well qualified to be conversant with the problems we are discussing at the moment.

Mr. AGUERREVERE[b] *delivered the following paper:*

[b]Mr. Aguerrevere spoke in Spanish.

Industrial Development in Venezuela[1]

PEDRO IGNACIO AGUERREVERE

I was asked to speak of the experience of Venezuela in investing the income from exhaustible resources in the creation of other income. I have not been in a position to prepare a document to read; therefore, I shall limit my statement to a few personal comments concerning this particular problem.

In 1914 Venezuela became an oil-producing country. The first commercial oil-well was completed in July of that year. Exports started in 1915 and increased in the succeeding years to the point where Venezuela reached the position of the world's leading exporter of oil and second producer. The effect of the development of an industry of such tremendous importance on our economy and the experience which we have gathered in the utilization of this development for the well-being of our country constitutes a subject on which volumes and volumes could be published. This experience would be extremely useful for other countries now in similar circumstances or which may be in similar circumstances in the future.

Before becoming an oil-producing country, Venezuela had a poor but well balanced economy. Our agricultural and various other products were sufficient to feed the country and the surplus provided the necessary exchange to import the manufactured goods required. The standard of living was rather low, yet the economy was balanced.

Today we have a great influx of exchange and a substantial rise in our standard of living, but our agricultural production and cattle raising have not moved on the same basis or at the same rate as oil production. Therefore, there is considerable concern in our country regarding what could take place if the revenue derived from oil suddenly came to a halt.

To face this situation, a few years ago one of our distinguished statesmen coined the slogan "Sow oil". It is a programme which we have been following since in Venezuela and we hope with it to balance again our economy.

The impact of a most advanced industry, such as the oil industry, on our primitive agricultural economy has not been detrimental. The influx of currency allows us to face the future with optimism and to prepare with a certain calm the necessary plans for increasing our production of foodstuff. If our country could produce

[1]Original text: Spanish.

all that it requires in foodstuffs, the excess of currency could be used to secure a rational industrialization which would be adapted to our markets within the framework of what was recommended by Mr. Abbink as being reasonable for a country in the process of development.

However, the oil industry has imposed a phenomenon at home which could be called "the tail wags the dog"; the number of people who work in the oil industry is about 10 per cent compared to the workers in other industries, but the wages and standard of living of the majority are deeply influenced by the oil workers' minority. Therefore, the problem before us is to secure within a rather limited period of time that which is normally secured within the span of several generations.

The only solution is intensive and speedy mechanization. As an example we have just made a very interesting experiment, cultivating in one of our provinces a block of 5,000 hectares solely by mechanized methods, the result being that within two years we hope to have there sufficient production of rice to meet the requirements of our country. Such a speedy mechanization of agriculture means, in turn, that the important problems of education of personnel and the purchase of equipment also arise.

In the over-all picture there are two ways to meet the crisis which might possibly arise from the diminution of oil production. The first is the diversification of our source of income in dollars, adding to oil other resources such as, perhaps, iron ore, gold, diamonds and possibly other minerals. The second solution would be to transform our agriculture in a few years through development and mechanization which normally require several generations.

The CHAIRMAN: Thank you, Mr. Aguerrevere, for your exposé. It has drawn our attention to a problem that is peculiar to your country: the lack of balance resulting from activities of a rather exceptional nature.

I now ask Mr. Filemon C. Rodríguez of the Philippines to read us his paper.

Mr. Rodríguez now holds an important position in his country in the administration called the National Research Council, and he is more particularly concerned with the Equipment and Industrialization Division—that is, precisely the problems we are discussing. Mr. Rodríguez is an engineer who, according to my information, has abandoned the purely technical side of his science for liaison between technique and administration. He is therefore highly qualified to speak in this gathering where we are considering technical and economic problems, so closely linked.

Mr. RODRÍGUEZ *delivered the following paper:*

Special Problems in Assessing Philippine Resources in Relation to Its Industrialization Plans

FILEMON C. RODRÍGUEZ

We of the Philippines consider it a special opportunity to be able to discuss the problems of assessing our resources in relation to our industrialization plans, before this Conference. We liken this to the practice of people of olden times of exposing their sick on the steps of the temple so that any passer-by may offer a remedy. We hope that from the exchange of ideas during our present discussions we may derive some assistance in the solution of our problems.

The Republic of the Philippines consists of a group of islands in the Malay Archipelago, located between 21° 10′ and 4° 40′ north latitudes and between 116° 40′ and 126° 34′ east longitudes. There are 7,083 islands, of which eleven have an area of more than 1,000 square miles each. The total land area of the Republic is 114,830 square miles. These islands were discovered by Magellan in 1521, colonized by Spain for more than 300 years, ceded to the United States in 1898, occupied by the Japanese in 1942, liberated in 1945 and granted independence by the United States in 1946.

This group of islands is generally of volcanic origin, being the higher portions of a partly submerged mountain mass. On the whole, most of the larger islands are traversed by mountain ranges, with wide valleys and deltas, extensive coastal plains, navigable rivers, waterfalls and volcanoes. Some of them are in great part overlaid with coral, which in disintegrating has resulted in particular soil characteristics markedly different from that of the other islands, where lava overflow and volcanic tuff and ash deposit make the soil cover. About 95 per cent of the land area lies in the eleven largest islands, and approximately two-thirds in the two great islands of Luzon with 41,000 square miles and Mindanao with 37,000 square miles of area.

The climate of the country is tropical throughout the year; it is warm and moist. The average temperature in Manila, 79.5° F, is typical of the lowlands through the archipelago. Baguio City, the summer capital, 5,000 feet above sea level, normally has an average mean temperature of 64° F. The temperature at night, even in the lowlands and at all seasons of the year, is agreeably cool, and in January and February, the coolest period, is sometimes as low as 59° F. at Manila. The hottest months are April and May.

The seasons are divided into the northeast monsoon, which brings frequent rains on the east coast of the islands, and the southwest monsoon, which brings the rainy season in Manila and on the west coast. In the southern part of the archipelago, the rainfall is well distributed throughout the year. The rainfall is very heavy, in certain sections as much as two hundred and fifty inches annually, and occasionally more.

According to census figures, the population is 19,234,182 for 1948 as against 16,000,303 in 1939, 10,314,310 in 1918 and 7,635,426 in 1903. The present rate of increase in population is 2.3 per cent a year. The population is unevenly distributed, the greatest density occurring in the island of Cebu and the least in Mindanao. The Filipinos have settled chiefly in areas along the sea coast rather than in the interior.

Of the 8,456,493 men and women gainfully employed in the Philippines in 1939, agriculture accounted for about 41 per cent; domestic and personal services, 29 per cent; professional services, 11 per cent; and manufacturing, industry, trade and transportation, the remaining 19 per cent. The Philippines has always been a predominantly agricultural nation, because of its tropical climate and naturally fertile soil, which are very favourable to agricultural production.

The Philippines is naturally blessed by an abundance of natural resources most of which have hardly been touched. These are divided for purposes of this discussion into four major classifications, as follows:

1. Land resources.
2. Waters.
3. Forests.
4. Minerals.

LANDS

Of paramount importance to the Philippines is its land resources. There are wide areas of good land susceptible to cultivation which is far in excess of present utilization. Out of the total land area of the Philippines of 29,740,972 hectares, 11,637,968 hectares are estimated to be suitable for agricultural use while the rest are forest, swamp lands and grasslands. The cultivated area of 4,479,270 hectares are devoted to 1,879,600 rice, 812,300 corn, 105,940 sugar, 33,000 tobacco, 270,840 abaca and 1,377,790 miscellaneous. Apparently, the limit of land utilization is the area that can be cultivated by the people under the primitive farming practices that are still in effect in practically all areas in the Philippines. Gradual mechanization that is now setting in will contribute to raise the present limit and permit greater area to be placed under cultivation with the same number of farm hands that are presently available. The area devoted to certain crops is also limited by the amount of water available for irrigation. This is true particularly with respect to rice lands because the better yielding rice variety needs water for a longer growing period than the rainy season, and shortage of water is felt, if dependent completely on rainfall, during the planting season and just before harvest.

The technique of soil conservation is not yet generally understood and damage due to soil erosion on account of the intense rainfall is very great. Depletion of the fertility of the soil is also going on at a fast rate because fertilization is practised only to a very limited extent.

The soil survey of the Philippines to determine the general soil type in different parts of the country for proper determination of the kind of crops that will grow best in the different localities has been carried out only to a very limited extent. Of the total agricultural land area, only 60 per cent has been studied by the Soil Conservation Survey. The absence of soil maps which will guide any study of our agricultural products of any kind which can be profitably and satisfactorily grown is an impediment to the proper evaluation of agricultural raw material sources for use of industry.

Out of the total area of 5,203,620 open and grass lands, 1,300,000 hectares have been judged to be suitable for grazing and livestock production. On the other hand, very little livestock production is being carried out. During the year 1945, the livestock population was 14,007,000 units which represented only 39.5 per cent of the total livestock population in 1939. The requirements of the agricultural land for cultivation alone demand the acquisition of 1,601,600 carabaos to supplement the present 1,317,130 carabao population. The yearly shortage of meat amounts to 129,000,105 kilogrammes, not to mention the dairy products which total 24,320,505 kilogrammes.

WATERS

Because of its tropical climate and abundant rainfall, the Philippines has plentiful supply of water flowing in surface streams or underground. There are many large rivers rising in its mountain ranges which have rich potentialities for power, irrigation and navigation. Among these rivers are the Cagayan, the Abra and the Agno Rivers in the north; the Pampanga, Angst, Pagsanjan and Agus Rivers in Central Luzon; the Bicol and Labo Rivers in Southern Luzon, the Jalaud and Binalbagan, Loboc and Palo Rivers in the Visayas, and the Agus, Cotabato, Agusan and Davao Rivers in Mindanao.

The total power potential in all the rivers in the Philippines has been estimated at 17 billion kilowatt-hours annually, of which only 154,920,000 kilowatt-hours annually is being utilized at this time. More hydro-electric power plants are now in process of construction and proposed during the next five years which will bring into future utilization an additional 400 million kilowatt-hours annually.

The Philippine rivers are also potentially useful for irrigation though very little utilization in this manner is still in effect. In 1941, the area of irrigated lands in the Philippines reached a total of 507,345 hectares, of which 18 per cent are within government irrigation systems, and the remainder are served by private systems.

The seas around the Philippines offer great opportunities for fishing. The waters of the Philippines teem with a rich variety of fish estimated at some 2,000 species. Fish, after rice, is the most important element in the Filipino diet. Fish is also raised in artificial fishponds built in swamps that are scattered in the different coastal regions of the Islands.

FORESTS

Aside from the value of the Philippine forests as watershed covers to protect against erosion, they are important assets for the lumber and timber products industries. The total national forest aggregates 17,495,192 hectares or 58.8 per cent of the total land area of the country. 71.5 per cent of the forest area is in the main islands of Luzon and Mindanao. One of the important export industries of the country is lumber and the so-called Philippine mahogany is in large demand in the United States and other foreign countries. There is no accurate survey of the different forest products available aside from timber such as resins, rattan, dye, barks, tanbarks, etc., although these also are substantial export products.

Extensive lumbering operations are now in progress, and last year's (1948) annual cutting of timber which totalled 797 million board feet may even be exceeded. In the year 1941, 942 million board feet of timber was cut. Due to the unusual heavy demand of lumber for local reconstruction, a temporary ban by the government on the exportation of lumber allowed only 14,490,000 board feet to be exported in 1948. It is expected, however, that this figure will increase considerably with the recent easing of restrictions and increase in export quota from 5 to 20 per cent of production.

MINERALS

The importance of the mineral resources to the economy of the country is illustrated by the fact that out of the total national production in 1941 about 3½ per cent came from the mines. The Philippines has quite a variety of mineral resources both metallic and nonmetallic and there are currently ten minerals produced in commercial quantities. The country is credited with having among the largest deposits of iron ore, chromium and manganese. During the year 1948, P4,623,149.53 of gold and silver was produced. Also, 252,000 tons of iron ore was extracted leaving 500 million tons of known block reserve. 73,182 tons of coal was produced out of a total blocked deposit of 50 million tons. 189,520 tons of chromite was produced out of a blocked reserve of 11 million tons of which 10,120,000 is of refractory grade, 450,500 of chemical grade and 320,000 tons of metallurgical grade. Nobody knows how much of these deposits are still unblocked.

Petroleum has been known to occur in the Philippines since the Spanish times, but so far nothing is known definitely as to whether it occurs in sufficient commercial quantities. Oil exploration has been carried out off and on since 1896, but a systematic survey and examination of our petroleum resources has so far not been made. The absence of a complete geologic study of the Philippines is also a great handicap. In 1947, a large-scale oil exploration was initiated by the Philippine Oil Development Company which now is doing its work in the Bantayan Area, the Cebu and San Andres District and the Bondoc Peninsula. The Philippine Government has, moreover, taken measures to encourage oil exploration in the Philippines by reputable oil companies.

Oil is known to occur in several places in the Philippines, such as Panay, Negros Occidental, Leyte, Cebu, and southern Tayabas. Petroleum seeps have been found in these places and in some of them, notably in Cebu, drilling has been continuously going on although on a very limited scale. The oil has been found to have high average content of gasoline and gasoline fractions, and its residue of oil hydro-carbon could yield valuable lubricating oil.

Oil is very important for the industrialization of the Philippines. In 1948, the importation of petroleum products reached what is to us a staggering figure of P71,945,045. This includes gasoline, kerosene, diesel oil, etc. Additional industrial development would naturally increase the petroleum requirements of the country which, unless oil is discovered in the Philippines, will have to be provided from abroad.

INDUSTRIALIZATION PLANS

The industrialization plans of the Philippines are but a part of the general over-all programme of economic development of the country designed to adjust the Philippine economy to its changed political status as an independent republic and to raise the level of production and income of the people and thereby better their living standards. Measures have been and are being taken to initiate the process of structural adjustments from sole dependence on a few agricultural export crops to an economy better fortified against outside pressures; and to enlarge the scope and possibilities of the domestic market and promote more effective distribution of goods and greater regional specialization by providing for the speedy reconstruction, extension and augmentation of transportation and communication services.

Under the programme, greatly increased agricultural production, mainly directed towards self-sufficiency in food, and improved quality and amount of export agricultural products, is envisioned. The corollary industrialization plans call for the establishment of different industries to process some of the raw materials for export and to produce simple consumer's goods out of raw materials available locally to replace some of the goods imported heretofore. These industries consist of: (1) iron-steel industry including blast furnaces and rolling mills, agricultural machinery manufactures, machine tools industry and shipyards; (2) ferro-alloy industry to process chrome and manganese ores; (3) petroleum refinery initially to process imported crude oil for local supply of petroleum products and later to process local crudes; (4) cement and concrete products plants; (5) clay products plants to produce brick, hollow tiles, pottery and ceramics, glass; (6) chemical industries including chemical fertilizers, such as ammonium sulphate, ammonium nitrate, superphosphate, etc.; sulphuric acid, explosives, caustic soda and soda ash; (7) lumber and timber products including structural timber, furniture, plywood, windows and doors, pulp and paper, etc.; (8) rubber manufacture; (9) textiles and apparel; (10) alcohol fuel; and (11) hydro-electric power.

The establishment of all of the above industries, of course, requires availability for as long as possible at reasonable cost of the raw materials which are to be extracted from the natural resources of the country, and assessment of such resources is therefore necessary.

SPECIFIC PROBLEMS OF ASSESSMENT OF RESOURCES

The *first important problem* met in the assessment of the resources is the same as that which, in varying degrees, is met in the different countries of the world. It is the indifferent attitudes of the people as a whole towards undertakings that do not produce immediate tangible beneficial results that can be recognized by the average individual. The deficiency in understanding of the value of preliminary investigations to the success of the ultimate projects, accounts for the little support that is received. On this account, such preliminary investigations including resource assessment work, are not given the desired financial outlays every year.

The *second problem* is the incomplete basic data due not only to insufficient basic information gathered but to the destruction of most of the valuable and irreplaceable records during World War II. The almost wholesale destruction of Manila and other principal cities of the Philippines, prior to and during the battle of liberation of the Philippines, was disastrous enough as to the visible physical loss of life and property. They were more catastrophic when the loss of valuable records gathered through the years and centuries is considered.

The minimum requirements for starting an accurate total appraisal of the nation's resources such as: (1) general mapping of the entire area, including topographic and economic mapping; (2) general and detailed geologic study of the whole country; (3) land classification; (4) soil survey; (5) long-term accurate observation of the flow of streams; (6) blocking and valuation of the mineral resources; are still in the course of preparation.

The *third problem* is the lack of trained personnel and technique in this task of assessing the country's resources. In the mining field for example there are only a few *graduates* every school year. Although there is now an increasing number of students of fishery techniques, the lack of equipment, and absence, so far, according to our Bureau of Fishery, of a feasible way through biological research by which the fish population of the Philippine waters can be assessed, is hampering this work. Also, there are available only limited trained agriculturists and veterinarians which limit the scope and extent in their lines of work. On the other hand, the lack of trained personnel is in turn due to lack of opportunities in these particular fields in the past. Before World War II, our economy was agricultural; we imported almost everything that we used, there was no industrialization programme to speak of, much less one with assured continuity and continued support which will require the assessment of the nation's resources as a vital part of such an industrial programme. Consequently, there were very few opportunities for people to acquire experience, or training in this line of activity. This situation is of course being gradually corrected.

THE REAL PROBLEM

But serious and difficult as the problems are in the assessment of the nation's resources, they do not loom large in the Philippine economic horizon today. Our real immediate problem is the early utilization and development of such of our resources as are now known, blocked, and assessed for the immediate benefit of the people. For the industries contemplated to be established during the next few years, we have the raw materials required during the economic life of the plants, and while more knowledge of the total resources available is important, this is now only secondary. The need therefore is for capital to establish these industries, from local sources and abroad; for technical assistance in the successful and economic installation and operation of the necessary plants; and, more important still, for sympathy and co-operation from the more-developed countries in our industrialization work.

There should be greater realization on the part of the industrially advanced nations that the industrialization of the less developed countries to enable them to produce more economically some of their basic requirements and to raise their national incomes and standards of living would, contrary to common short-sighted beliefs, increase their purchasing power abroad and expand their foreign trade for the benefit of all, importer and exporter alike. And, what is even more far-reaching, the development of the resources of the less advanced countries in this manner, taking advantage of the benefits of mechanized production, will contribute materially toward the building up of a better society throughout the world.

The Chairman: Thank you, Mr. Rodríguez.

Before we proceed to the general debate, I should like to inform you that we are going to have the pleasure of hearing two additional talks; they will be more in the nature of introductions to the general discussion, than full papers for, coming as interventions in the general debate, they must be limited to five minutes each.

First, we shall be addressed by our Egyptian colleague, Mr. El Banna.

I give him the floor.

Mr. El Banna: It has been noticed beyond doubt, and it is now a matter of common agreement that generally there is a fairly high co-efficient of correlation between high incomes and industry and between low incomes and agriculture. The more industrialized a country, the more it stands high in the income scale, and the more agricultural a country, the more it stands low in this scale. Hence comes the natural desire on the part of many agricultural countries towards industrialization.

The standard of living cannot be increased without an increase in the national income. The way this national income is distributed is, of course, important, but it is erroneous to believe that a redistribution of the national income alone, say by a system of progressive taxation as was done in Egypt lately, is the solution of the problem. To be concerned only with the problem of the distribution of the national income, without being concerned with effective methods to increase this national income, will only result in a decrease in the standard of living of the rich without increasing that of the poor to an appreciable extent. On the other hand, the dependence of the national economy on agriculture will increase the maldistribution of the national income, for the demand for agricultural land will increase without an equal increase in cultivated area. This will result in an increase in the value of land and in its rent. The cost of producing crops will increase with more and more difficulties to export.

Speaking of income, we should mean *per capita* income. This is why industrialization is closely related to the population problem. Any comprehensive programme of industrialization must take into account the population problem. In some countries with vast natural resources and which are still sparsely populated from an economic point of view, such as Canada, Australia and Brazil, there is no population problem and the desire and need of industrialization are not as great as in other countries such as China, Egypt and India where the population pressure is so great.

The following table shows the growth of population in Egypt 1897-1947.

Population of Egypt 1897-1947
Source: *Population and Wealth* by C. Issawi

Year	*Population*	*Percentage of increase during the decade*
1897	9,635,000	—
1907	11,190,000	16.1
1917	12,718,000	13.7
1927	14,178,000	11.5
1937	15,921,000	12.3
1947	19,040,000	19.6

It is to be noticed that we have this fearful rate of growth in spite of a high deathrate. This latter will undoubtedly increase. There is then a great danger if the population problem is not dealt with *pari passu* with the industrialization problem. Industrialization, by causing a drop in the deathrate before having an equivalent effect on the birthrate, may lead to a spurt in population which could absorb all the increasing productivity and increase the population pressure. In such a country, the birthrate is already high. Greater productivity from improved facilities, modern sanitation, control of contagious diseases, will result more in a decrease in the deathrate rather than a decrease in the birthrate. On the contrary the latter may increase as a result of an increase in the marriage rates which is encouraged by increased incomes. On the other hand, there is a cumulative effect resulting from the fact that the productivity period of life is lengthened, especially if an improvement in the mortality rates is most marked at the lower age groups.

So an ill-advised policy of industrialization, instead of increasing this standard of living, would ultimately decrease it and increase the population pressure. How to deal then with such a situation? A widely discussed measure is spreading the knowledge of birth control. But this is a long-term measure which cannot in the near future decrease the birthrate to any appreciable extent. Social, religious, and traditional factors are too rigid in this respect.

Education, on the other hand, is a good measure in itself. The more educated a man the more responsible and the more concerned he becomes with the future of his family. The Egyptian Government has had a vast educational programme to fight ignorance and illiteracy. But whatever good such educational programmes are, they cannot have immediate results in decreasing the birthrate.

The only hope then to tackle the population problem is to push development rapidly, so that a rise in the standard of living can throttle any increase in population.

A continued increase in population is inevitable, at least in the near future, so we have to industrialize the areas in question to an extent that the benefits of industrialization should outweigh the pressure of population.

This does not mean, however, that we should proceed on a policy of exploiting our national resources without taking into account some serious questions. Chief among these is the interest of the producers. The whole economy of a country might be thrown into disequilibrium by hasty expansion of productive capacity beyond the needs of normal consumption, local and foreign. For example, it has been said that the temporary world, and especially American, demand for stockpiling purposes according to the ERP may result in harming the colonial producers in Africa once the temporary demand has come to an end. Another striking example is the Egyptian cotton, the marketing of which has become recently more and more a serious problem as a result of competition both of cotton producing countries and of synthetic-fibres. In such a situation, industrialization is of great help. Textile industry in Egypt is more and more absorbing the Egyptian cotton and at the same time the Egyptian Government is following a policy of encouraging the cultivation of vegetables and fruits instead of cotton.

So a balanced policy of industrialization should be followed taking into account the population problem and the future demand.

INDUSTRIALIZATION PREREQUISITES

The principle of comparative advantage is a very useful guide to show us what lines of economic activity a country may specialize in. In the nineteenth century there was a simple and clear-cut specialization. Europe specialized in manufacture while the overseas territories remained primary producers of agricultural and mineral products, exporting considerable parts of their specialized output. This clear-cut division of functions has decreased. Primary production, especially after 1929, was particularly unprofitable, and the incentive to escape from it into manufacture was particularly strong.

Another factor has been the revival of protection resulting from military precautions, social policy or the beggar-my-neighbour policy. The industrialization movement in many agricultural countries has been greatly encouraged as a result of the two world wars because of the impossibility to import and of high prices of manufactured goods. Protection of local industry was made possible. Some industries which had a comparative advantage over foreign competitors survived even after the resumption of normal trade. A good number, however, had to close down unless sheltered from foreign competition.

Taking these factors into consideration we have to note, however, that the most important recent impetus to industrialization in most agricultural countries is, as mentioned before, the fact that they strive to increase their standard of living. This in itself is a sufficient factor.

The problem now is not whether a country should specialize in agriculture or industry, but what sort of industry a country should specialize in.

Hence comes the question of the prerequisites of industry. These are fuel, raw materials, capital, labourers, industrial organization, and effective demand for the products. This does not mean that the absence of one or more of these prerequisites will result in the impossibility of establishing an industry. Even the highly industrialized countries are lacking in one or more of these prerequisites, and they import them from the outside. On the other hand, a comparative disadvantage in one or more factors may be balanced by a comparative advantage in others.

Let us now see how far these prerequisites are fulfilled in Egypt:

As to power, Egypt has two sources: petroleum and electric power. Egyptian oil production is expanding and it can safely be said that it can meet local requirements. Continued efforts are made by the Egyptian Government to search for new resources and to expand the existing ones. Crude oil production has increased from 226,000 metric tons in 1938 to 1,329,000 metric tons in 1947 and to 1,886,000 in 1946. Even if existing oil production will not suffice our needs we can get it from the near markets in the Middle East where its production has increased substantially. As to the electric power it also shows substantial increase. It has increased from 300 million kilowatt-hours in 1939 to 600 million in 1947. The Asswan dam hydro-electric scheme which is under construction will produce considerable electric power estimated at 1,550 million kilowatt-hours of electricity per annum.

As to raw materials, we find that an agricultural country like Egypt, wanting to build up an industry, naturally thinks of an industry which uses its agricultural raw materials. In this way agriculture feeds industry with necessary raw materials from the local production. This need for an industry based on agricultural raw materials is accentuated if marketing of these materials becomes difficult and still more if the country's economy depends upon one crop. Egyptian textile industry, based mainly on cotton, is a good example. There has been considerable expansion in the output of this industry. Output of cotton yarn rose from 17,500 tons in 1937 to 32,500 tons in 1947 and still more in 1948. Production of cotton cloth increased from 65 million square metres in 1937 to 143 million square metres in 1947 and 155 million square metres in 1948. Sugar industry, based mainly on the local crop of sugar-cane, is also flourishing in Upper Egypt. Woollen, rayon, and linen production has had an appreciable expansion. There are many other agricultural industries which have flourished recently in Egypt and which show good prospects, such as dairy products, canning of meat, fish and fruits, production of processed foods and beverages and paper production. This latter has increased by more than three times its pre-war level.

Egypt has also a variety of very important minerals the mining of which is increasing more and more as a result of the continued efforts of the Egyptian Government. Chief among these minerals are manganese, phosphates, and last but not least, iron ore. The cement production has also increased from 323,400 metric tons in 1937 to 648,000 in 1947 and 768,000 in 1948. High grade iron-ore has been discovered in great quantities near Asswan where the hydro-electric power will be available from the dam.

Other industries are soap, superphosphates and glassware. Below is a table of important Egyptian industries in 1945 as shown by the Industrial Census, 1945, Statistical Department of the Ministry of Finance, Cairo, Egypt.

As to labour, we find that industry in Egypt has the advantage of the availability of workers with normal wages. The Egyptian worker can be adapted easily to the industrial system and is devoted to his work and can easily gain practice and experience. Skilled workers are increasing rapidly in number and the government's policy is to give special care to technical education. Furthermore, the Government as well as the different establishments employ foreign technicians and experts.

As to industrial organization, Egypt now has very efficient organizers, businessmen, bankers, and captains of industry with great managerial skill.

Part of the capital necessary to finance industry in Egypt can be made available from internal savings. During the last war, many people made great profits and there are great quantities of built-up reserves available for investment. The marked inclination on the part of Egyptians to invest in land more than in industry has decreased to a great extent, especially after they have seen how profitable industrial investment is. It would be better if the Government borrow in the internal market and finance new projects at a low rate of interest. The Egyptian Government has taken a very important step in establishing the industrial bank, with Government participation in capital and management. The functions of this bank are:

(*a*) Promotion and consolidation of industrial enterprises in Egypt;

(*b*) Lending to industry against tanbigle or personal guarantees;

(*c*) Giving financial support to graduates of technical schools to enable them to start independent enterprises; and

(*d*) Investing of surplus funds in industrial securities.

The initial capital of the bank has been fixed at £E1.5 million of which the share of the government is to be not less than 51 per cent, the remainder to be subscribed by banks, companies and private persons.

All these are important steps, but a vast programme

Important Egyptian Industries, 1945

	Number of establishments		
Industry	*Total*	*Employing over 50 persons*	*Number of persons employed*
Cotton ginning and pressing	90	71	15,651
Textile	9,644	137	117,272
Food	5,749	102	65,289
Tanning and leather	1,419	33	12,328
Mechanical and electrical	1,283	42	16,647
Extraction of minerals and stones	58	11	7,316
Chemical	449	47	15,013
Glass making	72	8	2,189
Materials of construction	354	18	8,424
Woodworking	2,103	22	13,809
Paper	386	33	8,784
Fuel	3	1	4,213
Tobacco and cigarettes	65	15	16,130
Others	545	28	13,079
Total:	22,220	568	316,144

of industrialization in Egypt will still necessitate borrowing from abroad especially if we take into consideration the fact that the prospects of drawing on a large scale on the sterling balances accumulated in London for Egypt are now dim.

As to the market for produced goods, we find that industrialization will result in a better standard of living and increased incomes for the masses. This will lead to more effective demand for produced goods. The more perfected the Egyptian industry, the more it will be able to compete with foreign industries. The Middle East is expected to be a good market for Egyptian products. A certain measure of protection may be needed, but tariffs should be reasonable, otherwise income may decrease because of high prices, and offset benefits of industrialization.

The development of transportation is of primary importance. In Egypt, while the length of first-class roads increased only slightly from that of pre-war, the length of second-class roads in 1946 was almost one and one half times that of pre-war, and a number of new railway lines were built. Nearly all locomotives have been converted as oil burners, and plans for the electrification of certain lines have been developed. The Nile makes available a cheap means of transportation.

Another problem of great importance is the availability of capital and how fast a developing country can absorb this capital which should be put to productive use and wisely allocated to different industries.

Social problems should be also dealt with. The Egyptian Government has a vast programme to combat disease, encourage co-operation, regulate relations between labour and management and establish housing programmes and social centres.

Widespread industrialization will decrease the relative importance of the simple exchange between primary products and manufacturers, and will increase the relative importance of trade in semi-manufactured goods. The importance of capital goods is likely to increase relatively to that of consumer goods because of the increased demand for them which industrialization brings, and because the developing countries are likely to produce, at least for some time, consumer goods rather than capital goods. But owing to differentiation of goods, and to the expected increase in income, there will be an increase in foreign trade in these lines too. So the impact of increasing industrial production in the developing areas upon the established industrial countries need not give rise to serious trouble especially if the latter adapt their economies to the changing situation, by gradually shifting resources toward lines of production where demand is expanding relative to supply.

Economic development of underdeveloped areas is to depend to a great extent upon foreign aid in one form or another from the more mature nations. There is a mutual interest in this respect: For the undeveloped countries, there will be an increase in productivity, in incomes and in the standard of living. In such countries the marginal propensity to invest is great. Investment outlets of the more mature countries will find a great stimulus, and the increased income of the developing countries will raise their effective demand, local as well as foreign. According to the theory of the multiplier and its application to international trade, it pays an economically mature nation to lend to a developing nation. Both will be better off provided the marginal propensity to save in the developing country does not exceed its marginal propensity to invest. Needless to say, for the world as a whole, a general rise in the standard of living will work for economic stability and peace.

Industrialization has a very good effect on agriculture. It is wrong to believe that these two lines of economic activity are competitive. Agriculture can feed industry with necessary raw materials and industry can come to the help if agricultural raw materials have difficulties in the foreign market. We have seen how the textile industry in Egypt is more and more absorbing the Egyptian cotton. Industry will help to mechanize agriculture, hence more efficient methods of production. The increased income which accompanies industrialization will increase effective demand for agricultural products.

So industrialization is the only hope for many nations to raise their standard of living. It involves planning and any comprehensive industrialization programme should be outlined and executed with care and caution.

The CHAIRMAN: Thank you, Mr. El Banna.

I shall now ask Mr. Rodríguez Arias, Economic Counsellor at the Argentine Embassy in Washington, to be good enough to address the meeting.

Mr. RODRÍGUEZ ARIAS:[c] I wish to avail myself of the opportunity to express my personal opinion in regard to the remarkable efforts at co-operation and exchange of scientific information which are taking place in this Conference with a view to the correct utilization of available resources. I have listened to the statements made by experts of international renown on these technical questions and these statements have made apparent the concern of the peoples throughout the world and their expectation that the task of raising the standard of living will be carried out as soon as possible.

All human activity which tends towards a noble objective always proceeds from a high ideal. This is an indisputable truth and is illustrated by the generous impulses shown by the scientists who are gathered here in this Conference in which I am participating on behalf of my country. That is why in my personal capacity I wish to refer to this ideal, which is the subject matter of this Conference, and to inform you of the point of view of an Argentine economist concerning the objective which we are seeking here: to raise the standard of living without any selfish preoccupation such as could not be admitted by science.

I am motivated in my statement to support in a constructive fashion those technicians who have been taking part in this Conference and who have stressed the importance of a general consideration of the problem of the utilization of natural resources. I fully appreciate that such a general consideration is within the scope of this Conference and that practical results, of universal value, will be derived from it. Exclusivity is not good

[c]Mr. Rodriguez Arias spoke in Spanish.

in any field, and particularly has no place in science, and I know that the United Nations has been able to leave such a conception aside and lay down by a unanimous resolution that the low standard of living which exists in certain countries has social and economic consequences which are bad for the world as a whole and which create a climate that is not helpful to the maintenance of friendly relations and the natural development of peoples.

The Charter of the United Nations affirms the common will to promote economic and social progress and to raise the standard of living of all peoples in a wider concept of freedom, practising tolerance and showing a desire to live in peace. I do not believe that anybody at this Conference could have said that industrialization should be carried out on a mercantile basis. That could only happen if the laws of economics are misunderstood or it were sought merely to protect established interests, and that kind of conception cannot exist in an organization which, as I have stated, defends the highest ideals. Industrialization must be accepted as a higher stage of human culture, applied to the exploitation of natural resources, primary products, and power to serve man and help him to attain a constantly increasing standard of living. From time immemorial all peoples have been seeking to attain this high ideal.

A businessman might not be very impressed by an enterprise manufacturing, say, shoes, if no profit were derived from its activity, but an international organization must aid any activity which helps progress and which is for the benefit of the human community. Such an objective can be attained, at the same time as a sound economy, on the basis of the maximum and rational utilization of all resources for the welfare of man. Already in the time of the Incas the criteria of such an economy of integral development lighted the minds of men to obtain from the "Maize Culture" that wealth of products which we admire today. We cannot go back and deny the right of nations to develop in an integral fashion. Neither can we say that industrial technique is a high level of superior culture to which some nations cannot aspire, because their historical fate is to produce basic materials at low price.

Economic Geography has already proceeded so far as to permit no one to doubt the existence of integral criteria for the maintenance of a good economy. It is now time to cast aside the type of principles which would tend to keep a country at a low level because it is primarily a producer of raw materials.

The effort was started in this respect in Argentina in 1910. In less than forty years results were evident, with the exception of a few adverse circumstances which will be surmounted before long. Argentina can be counted upon as being one of the countries with a high economic development, having its own merchant marine which guarantees its freedom of trade.

In this industrial effort, my country has to deal with many legal and social problems. These problems have always been resolved on a humanitarian basis. This ethical principle, subordinated to life in society, is the very pillar of its national sovereignty. President Peron has stated that we have not only created a state of economic abundance, but that we are also organizing the exploitation of resources within a framework of justice and respect for man in order to ensure the prosperity of each individual.

In the international sphere, we should like to see this criterion applied to each country. Wealth by itself, without benefit to the peoples themselves, only creates transitory satisfaction and does not furnish a guarantee for peace. There should be a proper relation between resources and their utilization. From the scientific point of view, no cause is served by increasing wealth if the cause of the peoples is not served.

I believe a most important result could be secured by this Conference by having a technical conference of people who use different techniques in the industrial field. The United Nations has already helped considerably by its technical assistance programme. This would be an excellent way to implement the valuable scientific work submitted here by a practical method. I am convinced that this is the right way and that we should continue in this direction.

The CHAIRMAN: I am much obliged to you, Mr. Arias, for what you have just said, and I note the desire you last expressed. Unfortunately, I am afraid that in this Conference we are rather in the position of minors, and do not have the right to make recommendations. Consequently, all that can be done is to transmit your desire to the Economic and Social Council.

Before asking if anyone wishes to speak, it might perhaps stimulate discussion if I very briefly recapitulated the main general ideas which have been developed today.

On some of those ideas I believe all the speakers have been in agreement, and I do not think it would be to any apparent advantage to revert to those ideas during your speeches. On the other hand, certain divergences of opinion have appeared. They are certainly likely to result in progress, and it is on them that our discussions should be chiefly concentrated.

First of all, it seems to me that we can acknowledge that all the speakers have agreed in recognizing the considerable importance of taking the nature of natural resources into account in drawing up plans of economic development. It should therefore be emphasized—and on that point I am completely in agreement with the last speaker—that the work of this Conference on natural resources may be of immediate practical utility to the forthcoming work of the Economic and Social Council.

It would be unfortunate if the economists and politicians who succeed us in this field do not take full account of the conclusions on which, without making any resolution, we have nevertheless found ourselves in agreement.

The second point seems to me to be extremely important, and there again I do not think there can be much discussion: side by side with the purely technical factors that have been discussed in our many meetings of experts, the human factor is of capital importance when one speaks of economic development. By the human factor I mean the population, the characteristics of whose social evolution are as important elements in drawing up a plan of economic development as the technical elements themselves.

I notice, however, that if, as I think, there is no disagreement on that point, there is perhaps one problem on which we are not all in agreement. When Mr. Abbink in his remarkable speech quoted to us the example of an industrialization plan which required the importation, into the country to be developed, of not only capital and equipment but also of trained personnel, he raised a point of essential importance.

I should like to think that for some years it should be regarded as indispensable, when new equipment is introduced into a country, to bring into that country at the same time engineers, foremen and skilled workmen. I wonder, however, whether, even in countries whose population is considered to be least developed, it would not be possible to use a modern technique—after all, we are here as technicians—the technique of accelerated training, to resolve that problem of the technical abilities of the population.

Let us not forget what has been done in the United States in the military field in order to train an army which, though formed of individuals who were untrained civilians, has conducted itself in so outstanding a way. That was a source of astonishment in the old military countries of Europe, and so I begin to wonder whether, among the important problems affecting the economic development of the various nations, the problem of the accelerated training of technicians is not essential, and whether mention should not be made of it in our report to the Economic and Social Council. Since Mr. Abbink has been compelled to leave, I should like Mr. Roelse, who accompanied him to Brazil, to give us his opinion on that matter.

There is a second point to which some of our speakers might revert. I refer here to the very interesting communication from Mr. Aguerrevere. Our colleague stressed the social difficulties that may be caused, when a powerful and very prosperous industry is suddenly developed in an economically backward country, by the difference between the wages of the workers in that new industry and the wages of the rest of the population.

I should like our colleague to tell us whether it has been possible to resolve that problem in his country by fiscal means. I know that that is perhaps only an inadequate palliative; but the recovery of a proportion of the exceptional wages by fiscal means would seem to me possible. I should like to know if those means have been employed.

Let us leave population problems and reach what has perhaps been the heart of the discussion: in a backward country, should the stress be placed on the development of agriculture or on that of industry? It is difficult to answer that question; but I have the impression that opinions are divided. Let me in honesty point out that the countries which are almost exclusively agricultural, want industry, while the countries which possess a powerful industry, would obviously prefer the industry of other countries not to develop too rapidly. In this connexion the observations of Mr. Arias on the higher ideals of the United Nations are extremely important and deserve emphasis. I am certain, however, that we have not heard today any speeches imbued with exaggerated egoism: it is rather counsels of prudence that have been given to us; and the examples from under-developed countries certainly confirm the dangers of ill-planned industrialization.

I believe that in this connexion everybody would be in agreement on the following points. First, it is desirable that industrialization and the modernization of agriculture should proceed together. Secondly, without a certain amount of industrialization it is very difficult really to raise the standard of living, for as soon as the minimum food requirements are assured, the standard of living is characterized by the abundance of manufactured goods. Thirdly, however, there is a danger of developing industries which will oblige the country either to increase its purchases from abroad or to find considerable markets for its goods abroad. Having emphasized those last two points, I think we may draw from them the conclusion that the industries which must first be developed are those which can use the raw materials produced in the country itself, and that it is advisable to develop them as quickly as possible while production can be absorbed by the local population. On the other hand, it is more dangerous to adopt a policy which would force the country to seek external markets that would be difficult to secure for a country not experienced in international trade.

I have no wish to abuse your patience. Having summarized the main trends, I shall now ask those who desire to speak for the first time to approach the microphones with which they have been provided.

I now call on Mr. Manuel Aguilar of Mexico.

Mr. Aguilar:[d] Our distinguished colleague from Chile has stressed in admirable fashion the dangers of excessive industrialization or industrialization insufficiently planned, in an under-developed country or a country which is not sufficiently industrialized. He has made a charge according to which we ourselves are guilty for what is taking place. He has stated that in a number of cases we ourselves do not know what we need or what we desire, and for this reason we do not manage to industrialize our countries efficiently.

I am sure that the majority of our colleagues would agree that this is not the case in most countries and, at any rate, it is not in Mexico. In so far as my country is concerned I believe that I am in a position to say that we know what we require and what we want. I believe that I can say with every assurance that our industrialization is planned firstly to satisfy our internal market, and it is upon the needs of our market—which have been explored and evaluated—that the first stage of our industrialization is based. There are certainly cases where it is necessary to secure credits in order to see to it that this industrialization does progress. In some cases we have to have recourse to friendly countries having at their disposal financial and human resources which we do not possess—all this in order to speed up the industrialization process which is so fundamental for our over-all development.

A concrete example of this is our oil industry. All of you are undoubtedly familiar with the discussions which have taken place between the United States and Mexico in respect to a loan for the development of our industry. This loan is not essential for the development of our oil industry, because that industry will develop whether or not we secure such a loan from abroad. Foreign aid is necessary only to speed up this development.

[d]Mr. Aguilar spoke in Spanish.

It was very interesting for us to hear what Dr. Aguerrevere said in regard to his country in connexion with the fact that the oil industry has brought about certain adverse results in Venezuela—in other words, that the stable economy which existed before 1914 has been replaced by an economy which is almost exclusively based on oil. We have had the same experience in Mexico. We have also seen the oil industry tending to kill in the old days a large number of other activities—for example, small industry or agriculture.

The danger of the oil industry was that it absorbed the other activities; it absorbed the greatest part of the activities which took place in our oil regions. After the nationalization of this industry we have surmounted this adverse experience. At the present, we have been able to secure a more stable economy, in which agriculture and mining and other industry are elements which are more or less in equilibrium, and in which the oil industry is a vital link.

The CHAIRMAN: I call on Mr. A. V. Karpov, Consulting Engineer, New York.

Mr. KARPOV: The very sincere appeal made by Mr. Rodríguez, of the Philippines, seems on the face of it to contradict the statements made by Mr. Abbink. But I think that the impression which may be gained here is a mistaken impression. Of course, we are now in a period of the industrial renaissance of the world, and the Philippines are probably ahead of many other countries; at least, the possibilities are better.

The appraisal which Mr. Abbink made is, of course, a helpful appraisal: what can be done and what cannot be done. If the whole world attempted to do everything, the result would be purely chaotic and nothing would be accomplished.

I had the opportunity to spend most of last year abroad, and I was very much impressed by the psychological factor: that most of the people think that such a high development has been attained in the United States that they would either like to go to the United States or would like to copy the conditions of the United States. I received that impression in many different countries.

In the United States, of course, we have an exceptionally high industrial development, but we came to that high industrial development under very peculiar conditions, and at present we are running it with an abundance of means, financially, at low interest rates on that money, and with the most expensive labour in the world. Any country which does not have the background which the United States has had would penalize itself heavily if it tried to copy the conditions of the United States. In the United States, we have today a tremendous experience—and that experience, of course, must be utilized in any country which is not as highly developed as the United States and which thinks in terms of industrialization. But it is obvious to me that that development cannot be attained simply by copying what exists today in the United States. The experience of the United States must be utilized to develop the methods by which the industrialization of the United States can be applied to each particular country, methods which must fit the economic conditions and, which is no less important, the cultural background of a particular country.

In that respect, I think that one of the things which this Conference could do is to stress the fact that everybody cannot be helped simply by copying what is made in the United States. Other countries should have the widest interest in the experience of the United States and should modify that experience to fit their own conditions.

The CHAIRMAN: I call on Mr. Van Tassel, the Executive Secretary of the Conference.

Mr. VAN TASSEL: I should like to take the time of the group to comment for a moment on one of the statements made by Mr. Abbink. I think we are all very grateful for an exceedingly vigorous paper which stated his position strongly. I think it must be said, however, that at one point Mr. Abbink was vigorously attacking a straw man. I refer to the portion in which he said:

"It is part and parcel of the doctrine that the world needs not to produce more but to divide what has been produced in the past, as though a tinier share to each individual in an increasing world population would create a Utopia—a fallacy that has been exploded many times in many countries and is even now being bitterly disproven in unhappy Britain."

I cannot but feel that this statement represents, very genuinely, an attack on a straw man, that this is not a view held by any considerable number of people supporting economic development, and that the last remark is particularly gratuitous. It seems to me that the production record of Britain in the post-war period, with its very considerable increase in production, is evidence that there is no view held there by any substantial group that the way to Utopia is to produce a tinier share for each individual in an increasing world population.

The CHAIRMAN: I will ask Mr. Roelse, Federal Reserve Bank, New York, whether he wishes to answer Mr. Van Tassel on behalf of Mr. Abbink.

Mr. ROELSE: Of course, Mr. Abbink introduced his remarks on that particular point by referring to the statements of someone at the Havana Conference who had suggested that before the United States of America spent any further money on its development, it should try to bring the rest of the world up to its level. He was trying to make the point that our development is far from completed, and that we need to look beyond just redistribution of resources. The need is for emphasis on all-round development in the rest of the world, as well as in the United States of America.

As far as his reference in the last phrase to Britain is concerned, everyone is entitled to his own interpretation of that situation. I will not either endorse or try to combat his reference in that respect.

With respect to one other point, I might just add one more point on the matter which was discussed. We found, when we got to Brazil, an impression which I think is probably rather widely held in other parts of the world. That is, that the financial resources of the United States and the accumulation of savings are so great that there is no possible use in this country for the accumulated savings and that, of course, there must be very large amounts that are just looking for an outlet in other parts of the world. I think that by this time a better understanding of that situation has developed; that to make up for our own war-accumulated deficiencies tremendous investment of capital is needed, and our own industries are even now having considerable difficulty in obtaining what we call "equity capital" or "risk capital" on reasonable terms, indicating that there is not a great surplus of capital lying idle in this country which cannot find a use at home and which must look elsewhere.

I should add that I think there are many companies, particularly in this country—individual investors tend to be shy—which are interested in expanding their operations in other parts of the world and are willing to take the risks involved in foreign investments.

On the matter of personnel, I am sure that Mr. Abbink would readily agree that, but for the time factor, there is no problem in training personnel for almost any kind of operation. In fact, the biggest electric power industry in Brazil, which is largely Canadian-owned, is staffed almost completely by Brazilian personnel, right up to the top engineers. I am sure he recognizes that this sort of thing can happen if you allow some time, but it does take time for the training of people, especially for the top jobs, the administrative and supervisory positions. But even at the lower level, if you have in the population a very considerable proportion of illiterate people who have had no contact whatever with industry, you cannot expect to train them overnight for industrial operations. In the first place, you have to train your technicians so that they can impart the techniques to the untrained people. Again, that is just a question of time rather than anything else.

The CHAIRMAN: I will now call on Dr. Rafael Reyna-Drouet of Ecuador.

Mr. REYNA-DROUET[e]: Ecuador's economy is primarily based on agriculture. We knew a period of prosperity when we exported considerable quantities of cacao abroad. Our cacao was considered of high quality in the Twenties and during this period of high exports we could say that our country was a centre for cacao. Our product was utilized in all countries of the world, but unfortunately a plant disease, *Escoba de Bruja* devastated our product. We have had to rely on another type of cultivation, particularly rice. At present, my country is exporting rice and thereby contributing to the world economy, though this should not limit the development of our economy.

We are confronted with a situation in which we have to implement the great development of our industry, as well as our agriculture. The Chairman has underlined the important point that it should be first ascertained which should come first, industry or agriculture. Certainly, opinions may be divided on this problem, but it would appear that this problem could be resolved by an analysis of the specific conditions existing in a country and, of course, by an objective analysis of the elements of an economy at a given time.

We have two quite different principal regions in Ecuador; in point of fact, we might almost say that we have two countries, the coastal area and the mountain area in the Sierra, which are two quite distinct regions. There are also two minor regions—the Oriental and the Insular (Galapagos Island). In the coastal area there is Guayaquil and other important cities, whereas in the Sierra there are tremendous mountains, the Andes, the climate is quite different and the population is different. In the coastal area are found the merchants and industrialists, whereas in the mountains there are cattle raisers, ranchers and agricultural activities in general. What we require, therefore, is to harmonize the economies of these two regions of Ecuador.

For this it is necessary to have a state plan to balance the two economies. For a long time the exporting area of Ecuador has been the coastal area. The mountain area does not export but produces for internal consumption, although there are considerable possibilities for development with a view to export, particularly in terms of fruits and vegetables. At present, however, this area does not produce for export but only for internal consumption.

In establishing an economic plan it is necessary to be familiar with foreign markets and it is necessary to know what a State needs in order to make possible a decision as to whether production for export should be increased or whether priority should be given to production designed for internal consumption. At present we have an intensive plan of development, particularly in the region of the Guayas, which is the most important part of the West coast of South America. Neither in Chile nor elsewhere in South America can be found a river as important as the Guayas. The Madelena, for example, flows towards the Atlantic Ocean and the Guayas is the only important river which flows into the Pacific. It is a very important region in which production can be developed.

Although the Republic of Ecuador has no well-developed economy, it was able during the war to contribute to the war effort of the United States by sending considerable quantities of balsa wood, for the building of light planes, and rubber. It is a country which needs to be developed in a suitable fashion and has no elements likely to upset its balance. There are possibilities in regard to oil, since we have oil fields in our country, but these are not as important as in Venezuela. We cannot say of our country as is said of Venezuela that it is a tremendous oil well. The Shell Company is carrying out explorations in certain areas but there are considerable regions not yet explored.

We need to develop our economy, yet we do not wish to imitate other countries which are already much more developed from an industrial point of view, countries such as the United States, the United Kingdom and other European countries. We wish to think in terms of Ecuador, we wish to think in terms of our own problems, though we wish, of course, to benefit from experience gathered by other countries and from the various systems and methods which have been applied elsewhere, and to adopt these methods and systems to our own specific conditions.

In connexion with our economic problems we have established in Ecuador a National Economic Council of which I am a member.

Mr. Chairman, at this point I would like a deal with a subject which seems to me important in connexion with the theme of this part of the Conference, namely the resource techniques which should be used to develop the economy of the less-developed countries. I refer to economic planning and in particular to the

[e]Mr. Reyna-Drouet spoke in Spanish.

organs which are capable of carrying it out; and I will speak of our experience in Ecuador on both these points.

In the years before the war, when an elementary sense of caution aroused by the threatening events clearly discernible on the world's political horizon suggested the advisability of taking in time the measures necessary to defend the national economy during the approaching war period, the governments and legislatures of that period did not attach sufficient importance to these portents, and consequently the Second World War took the country by surprise, and found it unprepared to withstand its economic repercussions.

The outbreak of war compelled the State to invade the field of private enterprise in Ecuador and to extend its powers of intervention, hitherto confined to banking. Thus the war marked a new phase in State intervention in economic affairs: various emergency legislative provisions were issued, notably the total requisitioning of foreign exchange by the Central Bank, and rationing and priority in the distribution of imported articles, with the establishment of maximum prices for their sale to the public.

At the time, these measures were believed to be sufficient to enable the country to withstand the war years without further damage to its economy; but as the war began to assume much greater proportions than the 1914-1918 European war, becoming really universal in scope, the country's internal situation showed obvious signs of perturbation, with all its serious consequences for the majority of the population. In view of this and of the need to take proper measures to safeguard the national interests and free the post-war economy, the National Congress of 1943 set up the National Economic Council for the purpose of "centralizing, unifying and directing all matters connected with production, distribution and consumption in Ecuador; directing credit into the channel of collective activities; increasing agricultural production and seeking the best solution for the problem of exchange in the interest of the national economy". Two years later, in 1945, the National Constituent Assembly of the Republic set up a new body called the Technical Economic Commission for the purpose of "co-ordinating and planning the economic policy of the State".

I thought it necessary to recall this background in order to show that the need to plan the country's economy has been recognized by the Ecuadorian Legislature on various occasions, a fact which may be considered illustrative of the national will, as the 1943 and 1945 legislatures in Ecuador belong to two distinct historical periods, separated by a violent change of government, such as is unfortunately too frequent in Latin America. This one took place on 28 May 1944 and led to a political change of front in the nation, with different men and different aims. On the matter in question, however, the views of the new government and the previous one coincided.

The bodies which preceded the present National Economic Council in Ecuador were merely consultative and advisory organs of the Executive; they were not constitutional bodies and their composition was not suited to the technical work required of them, consisting as they did of certain Ministers of State, such as the Ministers of Economic Affairs, Finance and Labour, representatives of the Chambers of Agriculture, Industry and Commerce, a representative of the National Confederation of Labour and a number of technical advisers who in that capacity were also members of the Technical Economic Councils or Commissions. These latter were included because it was thought, and many people still think, that a body in which the State and the various economic and social forces of a country co-operate, with the guidance of scientific and technical experts, is the best means of centralizing, directing or planning the national economy with a view to an appreciable increase in the various branches of production; but this apparently sound idea does not withstand a more careful analysis: for it is soon found that co-ordinated work within such a body is impossible for long periods, because its members represent different interests, whose inevitable clashes prevent it from providing the economic guidance which the country expects of it.

For this reason, and in view of the failure of these bodies, the structure of the present National Economic Council in Ecuador has been radically modified; but before describing its present form, I should like to say a few brief words on my country's economic plans.

It has often been said, and is still insistently repeated, that what Ecuador needs is a comprehensive programme involving the application of the principles of economic planning; but it has to be recognized that unfortunately not many people in Ecuador have much knowledge of such matters, as the best-known economists and financiers remain firm disciples of the old school of economic liberalism, and with a very few possible exceptions it is hardly to be expected that they would be converted overnight into exponents of a doctrine which requires both theoretical and practical study, or would acquire the different mentality needed to conceive and apply it; economic planning is so different from any of the methods previously employed in Ecuador that even if the legislator has recognized the need to plan her economy he has not attempted to do so, partly because of the defects of the organs set up in the past, and partly because of opposition from interests which apprehended that they would be in some way affected thereby, or of mistaken conceptions of planning.

A few years ago, when an Ecuadorian economist affirmed that the application of planned economy in Ecuador had been a complete failure, I had to challenge him and speak out in defence of planning, explaining a few elementary truths, in order to prevent him from misleading public opinion with his assertions, which were certainly made deliberately, as he is an intelligent man with a wide experience as manager of one of our principal banks.

In the first place, I had to explain that planning deals with changes in the economic order. The nature of the changes, the transition from an unplanned to a planned economy, must be achieved with a sense of what is expedient and practicable. The socialist solution supersedes private initiative, more for reasons of economic necessity than justice; but that is not what is needed or could be introduced in my country: the question is a more immediate one and consists essentially in discovering how much State control is required to remedy the irrationality and instability of the present economic system; for the planning measures proposed are necessary factors in any social order intended to protect the majority of the people from economic hardship and liberate them from poverty. But "planning is concerned with economic growth" even more than with achieving stability, "because instability is a disease resulting from economic growth", and the main argument for planning, as a permanent institution or policy, arises from the desire to avoid crises and depressions.

The collectivist nature of planning has often caused it to be confused with State intervention; but the economic history of my country, like that of all the countries of America for many years past, has been full of official interventions, to which the banker economist was referring when he spoke of the failure of planned economy in Ecuador, whereas in fact the establishment of an economic plan or "comprehensive scheme of foreseen economic processes"—had never been tried. It is true, of course, that all planning is State intervention, but not all State intervention is planning. Planning, moreover, is a social science.

My country needs an economic programme, conceived according to the doctrines of planned economy, in order to catch up with the times, because there is no doubt that the race for industrialization has already begun in South America. Argentina, Brazil, Chile, Uruguay, Colombia, Venezuela and Peru have extensive industrialization programmes and Ecuador can no longer remain behind, lest she may later find herself dependent upon her neighbours for her needs. It is hardly necessary to mention that almost all the countries of post-war Europe are now engaged in planning their national economies; at their head is Great Britain, and in spite of certain mistakes in the application of a correct economic policy—mistakes which have been much criticized—it is evident that this old established nation is striving to put behind it a period of economic liberalism which has lasted several centuries.

Ecuador has reached the crucial point where she must gradually transform her antiquated economic systems entirely and establish a State plan, or her economy will be unable to recover. Many Ecuadorians imagine that it is still possible to return to the old days when freedom of labour, industry and trade and the so-called law of supply and demand determined the economic balance and welfare of nations. Unfortunately for such dreamers those days belong to another epoch in the world's history in which the horn of abundance poured forth a plentiful supply of material goods upon mankind, provided everything was left to private enterprise. Now after this disastrous war which has scourged humanity, we have to learn to live in the new era in which we find ourselves and to solve our economic difficulties by means of other systems, which alone can enable us once again to enjoy those "good old days" which we now miss so much.

It is my conviction that Ecuador, and other countries which are at an early stage of economic development, can catch up with the industrial countries before very long, by means of their own resources and the efforts of their own people; but on condition that they display originality and foresight in applying the principles of planned economy, both in the geographical and human sphere, and that the men who put these plans into effect are influenced as little as possible by the interests of the minority of economically powerful individuals.

Perhaps the absence of a firm doctrine and conviction, on the part of many rulers and legislators, concerning the purposes of the modern State and the failure correctly to appreciate the State's ability to direct society and organize a strong and prosperous nation have been the cause of my country's economic backwardness, against which we are now reacting vigorously, taking the offensive on the economic front in order to strengthen the State, by liberating it from the cramped position in which it has always been situated, fighting on the defensive, with its back to the wall, against the pressure of the powerful minority interests that threaten to dominate and enslave it. This offensive has already begun in Ecuador, and the first steps have been taken to restore and modernize the national economy, which means bringing under control the so-called "live forces of the country"—the Chambers of Agriculture, Industry and Commerce, as well as the trade-unions which, with their love of gain, their lack of initiative and their irresponsibility, have dominated the economic life of the nation. These unruly elements have acted and continue to act to the serious detriment of the country's future, and so the time inevitably came when they had to be made to understand their new role in national production, finance and trade; for one of the purposes of the modern State is to give the individual a high degree of economic security, as proclaimed in the Atlantic Charter, to which Ecuador duly acceded, such security being necessary to enable men to live in peace and without fear. But for this guarantee to be effective, a considerable increase in a country's wealth is required, and this can quickly be achieved in countries in economic circumstances like those of Ecuador, when property really begins to serve a social purpose, in accordance with the principle stated in the present Constitution of the Republic. I believe that planning is the best way of making property serve this purpose, and thereby removing, or at least lessening, the present contradiction between the republican form of government of Ecuador and a backward and in some ways primitive economic structure.

Countries of this type need planning in order to make up their leeway and produce the goods of all kinds which they and other countries need; for at the present time, when the world's trend is towards rationalization in every field, the economic expansion of a country like Ecuador cannot be left solely to private effort and initiative, which formerly sufficed. Today a new economy is required to take the place of the classic political economy of natural laws, free enterprise and "perfect disorder": an ordered, dynamic, workable economy planned and directed by a responsible organ of the State Thus the classic *laissez-faire, laissez-passer,* the postulate of sufficient freedom for the individual at a time when he needed nothing more, has been replaced by the modern "joint effort" and "avoidance of dispersion", postulate of the same freedom now adopted by the beneficent economic system of which formerly the individual had no need. In this way the State, without invading the field of capital and without subjugating labour, will maintain those two factors of production fraternally united and, by methodically giving the people a share in reproductive circulation and consumption, will convert the nation into a great economic laboratory in which all the useful elements will be occupied and the useless will be humanely cared for. In this way the nation itself, and not the minority interests, will truly control the national economy.

From the foregoing, the following conclusions may be drawn:

1. The application of the principles and practices of planned economy has become an economic and social necessity if a country is to develop and free itself from its state of retarded development;

2. Planned economy is not the application of extremist politico-economic doctrines: it does not involve the abolition of private property but only requires such property to fulfil its social function as set forth in the Ecuadorian Constitution;

3. Planning is the proper means of enabling property to fulfil that social function, of overcoming the existing economic anarchy and of giving the citizen the security which he at present lacks; and

4. The responsible organ to elaborate and direct the economic plan which the country needs should be the State Planning Board or National Economic Council.

With a knowledge of the causes of the failure of the former economic councils or commissions, and with a clear vision of what the country needs in order to increase its economic potential and remedy its present state of material backwardness, the previous mistakes were rectified and the new National Economic Council was set up.

The Council now has a recognized place in the Political Constitution of the Republic, which represents the first step towards ensuring its efficiency, for it has very wisely been included among the organs of the legislative power, and has thus a very important standing among the constituent organs of the Ecuadorian State. Its members are appointed by the National Congress, with the exception of one who represents the President of the Republic. The Council is not only an adviser to the Executive, as the former councils were, but an organ which directs the national economy by drawing up "directives on economic policy" which are carried out by the government departments and by autonomous bodies such as the Production Development Institute, the Development Banks, the Highway Boards and others. These bodies have the task of drawing up practical plans on the lines of the general objectives of economic policy laid down by the National Economic Council. In other words we desire our National Economic Council to be the brain which thinks out and indicates the objectives to be attained by the economic plan, which should be the expression of a firm State policy; whilst the task of the executive organs should be to suggest measures for carrying out these general directives, by means of which the National Economic Council can maintain organic unity in the nation's economic policy, notwithstanding changes in the personnel of the Ministries and other dependencies of the executive power and in that of the autonomous institutions.

The Economic Council may also, during the Congressional recess, recommend to the President of the Republic to promulgate the necessary laws for the implementation of the economic plan by certain departments or autonomous bodies, the Executive being empowered to do so by a special provision of the Political Constitution of the Republic. These decrees are known as emergency decree-laws and have to be submitted to the next legislature for final approval and enactment as laws of the Republic, or abrogated if deemed contrary to the national interest. The Council has other very important functions which for the sake of brevity I will refrain from describing.

Ecuador is making a great effort to remedy her economic under-development, which cannot continue without endangering the very life of the nation. We know that the way is long and hard; there are many obstacles to overcome and many small and selfish but powerful interests to combat. In spite of the tragedy of the Ambato earthquake, the Ecuadorian people have not allowed themselves to be discouraged, and with the generous help of the sister nations of America, she will build better cities and farms to replace those which were lost. She also has a new opportunity to rebuild the economy of the regions devastated by the earthquake, along the lines which the National Economic Council is certainly now working out, combining the planning of the damaged areas with its general planning of the country. This is the only way of quickly developing the economy of certain countries, for the benefit of their own people and of humanity as a whole.

The Chairman: I call on Dr. M. R. Bloch of the Palestine Potash Company, Jerusalem.

Mr. Bloch: I have been, because of the history of my country and my people, confronted with undeveloped conditions after living for a long time in highly industrialized countries, so my experience may perhaps be of some value or interest.

What is the real characteristic of an undeveloped area? I have come to a comparatively simple conclusion. It seems to me that the most important "know-how" in industrial areas is the art of reading and writing. It is extremely important that a high percentage of the population should know how to read and write. The art of reading and writing is a social achievement. It is a social technique and in some respects is like the telephone. The invention of the telephone in itself might not have represented very great progress; it is the development of the communications network that has made the telephone an important tool. It is my experience that a highly developed "network" of literacy is the most important tool in the progress of technique. It is the most important "know-how" there is.

There is one peculiarity about this technique; it has not been diffused under economic pressure. The people of the United States and other highly industrialized countries have learned how to write and read not because they thought that it would give them a better economic opportunity but for religious reasons. Even so compulsory measures were necessary to obtain a widespread diffusion of this art. We cannot expect that this basic technique or "know-how" will be widely diffused only because of economic pressure. I believe that it will be necessary to invest a lot of money throughout the whole world to propagate this art without getting quick returns. Of course, this art is perhaps a bit dangerous, and one should not forget to diffuse some of the fundamental ideas which have been laid down in the books in which this art has been largely developed and through which it has been mainly diffused.

Mr. AGUERREVERE: The question has been asked as to whether Venezuela has applied any fiscal methods to correct the differences between the economic situation of the oil industry and other industries. Directly, perhaps not; unless we can call fiscal policy the setting aside of a large part of the national revenue to this particular purpose. I cannot recall the exact figure, but our national revenue was of the order of $600 million in the last fiscal year. This year it is estimated to be a little over $500 million. I think there is ample cash to carry on a policy of equalization.

Perhaps I did not previously make my point quite clear in this respect. We are not worried whether the oil industry in Venezuela is too large or too progressive, we are very happy to have it; our worry is to raise all other things in the country to the same level, which is an entirely different question.

Mr. AGUILAR: I apologize for having arrived late. I did not hear the statement which is in question at the present time. Our colleague sitting to the left of the Chairman has indicated that there were concepts in this world which touched upon the economy of the United Kingdom. I regret that such terms have been used with respect to that country. I believe that we all should admire the valiant effort carried out in the field of recuperation with new methods and systems different from those used heretofore.

The CHAIRMAN: If no member of the Conference wishes to speak, I think we might conclude.

When opening the meeting a short time ago, I mentioned "Point Four", and I stressed the importance that our discussion might have in connexion with that important feature of the modern economy.

I shall take the liberty of emphasizing that when "Point Four" was devised, it was made clear that the intention was that not only the United States but all the more highly developed nations should come to the assistance of the less-developed countries. I believe, therefore, that the anxiety displayed today by some speakers with regard to the doctrine professed by the United States or the more highly developed countries is hardly justified in view of the welcome extended to the American initiative in all the other developed countries.

I shall therefore conclude by expressing the wish that by action in the spirit of the observations—many of which I have no doubt are very useful—that you have made today, the development of the under-developed areas may be ensured along the most general lines; that it should not be confined to particular industries which might disturb the healthy social equilibrium of the countries to be developed, but should proceed along lines which reflect the broadest possible view of industrialization, that is to say, the view of it as a harmonious development of different activities resulting finally in a raising of the standard of living of the nations concerned and in what is essential to the world economy — satisfactory balances of trade.

Education for Conservation

Tuesday Afternoon, 30 August 1949

Chairman:

Khan B.M.A. Hamid, Chief Engineer, Irrigation Secretary, Government of West Punjab, Pakistan

Contributed Papers:

Education and Conservation

Alain Gille, Fundamental Education Division, United Nations Educational, Scientific and Cultural Organization

Extension Methods in Conservation Education

M. L. Wilson, Director of Extension Work, United States Department of Agriculture, Washington, D.C.

Discussion:

Messrs. Monod, Moreno, Thiery, Mrs. Snyder, Messrs. Harroy, Beltran, Compton, Kellogg, J. K. Edwards, Steidle, Clay

Background Papers:

Conservation of Natural Resources in French Black Africa and Education

Th. Monod, Director of the *Institut français d'Afrique noire,* Dakar, French West Africa

Contribution of Cuban Schools to the Conservation of Natural Resources

Abelardo Moreno, Professor of Zoology, Museo Poey, University of Havana, Cuba, and

Ramona Fernandez, Professor of Scientific Methodology, Havana Teachers Training School; Assistant, Zoology Laboratory, Museo Poey, University of Havana, Cuba

Soil Conservation in Nyasaland

W. J. Badcock, Chief Soil Conservation Officer, Department of Agriculture, Government of Nyasaland

Supplementary Education for Soil Conservation in New Zealand

D. A. Campbell, Senior Soil Conservator, Soil Conservation and Rivers Control Council, Wellington, New Zealand

Protection of Natural Resources: Education and Propaganda

Raymond Furon, Assistant Director (Geology) National Museum of Natural History, Paris, France

Methods of Teaching Conservation of Natural Resources in Jamaica

W. C. Lester-Smith, London, England

Agricultural Education in Uganda

R. K. Kerkham, Uganda Agricultural Service, Government of Uganga, Entebbe, Uganda

Educational Methods of Instructing Native Populations of Africa in the Protection and More Efficient Use of Resources

J. J. Deheyn, Senior Agronomist, Belgian Congo

Rural Education and its Influence on the Conservation and Better Use of Natural Resources in Nigeria

G. N. Herington, Senior Rural Education Officer, Umuahia, Nigeria, West Africa

Importance of the Study of Agricultural Industries in an Instructional Programme Dealing with the Conservation and More Efficient Use of Natural Resources

Jean Keiling, Paris, France

Programme Director:

Carter Goodrich

Programme Officer:

Herbert Schimmel

The CHAIRMAN: I declare open the twelfth plenary meeting of the United Nations Scientific Conference on the Conservation and Utilization of Resources.

I am deeply conscious of the honour done to me and to my country in my being accorded the privilege of presiding over this plenary meeting, and particularly a meeting which is to deal with the all-important subject of education for conservation, without which no amount of planning can carry us to the goal.

One of the ideals in the old civilizations was the need for seeking after knowledge, as may be seen from some old sayings which may be stated with advantage:

"Seek knowledge from cradle to grave."

"Desire for knowledge is a divine commandment for human beings."

"Knowledge is life and wealth."

"Knowledge is better than wealth because the latter thou hast to protect while the former protecteth thee."

Times have changed, life has changed, and so have the ideals. Knowledge is now the monopoly of the few. But it has to be so. As time has advanced and man has achieved greater control over the forces of nature, nature has retaliated and made man's problems far more complicated. Further progress therefore requires research to maintain humanity—nay, even to save humanity. Research can only be the monopoly of the gifted few, but the results are to be imparted to all units of humanity, and this again is an intricate problem.

Conservation is a matter of the greatest importance to humanity, and the Government of the United States is to be congratulated for having made such great strides in conservation and also for its progress in evolving a system of education for conservation. Whether this system is the most widely applicable and the best, or is unsuitable for other countries but can be conveniently amended to suit them, or is entirely unsuitable for most other countries which collectively or individually require a different system or systems, it will be our responsibility this afternoon to determine.

Education is the maximum development of the capacity of the individual to understand and deal with the critical problems of his civilization. The standard and extent of education must be brought up to a certain minimum level in all countries. The future of civilization depends on better care of resources. Therefore education for conservation, which is a special branch of education, should receive the greatest attention.

Conservation holds out the assurance of a better standard of living and reduced human wastage. It should make the world more beautiful, more orderly. The psychological influence on an individual who lives in and promotes a civilization whose dominating features are beauty, order, development, freedom from waste and a concern for human welfare, is impossible to over-estimate. It is time to bring into being such a civilization, and to set about it with all speed. This may be a practical way to the desired goal of all nations—to world peace.

As a contribution to today's discussion of education for conservation a number of specialists from different areas of the world were invited by the Secretary-General to prepare background papers based on the experience in their areas. UNESCO advised in the selection of these authors and assisted in making arrangements for their contributions. These papers have been circulated for the past several days among the conferees and will be considered as part of the record of this meeting.

We shall now hear details of the education for conservation practised or planned in some countries. I propose that a few papers will first be read or summarized, and that then a general discussion will be held.

I now have pleasure in introducing to you Mr. Alain Gille, who is an engineer in agronomy and has a Master's degree in ecology. He is now working with UNESCO as a programme specialist in education for conservation in the Fundamental Education Division. His report is entitled: "Education and Conservation". He has written an excellent report and also a paper which, by itself, summarizes several papers. I shall now ask Mr. Gille to read his paper.

Mr. GILLE *delivered the following paper:*[a]

[a]Mr. Gille spoke in French.

Education and Conservation

ALAIN GILLE

ABSTRACT

The present communication is mainly based on the specialized works, here synthesized by the author, of Messrs. W. J. Badcock, Chief Soil Conservation Officer (Nyasaland), J. J. Deheyn, Senior Agronomist in the Belgian Congo, R. Furon, Deputy Director of the Museum of Natural History in Paris, J. Keiling, Agronomical Engineer (France) and W. C. Lester-Smith, Soil Conservation Officer (Jamaica). This study deals with the importance of education in the application of conservation measures, and with educational methods calculated to secure the protection and better utilization of natural resources.

In the second part, attention is given successively to school education in the more advanced and in the less developed areas, to out-of-school activities for youth and finally to the education of the public in those two types of area.

The educational means employed (courses, lectures, publications, films, wireless etc.) are reviewed and illustrated by examples drawn from widely different countries: Honduras, the African Continent, Colombia, the Belgian Congo, France, Canada, Australia, Haiti, The Netherlands, Poland, the U.S.A., Finland, Luxembourg, Indo-China, Nyasaland, and Jamaica.

A. THE IMPORTANCE OF EDUCATION IN SECURING THE APPLICATION OF CONSERVATION MEASURES.

A plan for the application of measures for the conservation of natural resources should be based on the following three elements:

(1) scientific research;

(2) legislative and administrative measures;

(3) education.

These three elements are closely connected, and it is impossible to conceive of a plan that could neglect any one of them if it is intended to be effective. In particular, a plan which did not embody educational measures would be destined for failure from its very inception. Examples are not lacking to support this statement. Up to a very recent date, few educational curricula included courses on conservation. Governments were content with promulgating laws and orders, the body of which has been assembled in the *Revue Internationale pour la Protection de la Nature* and forms an impressive number of fascicules. When one considers the results actually obtained in this field, one is bound to admit that legislative machinery alone is not enough. We should be careful, however, not to conclude from this that such machinery is useless.

It is only by educating the people and appealing for their entire collaboration that the desired end will be achieved—the intelligent and wise utilization of natural resources in the general interest.

The need for such education is self-evident in view of the fact that, during the investigation we conducted on education in conservation, we received answers like the following:

"All (here) think only of taking advantage of the present without care for what is to come. They take their pleasure without troubling about future needs, hunt the year round without regard to breeding seasons, and for fishing employ methods which involve the extermination of a whole species."[1]

"While the European has achieved a creditable measure of success in his efforts to prepare good industrial workers or clever artisans in Africa, he has been much less concerned to teach the Negro to cultivate the soil well and he has still done practically nothing to make him what the British call 'soil conscious'."[2]

"A vast programme of education and preparation is needed to induce the population to understand the need for (measures aimed at the conservation of natural resources) and to collaborate in that work to the best of their ability. It must also be led to feel concern about the present state of things and be imbued with the ardent desire to work for an improvement."[3]

[1]From a report submitted to UNESCO by the Honduras National Commission. Tegucigalpa, 19 April 1949.

[2]J. P. Harroy. *Afrique, terre qui meurt.* (Africa, a dying land). Page 513. Marcel Hayez, Brussels, 1944.

[3]From a report submitted to UNESCO by the Director-General of Research, Protection and Regeneration of the Soil Section, National Federation of Coffee Growers. Republic of Colombia. 1949.

B. EDUCATIONAL METHODS FOR SECURING THE PROTECTION AND BETTER UTILIZATION OF NATURAL RESOURCES.

The methods employed to encourage the conservation of natural resources will vary according to the population for which they are intended and the stage of development of the area inhabited by this population.

School children constitute that section of the population which is most easily reached. If the child is made acquainted with these questions at a very early age, and if at the same time as he discovers the existence of animals, vegetables and minerals he learns that those are the resources which man utilizes to satisfy his vital needs, but that they can disappear if they are not rationally exploited, there is a great possibility that those ideas will stay with him later since the idea of conservation will develop in him as he himself grows up.

It is much more difficult to inculcate such ideas in adults who may be approached only from time to time and who use, as a matter of routine, methods of exploitation that have disastrous effects, such as forest and brush fires which, in tropical areas, lead to the destruction of the soil by the formation of laterites. In that connexion we may quote the following typical passage of a report which has reached us from Honduras:

"Our forest fires are the result of ignorance, thoughtlessness and above all, indifference."

"All the peasants are accustomed to have recourse to burning, for they are persuaded that this is the only way to prepare for the sowing. No one has taught them a better method, which would avoid soil erosion."[4]

Although, however, the adult population, firmly addicted to bad methods by the force of routine, may be more difficult to reach, the problem has become so serious in some areas that it is impossible deliberately to abandon a generation and bring influence to bear only on the young.

As J. P. Harroy says, one cannot wait for the disappearance of the present illiterate generations, for that would create a "hiatus between the barbarian parents and the educated children (which would continue) to slow down development by creating all kinds of social disorders, the fertility of the African soil continuing meanwhile to become exhausted".[5]

Speaking of the population of the Belgian Congo, J. J. Deheyn says:

"By educating the children one acts on the rising generation, and this is undoubtedly the best means of building a better future; but it cannot be the only one. When the better management of the common heritage is at stake, we cannot afford to wait, and the adults also must be educated."[6]

Action must therefore be directed simultaneously both towards the young rising generations and towards

[4]Extract from a Report submitted to UNESCO by the Honduras National Commission. Tegucigalpa, 19 April 1949.

[5]J. P. Harroy. *Afrique, terre qui meurt.* P. 516. Marcel Hayez, Brussels, 1944. X & 557 pp.

[6]J. J. Deheyn. Educational methods of instructing native populations of Africa in the protection and more efficient use of resources. Report prepared for UNSCCUR, August 1949.

the generation which now is engaged in working natural resources.

1. THE INTRODUCTION OF IDEAS RELATING TO THE PROTECTION OF NATURE INTO EDUCATIONAL CURRICULA

(a) *Highly developed areas*

This question has already been repeatedly studied by experts, particularly at the Inter-American Conference on the Conservation of Renewable Resources which took place in September 1948 at Denver (Colorado, United States of America).

We have no time here to summarize the teaching courses now practised in a number of countries. Those who are interested in this matter will find the information in the enquiry into education for conservation which we conducted for UNESCO.[7]

We shall give here by way of example a synopsis of the syllabus proposed by Dr. R. Furon in a report entitled: "Protection of Natural Resources: Education and Propaganda."[8]

In the first place, the author is of the opinion that the study of natural science, physical geography and economic geography is best adapted for the purpose of such education.

In the primary school course, general ideas of conservation might be explained in the natural-science manual and in the final-year geography book.

In the secondary school course, these ideas might be introduced in the sixth-grade zoology, the fifth-grade botany, the fourth-grade geology and the final-year general geography.

The author then gives an outline of the various sections of the curriculum for teaching protection of natural resources:

(i) *Primary school course:* This course, though very important, is the most difficult, being solely for young children whose knowledge is necessarily slight. Everything depends on the ability of the teacher to impart knowledge.

Under general programme the author reviews various natural resources and shows their importance to man. He describes nature such as it was before being exploited and stresses the importance of the plant covering which protects the soil.

He then draws a picture of the destruction caused by man in various regions (deforestation, exhaustion of the soil as the result of bad methods of cultivation, over-grazing) and the economic and social consequences that have resulted from it. He ends by describing the efforts at restoration that have been undertaken, and by pointing out that side by side with the large-scale efforts made by Governments, it is the imperative duty of all men to respect natural resources and to take daily care to maintain cultivated land, grassland and forests in good condition.

(ii) *Secondary school course:* Here, the teaching can be more broadly developed and adapted: animal wealth being dealt with in zoology, plant resources in botany, damage caused by soil erosion in geology, a general economic survey being given in the geography course preceding the second part of the *baccalauréat* (pre-university) examination.

In the sixth-grade geology course, the author recommends that the part played by animals in the life of man should be demonstrated, and at the same time, the advantages of protecting them and establishing reservations and national parks.

In the fifth grade, similar ideas will be given in the botany course by considering, for example, the value of grassland and forest as a protective covering for the soil, and the need for national parks.

In the fourth grade, the study of the soil and erosion will be introduced in the geology course.

During the last year of the secondary school course, natural resources will be studied from the economic point of view. Their present situation in the world will be described and the need for taking steps to protect nature will be emphasized.

All these ideas would be expressed in the course of lectures illustrated by stills (rather than by cinematographic films, which distract the attention of the audience) or, in the case of schools not equipped with electricity, by a series of large-scale photographic enlargements.

(b) *Less developed areas*

We shall take for example the Belgian Congo, where the native population is employed exclusively in agriculture, stockraising and forestry, the only activities carried out by natives on a large scale.

In his report, J. J. Deheyn[9] expresses the opinion that instruction in schools must be regarded as the basis of the campaign, and that it should therefore receive special attention.

"From the elementary school up, it is essential to stress questions of soil conservation, forestry and game protection and the proper care of domestic animals.

"At this stage instruction is purely educational; it is not intended as vocational training. If young pupils absorb almost unconsciously the main principles of agriculture, they will be ready to adopt these later when they are given methodical instruction in them for vocational purposes.

"Even before primary school, in the infant schools, an attempt is made to create a psychological attitude favourable to such instruction by interesting the children in garden work appropriate to their age.

"In the third year of primary school, which in rural districts of the Congo begins at about twelve or thirteen, a complete course in agriculture and stockraising is provided. The course is both theoretical and practical. The practical lessons must not be associated with heavy field work, but must introduce the children to the concrete aspect of the problem by observation exercises and experiments to demonstrate the theory taught. These various teaching methods in fact form a single process, intended to make the child understand what he sees in his environment. A special effort is made to show him the importance of improving certain techniques and the inadequacy of some traditional methods.

[7] "Education for the Conservation and Better Utilization of Natural Resources", Enquiry by A. Gille. UNESCO, July 1949.

[8] R. Furon. Protection of Natural Resources: Education and Propaganda. Report prepared for UNSCCUR, August 1949.

[9] See footnote 6.

"Throughout their school life, boys and girls receive agricultural instruction centered mainly on the study of basic principles—the necessity for humus and methods of conserving it; the prevention of erosion, reforestation and the choice of better species. The instruction must be illustrated at every stage by numerous demonstrations directly connected with the principles taught."

2. OUT-OF-SCHOOL ACTIVITIES FOR YOUNG PEOPLE

The introduction of ideas of conservation into educational curricula is a first stage.

While the young should first be reached at school, however, their attention must also be drawn to the problem of conservation during their leisure time so as to prove to them that it is not an invention of books but a problem of daily life which must therefore be given an immediate solution.

Youth groups, clubs and various societies have drawn up plans of campaign for the protection of nature.

The 4-H Clubs in the United States, Canada, Finland, Denmark, etc. are very active in this respect.

By way of example we shall give a summary of the work undertaken in Canada[10] by the 4-H Clubs in the Province of Quebec.

In their propaganda leaflet "Who are you, 4-H?", the nature and purpose of these clubs are defined thus:

"A 4-H Club is an association of young country boys and girls of between ten and twenty years of age working together to conserve our natural resources, more particularly the forest resources of Quebec."

Amongst the aims pursued, the following may be noted:

"To develop a forest conservation mentality in the young. To make them realize the value of research and technical knowledge in everything that is connected with the conservation of our natural resources etc."

A 4-H conservation manual entitled *En Pleine Nature* (In the Open Country) has been published.

Amongst other activities, the clubs organize competitions, some of which are called: "4-H Reforestation Competition", "4-H Forest Protection Competition" etc.

These clubs, of which there are now 187, have about 9,000 members, all actively engaged in the protection of nature.

Another form of activity has been the establishment of "Tree Days" and "Nature Protection Days", which are now widespread in a number of countries, such as Australia, Canada, Haiti, the Netherlands and Poland.

In Poland, for example, activities in 1949 were continued throughout the month of April and included the following: afforestation of waste-lands, tree planting in working-class districts, along highways and in the streets of towns. The school children also made parks, lawns and plantations for use as bird sanctuaries; they compiled inventories of natural monuments, took part in excursions and attended lectures and film shows on natural history.

The possibilities for out-of-school activities for young people in connexion with soil conservation are therefore very numerous and varied: they include excursions, competitions, school gardens, lectures, film shows and the placing of nests for birds.

There is no lack of enthusiasm among the young people. It is therefore for the leaders of the youth groups to take the initiative in introducing ideas about the protection of nature into their programmes.

3. EDUCATION OF THE PUBLIC

Here again, a distinction must be made between countries which are fully developed economically and little developed countries whose population cannot be reached in the same way.

(a) *Highly developed areas*

From the investigation we conducted[10] it appears that the education of the public in the conservation and better utilization of natural resources is a matter of world-wide concern. Propaganda campaigns have been worked out and are now being conducted in many countries.

Amongst the methods of propaganda to be used we may mention the following:

The employment of rural advisers whose task is to assist farmers and their families to solve their problems. The Extension Service of the United States Department of Agriculture has proved very effective in this respect, since in 1943, this service was carried on by male officials in 2,941 and by female officials in 2,058 of the 3,075 counties in the country. In addition, the Extension Service and the Soil Conservation Service have together drawn up a plan of work for improving agricultural and anti-erosion techniques. For that purpose, Extension Soil Conservationists posts have been established. These are responsible in the various States for managing all matters connected with registration for purposes of soil and water conservation;

Lectures to farmers by rural advisers or experts, in clubs etc. are one of the commonest and most frequently used methods;

Courses for adults: amongst others, we may mention the elementary courses for adults given in Nova Scotia, Canada. Much attention is given to the conservation of forests, the tree planting and the national management and use of the soil etc. Each class undertakes to carry out within the scope of its studies a definite task meeting the requirements of the group and community. In a region, for example, where the forests are worked, the task might be connected with afforestation, regulated tree felling or any other activity bound up with the economic life of the community. Studies are directed in accordance with this activity and relevant documents and material are distributed. Competent experts are brought in to give advice and assistance;

The projection of films and slides is also frequently resorted to, especially for the purpose of illustrating lectures. While films on agriculture and agricultural techniques are relatively numerous, however, films dealing particularly with conservation are less frequent and have only been introduced quite recently. Several countries have begun work on that task (including the United States, Canada and Australia);

Wireless programmes also co-operate in this campaign. Since the use of wireless is widespread, it is

[10]See footnote 7.

one of the most effective means of reaching the population regularly, even those sections living in the most remote parts of the country. In this connexion we may mention the effort made in the maritime provinces of Canada to organize children's broadcasts on conservation. The wireless is very frequently used for inculcating in the pupils ideas about the conservation of the soil and its resources, and of water resources, fish, birds, game, forests and all kinds of vegetation. Through the Canadian Broadcasting Corporation, the schools in the maritime provinces may obtain manuals for supplementing school broadcasts. To be able to understand the broadcast, the children must do a small preparatory task. Certain practical applications of the knowledge thus provided are proposed and explained in the abovementioned manual. For example, in 1948, one broadcast was on "Erosion, floods and tidal waves". The children were asked to bring to the class pictures illustrating the effects of floods and erosion, to study the spring floods of streams and rivers and to show how the water often carries away foot bridges. After the broadcast, some pupils were requested to study the damage caused by floods in Canada and read a paper on that subject to their fellow pupils. The task of other pupils was to study means of avoiding floods etc.;

Publications: most Ministries of Agriculture have a propaganda department which publishes leaflets intended to improve agricultural techniques. A few of these departments include in their programmes the publication of leaflets on the conservation of natural resources.

We should also mention the demonstrations carried out on model farms or even on private farms, whose owners then receive official assistance in varied forms (money, fertilizers etc.); the farm competitions which are organized in Australia, Canada and various other countries and which create rivalry between farmers inducing them to obtain better yields than their competitors; agricultural fairs; exhibitions organized by societies for the protection of nature (hunting exhibitions in Finland, exhibitions for the protection of birds in Luxembourg and the protection of the countryside in the Netherlands etc.), including itinerant exhibitions (like those organized by the Rice Office in Indo-China before the war) which thus are likely to influence a greater number of people; excursions into the country to bring the public, and particularly the town dwellers, into direct contact with nature.

We have so far stressed particularly the education of the farmers in conservation, for it is they who are the first to handle the resources derived from the soil. Before reaching the consumers, however, those resources must pass through the transforming industries which will make them fit for use. There again the problem of the conservation and rational utilization of resources arises.

In a report devoted to the place of the agricultural industries in a programme of instruction on conservation, J. Keiling[11] points out that such industries may, by analogy with the extractive industries, be considered as working through the intermediary of the farmers the deposits of fertility in their zone of supply. They should therefore take part in planning and applying a programme of education on conservation.

The programme proposed would be applied on the economic level by means of contests and comparisons between the farmers supplying the factory and on the technical level with the assistance of factory agronomists, who would promote co-operation between factory and farm: their task would be so to guide the producers that the products they supplied should be capable of rational utilization in respect of both quantity and quality.

After the education of the producers (farmers) and transformers (industrialists) in matters of conservation, it remains to educate the consumers who, especially in highly developed areas, are the urban populations. Such education will be effected by the means we have already reviewed (i.e. press, wireless, films etc.).

(b) *Economically little developed areas*

In the Belgian Congo,[12] propaganda for the protection of nature is conducted by Belgian agronomists, assisted in their work by highly trained native assistants and by native auxiliary workers with less intellectual education, called agricultural instructors, forest rangers or wild life wardens.

The principal function of the agricultural assistants and instructors (also called demonstrators or propaganda agents) is to persuade all the farmers in a particular district to adopt the recommended methods. This work is difficult. One must not forget the lack of understanding and absence of interest of the people with whom propagandists have to deal. Moreover, the propagandists sometimes recommend operations not sanctioned by custom; and farmers' universal suspicion of new methods is well known.

The author points out that the propagandists' work is frequently made possible only by an element of compulsion, which is justified by the aim of preventing impoverishment of the common heritage while improving methods of agriculture, stockraising or forestry for the exclusive benefit of those who apply them.

The period during which compulsion is used must, nevertheless, be as short as possible, and one must try to obtain an acceptance arising from reasoned conviction based on reflection, or at least the adoption of methods because they have been tested and become quasi-traditional.

To obtain results, propaganda must be intensive. It is hopeless to try for rapid results by dispersing one's efforts over immense areas. It is for this reason that in the Congo, in addition to the regular activities carried on throughout the territory, certain social groups have been chosen with the complete consent of all their members to be the subject of more intensive action. Every means is used to ensure that all the members of these groups are subjected to continuous propaganda carried out carefully and simultaneously in every field—hygiene, agriculture, organization, education, production and co-operation. It is hoped in this way to secure the rapid development of these groups towards a peasant agriculture—in the form in which it is known by peoples in an advanced stage of civilization—while conserving their own social organization and traditions. These

[11]J. Keiling. The place of the agricultural industries in an educational programme on the conservation and better utilization of natural resources. Report prepared for UNSCCUR, August 1949.

[12]See footnote 6.

groups, known as "*paysannats*," will act as the leaven in the mass, and the standard of living attained by their members will serve as an example and gradually extend over the whole territory.

The educational organization in the Congo also provides for farm schools and practical agricultural instruction centres.

The farm schools are intended to train good farmers by academic methods by providing an apprenticeship for young people from the elementary schools. In practice, it is found that only exceptional pupils are capable of benefiting from this type of education. The others become hardly better peasants than those who have not had the training. Unfortunately, the farm-school idea neglects native society as a whole and deals only with individuals. The pupils trained by these schools are sooner or later faced by a dilemma: either to follow the principles they have been taught and dissociate themselves from the clan or to integrate themselves with the clan and not adopt the methods they have learnt at school.

The farm school will not play a really useful part until it deals with a generation whose parents have already been subject to intensive propaganda. This applies to pupils in the *paysannats*.

By "practical centres of agricultural instruction" we mean lecture courses, with demonstrations, organized for farmers. This type of education has no chance of success except in populations which have reached a certain level of development.

Publications, pamphlets and press articles are excellent adjuncts to a well-planned propaganda campaign, but cannot suffice alone, in view of the state of development of the population of central Africa.

It is out of the question to hope for far-reaching changes in agricultural and stockraising techniques by the use of cinema propaganda alone. Nevertheless, this method must not be neglected *a priori* and is best made an adjunct to the whole system of propaganda. The enormous distances between rural centres are not an obstacle to the use of this means of education. In the Congo, the department responsible for propaganda was able in 1948 to organize approximately 1,200 instructional film shows attended by 1,300,000 spectators. Mobile cinema units, two to a province, are now being organized, and will tour the country in order to make better contact with rural communities. There is no need to emphasize the excellent results which may be obtained with well-chosen films in these circumstances.

In Nyasaland, soil-conservation propaganda is conducted amongst the natives in two phases.[13] In the first phase, the administrative officers who are concerned with the rural population prepare opinion for conservation measures subsequently to be adopted by drawing the attention of the native chiefs to the dangers of erosion. The Education Department assists that campaign by training the chiefs and school teachers to conduct propaganda in favour of the new agricultural techniques and by distributing sufficient literature on the subject in schools.

The second phase consists in applying the methods of conservation. It begins when the administration is satisfied that the natives have been sufficiently prepared by propaganda and education. The Native Authority Councils are then requested to take the necessary steps to secure the use, by the natives, of the agricultural techniques deemed necessary. Indigenous supervisors are trained by the Agricultural Department. Under the direction of Europeans their work in connexion with soil conservation has proved to be very effective.

In Jamaica[14] a ten-year conservation plan has been drawn up. Units of land for demonstrating soil conservation methods and mixed farming have been provided at various places in the island on the farmer's own land. The farmer receives advice on the work to be done, and the lay-out of the land, and he undertakes to apply the plan submitted. If the work is satisfactory, he is given a cash grant to assist him in his conservation work, including the purchase of material for planting, liming and manuring, and, later, for the construction of silos, water tanks etc.

In addition, the members of the Department of Agriculture, the Agricultural Society and other social service organizations arrange lectures and discussions on agricultural problems. Adequate literature is also published and distributed for the education of the rural population.

One method of encouragement which has proved effective has been the utilization of the population's love of music and the composition for that purpose of a soil conservation song called "Muddy Water".

IV. CONCLUSION

In this paper we have striven to draw examples from countries varying greatly in geographical situation, population, stage of development etc.

The sources we have used are reports submitted by experts in various branches of science on the countries which they know particularly well. We have made a synthesis of these works, taking care not to distort the thought of their authors.

The rather over-simple distinction between highly developed and little developed areas has proved necessary for a short paper such as this. The division of the public into two categories—young and adult—has also been necessary for the same reason, and because nature tomorrow will be the result of the principles of conservation inculcated in the young, while nature today depends on propaganda amongst adults.

Note: In addition, Mr. Gille submitted a survey by countries and geographical areas which has been reproduced by UNESCO. Below is reproduced the Table of Contents, which indicates the scope of Mr. Gille's survey.

[13] W. J. Badcock. Soil conservation in Nyasaland. Report prepared for UNSCCUR. August 1949.

[14] W. C. Lester-Smith. Methods of teaching conservation of natural resources in Jamaica. Report prepared for UNSCCUR. August 1949.

The CHAIRMAN: Thank you for your excellent paper in which you have covered most of the angles, clarified issues and made such concrete proposals. The next speaker will be Mr. Wilson, Director of the Extension Work of the United States Department of Agriculture. Mr. Wilson gives the leadership in extension work—the taking of education to the people on the land throughout the United States of America.

Mr. WILSON *delivered the following paper:*

Extension Methods in Conservation Education

— M. L. WILSON

I. WHAT IS EXTENSION EDUCATION?

The phrase "Extension Work in Agriculture and Home Economics" is an American phrase. It is a name for a system of informal adult education that has grown and developed in the United States in the last 40 years.

It is organized and administered by the publicly supported agricultural institutions and the rural people, and is independent of the system of formal education.

In a way "Extension Work" is a kind of invention. A social invention. There are many things that are unique about it, but it is in principle not necessarily new, nor is it necessarily uniquely American. It came about to meet a specific need.

Some words today are in world-wide usage. These words for ideas are not translated from the original into other languages but are taken over in their entirety. The telephone, for instance, was invented in this country, and when other nations started using it they also started using the word telephone. To the best of my knowledge the word telephone is used to describe this instrument of communication throughout the world. Although the word "extension" has come into fairly widespread use throughout the world it has not been uniformly adopted. In some countries other words are used to express the idea. In Great Britain, for example, the system of extension work, similar in many ways to ours, is called an advisory service.

The unique quality about extension work is that it is an *"informal-method"* type of education in contrast to formal education. Most of us in our culture think of the word education as a word expressing an idea that involves a *teacher,* a *pupil,* a *classroom,* and a *text-book* or a situation growing out of this particular set of factors. Our system of elementary and intermediate schools and colleges is all based on this situation. This system only began in the life of man after the development of the alphabet and writing. What we term informal education has been going on ever since man has been man. It does not necessarily involve the formal teacher and the classroom. Agricultural extension work in the United States is highly organized and is carried on through highly trained educational personnel. Informal education can be unsystematic or it can be organized. It works both with illiterates and literates and somehow produces changes in the content of the mind and the motivation of the personality.

In the United States it was generally assumed, before Agricultural Extension Work began to be recognized and organized, that farmers were too old to go to school. And that it was very difficult for them to learn new ways of doing things. We have often heard it said of localities where illiteracy is the rule rather than the exception that it is difficult to reach rural people. Those who hold this view believe that progress is only made through the younger generation who attend schools. As we see it, these two systems of education, the formal and the informal, are not competitive. They overlap each other to some extent and are closely related, but differ in methods and organization.

The function or idea of extension in the field of agriculture is one of dealing directly with farm people. This concept is being recognized as being on the same level as research, the college, and the school.

Today extension education is in the process of world development. Food and Agriculture Organization is planning to give assistance to member countries in the organization and development of extension education. This summer Food and Agriculture Organization is sponsoring two regional conferences, one in western Europe and one in South America, dealing with extension methods and types of organization.

Prominent among several assumptions on which agricultural extension is based are the following three:

1. That there is a body of knowledge and technology, based on science, which can be "extended" to the great mass of rural people.

2. That there are psychological problems involved in getting the interest of the people, so that they will have the desire to participate in the educational process.

3. Finally, that the people will be motivated by this new knowledge and grasp of technology to change their ways and do things differently than heretofore.

II. CONSERVATION EDUCATION

It is not necessary for me at this gathering to go into the content of conservation education. I assume, however, that we are largely concerned with people who live on the land and who use the natural resources of soil, water, woodlands, and wildlife. In addition I assume that the concept of conservation implies intelligent use and the prevention of misuse of these resources. Also involved is a general attitude or philosophy or pattern of relationships between man and nature. In addition, there are a number of specific practices based on scientific knowledge, some of which are simple in character, to do or not to do. And then there are the highly technical practices requiring professional judgment in their application.

It is easy to bring about change in democratic societies when the general attitude of individuals is receptive, and extremely difficult when their attitude is unreceptive or hostile. A Navaho Indian on a reservation in one of our Western States once told me there was "absolutely nothing to overgrazing—that the Navaho gods would give the Navahos plenty of grass if the white man would get off their reservation and stay off". That Navaho deeply believed what he said. Ways have to be found around such "blocks" in the people's patterns of culture. I am convinced that if given a chance the scientific in the field of human personality can give administrators and program builders many practical suggestions to meet such situations.

In extension education we have to find ways of changing fundamental attitudes or of getting around them so that there will be whole-hearted cooperation between men and science.

In dealing with the problem of conservation and the practice of conservation, we must recognize that conservation and its promotion include both man and nature. They are all pieces of the same pattern. Changes, growth and development of ideas in the minds of men and patterns of behavior of men, are just as urgent, and important as the physical aspects of conservation: Soil erosion, forest destruction, soil surveys, flood control, watershed development, irrigation, and drainage.

III. THE SCIENTIFIC BACKGROUND

Anthropologists and philosophers of history oftentimes characterize our age as a period in which mankind throughout the world is substituting science and technology, which grows out of science, for folklore and prescientific customs. *Science is capturing man or man is capturing science, whichever way you want to put it.* The problem, therefore, of widespread dissemination of scientific knowledge is a function of education. And the benefits of science to mankind are dependent upon mankind's using the results of science.

In many fields, and certainly conservation is one of them, scientific knowledge and techniques in relation to use of natural resources are far ahead of daily practices and ways of living. Extension education, therefore, seeks to speed up the educational process and to make the practices based on science part of the habits and customs of the people.

The science of man and his cultural and psychological behavior underlie the educational processes in the same way that the biological and physical sciences underlie the processes of intelligent use of nature. I feel that oftentimes there is a tendency among biological and physical scientists and technologists—primarily because of the high degree of specialization in their education—not to recognize this concept and to ignore the developments in the sciences dealing with human culture and human behavior when they get into the field where man is involved.

Today we have a growing understanding of what the anthropologist calls culture: that pattern in which are integrated the habits and beliefs and customs and everything else that has to do with human behavior. We are beginning to know how to study culture objectively by using the scientific method. We are beginning to learn a good deal about the processes involved in social change and the manner in which it takes place. We know that the democratic way is to work with the cultural pattern and not against it. We also know that you cannot arbitrarily transplant a trait or a practice from one culture to another. We think we know a great deal about how growth can take place and how it can be stimulated.

The other great field of science that contributes to our knowledge and understanding of human behavior is psychology, the study of the mind of the individual and the working of the group. Sociology also makes a notable contribution to this knowledge and understanding of man, particularly as it deals with the organization and structures of a group of people, the functions of leadership, and leadership patterns. Economics and political science likewise bring to bear their disciplines, especially in relation to systems of values and problems of wealth and government.

These sciences have now developed and have been integrated to the point where we are getting some basic educational principles out of them.

IV. BASIC PRINCIPLES THAT APPLY TO ALL MEN

I mention the principle that extension education has to work with a culture and not against it. And it has to work with a program that makes sense to the individual. But it does this through an organized program.

Another important element in the consideration of basic principles is the cumulative effect of scientific knowledge and the thing we call progress in relation to the rate at which change takes place. If extension education works it is producing social change. The man who is probably making the greatest contribution to the understanding of social change is Prof. William F. Ogburn, first at Columbia University and now at the University of Chicago. He thinks that change operates a little bit like compound interest—it gets started and one step leads to another. We could change from *horsepower* to *motor power* in our culture in a generation. But if the motor had been discovered at the time of Columbus it is highly probable that it would have required far longer for the change to take place because our culture was not ready for it. Things have to get started and simple things have to be done in simple societies, step by step, whereas changes in complex societies can take place at rapid speed, in several steps at the same time, so to speak.

If I were to list a few of the basic principles in extension education they would be:

1. The problem approach with a program based on the needs of the people.
2. Maximum participation by individuals.
3. Use and influence of local leaders.
4. Result demonstrations.
5. Maximum number of contacts leading to the same end.

V. METHODS BASED ON PRINCIPLES

Methods have to vary from culture to culture. They can be classified under different categories: (*a*) those mainly applicable to reaching individuals, and (*b*) those mainly applicable to reaching groups.

A time-tested and efficient method is person-to-person contact. Although it is highly efficient, obviously it cannot be used exclusively in reaching large numbers of people. In some cases it is essential that the person-to-person method be given precedence over other methods. Fortunately, extension education has many methods available for reaching the individual and for reaching the group. There are methods involving demonstrations that can be observed with the eye. Radio is an ever-ready means for bringing directly into the farm home up to the minute developments, be they the latest weather reports or current market prices for farm products. The weekly, daily, and farm magazines play a tremendous role in reporting and interpreting agricultural developments and research to rural people. And there are many other methods: bulletins, circular letters, posters, tours, exhibits, motion pictures, slidefilms, office calls, telephone calls, and others.

You may well ask why so many methods are needed and why the same information must be repeated through various media? I am coming to that presently, but before I do here is a basic principle that categorically answers the question:

If widespread response is desired, farm and other rural people must be exposed to educational teaching efforts in several different ways. In passing I'd venture to say that that principle applies to city people as well.

VI. EFFECTIVENESS OF METHODS

There are many things that I should like to say regarding our experience as to the effectiveness of different methods in conservation education. Time will not permit a detailed discussion of them in this paper.

First of all, there must be an extension program or plan of work in each area or unit. This program or plan of work is based on considered thinking and discussion by the people who live in the area as to the problem and the science and technology that can be brought to bear upon it—in which are the answers to the problem. Each area, or unit, therefore, must have a plan to extension education that grows out of the needs of the people and is neither handed down from above nor entirely developed in the area.

But the plan must have incorporated in it somehow the best that science has to offer. One of the most important extension methods is effective in this kind of situation. It is the method whereby the scientist and the man on the land, regardless of his development or social status, cooperate in their working relations.

Many specific methods can be used: conservation demonstrations on individual farms, specific demonstrations on plots or small areas or on farms of such character that the individual may see both the process and the results.

Other elements to further the conservation program include committee meetings, training of local leaders who will influence their neighbors, test-plot demonstrations, field days in which large numbers of people have the opportunity to see conservation practices and the use of machinery and technology.

Various informational media — newspapers, radio, farm magazines, and leaflets—keep the people in the area informed of the progress of their program.

Each area has to work out its own program. Basic to all this is the cumulative step-by-step process of learning and growth under the stimulus of methods that will effectively reach the largest number of people.

An effective extension program uses several methods so that there are a series of "exposures" influencing the individual.

A careful appraisal of the various studies conducted relative to extension work in the United States indicates strongly that the best results are obtained when a number of methods are used. This gives a continuity of so-called exposures to the idea and the new practice. Or in other words, rural people are influenced by extension education to make changes in behavior in proportion to the extent of contact with extension teaching activities.

I have with me two charts that illustrate this. Chart No. 1 shows the Extent of Adoption of Practices as Affected by Number of Kinds of Exposures.

It shows that as the number of different types of contact, or kinds of exposure to extension information, increases from 1 to 9 extension methods, the number of farm families changing behavior increases from 35 to 98 percent. The percentage of families responding increases rapidly as the number of contacts increases to 5 or 6 methods. If exposed in 5 different ways, approximately 7 out of every 8 families receiving extension information change their behavior. It seems evident then that if widespread response is desired, farm people must be exposed to educational teaching efforts in several different ways. To state it another way, repetition in a variety of ways is highly important to learning.

Chart No. 2 shows Rate of Adoption of Practices as Affected by Number of Kinds of Exposures to Extension Teaching Methods.

This chart shows that when the change in behavior is expressed in numbers of responses rather than in percentages of families responding, the relationship between behavior and extent of contact remains remarkably constant regardless of the number of media through which extension information is received.

From this and the previous chart it would appear that the problem of reaching groups in the rural population effectively is primarily one of coverage or contact rather than the lack of response to educational stimuli.

Copies of both these charts are available here with the mimeographed copy of my paper.

Now let us consider a concrete example of methods nd their effectiveness in terms of an individual farmer. ast fall I visited with a county extension agent in a airly typical cotton-producing county in the South. It s a county where there has been great misuse of natural resources. Among the farms I visited while there was a hill farm. This farm was a vivid example of good nd use. All the land that needed to be terraced was ı terraces, and good ones too. Crops were on the conıour; some of the land not adapted to crops was in voodland and provision had been made for wildlife conservation. And this farm also had a fishpond.

I asked this farmer how he had become so conservaion-minded. He said that it began some 25 years ago, when he started working with the county agent. That was when he was a boy in 4-H Club work. He had been raised in the county. He said that he had never attended college. Over the years he had worked closely with the county agent.

Among other things he had developed a crop-rotation system for his farm, and all in all had done a considerable amount of conservation work prior to the organization of a soil-conservation district. After the establishment of the district, he had a conservation plan worked out for his farm. He was diligently following it.

He told me that he had received a good many ideas from visits to a branch agricultural experiment station some 50 miles from his place. Every summer the county agent arranged for farmers in his county to visit the station.

For about 16 years this farmer had cooperated in conservation and related programs of the Production and Marketing Administration of the United States Department of Agriculture.

His yields had increased some 30 to 40 percent since he had started working with the county agent, with technicians of the Soil Conservation Service, and with the PMA program.

This is an example of the most advanced type of reaction on the part of an individual farmer. From a high point such as this it ranges all the way down to the individual who as yet has not been reached. As another generation comes along, trained in 4-H Club work and having a receptiveness to scientific practices, I would expect to see in the course of 20 years that most of the farms in the community would be equal to or better than the one I have described.

From an extension-methods standpoint this farmer I have mentioned is exerting demonstration influence on all his neighbors. His farm is a "living textbook" for every family in the community.

Now let us take a look at community action among farm people. Good examples of this are the grassed-waterways seeding demonstrations in the State of Nebraska. These demonstrations were worked out cooperatively with the farm people by State and county extension workers and the Soil Conservation Service. This type of demonstration is very effective on a comnunity basis. One Nebraska county agent in his 1948 report stated that in his county grassed-waterways are the number-one phases of conservation.

The 1947 report of Nebraska extension shows that 24 grassed-waterways demonstrations were held in the State in that year, with over 15,000 people in attendance. And in passing I may say that this was only one of a total of some 355 various methods demonstrations held in that year. Over 63,000 people attended these methods demonstrations.

In the United States, Cooperative Extension Work in Agriculture and Home Economics as an institution and as a function is recognized as being on the same level with college teaching in agricultural science, research in agricultural science, and administration of governmental agricultural programs. It has the wholehearted support of the voluntary general organizations of farmers and the farm cooperatives. It is carried on cooperatively with the State agricultural colleges and local governments. Its total budget last year was over 65 million dollars. It has a total professional staff numbering about 12,000, 77 percent of whom were in the counties working directly with farmers and other rural people, and 23 percent of whom were located at the agricultural colleges. Those at the colleges render an intermediate service between research and science on one hand and the county agents and county programs on the other.

The Cooperative Extension Service definitely is in the field of conservation education. It is and has been responsible for the general educational programs that help farm people to understand what their conservation problems are. It also helps them to develop programs that enable them to take advantage of services made available by other branches of Government. In addition, extension work emphasizes self-help by encouraging farm people to undertake the things they can and should do themselves on their own initiative and without assistance.

Cooperative Extension has been and is responsible for farmer understanding of various agricultural programs of the Federal Government as well as for developing an understanding of how the interests of the entire people and the individual landowner meet. Included in this are the programs of the Soil Conservation Service, Production and Marketing Administration, and Forest Service of the U. S. Department of Agriculture and the Bureau of Reclamation of the United States Department of the Interior.

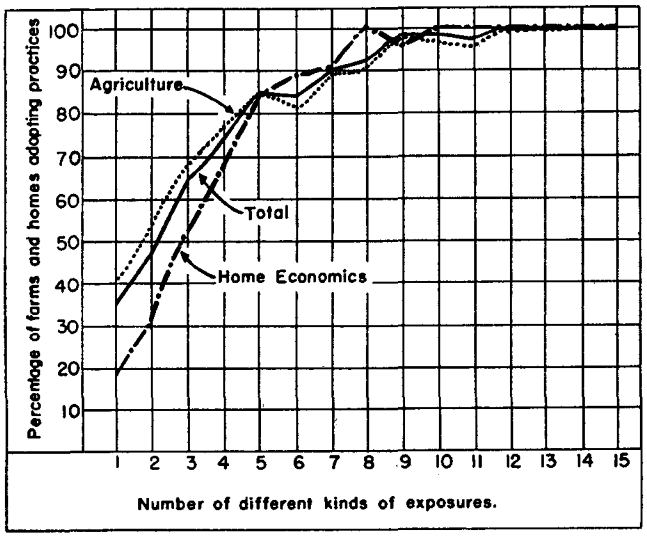
County extension workers help farmers to understand what soil conservation districts are. They have taken the initiative through meetings and other educational media in bringing about discussions and democratic decisions as to whether or not farm people desired to form such districts.

Last year the extension program was planned cooperatively by extension agents and local committees in over 56,000 communities, or 82 per cent of the approximately 69,000 communities located in counties having county extension workers.

I have mentioned local leaders and their importance. Last year there were over 962,000 individuals—men, women, and older 4-H Club boys and girls—who contributed freely of their time and effort to the progress of the American farm, of the farm home, and of rural America as a whole.

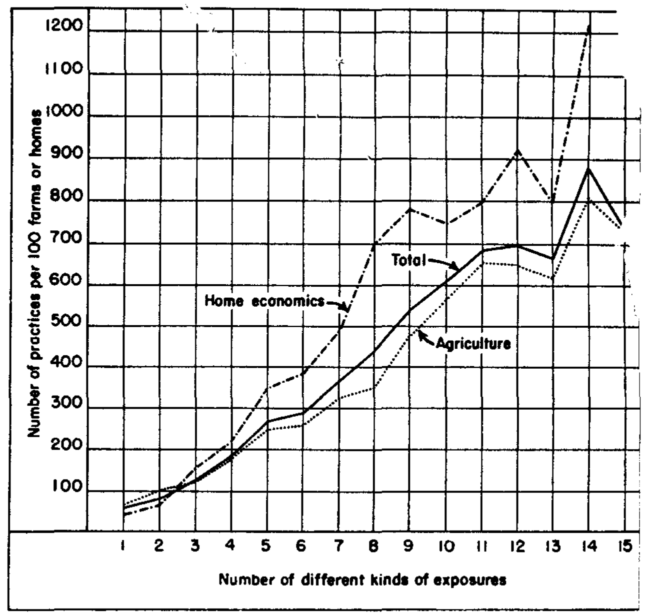
In connexion with the conservation of natural resources, over 161,000 different 4-H Club members, including those in corresponding projects, received training during 1948 in soil and water conservation; over 137,000 in forest conservation; and over 176,000

Chart 1.-- Extent of adoption of practices as affected by number of kinds of exposures



(2,507 farms and 869 homes)

Chart 2. -- Rate of adoption of practices as affected by number of kinds of exposures to extension teaching methods 1/



(2,501 farms and 869 homes)

1/ Wilson, M. C. Unpublished data.

in wildlife conservation. In terms of land area these soil and water conservation projects comprised over 228,000 acres, and the forestry projects over 44,000 acres. A sampling of conservation figures among adult farmers during the same period shows that over 325,000 were assisted in the use of lime on their land, and over 567,000 in the use of fertilizer. Well over half a million farmers in 2,803 counties reporting were assisted with problems of land use.

VII. SOME CONCLUSIONS

In the first place successful methods in conservation education will be those that have to do with man and his behavior, just as in the physical and biological field successful practices make use of the scientific knowledge of nature.

In the second place, in order to carry out the methods, it takes workers who are trained in background sciences and who know how to work with people and produce social change going in the right direction. I think that the body of scientific knowledge concerning the use of nature is still far ahead of the knowledge concerned with producing changes in mankind.

In the third place, we have enough experience of extension work in many lands to know that extension education works proportionately as well with preliterate people in simple cultures as it does with those in complex cultures, but at a slower pace.

I personally feel that the practices and more widespread acceptance of these fundamentals will speed changes in human beings and in human behavior.

We have held two conferences in cooperation with the Office of Foreign Agricultural Relations of the United States Department of Agriculture, in which we have tried to bring together world-wide thinking on extension methods. One conference was held last May, and the report on it will be published this fall. If any of you here desire a copy, please write me and I'll send it to you as soon as it is available.

Through the good office of OFAR, the directors of extension of the respective States in the United States have expressed a desire to be helpful to other countries in supplying them with information on request, about extension methods.

It gives me very real pleasure again to point out that FAO hopes to assist member countries in the development of extension work in an advisory capacity and to have people on its staff who have been trained in these lines.

I hope all nations in the United Nations will work together in this educational effort. A splendid example of educational cooperation is UNESCO's work in promoting discussions on food and people in member countries. Such discussions should be one of the fundamentals in extension programs—and discussion materials should be made available to countries all over the world. It is highly important in matters of this kind that all countries know they are taking part in a world-wide educational program.

Note: The point of view that I have presented in this paper is my own relative to recent developments pertaining to man's culture and personality. Stuart Chase has written a very readable book which presents the same point of view: *The Proper Study of Mankind, An Inquiry Into the Science of Human Relations.* Harper's, 1948.

Additional reference: Conference Report on The Contribution of Extension Methods and Techniques Toward the Rehabilitation of War-Torn Countries, Washington, D. C., September 19-22, 1944. U. S. Dept. of Agriculture. Extension Service and Office of Foreign Agricultural Relations, October 1945.

The Chairman: I thank Mr. Wilson for giving the Conference such a clear picture of the educational system and methods in the United States of America, which will be a guide to many of us.

I shall now ask Mr. Monod, who is Correspondent of the Academy of Sciences of France, Professor at the

Museum of Natural History of Paris, and Director of the French African Institute in Dakar, to give us information concerning education for conservation in Africa.

Mr. MONOD[b] *summarized his paper which is included among the background papers for this meeting.*

The CHAIRMAN: I now wish to introduce Dr. Abelardo Moreno, Professor of Zoology, University of Havana, who will speak on his ideas of what can be done for conservation through schools in Cuba.

Mr. MORENO[c] *summarized the paper prepared by Dr. Fernandez and himself which is included among the background papers for this meeting.*

The CHAIRMAN: Thank you very much. I shall now ask Mr. Rene Roberto Thiery, Agricultural Councillor at the Argentine Embassy in Mexico, to present his views.

Mr. THIERY:[d] I should like to refer briefly to my country's contribution to the solution of the problem we are considering.

A mere review of our programme indicates its transcendental importance in the co-ordinated planning of permanent solutions. We have heard, in the course of this Conference, the views of men of science whose technical knowledge is recognized throughout the world and they reminded us that the losses suffered by states from the changes in the soil have been so considerable as to cause every thinking person to be seriously concerned, and to require the adoption of decisive measures to prevent further deterioration. Education is obviously one of the basic means of overcoming the problem; many voices have been raised in the defence of the soil, the tree and fauna. Those principles must be translated into effective and immediate action, adopted as guiding rules of municipal law, and must be propounded in schools where children are taught to love their country by learning its history. Equal pains must be taken to awaken their hearts to the love of nature, which we regard as infinite and of which natural resources are an essential part. We must leave the resources of nature in the same condition, undiminished and unspoiled, to those who will follow us as we have received them from the preceding generations.

Fortunately in my country official action in recent years has made it possible to face the problem of erosion and conservation of natural resources in a realistic manner, and has led to the adoption of legislation commensurate with the seriousness of the problem and the available means. Moreover, the programme of action carried out by the Ministry of Agriculture and Cattle-Raising has benefited from the guidance of its current chief, Engineer Emeri, who will testify that investigation is the basis on which action is taken by his department.

I can thus cite to you the following educational measures which the institute of Soil and Agricultural Technique will adopt:

[b]Mr. Monod spoke in French.
[c]Mr. Moreno spoke in Spanish.
[d]Mr. Thiery spoke in Spanish.

(a) research on the various aspects of erosion and soil and water conservation, these problems being closely linked with progressive soil erosion.

(b) dissemination of basic information on soil conservation and its importance in an agricultural and cattle-raising country, beginning with simple lectures in agricultural schools, organizations, etc. and gradually extended to other educational institutions.

(c) practical demonstrations in the field, presented in detail to enable the farmer to follow step by step the gradual process of conservation.

The three aspects have already been dealt with by the above-mentioned Institute in co-operation with the Bureau of Experimental Stations; a series of experiments for the study of the problem of soil and water conservation are in progress. The dissemination of information by means of conferences, lectures, meetings, etc., all accompanied by demonstrations, is being carried on to the extent possible within the available means.

The practice demonstrations in the field, which take the form of projects carried out under contract, have proved to be one of the most effective means of teaching methods of soil conservation, and the above-mentioned Bureau is devoting particular attention to it. At the same time, a plan for research and dissemination of special conservation methods is being implemented. Trial demonstrations are being conducted of contour plowing, strip and terrace farming, of subsoil cultivation, mulching, laying protective strips, rotation of crops suitable to the area—including advice on planting for fodder, etc.

Because of the connexion with the educational problem which should tend to form an international conscience, I consider it useful to mention the economic and legislative measures which are being taken in my country in order thereby to present a general panorama of our activities in this field.

The first measures include the following:

(a) Adjustment of minimum units of land necessary for reasonable exploitation of the soil in conditions which ensure conservation of the soil.

(b) Adjustment of the type of exploitation, changing the orientation in accordance with the recommendations of official agencies which have carried out the necessary studies, with a view to the development of cattle raising and the improvement of the living conditions of the herdsmen.

(c) Reduction of mortgage and loan credits to limits which are reasonable and which are ensured through the advantageous use of the soil and the minimum necessary areas.

That aspect has been fully considered in the official instructions for settlement which consider the points indicated in order to carry out sales of land, subdivision of fields, etc., taking into consideration the minimum areas necessary and the reduction of mortgage and loan credits.

Moreover, there is obviously a direct correlation between the measures indicated above and legislative standards which should contribute to bring nature into harmony with the forces of man for the benefit of society.

In that connexion, I might recall that in the Constitution which was recently approved, the social function of the land is recognized and ownership is made possible for all of those who work the land. In addition, the administration has power to develop and increase the yield of the land in the interest of the community. Thus, the text of the Constitution testifies to better legal protection of the human element which inhabits the country and lives on the land. In that way not only is undesirable exploitation of man outlawed, but also irrational and equally detestable exploitation of the land is eliminated.

Within those general outlines, reference might be made to recent approval of laws for rent and for rural factories, for conservation of forest resources, for research in agriculture and cattle-raising, the decree of marginal zones and the draft of a national law for soil conservation which is now under consideration in the Legislature. In Argentina it is characteristic that the contractors in rural developments are not the owners of the land which they work, and therefore the first legal measure referred to above, the law of rents and rural factories, is especially important. That law abolished any contractual regulation which directly or indirectly led to the erosion, impoverishment or depletion of leased land as might occur in the region of the pampas to which reference is made in a work submitted by the Ministry of Agriculture and Cattle-Raising to this Conference. Supplementing that provision, the Ministry in question was empowered, in the same article, to determine the technical conditions under which continuation of exploitation would be allowed pending the performance of necessary soil conservation work. For his part, the worker of the land can, if he chooses, cancel the contract or perform the work for the account of the landowner if the landowner does not do so within the period allowed.

Similarly, if the performance of conservation work totally or partially interferes with the use and development of the farm land, the tenant can obtain a reduction or even a complete discontinuation of his rent payment during the corresponding period. On the contrary, if the erosion, impoverishment or depletion occurred because of a superior force or because of fault or negligence on the part of the tenant, the landowner can request cancellation of the contract.

The technical functions of the Ministry of Agriculture and Cattle-Raising are extended, since it is given the right to set conditions for the exploitation of private property occupied by agents.

It should be stressed that it is precisely in this erosion zone that exploitation of the land by tenant farming and share-cropping occurs on a large scale. The legislation already mentioned, together with the law on agricultural surveys and a recent decree, will lay down guiding lines for the exploitation of marginal areas where the cultivation of certain grains is ceasing to be productive. The decree on the delimitation of economically marginal areas is designed chiefly to bring about better plans for soil use, which will ensure the maintenance of productivity and a better life for the rural worker. In this way, the agricultural population of these areas will learn how to increase their incomes and at the same time realize that it is their responsibility to work in accordance with the social requirements of the land of a country which promotes protection not only for the producer but also for the soil, through its agricultural tradition of peace and international co-operation.

All these measures are designed to put an end to the irrational exploitation of the earth by man. It is no longer possible, as it was before, to force the tenant farmers of vast areas of the pampas, for example, to throw away seed on dried-up land exposed to the destructive action of wind or sporadic rainfall. This legislation authorizes a better organization of agricultural activity, in a way which, not so long ago, was impossible because of contractual relations. Indirectly, the steps taken constitute an educational plan for everyday life.

In a similar connexion, I might recall that the law on tenant farming obliges landowners to establish schools on estates with more than twenty-five farmers where there is no public educational establishment within ten kilometres of the main building.

I should like to refer very briefly to certain other aspects of Argentine legislation on conservation which are connected with what has gone before.

Thus, for example, the Forestry Law stresses the importance of soil conservation, and the need to protect it by regulating forest exploitation, by encouraging tree planting and regulating soil use so as to maintain the cover which protects it from erosion. The draft law on soil conservation will constitute an invaluable legal instrument which will cover a wide range of problems connected with the conservation of the basic renewable natural resource in the Argentine economy, the soil.

This law will establish regulations for land use. It will lay the foundation for soil research and expert planning; it will determine the edaphological standards that must govern land settlement, credits, agricultural insurance and land tenure *inter alia.*

Lastly, in the international field I may mention that the Inter-American Agreement on Plant Health, signed at Buenos Aires, and referred to in one of the experience papers submitted by experts from our Ministry, which will be printed in the records of this Conference because it arrived a little late, establishes international action for mutual co-operation in the fight against agricultural pests and diseases. Argentina, Brazil, Uruguay and Paraguay were parties to that Agreement and it remains open for signature by other countries.

Among the important aims of the Agreement is the co-ordination of defensive measures against agricultural pests and diseases, the contracting countries undertaking to give each other mutual assistance and to exchange information, experts and any defensive equipment they may possess. Specifically, it provides that every five years an Inter-American Conference will be convened to study common problems of plant health. I might also refer to the recommendations for a joint Inter-American prophylactic campaign against animal diseases, approved by delegations of twelve American countries, which stress the need for co-ordinated action on a scientific basis and along lines similar to those recently adopted by the Inter-American Agreement on Locust Control, also promoted by Argentina.

These agreements all provide for the exchange of information and so help to train experts, which has an important bearing on the educational problem.

Mr. Chairman, in these few words I have tried to give a brief account of what my country is doing in the field of education in conservation practices, and at the same time to outline the methods whereby the State is trying to prevent the loss of its natural wealth and thus to promote the welfare of a hard-working and peace-loving people.

The CHAIRMAN : We have heard some excellent statements on the methods employed in various countries. Considering the shortage of time, I think it would be desirable and advantageous to concentrate discussion on methods to be used with illiterate and backward people. These questions, for example, might be discussed : What forms of education for conservation can be used effectively with illiterate people? What appeals are effective with literate and illiterate people — economic appeals, religious appeals, other appeals? Are democratic processes of group action effective? How can local in-group leaders be discovered and developed into effective conservation leaders among their own people? There may be other similar questions relating to the class of people I have mentioned.

Miss SNYDER : In the light of the discussion of the need for involving the people themselves in the understanding of the conservation problems and the solution of those problems, I should like to raise a few questions which were touched upon in the papers themselves.

Mr. Gille spoke of the difference between policing actions, which were described as rather short-term and emergency measures, and education as a long-term necessity for any sustained programme of conservation. He gave a number of interesting illustrations of that kind of long-term education, which is concerned with involving the whole-person response of the people appealed to, rather than controlling a single and limited function—for instance, the function of land-management.

I was struck particularly by his remarks, from the report on the Belgian Congo, on the necessity of working with natural social groups. I think that there might be some interest in further discussion of that point—its meaning and its nature, its character.

I was also struck by his reference to the use of music in the Jamaica programme. A song was written about soil conservation and, according to the report from Jamaica, that song has been a really effective element in education. That is an instance of the kind of whole-person involvement that seems to me of basic importance —to be involved in what the papers of Mr. Fernandez and Mr. Moreno spoke of as ecological principles and habits of ecological hygiene. I wonder whether Mr. Gille could at least read the words of the Jamaican song if he does not feel prepared to regale us with the music itself.

Mr. GILLE: In reply to the second question, I have a copy of the song, which I will have circulated.

With regard to the first question, concerning the Belgian Congo, in the absence of Mr. Deheyn the most competent person to speak is Mr. Harroy, who is here.

Mr. HARROY :[e] I have been rather taken by surprise, but I think that the results of the Technical Conference on the Protection of Nature, which ended yesterday, form a reply to the question which has been put to us with regard to the ecological aspect. It is enough to read Resolution No. 1 of that conference to realize, what Mr. Monod has just pointed out in a masterly manner, that problems cannot be considered independently of the environment, in the broadest sense, of the organisms whose reactions it is desired to change. Those organisms naturally include man.

You wish to bring about a change in the habits of human beings in under-developed countries. You are dealing with people who have traditional cultural habits which are adapted to the surroundings in which their ancestors lived, for the indigenous peoples have always used the empirical method. During the centuries that method, by means of a series of unsuccessful experiments, has enabled them to develop certain cultural techniques which have been handed down from father to son, and which Europeans have sometimes found surprising and tried to change.

I will not waste your time by giving examples to show that these ancient cultural methods were often good and that after having tried to replace them by techniques which had been tested in the temperate zone and which we wished to teach the natives, we finally had to admit that it was the old methods which took account of ecological conditions in the regions concerned, and that our methods, superimposed from outside, only caused trouble where before there had been equilibrium—precarious perhaps, but still equilibrium.

Now in reply to Miss Snyder's question as to what we should understand by the social groups whose ideas concerning agriculture we tried to change by education.

As Mr. Monod said, when we wish to teach an individual from a peasant group these new techniques, we take him away from his surroundings and send him to school. When he returns to his group he is faced with the following alternatives: either not to put what he has learned into practice because he is reassimilated by the group, or else to try to apply it, in which case he becomes a kind of freak. He may even become a victim of the group, for it is well known that when he returns to his old environment the group communism prevails, so that if he obtains good results by means of the superior cultural methods he has learned at school there will be conflict with his fellow tribesmen, who consider the fruits of his toil as a bonus to be shared. The results of the greater efforts he has generally been taught to make are therefore appropriated by others.

I could give endless examples to show the unsatisfactory or fleeting nature of the result of teaching isolated natives who subsequently return to their ancestral community.

For that reason, in the Belgian Congo we have endeavoured to organize educational programmes on a limited scale, dealing not with one single aspect of the problem—the method of planting maize, for example—but with every aspect of life which should be simultaneously altered if equilibrium is to be preserved.

Thus, for instance, it is often said that once the concept of land ownership is developed in the indigenous population, we shall have taken a considerable step forward towards soil conservation ; the native who will say

[e]Mr. Harroy spoke in French.

to himself: "This plot of land is mine" will want to cultivate it. If you do not succeed in altering the native's social concepts as well as his technical methods of cultivation—since they are both parts of a whole—and if he is given ownership over the land from one day to the next, his first idea will be to sell his land now that it had become something which could be converted into cash. An instance has already arisen where full ownership of a certain piece of land was given to a Negro in the hope of encouraging his sense of the value of land and where this Negro sold it the following day in exchange for an umbrella; this man had not been adequately trained in the concept of land ownership.

It is for this reason that in the region of Sankuru, under the auspices of the *Compagnie cotonnière du Congo,* and in the region of Turumbu, under the auspices of the *Institut national pour l'étude agronomique du Congo belge,* schemes, undertakings and experiments in peasant-type settlement were instituted; that was done according to technical methods which required the services of quite a large number of Europeans, as well as of agricultural assistants, auxiliaries, and of advisers who went from village to village, from house to house, with advice received from the courses in cultivation which they received periodically. In these regions, efforts have been made to transform everything, simultaneously taking into account the factor of this human ecological complex; the forest was divided into strips, some of which were left in their natural state and others systematically cleared. The natives were called upon to carry out certain work. Here I emphasize the phrase which Mr. Gille borrowed from my colleague Mr. Deheyn's report. It was necessary to make use of certain provisions, familiar to all of you, from the decree of 1933 concerning the conscription of the indigenous population, a decree which valiantly took the bull by the horns and proclaimed obligatory work and cultivation of land of an educational nature in the Belgian Congo; i.e., the natives living in ordinary settlements could be compelled by the authorities to carry out cultivation or reafforestation. The provision relating to reafforestation did not date back merely as far as 1933; it was part of cumulative legislation which had originated approximately as far back as the beginning of the war.

You see that the concept of conservation is already becoming apparent; but it is always connected with and adapted to that community spirit which, for the time being, it is useless to attempt to deny. The natives are not individually given the responsibility for carrying out reafforestation; the collectivity is called upon to do so; it is the collectivity which undertakes the responsibility for cultivating a certain product according to a certain type of rotation. For rotation of crops is obligatory in the plan for the indigenous peasant settlement of the Sankuru and of the Turumbu, types of cultivation are compulsory, and methods of planting and harvesting supervised.

Along with this agricultural training, there are, in this region, primary schools to which particular attention is given. Special social and medical welfare also exists.

With regard to educational methods used, I have been present in Africa when films were shown and I was able to see for myself how difficult it is to use this method. The reactions of primitive populations to a picture are generally quite the opposite from those expected by the European who is showing the film.

A certain state of mind must therefore be created; a scientific study must be made of the reactions of primitive man to a picture projected on the screen. If moreover a beginning is made by studying a small region, a certain defined social group, this would make it possible to accomplish gradually the ethnological studies which Mr. Monod has just defined with his usual Cartesian clarity.

Thus, within the social groups which we are attacking from the outside from the ethnological and technical standpoints and now also on the plane of human ecology, it is to be hoped that a new mentality will one day be formed, a mentality that, becoming more ingrained with time—which fortunately is working in our favour—will succeed in creating a peasant spirit in the African native, without which it is impossible to conceive on that continent of the conservation of the most important of natural resources: the soil.

The CHAIRMAN: I would now ask Mr. Beltran, from Mexico, to make some comments.

Mr. BELTRAN:[f] In the matter which is before us there are two aspects which are essentially interesting. One of them is the division which must be made between the education of adults through extension activities and education in the schools themselves which is undertaken for a longer period.

As I have very little time at my disposal, I shall speak very briefly on the work of Drs. Moreno and Fernandez dealing with general ideas on education. It has been said that these general ideas should be applied in certain countries. In my country we did apply some of these ideas. Perhaps we look at these matters from a different point of view, but we do deal with the matter of conservation in school after school. The general education takes place in elementary schools and non-specialized schools; on the other hand, the specialized schools take up the same subjects and introduce them in the preparation of teachers. As regards general education, we have had the basic principles of conservation in our programmes since 1945. It is not considered necessary to overcrowd the studies with problems of conservation, which would bring about results not called for. We endeavour to mention the basic problems which arise in our country. Teachers in elementary and secondary schools must teach these principles. However, the teacher is not prepared for such subjects, and therefore the problem becomes difficult. It is necessary to establish courses in the field of conservation for the teachers. Since 1946 I have been giving such a course at a teachers' college.

At this college we speak about the protection of nature and of other matters. We do not endeavour to create a specialist on the problems of conservation, but rather to give the future teacher a basis on which he will be able

[f]Mr. Beltran spoke in Spanish.

to explain to his pupils the necessary practices of conservation that may be of the greatest importance in rural areas and which will introduce the spirit of conservation in the minds of pupils.

The Ministry has complemented this work by publishing pamphlets on these matters, sometimes in 100,000 copies or in 150,000 copies, which are sold for five cents a copy, and therefore their circulation is very wide. We have already published three such booklets. One is called *Man and Land;* the other two were written by me and are entitled *Natural Resources of Mexico* and *The Problems and Practices of Nature.*

We have intensified the studies of the teachers colleges, and we hope that in the future, perhaps next year, we shall be in a better position to establish special courses for these teachers.

As regards the question of the preparation of specialists, we also have a programme in this field in the National School of Agriculture, where our young agronomists are educated in this field. Often the programmes are old, but they are rearranged slightly in order to bring out new problems and new techniques that arise. With the aid of these schools we hope to be able to have the necessary number of specialists.

The Biological Faculty of the Technological Institute has also introduced a series of subjects which deal with the problems of conservation, but naturally from a slightly different point of view.

We also have programmes which prepare people who will conduct the necessary research in the future. When we speak of conservation we must have a series of basic principles, and for this, research is obviously called for.

I could mention other aspects of the problem, but as my time is limited I shall only say that the most interesting part of this Conference is that it brings into focus our ideas on education and shows what has been done up to now. Mr. Moreno has shown us the contribution of the Cuban schools in dealing with the problem of conservation. But in general, he said, it is the contribution of schools as such, not necessarily the Cuban schools. I am happy to say that our country is also interested in this problem, and we have given our attention to these matters.

The CHAIRMAN: I now call on Mr. Wilson Compton, President, Washington State University.

Mr. COMPTON: I am particularly glad to have an opportunity to participate in a meeting presided over by my friend from Pakistan, and shared in by my colleague, the Director of Extension Work of the United States Department of Agriculture, Dr. Wilson, whom you recognize as one of the most wholesome influences in American agriculture in this generation.

I think that the subject—and I am speaking not so much about the prepared papers that have been given here this afternoon, but more about the problem in general of conservation education—is the single most important topic of this Conference.

I am not a scientist, and I am certainly not a great scientist. I am a great respecter of scientists. I am not a national government officer, nor a university professor. I am merely a university president.

About two weeks ago, the Secretary of the Interior of the United States of America said to us in this room:

"Conservation touches not only the ability of people to live well, it touches their ability to live at all. . . . You are participating in one of the greatest adventures of the human will and mind in this century."

If Secretary Krug is right—and I think he is—it is because of the limitless possibilities of public education inherent in the objectives of this Conference. If these possibilities are converted from talk about conservation into the practice of conservation, it will be far more because of what gradually gets into the minds of men and women throughout the world than of what gets into the statutes of governments under which we live. So it may be appropriate for an educator to comment for a moment on the significance of education in conservation. The eminent Dr. Bronk, on behalf of the National Research Council, said to us:

"Knowledge of men and nature is our greatest resource. But the world will be as men choose to make it."

What are we choosing to make of it now? If we think of our resources as material, what are we doing with them? We have all been saturated during these past few weeks with new information, and it is not my intention to add to the barrage of statistics, but rather to suggest a few interpretations appropriate to the purpose of this session on education.

Of all primary materials produced the world over today, about 70 per cent are used for food and comfort, and about 30 per cent for industry. Products used for food are merely the means of sustaining the existing standards of living, low or high as they may be. Products used for industry are the means, and practically the only means, of gradually improving the existing standards of living. If we have any one single significant yardstick of improvement in living standards, it is in the increasing proportion of goods which are used to "make things", this means "used for industry". If we think of agricultural products as including generally our replaceable materials—our farm and forest and animal products—we have this comparison: Seven-eighths are used for food and one-eighth is used for industry. Similarly, we may regard mineral products as including generally our irreplaceable materials. Practically 100 per cent of these are used for industry or for fuel. We have in different countries and, to a large extent, within the same country, the extremes of production, from practically 100 per cent food with no industrial production to 60 or 70 per cent or, in small areas, over 90 per cent industrial production with relatively small food production. At present, about one-third of the world's industrial production is from agricultural materials and about two-thirds from mineral materials.

We need more industrial production, and in the long run we know that we need proportionately more production from agricultural materials which are renewable and proportionately less from mineral materials which are irreplaceable. Many of you were thrilled last week, as was I, at the recital of Dr. Coady, of Nova Scotia, on the experience of the Antigonish movement under his direction in recent years, and you will recall his statement on resources that man has abused the natural resources upon which he is so dependent, firstly, because of just plain ignorance on the part of the human race, since men did not know how to treat the earth, and, secondly, because the great masses of the people lack interest in the conservation of natural resources. He said that this was due to the fact that they lacked ownership. The good earth, said he, was not theirs, so why should they care?

In this Conference, emphasis is constantly and particularly given to the importance of actions by governments and by legislatures. I do not doubt or question the importance of these; some are indispensable, as in water and river development. Certain it is that in many ways society is able to make more provision for the future than is the individual. The only way for society to act is through governments and legislatures. Governments and legislatures must, of course, provide a climate in public policy encouraging to conservation, or there will be no conservation. But what governments can do for individuals at comparatively large public expense is vastly less than, under favourable circumstances, individuals can do for themselves at comparatively small public expense.

Therein is the great interest of the educator and the great challenge to public education. An achievement in conservation, undertaken because it is required by statute or by regulation of government, may be valuable. It will be doubly valuable if it is done voluntarily, and it will be trebly valuable if it is done as a result of the study and the thinking and the determination of the individual who does it. I believe it was Dr. Lewis, of the FAO, who a few days ago made the statement that:

"The desire of a farmer to make a good living and to leave a better farm to his children is a more forceful incentive than anything that the government itself can give."

At the outset of this Conference, the Secretary-General, Mr. Lie, said to us, "We can make science work for us in peace as it worked for us in war." In the long run, we will do that only if we hold before ourselves as a major objective that millions of men and women and eventually hundreds of millions shall have an active interest in what happens to the lands, the forests and the waters, and that they, and not merely their governments, shall be the conservationists. That, I grant, is a long-range objective, but conservation, if it does not have long-range objectives, is the form without the substance.

We are interested, of course, and greatly interested, in what governments can do to secure the conservation and proper utilization of natural resources. That is a matter of laws, of regulations, of appropriations, of public works. We are more interested, I hope, in what intelligent individuals, with proper information, guidance and encouragement, can do for themselves in their own enlightened self-interest and in the interest of the community of which they are part. That is a matter of education.

As an educator, therefore, in a Conference composed largely of eminent government officers from all over the world, I want to put in a good word for the ordinary man and for the possibilities of eventually making the ordinary man through courageous education the world's greatest conservationist.

Mr. Kellogg: Much emphasis has been laid, during today's meeting, on the failure of man to maintain his resources and to check erosion, deforestation and things like that. One speaker even suggested that in an educational programme we should start with the facts and go on from there to man's waste of his resources. It seems to me that that would not be a very inspiring programme. Actually, men have been highly successful in improving resources to a point far beyond their natural condition and in raising their productivity far above the natural level. It seems to me that to lay the emphasis on the potentialities that men now have would be a great deal more appealing, especially to youth, in an educational programme. We are not seeking some primitive balance of nature at its original level; what we are seeking is a cultural balance between people and resources, and that balance is often far, far above the natural balance, and one in which we should use all the achievements of man's culture, including particularly the facilities of the natural and social sciences.

Mr. J. K. Edwards: I shall not take very long, but shall try to come right to the point. Everyone who has attended these meetings has been tremendously impressed by the vast amount of knowledge which has been put forth, and all those of us who are in any way connected with a programme of getting this knowledge down to the farms are greatly concerned. To talk and exchange ideas is good, but we must have some means to reach the farms, so as a follow-up to the explanation of the extension principle described by Mr. Wilson. I should like to give a few experiences which a small group of Americans have had in Saudi Arabia in the last two years.

We landed in Arabia with pressure on us to show what Americans could do. That was the situation and we did not have much time to educate anybody about what we could do. So we talked with a few of the Arab leaders, particularly the King and the Crown Prince and we told them we were there to do what we could and we asked them for their ideas about how we should approach the problem. These men had probably never heard of what we should call an extension programme, but they told us to show the people something better—we were not to waste time, but to show them how to do something better. One of the leaders suggested that if we could show them how to produce a stronger donkey, or a camel which could go faster and carry a heavier load, we should have made a contribution to the country.

We therefore started with what we had in the way of equipment to show the Arabs what could be done. I want to quote the case of one Arab farmer who saw what we did and got the inspiration that he could do the same thing. In turn, many of his friends and neighbors came to the conclusion that they could do what he did. To cut the story short this man saw what we could do with tractors, improved seeds, a little fertilizer used in check strips and the efficient use of water, and he started to do likewise on an undeveloped piece of ground. He dug a well, put a small pump on it, got some seeds and fertilizer for demonstration purposes, and this year raised his first crop on about three acres. He now has wheat enough to feed himself and some over to sell, he has alfalfa to feed his animals and also some to sell, and he has grown vegetables and melons which are a revelation to his neighbours.

Mr. Wilson was very careful to trace the development of extension in America and I think our brief experience in Saudi Arabia, 10,000 miles away, is a good augury that the same principle will work anywhere where there are human beings. Any human being who can see, taste and hear is the basis for an extension programme. We could not speak Arabic, there are very few radios or newspapers in Arabia, so how were we to start in conditions like that? However, the King told us to show the people, and that is what we tried to do; simple as it is, that is the best way to make progress—show them something better.

Mr. STEIDLE: I wish to report four projects on conservation in the Commonwealth of Pennsylvania. First is the "Conservation Workshop" held during the Summer Session for the last four years. 267 public school teachers, selected geographically, part expenses paid, have attended the classes, and are now passing on the teachings to others in their home schools.

During the past two summers the Pennsylvania Sportsmen's Association, an autonomous organization, sent 207 selected boys of high school age to a summer camp at the College for specific elementary instruction in conservation. These boys return home prepared to teach other boys in youth movements, and write essays in local and school papers.

Mr. Wilson mentioned the agricultural extension services. The Pennsylvania State College also offers mineral industries extension services, not through county agents, but through as many as 200 class centers in 39 counties. These classes are attended by about 4,000 workers in the mineral industries each year since 1893. Conservation is a principal objective.

I give an orientation lecture course to all new students in the School of Mineral Industries. Two years ago I prepared a land utilization map of the Commonwealth now published in seven colors. The map, irrespective of counties, shows the known sources of primary wealth—plants, animals and minerals—fundamental products of Mother Earth, far removed from the printing press. The map has been circulated among a majority of the Service Clubs and high schools of the Commonwealth.

When I prepared the map, I did not have in mind all of the ways in which it would be used. However, the Department of Public Instruction in Pennsylvania is placing a copy of this map in each of the high schools of the Commonwealth, so that the young people may have the chance to see the state divided into sections and to see what each section produces in the way of primary wealth. There may be wool and coal and oil in one section, there may be tobacco in another. At a glance, the student in the high school will be able to learn just a little bit more about his great state and the primary wealth that comes from each section. In that way, he learns that the source of primary wealth is far removed from the printing press.

Mr. CLAY: In the four papers that we have had from British colonies—and certainly in the three from Africa—one point is stressed in connexion with education for conservation: that we must educate the native authorities, who are very important people. As a background for those papers, I thought that I might explain the significance of those people.

As the Conference probably knows, our development of the colonies has rested on what we call a system of indirect rule—that is, when we have taken over the trusteeship or protection of these territories, we have, so far as possible, used existing and established native authorities as the basis of our administration. I think initially that probably was done largely for reasons of economy. In any event, those established native authorities are a vital part of our organization of the administration of these territories. They are concerned with the administration of law and, in that connexion, they have the right to enact legislation so long as it conforms with our sense of justice. They are important people. In most cases, they are elderly, as would be expected in view of their knowledge of native customs and their native law, and therefore are conservative. But certainly, in the matter of soil conservation education, they have an important part to play.

Alongside that chain of native authorities, we have set up in most colonies a parallel organization of British administrators, in many cases also linked with native administration, from the Governor down to what we call the district officer, running through the provincial level. Associated with that administrative chain are technical officers of the various departments concerned with conservation and utilization of resources, forming teams at the various levels. At the headquarters, we have the organization of the heads of departments—agriculture, mining, forestry and so forth. At the provincial level, we have the provincial commissioner and his team of technical well-trained officers. Below that, we have the district officer, the man in intimate touch with the native authorities—and in many cases he acts alone, without technical assistance.

We have recently been considering what we term mass education or community betterment—the latter is probably the better term—and the place of this organization and the native authorities in achieving mass education. We have come to this conclusion: that the education of the native authorities is not a matter for the activities of one special department; it is a function of all departments, integrated into one team. It is the function of the provincial team, headed by an administrator and with its team of professional officers, to formulate local policy in conservation and utilization, particularly of land resources, and to apply their plan by propaganda and get the educated native authorities fully conversant with what they regard as a sound policy of land use within the areas covered.

I have touched briefly on that because we regard it as fundamental that in any work we do in the conservation of resources, we must by all means educate the leaders of the people, these native authorities, and carry them with us in any of that basic work.

I should now like to touch on the question of the normal educational system which has been developed in the colonies. It consists of the primary school—that is, the village school—the secondary school, and the colleges or even universities which are now being established on a regional basis throughout the British colonies. I have always felt that in addition to the adult education in conservation and in general development, it is most valuable to instill in the child, by demonstration and example and by talking to him, pictures of what could be achieved within his own village. I have always felt that in our attempts to define an educational syllabus for the village schools, we have in many cases been so desirous of cramming into that syllabus all the known subjects which normally fill a curriculum, that we have left no room for a subject which I regard as essential: we have not left time for one or two hours a week, particularly in the senior classes, for a subject such as civics or better living. When I went to Northern Rhodesia some years ago, I was interested to find that in that colony they have, as part of their teacher-training, a definite place for civics as an essential part of the primary education system. In the one or two hours a week that are devoted to it, talks are given on the organization of the administration of the particular area, on the administration of justice, on soil conservation, on better breeding of livestock, and so forth. Those talks are implemented—and I regard this as essential in primary education—by pictures on the wall which stimulate an interest in the child for a better way of life and for a wider horizon than has circumscribed his own little village. If that line is followed, I think that can be one of the most valuable fields for the development of a soil conservation programme and a general conservation programme in connexion with natural resources.

I also think that the value of the school gardens, which has been preached many times, lies not so much, as has been brought out in Mr. Herington's paper, in the possibility of teaching agriculture to the small child—that is quite impossible under the circumstances—as in the chance to give him a love of beauty, a knowledge of the birth, growth and death of plants, and a familiarity with what can be done by sound measures. It is as easy to teach him the use of manure with a pretty flowering plant as with a cotton plant.

Those are some small points in connexion with the elementary school system. I should now like to refer to the value of what we call adult education. We are developing adult education and we are bringing into use such aids as the cinema, the wireless, the Bureau of Publications. We are also developing mass literacy in order to spread the ability to read: by means of the published word, propaganda and education can be spread in regard to such essential matters as conservation.

I simply wished to outline those three essential avenues of education: 1. The authorities concerned with the local government of the people; 2. The educational system which enables one to get at the child through the establishment of some section called civics or better living in the educational curriculum; 3. The attack on the adult population by means of mass education.

I should like to finish by referring to the training of the essential agents in adult education. We have a feeling in many of our colonies that, in many cases, we have been too elaborate in our attempts to get down to the adult cultivator in the villages by having far too many projections from technical departments right down to the village level. We have led to confusion, I believe, by trying to get each department into a separate watertight compartment, right down to the village.

We have now come to the conclusion that there is an essential trio in dealing with villages in primitive communities, a trio which is essential for the joint education of those people to a higher standard of life. That trio, we think, consists of the medical man (that is, the village dispenser—don't call him a medical officer); the village schoolmaster; and one good village farmer, if you like to call him that, who can be the extension medium for the joint land use departments—veterinary, agriculture, forestry and, where necessary, the water irrigation department. If we can limit it to those three, we feel we have a spearhead of attack on the general improvement of village life which is far better than a multiplicity of agents all bombarding the villager with a multiplicity of advice, leaving him wondering what to do next.

For that reason we have conceived again that in the training of schoolmasters, agricultural workers and, preferably, medical workers also, these three essential agents in rural bonification should be trained jointly at joint training centres. We do not believe that a village schoolmaster, when he goes out, should be purely a schoolmaster. We believe that he should have a background for his contacts with the adult parents which should include a wider appreciation of general policy in rural bonification, including soil conservation. We believe also that the dispenser should, similarly, have that background, and we believe that the three of them, jointly trained together and jointly established together in a rural community are in a far better position to withstand all the conservatism of the old people of the tribe working as a team than as isolated products of our educational system. Therefore, we attach great importance to this joint training and the establishment in teams of a minimum of three of persons in rural areas.

The CHAIRMAN: We have had many excellent speeches and a great deal of material and food for thought. Each country will have to evolve its own methods for the salvation of the territory concerned, but the fundamentals which can be applied to all countries are the same. It is the method of approach which has to be different, according to the traditions of the people.

In our rural areas in Pakistan, where literacy is neither extensive nor of a high order, the method of approach which has paid so far is one of example. We have a system of holding festivals on various occasions, and we hold them near some centres where we have something concrete to show the people. We carry out models from research institutions, we prepare others on the site, and we have a farm in which we have tried a system which has been successful. There it is that we hold the festival. People love festivals. At the word "festival" they flock up and we take advantage of the situation to take them around and show them what concrete achievements we have made. It is the immediate profit chances which appeal to such farmers, and not any long-term policy.

Another difficulty we find is that the student from the rural area in the primary classes has no objective. If his means do not permit him to go ahead beyond the primary stage, he leaves the school and comes back to the land, but if he can carry on he starts thinking and his first aim is to get some kind of government job which carries some dignity or glamour with it. Therefore, any attempt to teach him something of value is really lost. He is all the time thinking how he can best get into government service. Under these conditions, therefore, the fight for literacy is really difficult, and the only way we have found is by example.

I may quote another example. We constructed the Sutleg Valley project—a big canal project in the Bahawalpur State, which is a unit of West Pakistan. The local residents used to carry in their wheat grain and then sit idle for about two months because they had the grain available. After that came the date palm and mango season, with cheap materials for food available, and they would not move out. Thus the valuable summer was lost in just growing ordinary low-grade millets. They would not grow cotton, and they would not grow rice. We were at our wits end to know what to do, and then we imported good farmers from Punjab and sold them government lands in small parcels, scattering them well over the whole of the State. In about two years the whole aspect had changed. The State residents found the Punjabi farmer growing wheat in a better form and getting more money out of it, growing good cotton and rice, and being in every way more fourishing. In two or three years the old residents completely changed their habits and followed in the tracks of their betters. It is in this way that we can get better results by approaching the illiterate people in the rural areas in our country.

Problems also exist in developed areas, but in the under-developed countries the question of training a large number of workers arises. Mr. Wilson has mentioned the figure of 12,000 workers, but it is difficult in such under-developed areas to obtain even 1,200. Yet all these problems have to be tackled if conservation is to have any real significance, and although in almost every country a start might have been made, good progress has yet to be obtained.

The background papers which were prepared for this meeting follow:

Education and the Conservation of Natural Resources in French Black Africa

TH. MONOD

I. THE PROBLEM

In the face of the ever faster process of evolution that tends to impose on all Africa a civilization of material progress, the "benefits" of which are too often doubtful, it is right that human conscience should awaken to a number of questions which are of a serious character inasmuch as they involve the whole future of a continent and of the beings that inhabit it, who are not mere taxpayers, ciphers, voters or figures in labour statistics, but men.

Though it is right and necessary to think of the material aspect of human problems, we must sometimes put that aspect out of our minds and consider the no less essential non-material aspect.

The words "natural resources" will not therefore be taken here in their purely utilitarian sense, as if they were sufficient to express a reality that is infinitely richer and more beautiful. Even without going so far as to consider Africa only in terms of exploitation, profits, earning power or dividends, thus running the risk of losing sight of the only important factor, eternal man in his local melanic aspect, we must remember that he is placed in a natural environment of which he forms part and towards which he in his turn has high responsibilities.

In short, if man is what he claims to be, something more than a digestive tube, he should be ready to recognize that if nature has her "resources" she has also her beauties, a no less precious heritage.

II. THE FACTS

Man, in Africa, whether he be black, copper-coloured or white, has never considered nature, either living or inanimate, as anything more than a profitable booty; it is a *Raubwirtschaft*, an economy of plunder, with the motto: As much immediate profit as possible. The future? What do we care? After us the deluge or the desert, but what does it matter? Our successors will just have to fend for themselves as we did.

Such is the general state of mind, and it will have to change if the conferences for the conservation of natural resources are to be anything better than insignificant and platonic confabulations.

So long as man remained one of the elements of the biocoenosis, in a state of equilibrium with his environment, he was able to do little damage. But the tool and the domestic animal were to increase his destructive power considerably, without enabling him to anticipate the ravages that modern mechanical progress was to render possible and therefore tempting to him.

We know the outcome, and it may be summed up in the title of a recent book: "Africa, a Dying Land".

Ill-advised clearing that exposes the soil to irremediable deterioration, deforestation, rapid exhaustion of the land through cultivation without fertilizers, the massacre of large animals, on the most varied pretexts and often from pure wantonness, the use of fishing appliances capable of causing local depletion of waters or at least irrational exploitation of stocks and so on. There are various forms of exploitation of natural wealth, now criminally imprudent, which might well lead to catastrophes not only of an economic and material order but also—and these cannot be less serious—of a human order. Thus the development of an agricultural or industrial enterprise on European lines (plantations, mines, factories) involves the most serious consequences for man (detribalization, demoralization, proletarization) which are a matter of concern, and rightly so, to all who are responsible for the future of the Africans.

III. THE REMEDIES

Africa, a continent in so many respects treated as a poor relation, rich in tropical diseases but poor in men, in fertile soil, often in water or in food, looks to the fraternal intelligence of the nations—since she herself has for the moment no voice in the matter—for the verdict that will either condemn her to the ferocity of an exclusively profit-seeking exploitation or guide her towards the adjustments necessary for the full development of the African man in every domain—including, naturally, that of the mind.

What must be done, what can be done, to heal the wounds already inflicted and to prevent the profitable pillage of Africa from continuing and increasing, as many would wish?

In the particular problem with which this paper is concerned, and the solution of which is largely of a psychological nature, *action* must be taken no doubt but, as a prerequisite of any effective action, first it is necessary to *convince.*

(A) TO CONVINCE

1. *Whom?*

The answer to this first question is of course everybody, implying some discrimination in the existing situation of Black Africa, where the administrative authority is in the hands of the European. The opposition of the terms "élite" and "masses" would not be enough; there are uneducated and narrow-minded Whites who do not belong to the masses, just as there are among the latter, unnoticeable and mostly unnoticed by the passer-by, some noble personalities. We shall therefore keep to the White-Black notion.

(a) *The European:* It is all the more important to exert an influence on the European since he alone can take the necessary decisions in administrative, legislative and other fields. Unfortunately it must be admitted that questions of this type, for instance the protection of nature, are generally either ignored by him or held to be of little account. The urgency of the danger, the senseless or criminal behaviour of man, even civilized man, towards nature and the living being, the heavy responsibilities of a generation that is accountable to posterity for the treasures entrusted to it, the necessity, at last obvious, to think of the future of this planet on a large enough scale—all this appears singularly futile to the great majority of white men in Africa. Why so many vain preoccupations? Are things not very well as they are, and have they not always been the same? We must therefore teach and explain—in fact, convert. Nothing less than that will do and it is worth attempting when the future of a continent is at stake.

(b) *The African:* Though doubtless less guilty, since he still sins only through ignorance, he must also open his eyes, learn, understand, renounce certain destructive practices, husband the riches of his soil and think of posterity; he must feel his community of interest not only with his fellow tribesmen but with all his brothers in colour, in space as well as in time. There also, a slow and difficult but indispensable work of education is called for, with the tremendous handicap that attaches to the changing of a mental attitude in a population mostly illiterate.

2. *How?*

In endeavoring to bring the African man, whether he be white or black, to a better conception of his relations with nature, what means will be used? What can be attempted? There must be no innovation for its own sake, but when ordinary methods are used, they must be intelligently adapted to local conditions.

(a) *Schools:* They are the very foundation of the edifice to be built, and will henceforward educate men to be aware of the seriousness of the problem. This implies that the schools will be able effectively to influence the children, and that the teachers will themselves possess an adequate education. But no place has yet been given in school curricula to the protection of nature: they make no provision for courageous and ceaseless action to promote respect for life in all its forms, and to prevent cruelty to animals, brutal games, certain methods of slaughter, unnecessary destruction of animals or plants and so on. And how could the educators think of stressing problems with which they are still only too often unacquainted? In this continent, cruelty to animals is general, but it is innocent, instinctive and ancestral, as it still is with many Europeans. When will Pity raise her smiling face over Africa? Not, at any rate, until the school, taking its responsibility in this respect seriously, contributes its large, its irreplaceable share to a labour which can only bear fruit in the distant future if it assumes today the character of a crusade. But this labour must also be deliberate, well-directed, encouraged and, where necessary, where stupidity and selfishness would hinder its progress, imposed.

Why should not every African school have its trees, its flowers, its little "national park", its festivals in honour of trees, seed-time, flower-time, birds and the soil?

(b) *Printed matter:* Even if well-directed, schools today would find difficulty in taking effective action, owing to the almost complete absence of adequate literature, textbooks, readers, pamphlets, tracts, posters, and the indispensable material for any propaganda effort, whatever it may be. Not that the educational value of the printed word—especially in Africa where very few can read—should be over-estimated, but printed matter is still indispensable to the teacher, for it provides him with the very substance of his instruction, lesson programmes, practical examples, advice on adaptation of the subject to local conditions etc.

Propaganda methods and the use of slogans are not to be rejected *per se* but only for the absurd or vile use to which they are put by some. There would be no harm in having the walls of African schools covered with intelligent watchwords that would be disseminated, in their turn, by postmarks and official prints.

(c) *Broadcasting:* By this means, oral school teaching may be extended. There are for the moment very few listeners in Africa, but their number will increase and it is certain that stations will always be willing to broadcast news reports, talks and appeals provided they are given the text. Here again, the problem will arise of preparing the documentary material and keeping it up to date.

(d) *Films:* This medium presents a problem akin to that of broadcasting, but with these differences, (1) that the cinema in Africa reaches many more Africans than the radio and (2) that preparation of the document is much more costly. The question of the cinema in Africa is at last beginning to be studied by all those who know what a mass of nonsense, moral or material ugliness and coarseness, is represented by European films, as viewed in the tropics, as well as the magnificent part that could be played by so effective a means of education. There can be no doubt that in the future, besides educational films dealing with health, domestic economy, agriculture etc., films on other subjects will come to the support of the converging efforts being made to remove the threat to nature.

The educational film must not become simply an extra incitement to the African to absorb the influences of the ordinary cinema, which are, to say the least, mixed, but should have special distribution, especially as it will have to be mobile in order to reach the villages and peasants.

(e) *Cultural institutions:* These include not only those institutions which have a specific purpose (such as museums, societies, clubs, educational, scientific or artistic associations) but also all those which, in addition to other activities, contribute in some measure to the protection of nature, such as many youth movements (scouts, youth hostels etc.) and political and religious groups. There again, the educational work will amount to pioneering, and even where goodwill exists it will need to be strongly backed by specialized information, raising once again the question of a continental or regional organization to supply documents and advice to schools, radio, associations etc., and to co-ordinate at the top level all the activities planned for a given territory.

Local scientific institutions (geological and agricultural services, natural history museums etc.) would obviously give such an organization the most sympathetic welcome and all the assistance required to give its work the desired character of scientific precision.

(B) ACTION

Let us suppose that public opinion has been won to our cause and that the country's authorities are disposed to give living reality to the principles that have at last been accepted; let us suppose that the formulaes expressing our ideals have become axiomatic and have replaced scurrilous news items and erotic obsessions in the Press and on the screen. What official steps will be taken? What will the new policy be?

It may be summed up in the following five propositions, and I ask that the *adjectives* should be noted, for they have not been chosen at random.

1. *Effective* protection of nature

For the moment, without the backing of a public opinion that ignores a problem which appears to be of little account because superficially it affects neither the table nor the pocket-book, the protection of nature or, what to my mind amounts to exactly the same thing, the conservation of natural resources, has to be reduced to: (*a*) the action of a few isolated individuals, which goes unheeded—*voces in deserto*—and (*b*) the promulgation of a few administrative texts, perfect in substance but sometimes, it is said, not strictly enough applied, so that they become inoperative. When everyone, governors and governed alike, understands, as they will sooner or later, a legislation both precise and effective can be elaborated, which will draw the logical conclusions from the established principles and ensure their application. It will provide for the total or partial protection of certain animal or vegetable species (and consequently for the control of shooting and fishing) and of whole biotopes (forests, for instance), for the creation of national parks and nature reservations, for the defence of the soil against erosion etc.

Africa is vast enough to allow a place to the animal without in any way jeopardizing the material interests of human beings, to reserve vast areas where, safe from fire, guns and motor-cars, the fauna, and especially the large mammals, can find once more the conditions of a normal existence in a spontaneous biological equilibrium far removed from the causes of disturbance inevitably brought by human activity.

There is no need to stress, not only the scientific value of such measures, which is often immense, but also their practical importance in various fields (soil, local climate, hydrology, conservation of useful species etc.).

2. *Reasonable* exploitation of natural wealth

The time has passed when man could consider nature, especially tropical nature, as an inexhaustible reservoir from which he could draw without stint. Henceforward, he will have to be more prudent and think of the future. Whether in matters of forest exploitation, picking wild produce, fishing or shooting, it has become necessary to adjust consumption to the stock available and its capacity for reconstitution. Attention should also be paid to the tremendous increase in destructive power represented by the machine in Africa and to the obvious perils of certain spectacular clearance operations which posterity may well have cause to regret. It is a strong temptation for the sorcerer's apprentice to abuse his power; but let him beware of the consequences . . .

3. *Organized* scientific research

As the beneficiaries of Africa that we are, and still more as the wise beneficiaries that we should be, it is our first duty to familiarize ourselves with the natural resources of Black Africa both as they are now and as they are likely to develop in future. At every step, serious and urgent problems arise, which we cannot answer with any accuracy and whose solution has so far been left to the hazards of willingness and incompetence. For instance, in one region, what area may safely be cleared of forests? In another, should fishing nets be allowed with a mesh as small as 3 mm.? Elsewhere, should bulldozers and mechanical ploughs be let loose without restriction on the wooded savannah? Should such and such an animal which is harmful or presumed to be harmful be destroyed? How should this parasitic fungus be fought, or that migratory acridian be kept off? How should these woods be protected against termites or terredos, or that canal be prevented from silting up? How can a race of cattle with this or that quality be obtained?

Happy-go-lucky solutions, the mere use of common sense, day-to-day empiricism, are no longer sufficient. Scientific research now has a voice in the matter, and the fact is coming to be recognized. Institutions such as the *Institut Français d'Afrique Noire* (1938),[2] the Intercolonial Research Institute,[3] the Institute of Central African Studies[4], an International Conference of West Africanist[5] etc. are an encouraging sign in this respect. What would have seemed Utopia only twenty years ago is gradually becoming a reality: the usefulness of the technician is at last acknowledged, and he is setting to work with resources which are still modest but which are being improved every day; tomorrow he will be consulted and obeyed.

It is, however, important, in order that his labours may bear fruit:

[2]Dakar, Saint-Louis, Conakry, Bamako, Diafarabé, Niamey, Abidjan, Mount Nimba, Abomey, Cotonou, Lomé, Douala.

[3]Adiopodoumé.

[4]Brazzaville.

[5]Dakar (1945), Bissao (1947), Ibadan (1949).

1. That there should be effective co-ordination between all the services and organizations concerned, in order to avoid the ever-recurring dangers of duplication of work and useless innovations where it would be more sensible and economic first to strengthen what already exists;

2. That there should be active international collaboration to palliate as far as possible the vagaries and absurdities of the political frontiers, which are of course completely ignored by climates and living beings.

4. An *intelligent* system of education

This, in my opinion, does not mean simply and lazily copying some system born under other skies in a radically different mental and historical environment.

If the cause of the protection and conservation of Africa's natural riches, much of which have already been squandered, is ultimately to triumph, it will owe its victory largely to the action of the teaching profession, provided that its members show themselves capable of true leadership .

Intelligent education means a system that will ceaselessly stress the African context, that will put the progress and the good of Africa first and, far from artificially detaching the child from the environment in which he is to spend his life, will try to teach him respect and love for it, and to rid him of the false feeling of shame that was too often instilled into him in the days when "nakedness" and "savagery" were seriously regarded as synonymous.

5. *Enlightened* cultural activity

Here again, if the African is to play a useful part in a movement that so closely affects the future of his country and of his race, his attention must be systematically drawn towards this inheritance which has to be defended, towards its riches and its beauties. The "natural resources" aspect is, moreover, only one side of a larger problem, which embraces the products of human activity, both material (archaeology and the figurative arts) and non-material (oral poetry, music and dancing). The social and educational role of the museum should not be overlooked and it is regrettable that in French Black Africa[6] the question has not yet been given all the importance it undoubtedly deserves.

IV. CONCLUSION

In face of the twofold threat to Africa constituted by certain traditional methods and certain effects of modern mechanical progress, a policy must be first defined and then applied.

It is impossible to exaggerate the responsibility that rests today on those who, with the administration of the various territories of Black Africa, have the whole future of the continent in their hands. Until now, there have been too many temporary expedients, improvisations and groping efforts, with material success as the only criterion of achievement. The time has come to look towards wider horizons and to see farther afield, to look ahead in order to see clearly, constantly bearing in mind *even the distant future* and the geological amplitude of the problem.

Such is the perspective in which the present debate must be seen.

I would add two further remarks which I think are essential.

Firstly, inasmuch as the *conservation* of natural resources aims at their exploitation, we must never lose sight of the African human factor. Behind production and the dividends it may bring there are always the man and his work. Though rarely mentioned in reports, plans or statistics, they are both very real, very concrete.

Secondly, we must have no illusions as to the quasi-miraculous or magical efficacy of administrative texts. Nothing is easier than to draw up a law, a decree or an order: it is far less easy to have it applied when the protection of nature is involved, for it can be enforced only in so far as it is accepted by the popular mentality of the moment. In a favourable psychological atmosphere, everything is easy, and it is therefore towards such a change of the state of mind that we must work.

There is as yet no organization officially entrusted with this indispensable task in Black Africa. If the question is to be taken seriously, this specific activity will have to be developed fully. Sooner or later services will be created even in Africa for the conservation of natural resources,[7] working in close collaboration with all the organizations concerned (agriculture, forests, teaching, broadcasting, scientific institutes etc.), with the four following objectives:

1. To collect the necessary documentation and keep it up to date;

2. To ensure its dissemination;

3. To promote co-ordinated research by specialists;

4. To provide technical advice to public authorities and see that the proposed measures are applied.

Such a project may, even today, seem surprising to many people: but some day people will be astonished that it was not until the middle of the twentieth century that problems of such obvious importance were at last recognized as such and considered without derision or scepticism.

[6]Where there are still only the four museums Dakar (*Institut d'Afrique*), *Abidjan* (*id.*), Abomey (*id.*), and Foumban (*id.*).

[7]Or "natural wealth", which would cover problems that might be neglected by action identifying the *useful* with the *material*.

Contribution of Cuban Schools to the Conservation of Natural Resources[1]

ABELARDO MORENO
RAMONA FERNANDEZ

ABSTRACT

The burden of this paper is that the conservation of natural resources is a problem that requires the co-operation of all and that education cannot evade its great responsibility in this matter. Therefore, our aim should be to put conservation education on a footing of equality with the great and permanent objectives of universal education and to add to the attainment of these objectives a new value, namely *biological thought*, which consists in developing a new attitude or process of collective thought in the individual.

We can describe the purposes of the school in this field more clearly by stating the following four objectives:

1. To bring about an understanding of the oecological process of nature and life;
2. To make the student feel that he is an integral part of his environment and to make him consider it as his own to be loved and protected;
3. To apply biological thought to the problems and situations in the life of the student;
4. To form habits of oecological hygiene so that the student will automatically tend to preserve the oecological cycle.

We believe that the content of this subject in elementary, secondary and vocational schools should combine the following characteristics:

1. It should be very concrete;
2. It should include activities that are intended to explain and give a grasp of the basic ideas of the biological cycle and activities that refer to the contribution which the student can make to the conservation of natural resources;
3. It should constitute a *general educational principle* which should permeate the entire work of the school and influence all subjects, particularly those related directly to these matters;
4. It should be essentially objective and practical.

The work of the school should be supplemented by ample and effective support from official and private sources.

It is imperative to begin at once, for the destructive work of man has reached alarming proportions. Fire, forest thinning, hunting and fishing, which take place even during the periods when they are forbidden, the complete ignorance of the rural populations and the indifference of the authorities, are impoverishing our natural resources at a rapid rate. We repeat that co-ordinated action—educational, official and private—is urgent.

Let us not permit ignorance, selfishness or indifference to retard this progress that is of such vital importance, for this would mean the irreparable loss of many years.

I. INTRODUCTION

We shall not introduce this paper by explaining the importance of natural resources or the importance of education in any large collective enterprise, for the importance of education is self-evident to all democratic peoples and the importance of conserving natural resources needs no explaining in a conference called into being on account of this very fact and the urgent need to publicize it.

We propose to show how the force of education may be combined in the schools of our country with the need for conservation.

Cuba is a small island with an area of approximately 111,000 square kilometres and has a moderate tropical climate throughout the year. The land is mostly flat; there is an abundance of water; and the soil is naturally fertile.

The island has approximately 8,325,000 hectares of cultivable land and a population of some 5,000,000 inhabitants. Except in areas where there is heavy clay and a slightly undulating terrain or where there are hills or very steep slopes, there is no serious erosion problem in Cuba. For this reason the damage resulting from these natural causes is small and not very dangerous.

On the other hand, the destructive action of man has reached alarming proportions; fire, forest thinning, the complete ignorance of the rural population and the indifference of the authorities are impoverishing the soil at a rapid rate. Not one single industry or enterprise or official or private activity has given thought to the conservation of natural resources.

The problem in Cuba is not an immediate one, but it is rapidly and surely becoming serious. The problem is aggravated by this fact and by the additional fact that conservation of natural resources is a slow and biological process that has its own natural cycle of evolution, for

[1]Original text: Spanish.

in an emergency the same solution cannot be applied here that is applied to shortages of goods, equipment and the like. The biological cycle cannot be hurried in the same manner as the manufacture of shoes or the construction of warplanes. We must begin now, and we must not let ignorance, selfishness or indifference retard this progress that is of such vital importance, because this would mean the irreparable loss of many years.

This is a problem that requires the understanding and co-operation of everyone and, since it is a common task, education must deal with it. We therefore believe that education must henceforth play a continuing and effective role.

If we examine briefly the evolution of human culture, we shall find that it has alternated between periods of concrete, specialized and analytical knowledge and great comprehensive and basic synthesis. There was once in Greece an epoch of golden, cultural splendour when philosophy represented an abstract of all knowledge—not placing its branches in juxtaposition but as a force unifying the various currents of the human mind. Humanism, with its "naturist" tendencies, followed a similar course. Every period of synthesis has been followed by a period of analysis and specialization. Today, after busying ourselves for many years with analytical detail, we are on the threshold of another great cultural synthesis. Oecology, representing the union of nature and man, seems to be cast for a leading role in this synthesis.

Consequently, in an educational scheme for the near future there is no room for any plan for training specialists. On the contrary, our aim should rather be to align education on the conservation of natural resources with the great and permanent objectives of education in general and to take our stand beside the conquests which the great cultural movements for synthesis have bequeathed: truthful thought, quantitative thought, social thought and aesthetic thought. We shall now add *biological or vital thought.*

The purpose of this education is to develop a new kind of collective thought, a new category or value. May this new mode of thought become part of our daily reflection of the premises of our standards of conduct, of our emotive life. We have given the name biological or vital thought to this new attitude which moulds thought. To acquire this method of thought will require years of combined and continuous effort, yet it is only in this manner that the stability and wealth of the nation can be assured, and of all the countries that are penetrated by a consciousness of this purpose.

II. BRIEF DESCRIPTION OF THE CUBAN SCHOOL SYSTEM

The Cuban school system was established with the ultimate aim of consolidating the work of nation-building to which impetus was given by the wars of independence. The culmination of this work is the education of the citizen, and this task is the purpose of the slow and continuous efforts of the school. Our schools thus came into being as the result of a desire for liberty, and they are based on the principle that all Cubans are entitled to receive an education that will bring them as close as possible to the permanent values and the ideals of our nation. It is the duty of the nation to provide this education in accordance with its possibilities and in accordance with the latest progress in education.

From the very beginning the Cuban school system regarded faith in the perfectibility of man as a fundamental principle of education; it is therefore a school in the democratic tradition.

The system has four principal divisions: elementary school, secondary school, vocational schools and university.

Its general characteristics are political and religious freedom, centralization and compulsory attendance.

Elementary, secondary and vocational education is free, and in the university 40 per cent of the tuition is paid.

The various divisions may be further subdivided as follows:

Elementary School	Kindergarten and pre-primary school Elementary primary school Advanced primary school
Secondary Schools	Institutes of secondary education
Vocational Schools	Teacher training schools Home schools Training schools for kindergarten teachers National school of journalism Industrial technical schools Polytechnical schools Schools of arts and trades Schools of plastic arts National school of fine arts School farms Forestry schools
University	(thirteen faculties)

It is the endeavour of the Cuban elementary schools to train the useful and patriotic citizens whom Cuba needs, that is, to develop fully an integrated personality in the citizen so that he may make certain the triumph of democracy.

This is done by developing, in addition to other things, the types of thought referred to in this paper: truthful thought (developed through use of the scientific method), quantitative thought (a result of the economic age in which we live), social thought (which attempts to inculcate civic responsibility and train the individual in the human relations proper to a rich, sincere and varied social life), and aesthetic thought (which attempts to cultivate sensibilities in order fully to develop the human personality).

The secondary school continues and improves what the elementary school has done and also develops a broader point of view. It also attempts to give vocational assistance and guidance.

The vocational schools try to offer the best specific preparation in certain kinds of work.

Finally, the university provides specialized study for the liberal professions.

This entire organization, which at the present time does not concern itself with problems of conserving natural resources, must add to the accomplishments just mentioned still another accomplishment, namely biological thought, and it must implant education on conservation as an attitude or manner of collective thinking that is deeply rooted in the individual.

III. PROPOSED CONTRIBUTIONS OF THE CUBAN SCHOOLS TO EDUCATION ON CONSERVATION

A. DEVELOPMENT OF BIOLOGICAL OR VITAL THOUGHT

In the elementary primary school it is not possible to give complete information or abstract explanations, but even as quantitative thought, which by nature is more abstract and difficult than biological thought, is acquired in school by means of a series of teaching devices, it is likewise possible to hope for the development of biological thought in the elementary school.

In the secondary and vocational schools, the basic problems will be dealt with more intensely and they will be developed more fully and deeply.

We believe that the aims are the same irrespective of the school and that only the method of attaining these aims varies, according to the manner in which the subjects are organized at the various grades of instruction.

B. OBJECTIVES

A statement of the following four objectives will enable us to give a clearer idea of the purposes of the school in this field:

1. To bring about an understanding of the oecological process of nature and life;
2. To make the student feel that he is an integral part of his environment and to make him consider it as his own to be loved and protected;
3. To apply biological thought to the problems and situations in the life of the student;
4. To form habits of oecological hygiene so that the student will automatically tend to preserve the oecological cycle.

C. EDUCATIONAL CONTENT AND ORIENTATION IN THE ELEMENTARY AND SECONDARY SCHOOLS

We do not believe that this is the time to decide on the content of the various school courses, but we do believe that certain general indications on their choice and direction should be given.

1. We believe that these courses should be very concrete and real and always adapted to the community of which they treat with respect to examples, calculations, problems and the like.
2. They should include two principal kinds of information and activities. Those intended to explain and give a grasp of the basic ideas of the oecological cycle and those that show the student the contribution he can make to the conservation of natural resources. Let us not fall into the error that was made in including citizenship in the primary school. The course in citizenship was for the future and not the present citizen.

Education in conservation in both the elementary and secondary schools should emphasize the contribution that the student can make in order that it may constitute a substantive rule of conduct, a principle for the present life of the pupil.

3. We are inclined to consider this subject of conservation as a *general educational principle* that should permeate the entire work of the school and influence all subjects, particularly nature studies, agriculture and geography in the elementary school, and agriculture, biology, natural history and geography in the secondary school.

This subject should be made to fit in the organization of studies in the Cuban elementary and secondary schools.

In the vocational schools matters are different. Technical and industrial schools, forestry schools and others that are more directly concerned with conservation questions should, in addition to the general training which they provide, also give specific courses on conservation to impart special knowledge and techniques according to the nature of the particular vocational school. This training, added to the general preparation of the primary school, would supplement the education of the active and productive elements in these fields. The training in those vocation schools that are less directly concerned with conservation problems would be similar to that given in the secondary schools, because its purpose would be the same, namely, to develop general habits and attitudes among the inhabitants that would enable them to understand, accept and follow the directions of the other group.

4. Encouragement should be given to extra-scholastic activities, directed training, visual and experimental processes and, above all, a constant application to real problems of interest to children and young persons. Thus prepared, the student enters the university, imbued with this new attitude or mode of thinking. In faculties such as education, science, philosophy and literature, which also serve to train teachers for the secondary and vocational schools, a selective programme should be drawn up to provide advanced training in the principles of this subject.

A professor thus trained is able to create in the student a new understanding of the matter, a new way of seeing and living in the biological cycle which is due to him as an integral part of his environment, and thus he may feel that it is his own to be loved and protected.

IV. SUPPLEMENTARY WORK AND OFFICIAL SUPPORT

The work of the school will be of little value if other agencies fail to make of conservation problems a reality in the life of the community and if the authorities fail to give all the assistance that this great enterprise requires.

We offer below some suggestions for a beginning in developing a programme of general education on conservation of natural resources:

A. Co-operation between the Ministry of Education and the Ministry of Agriculture.
   1. Establishment of a research and information office for making surveys, investigations, statistics etc;
   2. Establishment of publicity offices to publish illustrated pamphlets and supervise commercial advertisements in order to make them contribute to the development of biological thought;
   3. Reservation of national parks and forests and nature beauty spots in general;
   4. Short training courses for teachers;
   5. Scholarships for students;
   6. Films and radio broadcasts for rural districts and small populated areas;

7. Help for rural social workers.

B. Support of private institutions: civic clubs, press, radio etc.

V. CONCLUSION

1. The general educational principle of the Cuban schools is faith in the perfectibility of man; this permits the introduction of new values and new objectives in education.

2. These values include all sectors of education in the country from primary school to the university.

3. The educational programme comprises two kinds of education:

(*a*) General education for all students, the purpose of which is to develop habits and attitudes and an understanding of the basic principles of conservation;

(*b*) Special education intended to train specialists and technicians both in vocational schools dealing directly with problems of conservation and at the university.

4. The work of the school must be supplemented by co-operation between the Ministry of Education and the Ministry of Agriculture and by other official and private support.

Such is a general sketch of the programme according to which education on conservation could be introduced in the schools of Cuba.

We believe that other Latin American countries are faced with similar problems, and we hope that our humble project may serve as a stimulus to those countries in need of a solution similar to ours.

We trust that at a future conference we shall be able to report not only on what could be done in Cuba, as we have done here, but also on what we are doing and the extent of the success achieved by this new educational system, which will assist in creating a better future for our beloved countries of America.

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Soil Conservation in Nyasaland

W. J. BADCOCK

ABSTRACT

In Nyasaland there are two approaches to the problem of soil conservation. The first might be termed the administrative-educational approach. This implies active propaganda by touring Administrative and Agricultural Officers, drawing attention of Chiefs and sub-Chiefs to the dangers of soil erosion. This work is supported by the Education Department through the Jeanes Training Centre, at Domasi, near Zomba, where Chiefs, Village Headmen, and other community leaders are given courses with a strong agricultural bias. These courses have been very valuable in cultivating an awareness of mind among many of the more influential members of communities to the dangers of soil erosion.

The second approach is more direct. When the Administration is satisfied that propaganda and education have sufficiently prepared communities for concentrated soil conservation work, arrangements are made for the promulgation of agricultural rules under the jurisdiction of local Native Authorities.

Simultaneously with these activities the Agricultural Department trains soil conservation supervisors. These men are taught to use simple levelling instruments for marking contours, how to treat gullies, methods of storm water disposal, the value of crop rotations, and grazing control.

Two of the most important crops grown in Nyasaland are maize and tobacco, crops planted in lines and thus "bad" crops from a soil conservation point of view. Government soil conservation policy on cultivated lands has accordingly been based on contour boxed ridges. The response to this has been most encouraging, and substantial progress has been achieved in improved soil management.

INTRODUCTION

At the time of the introduction of British Administration to Nyasaland the population of the country was sparse and it was possible for the traditional methods of native agriculture to be pursued without any serious depreciation of the natural resources of the country. During the last two decades, however, the population of the country has increased very rapidly, partly due to improved public health measures, but to a larger extent due to immigration from surrounding territories. The population of the southern Province, for instance, doubled during the period 1926-1936; this coincided with, and was largely due to, the development of European "estate agriculture". In the northern and central Provinces, the population increase has not been so great, but it has nevertheless been very considerable. This large increase in population was not marked by any change in the traditional methods of agriculture, thus soil erosion rapidly became a problem of some magnitude. District Commissioner's reports from Chiradzulu district early in the 1920's drew attention to special measures taken for the protection of steep hillsides.

THE DEVELOPMENT OF SOIL CONSERVATION MEASURES

As already stated, the first positive measures to prevent soil erosion were in Chiradzulu District where the District Commissioner prohibited the cultivation of steep hillsides early in the 1920's. This was followed in 1924 by the first Protectorate legislation which provided for the reservation of steep hillsides and strategic water catchment areas as forest reserves. Later, in 1928, the District Commissioner of Chiradzulu found it necessary to introduce regulations for the protection of river and stream banks; it is interesting to record that once again these measures were adopted as a basis for Protectorate legislation and were incorporated in a Forest Ordinance.

While Government became aware of the damage being caused by soil erosion during the decade 1920-1930, little positive action was taken, except for the record of continuous and active measures being taken by succeeding District Commissioners of Chiradzulu. The first record of funds being specifically provided for soil conservation measures is in respect of work on the Malowe hills in the Lower River district in 1931 when the first bunding of native gardens was inaugurated. There is ample evidence that the rate of soil erosion increased at an alarming rate during the early 1930's and by 1935 the government found it necessary to appoint an officer specially for dealing with soil conservation problems. This officer's activities were wisely confined largely to the reservation of steep hillsides and water catchment areas, and thus prevented the further devastation of virgin bush. This had the net result of preventing the spread of soil erosion to new areas but did little to protect cultivated areas where, in spite of active propaganda by all government field officers, the ravages of soil erosion became increasingly serious. Further development of soil conservation work was interrupted by the war.

In 1945 the Post-War Development Committee drew attention to the gravity of the serious increase in soil erosion and made recommendations for the adequate provision of staff and funds for conducting a comprehensive soil conservation programme. The Government took immediate steps to implement the recommendations, and funds were made available for the Agricultural Department to employ a large number of soil Conservation Rangers for marking contour lines on native gardens and supervising labour employed to construct storm drains and on gully-control work. This has resulted in the rapid adoption of contour ridge-cropping. In many areas soil erosion has been effectively arrested and in a few instances real soil recovery has been achieved. In 1946 a Natural Resources Ordinance was enacted to provide Government with comprehensive power to enforce improved methods of crop and animal husbandry, but for various reasons the Ordinance did not prove suitable for local conditions and has recently been repealed and replaced by a new Ordinance which has provided for the formation of Provincial and District Natural Resources Boards with wide executive powers.

ADMINISTRATION AND PROPAGANDA

There are two main approaches to the problem of soil conservation in Nyasaland. The first might be termed the administrative-educational approach. This implies propaganda by touring Administrative and other Departmental officers directly concerned with rural populations, drawing the attention of Chiefs, sub-Chiefs and other community leaders to the dangers of soil erosion. This work has gone on for a number of years and there are few natives, even in remote villages, who are unable to detail the dangers of soil erosion and measures that should be taken to conserve their soil. The Education Department has given strong support, and very valuable work has been done at the Jeans Training Centre near Zomba, in training chiefs, community leaders and school teachers to spread propaganda for improved methods of agriculture. The Education Department has also produced and distributed suitable literature for use in schools which in time will no doubt have considerable value in spreading knowledge on improved methods of farming.

The second approach to the soil conservation problem is more direct. When the Administration is satisfied that propaganda and education have sufficiently prepared communities for more concentrated soil conservation work, Native Authority Councils are invited to introduce rules to enforce improved methods of cultivation. Simultaneously with these activities the Agricultural Department has trained large numbers of soil conservation supervisors. These men are taught to use simple levelling instruments for marking contours, how to prevent the development of gullies, the elementary principles of crop rotation and grazing control. They are not highly trained, but under careful European supervision have done valuable work.

FIELD WORK

Before field operations commence in any area, care is taken to ensure that local chiefs are fully aware of the proposed programme of work, and their full co-operation has to be enlisted. Arrangements for this to be done have to be made through the District Commissioner, who in some instances finds it necessary to consult officers of the Agricultural, Forestry and Veterinary Departments for information on technical problems that might arise. Field operations might include the movement of people from the steep hillsides and important river catchment areas, which in turn implies finding resettlement areas, the reduction in the number of livestock kept in an area, the enforcement of rotational grazing, and assuring the application of proper methods of cultivation.

When full arrangements have been completed for implementing a programme of work, field operations are supervised by Departmental officers through their own African field staffs. Usually the population has been so well prepared by propaganda informing them what they are expected to do, that little serious difficulty is experienced. In cases where cultivators or stock-owners contravene any of the rules applied, Native Authority courts have adequate powers for dealing with offenders. In addition to operations on Native Trust Land, a considerable amount of advisory work has been done on European-owned estates, many have been surveyed for contour bunding, and in general the European estate owners are taking more adequate measures to protect their estates against erosion.

CROP HUSBANDRY

Crops fall into two groups (1) annual and (2) perennial. The most important annual crops grown in Nyasaland are maize, tobacco and cotton. The first crop is the staple food for the entire African population while the latter are important economic crops. Tobacco is produced by both Africans and Europeans, while cotton is now almost exclusively grown by Africans. These three crops are unfortunately all "bad" crops from the soil conservation point of view, because they are grown in lines and provide a very incomplete soil cover. The predominating importance of these crops in agriculture meant that soil conservation measures had to be suitable for protecting soil from erosion when planted with these crops, and a system of contour ridge cropping has been adopted. Soil Conservation Supervisors mark out contour lines at 3-foot vertical intervals on gardens; these are known as "marker ridges" and are supposed to be permanent, the remainder of the gardens are then made up in ridges 3 feet apart based on the "marker ridges". These same ridges are suitable for planting sweet potatoes and cassava, and have been used for other crops such as groundnuts and beans. Nyasaland soils are on the whole porous, and experienced farmers state that when contour ridges are properly constructed they are quite adequate to absorb all normal rainfalls.

The most important permanent crop grown is tea, which is an exclusively European crop. Tung tree planting has developed in recent years and it is now a crop of appreciable economic importance. From earliest times, when planting tea, some measures have been taken to prevent soil erosion, but in many instances they were inadequate and serious erosion has resulted. All recent plantings, however, have been carefully done and many estates are attempting to rectify their earlier errors. The tea plant provides a fairly complete ground cover and if properly attended presents no serious soil conservation problems.

Tung plantations present numerous difficulties. The trees are widely spaced, thus leaving large areas of soil uncovered. If ground cover crops are used, in most instances yields are reduced. The Tung Research Station is investigating this problem but as yet no satisfactory solution has been found; in the meantime on some tung plantations soil erosion presents a serious problem.

Some comment is necessary on crop rotations. Government policy is based on half the land resting and half under crops, but in many areas this is impossible owing to land shortage, and compromise methods have to be adopted.

ANIMAL HUSBANDRY

Cattle are confined to a few limited localities, due mainly to the distribution of the tsetse fly which, as in other African territories, seriously interferes with the livestock industry. The standard of animal husbandry in Nyasaland is extremely low and where cattle are kept in appreciable numbers there is almost invariably quite serious soil erosion due to excessive movement and large concentrations of stock, and in part to the unwise use of grazing grounds. Work in Ncheu and Dedza districts during recent years, where grazing has been carefully controlled and stock movements restricted, has shown that spectacular improvements of pasture and thus of grazing capacity can be achieved at little expense. Goats and sheep are kept in small numbers and cannot be regarded as of any serious significance in relation to soil conservation.

ROADS, TOWNSHIPS AND VILLAGES

The disposal of storm water from road drains, townships and bare village compounds frequently provide sources of gullies. These all receive attention; grass planting as a means of absorbing water and slowing down water movement has been widely adopted. In many instances gully check dams have been constructed.

FORESTRY

The Forestry Department has for many years encouraged the reservation of village forest areas to provide fuel and building poles. The work has been very successful and these small reserves have provided both fuel and building pole supplies in relatively treeless areas and usually provide an effective cover on steep hillsides.

SUMMARY

The history of the development of soil conservation measures adopted in Nyasaland has been briefly described, as have also the various measures being taken to combat soil erosion.

The Government is now forming a Soil Conservation Section of the Agricultural Department. Specially trained staff is being recruited and mechanical equipment obtained for implementing the recommendations of the Post-War Development Committee, and continued improvement in the measures being applied may be anticipated.

Supplementary Education for Soil Conservation in New Zealand

D. A. CAMPBELL

ABSTRACT

As soil conservation involves so many aspects of human affairs, the Soil Conservation Council administering the Act has organized an informative service. Information is disseminated through suitable channels via various media described in the paper to the rising generation, the farmers and the public. This service is complementary to the existing well-organized educational services in the country. Useful experience has been gained in various techniques of disseminating information, viz., photographs, film strips, movie films, posters, newspapers, newsletters, bulletins, a soil conservation journal, scientific papers, radio, agricultural and pastoral show displays, demonstration farms, conservation farmers' competitions and co-operative work with farmers.

INTRODUCTION

Since conservation is fundamentally a problem of human oecology embracing many aspects of human affairs, the Soil Conservation and Rivers Control Council early realized the major role education had to play in its soil conservation programme of obtaining information, disseminating information and applying information in its operational programme.

An information service was imperative because the over-all changes in catchments brought about by farming had culminated in serious soil erosion and increased run-off in the upper catchments, and increasing flood hazards, bank erosion, sedimentation and interference with drainage on the richest farming land downstream.

The dissemination of information was arranged so as to supplement the existing comprehensive educational curricula in primary, secondary, university and adult education spheres and was implemented by prudent injection of suitable information in an acceptable form at the various levels in the established system.

Investigation and experience revealed that attention had to be focused on the rising generation, the farmers and the public; and suitable media had to be used to cater for the conservation interest of each group, in an integrated programme.

PRESENT EDUCATIONAL ORGANIZATION IN NEW ZEALAND

The Council's educational programme for soil conservation has been moulded to supplement the existing comprehensive educational services evolved in New Zealand, pertinent details of which are discussed below.

Primary education: Continuous progress has been maintained in adapting the primary school syllabus to meet the needs of changing times, and emphasis has been given to relating studies to the dominantly rural environment. (1) (2)[1] To stimulate the strong element of natural science itinerant agricultural instructors foster and lead teaching thought and student activity, and in rural areas give practical emphasis to this in organizing agricultural boys' and girls' clubs in each locality—projects such as calf-raising, lamb-raising, chicken-raising, crop- and vegetable-growing are made competitive to stimulate development. (4) In this way an academic and practical basis is provided to nurture conservation principles and practices.

Secondary education: Secondary education in New Zealand is well organized and has been progressively oriented to suit the country's needs.

The pioneering work of J. E. Strachan at Rangiora (3) (4) has borne fruit and secondary school curricula have been brought into line with his concepts as a result of the later activity of the Consultative Committee's recommendations. (5) (6) Around the core of cultural subjects—English, arithmetic, social studies and natural science—specialist vocational subjects are developed.

Besides a general conception of conservation of natural resources which is integrated with social studies (geography, history and civics) biology and physical

[1]Numbers within parentheses refer to items in the bibliography.

sciences are prominent in the curricula of secondary schools to provide a scientific basis for conservation mindedness.

In many rural secondary schools comprehensive agricultural courses established on the sound foundation of school farms provide training in farm management which includes conservation principles. (7)

Teachers' training colleges: The original studies in natural science have been augmented in recent years with geography on its broadest basis, which includes special treatment of conservation of resources—particularly the farming resources in New Zealand. The bias given for conservation in natural science and geography is an important factor in the teachers' interests and activities subsequently.

Universities: The growing trend of greater interest and activity in science is reflected in the increasing numbers of students taking science for B.Sc. and B.A.—particularly various biological sciences, which augurs well for the growth of conservation thought. (8)

In the agricultural colleges the degree courses have been progressively revised and conservation concepts in the several agricultural sciences are being continually reinforced while at one college a special soil conservation training course is made available by arrangement between the Soil Conservation Council and the college's authorities.

Diploma students, who form the majority of students at agricultural colleges, receive instruction in soil conservation principles as part of their agricultural training, which assists them to adapt themselves readily to conservation practices necessary in various districts.

Workers' Educational Association: The Workers' Educational Association has evolved to meet the demand of adult education in New Zealand, and its coverage of study topics is wide and unrestricted. Consequently there is ample scope for development of conservation studies in relation to the problems discussed by the organized groups throughout the country.

Farmers organizations: In the adult education field direct contact with the farmers through their own organizations—Young Farmers Clubs, Federated Farmers and Agricultural and Pastoral Show Associations—has been made effective through the Regional Local Authorities set up by the Council.

Catchment Boards: Catchment Boards' services have been used to provide close liaison with their farmer rate payers, and the Mobile Cinema Unit, Demonstration Farm Units and co-operative conservation work with farmers were conceived and developed to cater for this service.

Agricultural and Pastoral Associations: These, the oldest organizations, were originated to stimulate interest in better farming, and spread knowledge gained among farmers as widely as possible. The technique chosen for doing this by competitive activity has achieved a great deal in improving breeds and standards of production of livestock, crops and farm management but the competitive element has tended to make this splendid movement too restrictive. Only the better breeders appear to have gained directly, although the indirect benefit to all farmers and the nation is enormous.

Spontaneous development of other farmer organizations indicates that the original objectives of the A. & P. Associations have not been entirely fulfilled.

Federated Farmers: This relatively new organization has resulted from the consolidation of several well-established farmers organizations, notably the Farmers' Union. The new organization is non-political though its Action Committee takes a very active part in all matters concerning the primary producers in New Zealand. There are 700 branches organized throughout New Zealand with a total membership of 47,000 and each branch has its President, Committee and Secretary.

Regular meetings are convened at which local farming problems are discussed and, when necessary, resolutions are formulated which are passed on to headquarters.

Lectures are arranged on farming topics and lively general discussions take place; matters of interest are ventilated in the official organ of the Federation, "Straight Furrow", a monthly journal run on modern lines, and containing direct useful information and views on the full range of the science and practice of farming, including management and conservation problems and political problems as they affect the farmer—taxation, wage stabilization, price control, marketing organization etc. Regional organizers operate to foster and integrate the movement, and all this service including the monthly journal costs the individual farmer £1 per year.

A hill country section of Federated Farmers has been organized and is taking a very active interest in conservation work in collaboration with Catchment Boards and State Departments.

Young Farmers' Clubs: This movement was originally sponsored by the Farmers' Union as a "young brother" organization, but was later organized by the Department of Agriculture working in close co-operation with Federated Farmers. The 314 clubs with a membership of over 9,000 are doing very good work under very progressive and dynamic leadership.

Competitions of many kinds—from shearing to public debating—are organized, and regular meetings are held, at which debates are sponsored and visiting experts lecture on and discuss a wide variety of topics directly related to agriculture and conservation.

PERSPECTIVE IN EDUCATION FOR CONSERVATION

The tendency to live too much in the past with our study of records has resulted in static education in the past. More recently there has been a big trend to interpret this past information in terms of the present and give it life, but the reform mentally needed is not only to give the past life in terms of today, but in addition to take both and project them into the future in order to give the present the dynamic and evolutionary bias that is the essential core of biology itself. What is history and genetics if the former does not mould the mind and make it plastic and the latter if it cannot be made to create the mind and body of to-morrow? What are the prospects of human survival, if we do not think and plan in terms of peoples' needs in the future? Otherwise, how can the present be dynamic and progressive enough to plan and discipline human evolution and population pressure in terms of land capability and food production? Today we depend too much on rare individuals to give this orientation and tempo to education. Education must grow from one of preparation for life to preparing to make continuity of life on earth possible. Conservation provides a seed-bed that nurtures these concepts and holds a challenge to translate these tenets into reality so that man may maintain equilibrium with his environment instead of forcing deterioration upon it—a prospect which can only bring ruin in the wake of his elimination from the earth.

Progressive modification of curricula to keep education in step with the needs of mankind is man's surest safeguard in achieving the necessary adaptations of his civilization to its changing environment. To meet New Zealand's needs the Soil Conservation Council is attempting to supply adequate information through the best channels to bring about what it considers to be some of the desirable objectives.

SOIL CONSERVATION COUNCIL'S EDUCATIONAL ACTIVITIES

The Soil Conservation Council commenced its educational activities in 1944 when the author was appointed as educational publicity officer and a simultaneous approach was made on the following educational activities.

Photographs: A comprehensive photographic coverage of all aspects of soil conservation problems was initiated and black and white and colour photos taken, recorded, processed and made available in regional collections for illustrating publications and for the preparation of slides, strips and special displays. Photographs carry conviction and finality difficult to surpass by descriptive effort and in consequence provide the basis of several media reported on below.

Posters: Posters have been circulated freely and exhibited in government offices, and in post offices and railway stations particularly. To date the majority of these have been sponsored co-operatively by the State Forest Service and the Soil Conservation Council, but posters specifically for soil conservation portraying wise use and misuse of the land are in the course of preparation.

Poster advertising has been so successfully and persistently used that the psychological effect on the public is not as ephemeral as it may appear to be. In fact the poster appears to transcend in efficiency many other media owing to association of such ideas as that it pays to advertise, and that there is therefore substance, truth and service to back up the worth-whileness of the advertised material—so much so that people accept in sincerity such information.

Film strips and slides: Film strips or slide films with a commentary and mounted slides were prepared to cater particularly for the needs of teachers and lecturers, whose interest in the problem was being developed by the Council's publicity programme. To date six film strips of a general nature have been prepared and copies have been forwarded to the nine Educational Boards' Film Strip Libraries in New Zealand. From there they are available free to all primary and secondary schools in the country. Copies have also been supplied to agricultural colleges, Catchment Boards and interested teachers and lecturers. Since copies can be purchased cheaply (2/6) many teachers and lecturers have equipped themselves with private sets of strips.

Such general topics as "Soil Erosion in New Zealand", "Floods and Flooding", "Save our Land", "Forest Inhabiting Birds" (colour) are being followed up with the production of general and technical strips on types of erosion, conservation methods and forestry.

Movie films: This most versatile medium of expression and powerful instrument for disseminating information has been developed extensively owing to the comprehensive coverage and general appeal it makes possible.

The unforgettable appeal of American films such as "The River" and "A Heritage to Guard", "For Years to Come" and later the English film "Rape of the Earth" inspired confidence in the merit of documentary films in the conservation education programme of this country.

To date 16 documentary films (16mm), 400 to 800 feet in length and sound recorded (5 in colour), have been produced for the Soil Conservation Council's own circuit.

A Mobile Cinema Unit has been on the road for the past three years working on a well-planned itinerary of approximately three weeks in each Catchment District. The Catchment Board virtually takes over the Unit in its territory and makes a pre-arranged series of screenings to adult audiences in the evenings and to secondary school children in the afternoons.

As the Unit is equipped with a power-generating unit and is fitted for rear projection of films in daylight there are few limits to its use in country districts. A permanent operator travels with the Cinema Unit and is accompanied by one or more Catchment Board members or by the Soil Conservator of the district, who are prepared to answer questions and promote discussion at the close of the 90-minute programme.

The programme is conceived well in advance and the films are produced to be complementary to each other in rounding out the film programme.

In the programme four types of films are used:

1. General interest films—Aspects of farming, overseas films, or news flashes of topical interest in soil conservation and river control.

2. General films of soil erosion and flooding and soil conservation practices.

3. Technical films on specific causes of erosion, e.g. fire, pests, over-grazing or imprudent cultivation and means of combating same.

4. Regional films portraying the problems of regions in perspective and detailing over-all and specific conservation measures for that region.

During last year's circuit 153 public screenings were made to 10,142 farmers and 99 screenings to a total of 22,411 secondary school pupils. It has been shown (9) that the effect of screening to specialist audiences is out of all proportions to the size of the audience.

The tour of duty of the Council's Cinema Unit advertises and creates a considerable demand for the films screened, consequently six copies of each are supplied to the National Film Library, which caters for requests from schools, colleges, and interested societies for the loan of film programmes. It is estimated that there are some 2,000 projectors supplied from this source.

In addition, films are borrowed by other government departments, and this extends the Council's publicity and information service.

Complete programmes are loaned to Organizers of the Federated Farmers which are screened by the Organizer at many small country centres during the course of the annual coverage of his territory.

Already successful trials have been made in producing general interest, 35-mm conservation films for theatre circuits. Such documentary shorts (10-12 minutes) have, it has been found, an appeal to the general public and if well produced merit inclusion on the circuit with a first-class feature and are thus seen by a proportionately larger public.

Newspapers, farmers' journals and technical publications: The Council's staff is at all times ready to assist in the supply of information and advice and prepare articles for publication through the above channels. It is being found that there is a growing demand for this service and publishers in New Zealand are doing an increasingly important national service in featuring soil conservation work.

Newsletter: Topical matters of interest in work, experimental information and conservation generally are collated periodically and circulated to workers in related fields, Catchment Boards and their staffs.

Bulletins: Several bulletins—The "Menace of Soil Erosion", "Tackling Problem Land at Molesworth", "From Forest to Farmland", "First Steps in Soil Conservation", "Down to the Sea in Slips", "Public Enemy No. 1—Fire", "Willows and Poplars for Conservation Work", "Soil Erosion and Soil Conservation in New Zealand" and "Conservation Work on Wither Hills"—have been published for distribution in schools and colleges and to farmers through Catchment Boards, and the Federated Farmers organization. As more technical information becomes available bulletins of a technical nature will be prepared as well.

The circulation of those issued to date has ranged from 20 to 80 thousand according to the range of usefulness (there are 80,000 farmers approximately in New Zealand).

By this circulation of free, well-illustrated bulletins to farmers, teachers, bankers, stock and station agents, land appraisers, advisers and agricultural instructors, a permanent record for reference is available for them, while journalists freely use them in the preparation of conservation articles.

Soil conservation journal: Publication of its own monthly journal has been under consideration for some time by the Council, and concrete proposals are now under action to publish a monthly journal in close collaboration with the Catchment Boards. This will provide a much needed outlet for the dissemination of certain information.

Scientific papers: Scientific papers prepared by the staff and other authorities on conservation matters are cyclo-styled and distributed freely to Catchment Boards and their staffs.

Radio: To date use of radio has been confined to relatively few talks as fuller use of this information medium has not been possible owing to shortage of staff. However, as data from conservation experiments become available an increase in the use of this service will be developed.

Displays at agricultural and pastoral shows and agricultural and industrial exhibitions: During the past five years comprehensive displays have been made at the principal shows and exhibitions with the following materials:

1. Local, regional erosion and conservation photographs.
2. Back-lighted, enlarged colour photographs.
3. Models of farms comparing wise and unwise land use.
4. Models of conservation structures and practices.
5. Working model of rain falling on different types of ground cover—forest, grass, cropped and bare land—from which the run-off (turbid and clear as the case may be) is collected in large bottles.
6. Backdrops or murals of good and bad land utilization (farming and forestry).
7. Models of river and stream control structures.
8. Rear projection of film strips with synchronized, sound-recorded commentary or alternatively rear projection of 16 mm. talkie films in a marquee producing an animated picture-on-the-wall effect.

Demonstration farms: Several pilot demonstration farms to test the practicability and feasibility of conservation measures in a unified farming programme have been set up on problem areas to date. On the first one, established four years ago on 400 acres of virtually abandoned, rolling to steep hill country, in a 15-inch rainfall area, where depleted native pastures (the result of over-grazing by sheep and rabbits and excessive burning) were severely sheet- and gully-eroded, the results of a recovery programme based on remedying the causes have been very gratifying. Fire and grazing control has resulted in generous reseeding and sward improvement which overcame sheet and gully erosion in this period. Contour banks and contour cultivation on 80 acres of the lower slopes, fallowing, seeding and fertilizing to permanent pasture, and spelling have made it possible to carry the equivalent of two sheep per acre. In addition, sub-division fencing, debris dams, tree planting of ruined land, pressure water supply and judicious stocking with cattle after the first year have made this transformation possible.

To sponsor as much district interest as possible and give a lead to the local authorities, a local farm advisory committee operates through the soil conservator in the management of the farm.

Measurement of the changes and the over-all results achieved, including costs, provide data for publication and for movie films.

During field days organized parties from Young Farmers Clubs, Federated Farmers, Chambers of Commerce, Government departments, Catchment Boards etc. have found much food for thought and discussion.

Experience with this and other demonstration farms has proved that the interest and confidence of farmers is captured in this practical way, and the real test comes when farmers seek advice and assistance to implement such comprehensive conservation practices on their own farms.

Farmers' conservation competitions: In order to quicken interest in soil conservation, farmers' conservation competitions have been initiated by the Council and are in the process of being organized regionally by Catchment Boards. In terms of farmers' competitions organized in the past the prospects of this form of encouragement are good.

Co-operative conservation work with farmers: Not only has the Council used all the indirect means in its power to promote soil conservation but it directly assists farmers to adopt soil conservation measures in certain cases. Through Catchment Boards the Council finances a one-for-one subsidy for tree planting on eroded, privately owned lands, which includes the cost of fencing.

In addition a three-for-one subsidy is available to farmers for gully and stream control work that requires the use of structures. Plans and the finished job are inspected prior to payment of subsidy.

SUMMARY

In conclusion it may be stated that the Council is ever alert to adapt its supplementary educational programme for soil conservation in the light of experience and changing needs. In this country which derives 98 per cent of its exports from the land and whose prosperity—nay, survival—intimately depends upon productive and permanent soil and water resources, its educational programme must permeate all strata of society whose sheet anchor is the soil.

This educational programme for soil conservation in New Zealand involves providing information for three major groups—the rising generation, the farmers and the public—on the basis that there is a well-developed and integrated compulsory and free education service operating, and that public conscientiousness is sufficiently aroused and informed to demand far-reaching legislation embodied in the Soil Conservation and Rivers Control Act, 1941.

The Council has arranged for the dissemination of suitable supplementary information to these groups of people within the existing organized educational service through the media discussed—photographs, film strips and slides, movie films, posters, newspapers and farmers' periodicals, newsletter, bulletins, conservation journal, scientific papers, radio, Agricultural and Pastoral Association Show displays, demonstration farms, farm conservation competitions, and co-operative conservation work with farmers.

But it must be clearly understood that this is merely the beginning of a service that must expand as experience and response dictate to meet the fundamental needs of soil conservation.

(Author's note: This paper was illustrated with a 16 mm. sound and colour movie entitled "Soil Conservation Work on Wither Hills", a documentary film dealing with the comprehensive conservation measures adopted to control soil erosion and restore the land for cattle and sheep utilization.)

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Protection of Natural Resources: Education and Propaganda[1]

RAYMOND FURON

ABSTRACT

The bad use of natural resources (soils and forests in particular) hampers their renewal. The natural balance formed by the association of soil, water and vegetation has been destroyed. Rain and wind cause serious erosion of denuded soil.

Technical services work to repair the damage, but their action cannot be more than local.

Propaganda, with all the means at its disposal, could serve to arrest and limit the evil. There could be propaganda in schools by introducing the protection of nature as a subject in the primary and secondary curriculum. The present paper outlines a possible programme, comprising both school lessons and lectures. Teachers could extend the propaganda outside the school.

THE DIMINUTION OF NATURAL RESOURCES

Primitive man, still ignorant of cultivation and stock-raising found means of existence on the earth's surface. He used the resources of nature; roots, edible leaves and fruits, animals he caught by force or cunning, water to quench his thirst, wood to make fire.

In time the population grew, civilizations were born, man invented crop-growing and stock-raising. His needs increased steadily. Farmers partially destroyed the forests in order to obtain land for cultivation. Later, after the discovery of metals, came the mineral resources.

We are not concerned with mineral resources in the present paper but we refer to them in passing, as they have the special characteristic of being non-renewable. A mine is worked until all the ore is exhausted: after that it ceases to exist. By contrast, natural resources of animal and vegetable origin can be renewed, provided that they are used in a very different way from that used in a mine.

[1]Original text: French.

It is precisely the latter condition which has not been fulfilled. In various countries, man has not used the forests, he has savagely destroyed them by axe and by fire, either for the sake of the timber or to obtain land for cultivation. Without even any concern for the climatic conditions, civilized man planned to transform pastures into agricultural land and extend farming on an industrial scale to the tropical and equatorial regions.

The natural balance formed by the association of the soil, its vegetable cover and water has been destroyed. Natural forces have come into play. Atmospheric agents (rain and wind) have affected the soil denuded of its plant protection. The result has been considerable erosion of the soil, which is carried away by wind and water and in many places has totally disappeared.

It is now realized that the earth's natural wealth (forests, grassland, water, cultivable soils) is constantly diminishing, whereas the population is increasing.

FUNCTION OF TECHNICAL SERVICES

Various technical services are studying means for the effective protection of the earth's natural resources against eroding agents, destructive animals (ranging from insects to certain mammals) and man's ignorance and lack of foresight.

All the civilized countries have services for soil conservation, water and forests, agricultural entomology etc. The campaign is scientifically organized. In the United States in particular restoration work on an enormous scale has taken place and the organization of the Tennessee Valley Authority is a model example.

Theoretically, technical services are capable of repairing the damage, if local and climatic conditions permit. Unfortunately many countries have no technical services; and in addition considerable capital, which is not forthcoming, would be needed to prepare for useful and pacific work of this kind.

In spite of this lack, some attempt at least can be made to arrest the progress of the evil. But the fact is that people are either unaware or insufficiently aware of the evil. Nothing less than active propaganda in all the countries of the world will succeed in interesting all those responsible for the day-to-day management of the natural resources.

PROPAGANDA IN SCHOOLS

Every possible means of propaganda should of course be used (books, pamphlets, press and radio, lectures). The most useful means would be propaganda to children, from the primary schools upwards.

Three-quarters of the population of the world live without books, newspapers and radio. Even in countries where the number of illiterates is high, there are numerous primary schools, attended by millions of children. In the highly civilized countries almost all the children attend school. Children have confidence in those who guide and instruct them. They accept with an open mind and without question what is told them by their teachers.

The same applies to secondary schools.

Propaganda directed to young people can bear fruit rapidly. It is important that our future citizens, farmers, business men or statesmen should at least know the facts of this great problem of the protection of natural wealth.

INSTRUCTION IN THE PROTECTION OF NATURE

INTRODUCTION OF THE TEACHING INTO SCHOOL SYLLABUSES

A knowledge of natural resources and their use and protection should be taught.

All that is needed is to introduce a new item in the primary and secondary school curricula.

It could take the form of an annual lesson followed by the showing of films.

Two lessons can easily be fitted into the primary school syllabus and four into the secondary (6th, 5th and 4th grades and final-year course).

ILLUSTRATED LECTURES

The actual lesson, which would be based on the appropriate chapter in the textbook, would be followed by an illustrated lecture.

The lecture would consist in showing photographs and commenting upon them.

The material used for this purpose could be either still photographs or cinematographic film. The writer is in favour of stills, for the following reasons:

1. Most primary and secondary schools do not possess film projectors, or even electric current, except in the towns;

2. Films distract the attention of the audience, who follow the movements on the screen and do not listen to what the commentator is saying; this applies to adults also;

3. With stills the lecturer can vary the length of his remarks. An excellent one-hour lantern slide lecture requires a maximum of 50 plates.

The illustrations should be carefully chosen in order to show:

(1) Damage and destruction to vegetation (grassland or forest) by:

Excessive felling of trees,
Intentional burning (bush fires),
Use of plough or tractor,
Goats and over-grazing by cattle,
Wind and rain.

(2) The means of restoration:

Land levelling with bulldozers,
Terraced cultivation,
Tilling methods,
Reafforestation,
Drainage of swamps and irrigation.

Examples should be drawn first from the country concerned and then from any other countries, in order to show typical cases and the universality of the danger.

Since most schools throughout the world do not even possess a projector, the production of low-cost apparatus or the preparation of a series of photographic enlargements about one metre square, which might be kept like geographical maps, should be contemplated.

This is a matter which requires consideration, to avoid the risk of distributing expensive material which would be useless owing to the lack of facilities in the schools.

Both the projectors of all kinds (electric, lamp or daylight) and the series of photographs should, of course, be distributed free, as most schools have no allocation for such expenses.

If this propaganda is to succeed it must be backed by ample funds and continued with perseverance.

COURSES ON THE PROTECTION OF NATURE

The study of natural wealth and its protection can be introduced at quite different points in the teaching curricula: in natural science, physical geography, economic geography.

In the primary school course, the same lesson can be introduced twice: once in the natural science manual and again in the final year geography book.

In the secondary school course, four lessons are conceivable: one in the sixth grade zoology syllabus, one in the fifth grade botany, one in the fourth grade geology and one in the final year general geography.

An outline of these courses for spreading the idea of the protection of natural resources is given below.

Primary school course

This course is both very important and the most difficult, being solely for young children whose knowledge is necessarily slight. Everything depends on the abilities of the teacher.

General programme: Human life is sustained by the products of the earth: water, cultivated plants and domestic animals. Among other natural products, the forest supplies wood for building and heating, and pulp for paper.

As domestic animals live mainly on plants, plant products condition the very life of man.

Non-cultivated vegetation (forest and grassland) is prevalent over the whole earth, except the desert regions, and virtually constitutes a protective cover for the soil.

In crop-growing regions man has destroyed the wild plants (trees or grasses), and replaced them by the cultivated plants upon which he lives. In farming, man works the soil which nourishes the wheat, maize, rye, beetroot, rice, vegetables etc.

Every good farmer takes care of his land and maintains it in good condition in order to obtain a harvest from it each year. To prevent it from becoming impoverished and barren, he puts in natural fertilizers, such as animal manure, or artificial fertilizers.

Thus the whole life of human societies is based primarily on the products of the earth.

Consequently, the soil itself, and cultivable land, water, grassland and forest are natural resources varying in quantity and quality in different climates.

These natural resources should be neither squandered nor destroyed. If there were no grassland, forest or cultivable land left, the earth would be a desert on which human life would be impossible.

Yet, in many regions, man squanders and destroys the natural resources, thereby causing a series of catastrophes which he had not foreseen.

Sometimes, instead of working a great forest by leaving the young trees standing and by replanting, he cuts down all the trees. This means that he has destroyed the forest for a long time to come, perhaps forever. The rainwater, which formerly penetrated slowly into the soil to feed the springs and wells, is no longer retained on the slopes by the vegetation; it rushes down and swells the torrents too suddenly, and so causes floods. The soil which formed the forest floor is carried away by the rainstorms, leaving a surface of barren rock.

Or else he cultivates his land badly and so after a few years it becomes barren. He abandons it, cuts down and burns a piece of the forest, cultivates the soil for a few years and then begins the same process again at another point. Not only does the area of the forest diminish quite rapidly but the soil, left without protection, may also become a prey to wind and water. Storms and gales remove a few millimetres or centimetres each year, ditches and then veritable gullies furrow the abandoned fields and here again the cultivable land disappears.

It is common knowledge that if too many cattle are put to graze in a meadow, they trample down the grass to such an extent that whole patches disappear. In humid countries the meadowland becomes a swamp; in excessively dry countries the wind blows away the soil.

In many countries, the earth which nourishes man is thus made the victim of his own ignorance, negligence and foolishness.

This misuse of the earth often ends in ruining those responsible for the misuse by forcing them to abandon their ravaged lands and farms. Moreover, failure to respect property which is the common patrimony of all mankind to be passed on from generation to generation is a real crime.

At the present time vast areas are suffering from excessive deforestation and from the ruination of cultivable land because the soil has been carried away by water and wind or allowed to become barren. The level of the ground waters which feed our springs and wells is steadily sinking. Cultivable land is becoming scarcer and if these bad practices were to continue for long some already undernourished populations would be threatened with famine.

Scientific organizations are striving to counteract this diminution of our natural resources, by organizing re-afforestation, reclamation of grassland, better cultivation methods, and by prohibiting the exploitation of certain threatened regions.

Side by side with these large-scale efforts by Governments, it is the strict duty of all men to respect natural resources and to take daily care to maintain cultivated land, grassland and forests in good condition.

Secondary school course

Here the teaching can be more broadly developed and adapted: animal wealth being dealt with in zoology, vegetable resources in botany, damage caused by soil erosion in geology, a general economic survey being given in the geography course preceding the second part of the *baccalauréat* (pre-university) examination.

(a) *In the 6th grade — Zoology:* Part played by animals in the life of man: food and clothing (wool, fur). Wild and domestic animals. Advantages of protecting animals. Examples of certain species totally destroyed or become rare through intensive hunting and shooting.

Harmful animals (from insects to mammals), causing 200,000 million francs worth of damage every year in each country the size of France.

Land and water microfauna.

The importance of fishing and the disappearance of fish in over-fished areas.

Large reservations: national parks etc.

(b) *5th grade — Botany:* Natural distribution of plant life in forest and grassland.

Forests and grassland are natural wealth. The forest supplies us with wood (wood for building, cabinet making, heating, pulp for paper etc.). Forests should be worked rationally, not destroyed. Only part of the trees should be cut each year. Reafforestation. Dangers of destroying mountain forests: bare slopes do not retain the runoff, which rushes down into the torrents and causes floods.

Grassland serves as pasturage for domestic animals during good weather. Storing dried grass: hay. Importance of hay, still unknown to many peoples whose livestock is in constant danger of starvation.

Protection of the forest against misuse and fire.

Certain types of vegetation particularly useful to man, cultivated plants, require large areas of ground which could only be created at the expense of grassland and forests.

This practice of extending cultivated areas ceased in Europe quite a long time ago. It still occurs in America and Africa.

In Africa the practice of setting fire to the bush ravages the grasslands and the edges of forests. The quality of the grass is steadily deteriorating and the soil is becoming absolutely barren.

General consequence of the rapid destruction of forests and grassland: denuded of its plant covering, the soil is exposed to the action of atmospheric agents (wind and rain) and is carried away. It is a fact that forest, grassland and cultivable soil areas are diminishing all over the world.

Great importance of protecting nature: national parks etc. Importance of individual action.

(c) *4th grade—Geology:* After a study of contour changes due to the action of atmospheric agents, attention should be drawn to the special case of soil erosion, which in practice means the removal and disappearance of cultivable land.

Nature of the soil, a complex living organism composed of mineral, animal and vegetable elements. Circulation of air and water. Distribution of soils according to the nature of the sub-soil and the main climatic zones.

Utilization of the soil. Natural vegetable cover in all non-desert countries: grassland and forest. Destruction of natural vegetable cover by man in search of land on which to cultivate the plants particularly suitable for his food. Stock-raising.

The natural balance is very easily upset and in many cases the soil ends by being denuded of vegetable cover: total destruction of the forest or grassland by felling or burning, destruction of grassland by over-grazing (East Africa), maintaining insufficient vegetation during the ploughing and after the sowing season.

Action of rain: drops of water form rivulets which run down the slopes. This runoff breaks up the particles of soil, loosening them, shifting them and finally carrying them away. Ever deepening furrows, and then veritable gullies form and the soil is carried down towards the torrents and rivers. The land is left bare and torn, totally unfit for cultivation.

Action of wind: the phenomena of erosion, soil removal and sedimentation caused by the water runoff take place also as the result of wind action. Air in motion, or wind, spreads rather like water and affects denuded loose soil. It breaks up the particles of soil, shifts them and carries them for quite long distances.

Climatic action: laterization and hardening of lateritic clay in tropical countries.

(d) *Final Secondary School Year:* Economic importance of natural resources, animal and plant, wild and domestic.

The forest. Original and present extent. Forest products: wood for building, heating, pulp for paper. Tonnage and commercial value. Import, export. Useful forest area is diminishing owing to destruction, whereas a rationally worked forest is permanent capital. The need for reafforestation. Campaign against industrial deforestation and voluntary burning.

Natural grassland. Its extent and economic function. Stock-raising.

The soil. Its nature. Soil changes. Its economic function. Main crops: cereals, oil-bearing plants, cotton etc.

Water. Water courses and ground water. Its economic function: nourishment of plants, animals and man. Springs and ground water sources can only be maintained if the natural balance is not upset and water can infiltrate into the soil.

Soil erosion. When man destroys the association between the soil and its vegetable cover, the soil is denuded and rapidly becomes a prey to atmospheric agents such as water and wind. The soil is carried away by the water runoff and by the wind. Examples. A time comes when the cultivable soil disappears entirely. Owing to the destruction of forests and to the farming of vast areas which are subject to the ravages of erosion, the earth's cultivable surface has already shrunk (North American grassland, coffee and groundnut areas etc.).

In these ways the natural resources of the earth are lessened. Other consequences follow: floods, lowering of underground water levels through lack of supply, decrease in spring water, filling in of reservoirs with sediment brought down by water courses.

Man must cease to destroy the natural wealth and must restore the areas where his short-sighted actions have caused deterioration.

Great organizations like the Tennessee Valley Authority have succeeded in restoring the economy of a region seriously affected by erosion. Reafforestation and better crop-growing methods are effective weapons against the action of atmospheric agents.

The need to protect all nature against any damage tending to upset her precarious natural balance.

FUNCTION OF THE TEACHER OUTSIDE THE SCHOOL

Propaganda of this kind in the schools may easily be extended outside by means of public lectures given by teachers.

City dwellers will always be interested, but being seldom in direct contact with nature they will have little occasion to help in protecting natural resources.

By contrast, the minds of country people everywhere must be influenced, for it is they who are largely responsible for the destruction of natural resources: by intensive forest exploitation, extensive crop-growing, overgrazing by livestock etc. They are people difficult to convince and, outside Europe, entirely without thought for the future.

Here again, the highly important function of the elementary school teacher may be seen. He lives in daily contact with the country people; he knows them and talks with them. Whether it be in Europe or in Black Africa, the school teacher can give an annual lecture in the village and will have some chance of convincing a proportion of his adult audience. They have a certain confidence in him because they consider him almost as one of themselves, whereas a lecturer from the town would have no success.

Methods of Teaching Conservation of Natural Resources in Jamaica

W. C. LESTER-SMITH[1]

ABSTRACT

The soil of Jamaica, which is the primary natural resource because of limited land-room for a large and rapidly increasing population, is being rapidly exhausted. This form of wastage, mainly due to accelerated and uncontrolled erosion, has been in progress for well over a century and has brought fertility to a dangerously low level.

This paper indicates the present state of the chief natural resources of the island and how they have been brought to this state. A brief outline is given of the means recently taken to promote measures for the conservation, better use and improvement of these resources, and of the organizations and methods which are providing education and guidance for the purpose.

The chief difficulties encountered in initiating soil conservation work are mentioned; they are mainly the aversion to change long-established practices, the high cost of the work because of local topography and shortage of capital due to low productivity and lack of thrift.

An indication is given of some of the soil conservation measures considered most appropriate to certain soils or crops.

INTRODUCTION

The natural resources of Jamaica, the third largest island in the West Indies (approximately 4,000 square miles), are the exhaustible resources: soils, minerals and water; and the renewable resources: forests, wild life and the human population. These interact on each other in a variety of ways, but as agriculture is essentially the basis of the island's economy, the resources require consideration primarily in their relation to the fact that the continued existence of the people must be based on the best use of the soil. The methods and techniques adopted, and the organizations for promoting improved land usage are thus an important factor in educating the people as a whole to gain the desire for the protection and more efficient use of their national resources, and to reach agreement on the means by which this can be accomplished. This paper presents a summary of the natural resources position and a brief outline of the organization and methods through which education and improvement have been commenced.

Before considering the resources themselves, two natural phenomena that materially affect the resources and their interactions have to be taken into account, namely, climate and topography.

Climate: Though the climate is sunny and equable, periodic years of drought are experienced, interspersed with occasional short spells of heavy rain, hurricanes and other less violent tropical storms, mainly wind. Rainfalls, usually localized in area, can be intense—between 10 and 30 inches in a 24-hour period—and are a predisposing factor in the serious erosion and flood damage that occurs. Heavy falls of rain commonly occur after long periods of dry weather, when the land is without its maximum plant cover. Only very limited areas are affected by wind erosion.

Topography: The island is very mountainous, ranging from a small area of coastal plain through an insignificant area of coastal cliff (200 to 2,000 feet) merging into the main (four-fifths of total) area of elevated limestone plateau (1,000 to 3,000 feet), and culminating in a small interior mountain area rising to nearly 7,500 feet. Under ten per cent of the island is flat; about four-fifths of this is largely coastal plain and one-fifth mangrove and other swamp land. The whole area of the island can be divided into five typical slope-groups as shown below:

	Slope-type	*Slope range* (Per cent)	*Approximate percentage of total area* (Per cent)
I.	Gentle slopes (including flat land)	0 to 10	10
II.	Moderate slopes	10 to 25	20
III.	Steep slopes	25 to 50	35
IV.	Very steep slopes	50 to 70	25
V.	Precipitous slopes	70 to 100	10

Consideration of the above facts might lead to the opinion, on conservation grounds alone, that nearly half the total land area should be retired from any form of

[1]The author of this paper was engaged on activities in connexion with soil conservation in Jamaica for just over three years (1944-47).

cultivation other than controlled forestry operations; but economic factors, chiefly the necessity for increased production and more land-room, generated by the high and rapidly increasing population density (over 300 per square mile) do not permit such an extensive degree of land retirement.

NATURAL RESOURCES

Forest and plant cover: The ancient Arawak word from which the name Jamaica is said to be derived means "land of wood and water", and there is evidence that at one time the island was mainly covered with dense forest. Little of the original forest cover now remains except on a few of the higher and most inaccessible interior mountains. Indiscriminate overcutting in the past has reduced the area nominally under forest and woodland to about a quarter of the total area. About one-fifth of this is rocky karst-land of which considerable sections in the more accessible areas have been so heavily cut over for the production of charcoal, that the deforestation and subsequent erosion seriously retard and reduce the rate of natural regeneration. On the other areas of coastal and less rugged interior land, deforestation has been steadily progressive, in part for the extraction of timber, but to a much greater extent to provide for crop production.

Almost the only forest product now exported is logwood, and the importance of this industry has diminished considerably, though there are indications of a slight revival. The logs mainly come from grassy savannah areas on the coastal plains where they are plentiful, so that this small industry does not materially affect resource conservation.

Exclusive retirement from any form of cultivation, overcutting and stock-browsing, along with afforestation and other suitable forms of plant cover, is recommended for all areas with a slope of over 70 per cent.

The forest department has a long-term scheme in hand for the afforestation of parts of the deforested watersheds, and for the acquisition of additional areas for protective conservation purposes, but much of the land that should be reserved has long been in private ownership and either deforested or considerably degraded. Difficulties are experienced in the reafforestation of some areas because previous land-use and erosion have so reduced the fertility that a different vegetation climax has been established, and to effect a change back to forest conditions is exceedingly difficult.

Soils and agriculture: There are several soil types but three are of chief importance. Predominating are the red earth and allied soils, derived from the white limestone formation, with gentle to very steep slopes; the alluvial soils of gentle slope; and the shale and conglomerate soils of montane derivation with moderate to precipitous slopes. The measures recommended for the control of soil erosion on land used for agriculture necessarily vary with the degree of slope, soil type, nature of crop or stock usage etc. In general, because of the broken nature of the land, anti-erosion measures are based on level contour works with vertical intervals of from four to twelve feet. Whenever practicable these measures take the form of plant-barriers, since the cost of earth works and stone-terracing is very high as it has to be done by hand labour owing to the steep or rocky nature of the land.

The limestone soils lend themselves to various forms of conservation, ranging from simple plant-barriers on the deeper and more permeable red earth soils to various types of stone-terracing on the more marly moderate slopes and steep rocky soils. The alluvial soils generally require drainage, so that the conservation measures recommended usually comprise plant-barriers augmented by contour drains. The shale soils create difficulties in soil conservation because of their steep slopes, the intense rainfalls to which they are subject, and their non-cohesive nature, all of which combine to make control of surface run-off most important, yet any appreciable hold-up of water predisposes them to landslips. Even under dry weather conditions, a fair amount of direct gravity erosion occurs on the steepest slopes. Little experience has been gained of methods of conservation on these soils, but observation points to contour hedges of dwarf bamboo as likely to be most useful. The conglomerate soils may prove to be a separate problem.

Many of the soils are acid and have a low lime, phosphate, humus and other colloidal matter content. This has an important relationship to the commonly low fertility status of the soils, to their tendency to erosion, to the difficulty experienced in raising their productivity and to the high costs of production.

Among the crops which caused the greatest erosion in the past was coffee grown as a plantation crop on steep shale soils. Its recent resuscitation as a small settlers' crop mainly on the limestone areas alleviates the situation to some extent, particularly as soil conservation measures considered effective and suited to this crop and the latter soils are available. These comprise the establishment of contour hedges of one of the Bowstring hemps, which grows wild locally; but it is very difficult to get this control measure adopted as there is much antipathy to making use of the plant for fear of its too rapid spread.

Other crops which, from their continued methods of cultivation cause most erosion are bananas, yams, ginger, tobacco, and minor crops such as scallion, red peas and tomatoes. Most of these are grown on monocultural systems and the age-old practices of keeping them clean weeded, usually without a surface mulch, with no soil conservation measures and with forms of drainage that induced much gully- and sheet-erosion through the rapid removal of surface run-off, have done untold damage to the land and its fertility. Bananas, by reason of the large acreage and their migration over the land and up the slopes, have caused most erosion. Yams can be considered a good second as there is probably not less than three per cent of the total land area under this crop in any one year; in addition, this crop is largely grown as a shifting cultivation.

There are large areas of poor low-grass pasturage, frequently established in wide-spaced coconuts, wild pimento, limes and other citrus. Many of these areas suffer from either overgrazing or sheet-erosion, or both; run-off is in any case high. In better pasturage areas gully-erosion is not uncommon, and goats, which have almost doubled in numbers within recent years, through uncontrolled herding and browsing in the drier parts of the island, do much damage to gully sides and rocky areas with a scanty plant cover. In parts, where the holdings are small and fragmentary and fencing poor or absent, cattle trespass, and the overcutting of fodder grasses (often conservation plant-barriers) does much damage when supplies are short at the end of dry periods. In the areas subject to wind-erosion there is great reluctance to adopt control measures on account of costs, the grudging of land-room and fear of crops being affected by over-shade and root invasion.

It is exceedingly difficult to wean the cultivators from their long-practised methods which are the cause of so much erosion and of irreparable damage to water resources, various public utilities, life and property. The continued wastage of soil resources, still largely unappreciated, is a menace that may easily reduce the island to a starvation level.

Water: Jamaica still has extensive and valuable water supplies. In the main these take two forms, the large and apparently unreduced underground reservoirs collected by the white limestone formation, which covers the greater part of the island, and the streams which flow more or less as a result of direct rainfall in their catchment areas. Owing to deforestation, the reduction in plant cover and erosion, many of these latter now only have a transitory flow. Some have an extremely high hydraulic gradient and the damage they do in the way of flooding, silting and meanders as a result of their intermittence is extensive. There are about 25 small rivers, at least twice that number of smaller streams, and many small springs and wells. Some of these waters have mineral properties. Few, if any, of these water supplies have been given throughout their course the protection and reservations they deserve. Water supplies, principally from underground sources, are used for the provision of public utilities, for irrigation and for the generation of hydro-electric power and lighting services. There are still parts of the island which suffer from inadequate supply or even lack of water, and plans have been devised both for providing irrigation and for alleviating shortages in some areas. In many places the only water available at present is that obtained by catchments from direct rainfall.

Minerals: The chief mineral resources are bauxite, gypsum, and other limestone formations which provide supplies of lime that are of value for meeting soil deficiencies. The bauxite deposits underlie areas of the red earth soils, the most important sections of which have been acquired by commercial interests. Up to date these deposits are largely untouched and it is believed the interests concerned plan primarily agricultural usage of the land for the immediate future. Legislation exists to facilitate extraction of mineral resources and to ensure that this is carried out in a manner conducive to public interests.

Wildlife: Fish is the main wildlife resource of value but fishing has never been organized on a commercial scale. Plans are under consideration for the development of a fishing industry, both in respect of coastal and inland waters, primarily with a view to the augmentation of local food supplies.

Population: Population of the island, at present well over 1¼ million, is increasing more rapidly than its resources permit, at a rate of about 20,000 a year. This is a matter of vital importance in view of the limited land-room and the factor of unemployment which create special problems, particularly in relation to nutrition and land settlement. In this connexion it is important to note that in the sugar industry, the largest employer of labour, work is mainly seasonal and therefore leads to considerable under-employment. These facts considered in conjunction with low soil fertility and production, the increased imports of essential commodities, and the costs of social services and public utilities maintenance and repair work resulting from erosion damage, explain the rising costs of living and high labour rates which create a vicious circle.

EDUCATION FOR CONSERVATION

Education for conservation implies the creation of a national desire to conserve, strongly reinforced by an appreciation of its vital importance, not only to the nation, but to each community and every individual, irrespective of occupation. For this purpose it is important that there should be a realization of the meaning of conservation in its widest sense: of the careful husbanding and wise use of the exhaustible resources and the improvement and careful management of the renewable resources. This realization must be raised by education to a pitch that will stimulate and ensure agreement on policy and procedure and impel necessary action.

Essentials in a programme of conservation are research and extension work, to devise the best methods to be adopted and to convey this information to those concerned in a way that is understood and appreciated. These two essentials imply a third: that of finance to provide the means to achieve the end in view. Administration is necessary to co-ordinate the plans as a whole and to direct the work into the most profitable and acceptable channels.

Conservation plans in Jamaica were originally based on an agricultural subsidy scheme propounded by the Jamaica Agricultural Society for a five-year plan which, after subsequent consideration, was converted into a more comprehensive Ten-Year Plan embracing agricultural and other resources, as well as social welfare. Under this Plan the capital cost of development was provided for by grants under the Colonial Development and Welfare Act. Agricultural and social rehabilitation, urgently necessitated by the hurricane of 1944, was a primary part of the scheme and included soil rehabilitation as one of the essential priorities.

Methods of starting and furthering measures for soil conservation had been studied by those concerned at an earlier date, and legislation of a democratic nature had been prepared for consideration in this connexion but with the initiation of the Ten-Year Plan was deferred.

To implement these plans a scheme was drawn up to provide numerous small soil-conservation and mixed-farming-demonstration units on the farmers' own land throughout various parts of the island. An appreciable number of such units were initiated and some have made progress and created a desire for their extension. This scheme provides for advising the farmer of the work to be done, assisting with the lay-out, and obtaining his agreement to carry out and maintain the recommended measures. When the work is satisfactorily completed the farmer is given a cash grant, usually half of the cost of the work subject to limitations as regard maximum rates and total cost. These grants provide for assistance in almost all forms of soil conservation work, including material for planting, and for liming and manuring the land, while further schemes provide for assistance in the construction of cattle sheds, small silos and water tanks, and even for the supply of livestock. Later, a Central Farm Improvement Authority was established, with local branches in each district, to examine and formulate schemes for the wider application of soil conservation work.

The administration of these and other soil conservation schemes is as follows: The research and advisory work is carried out by the Department of Agriculture, through its research or district staff. The lay-out and other extension work is done by the local staff of the Agricultural Society. The Society is a non-governmental body with branches throughout the island the members of which are primarily landowners and small cultivators who contribute towards its maintenance; the balance funds are provided by Government grant. This gives the Society the almost complete independence which its members demand. Members of the staff of the Agricultural Department as well as of the Society and of other social service organizations visit the Society Branches (usually conjoined for such purposes into local district groups) from time to time and give them addresses and discussion talks on various matters of agricultural and social importance. A number of independent social organizations and other departments of government similarly contribute to rural education and propaganda in this way and by the publication and issue of literature.

A stimulating method of appeal and education was found in the national love of song and music, and a soil conservation song "Muddy Water", the inspiration of a Jamaican, was devised and has proved popular with adults as well as juveniles. The interest of the younger rural population is catered for both through the schools and also to a great extent by a "4-H clubs" section of the Agricultural Society. The latter, which held its Golden Jubilee in 1945, publishes an agricultural journal, recently renamed "The Farmer", and has done and continues to do much valuable practical, educational and propaganda work to stimulate and encourage the conservation of Jamaica's most important natural resource—its soil.

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Agricultural Education in Uganda

R. K. KERKHAM

ABSTRACT

Experience in Uganda indicates that agricultural propaganda must be based on sound knowledge of local farming systems and economics. New ideas and new methods will in time be adopted by the farmer provided they are in fact economic for him with the resources at his disposal. The rate of adoption depends upon a well-directed method of approach. Extensive propaganda to get the full co-operation of the leaders of the people is essential, and to get this they must have a real say in the direction of projects. This extensive propaganda has been much assisted by work with progressive farmers' groups and the use of keen farmers to demonstrate new ideas. Government-controlled farms or villages have not proved valuable as demonstrations. Smallholders courses have not proved successful.

INTRODUCTION

Uganda is situated near the equator in the centre of Africa. Its land area is 80,000 square miles with a human population of about 5,000,000 people. The density of population is not evenly distributed; the lower slopes of the hill country in the west, the lower slopes of Mount Elgon in the east and the country bordering Lake Victoria in the south are densely populated, with 400 to 500 people to the square mile in some villages. The drier, less fertile country of the north-east is very sparsely inhabited.

Most of the country lies between 3,500 feet and 4,200 feet in elevation. The country has little developed mineral or industrial wealth, but is more favoured by its soils and climate to farming than most of tropical Africa. Production is based on the small family farm, the main export crops being cotton and coffee with some tobacco, oil seeds, maize, tea and other minor crops. The principal crops produced for local consumption are millets, bananas, sweet potatoes, beans, groundnuts, cassava, tea, tobacco and sugar.

A small amount of land has been sold or leased by the government to non-Africans for farming, where sugar, tea and coffee are the main crops grown.

During recent years a considerable amount of success in persuading African farmers to adopt improved methods of farming has been achieved. Adoption of strip cropping in the Teso district and in other districts of the north and the east, improvement in livestock management in the Buganda Province and farm contouring in the Kigezi district are perhaps some of the more obvious improvements. A discussion of how these improvements were brought about may prove useful to other Governments faced with similar problems. Success depends upon 1) sound and proved agronomic measures to recommend, 2) obtaining the confidence of the leaders of the people, and 3) adequate means of putting ideas across to the farmer.

EXPERIMENTAL INFORMATION

Owing to favourable circumstances the Uganda Government has been able to afford a relatively large staff of agricultural technical officers since the middle 1920's. The small size of the country has helped these officers to obtain a thorough knowledge of the country upon which to base their experimental work, and to keep in close contact with the field extension staff. Such considerations are sometimes more important than the scientific value of the research work carried out. One frequently hears that the African farmer fails to improve his farming methods because he is too idle, or too conservative, to adopt new measures. There is some truth in this, but in certain cases the measures recommended have been economically unsound in view of the limited resources at the farmer's disposal. The African farmer, like his counterpart elsewhere, wishes to obtain the maximum return for the minimum expenditure of energy. He will sometimes exert a little more energy if the return obtained is sufficient, but is unwilling to increase his work output rapidly. Such an attitude is not peculiar to Africa, and is not necessarily undesirable provided he maintains the fertility of his soil so that his successors will be able to obtain the same return per unit of energy expended as he did.

Experience in Uganda suggests that an improved method will be adopted readily whenever the additional response in crop yields or cash return occurs rapidly, but that long-term improvements with little immediate financial return are much more difficult to introduce. Better land usage and maintenance of soil fertility require reorientation of farm layouts, modifications of rotations, capital expenditure on improvements to water supplies, buildings for livestock and earth works for prevention of erosion, all of which need several years to produce a return in increased yields or reduction of labour. In such cases the individual farmer is unlikely to carry out improvements himself. In Uganda capital improvements have been carried out by the central or local governments and paid for from their revenues.

CONFIDENCE IN GOVERNMENT RECOMMENDATIONS

In the long run the confidence of the people is based on results. Nothing destroys confidence so much as impracticable advice or suggestions that Government has not kept its promises. The Agricultural Department undoubtedly at one time lost much prestige in the Teso district by recommending that farmers make manure in covered yards when they had no adequate means of carting the manure so produced to their fields. In the same district groundnut growing has not increased since the year when this crop was recommended and intensive propaganda undertaken at planting time; this happened to be a year when very low prices ruled at the time of harvest.

The extremely rapid spread of strip-cropping in the Teso district from 1939 to 1944 illustrates many of the requirements for rapid spread of improvements. The system recommended, though by no means perfect agronomically, is reasonably effective and entails little extra work. Administrative and Agricultural Officers in charge of the district worked together in close collaboration and knew their district well. The Teso chiefs had confidence in them for this reason, and also had themselves sufficient standing among their people to be regarded as reliable men. In these circumstances the new system of farm layout became almost universal within five years, and is now regarded as an old established Teso custom.

METHODS OF PUTTING IDEAS ACROSS TO THE FARMER

In primitive areas there is no doubt that the most effective means of persuasion is by using the established administrative machinery, i.e., extensive propaganda throughout the tribe without concentrating on particular groups or individuals. In Uganda extension of cultivation of cash crops, particularly cotton, has been produced almost entirely by this means. The European administrative and agricultural staff decide what crops should be encouraged in each area. The Agricultural Department has senior African staff in each county, with subordinate staff who reach each village; their function is to advise on methods of growing and assist with marketing, supervision of seed distribution, maintenance of nurseries and the like. The chief has a very strong incentive to produce results because his job will depend partly upon his success.

Such methods are still necessary even in Buganda, the most advanced part of Uganda in so far as adoption of a cash economy and education are concerned. By themselves, however, they are not ideal methods of putting across improvements without a very obvious cash benefit. The educated African farmer does not accept the advice of his chief without question. The chief in an educated tribe tends to have many duties not required of him in more primitive conditions, and frequently has been brought up in an environment where he has not had day-to-day contact with farm activities.

From 1930 to 1940 the Department of Agriculture endeavoured to supplement extensive propaganda by running training courses at experiment farms for selected small farmers. Missions ran farm schools with the same objective. The suggestion was that these men would act as demonstrators when they went home to farm on their own. The courses lasted either one or two years. Both youths straight from school and older men with their families attended some of these courses, and several hundred farmers were trained in this way. The courses were well run and of a practical nature. At the end of ten years this system was abandoned owing to poor results. The best of the students in many cases decided to engage in paid employment, where they found that they could make more money than they could as farmers. Those who went back to their villages and made a real attempt to farm were looked upon with suspicion by the village leaders and neighbours; in some cases their suspicion was shown by allocating them very poor land or by poisoning their cattle. It is probable however that some form of Farm Institute training will have to be restarted in Buganda for training the sons of wealthy landowners and farmers now that increases in farm prices have enhanced the attractions of farming as an occupation.

Following the virtual failure of the small-holder system of training the Department started giving training to groups of people from one village. Departmental field officers were asked to select villages where the people were keen for special training. Groups of the leaders from these villages have been sent to one of the experiment farms for a week or two to see new systems put into operation. Their local agricultural instructor, the chief, the schoolmaster and other local worthies have gone with them. In other cases special attention has been confined to advice given in the village by normal field staff. Groups of farmers have been encouraged to meet together to discuss their farming methods and sometimes to form small farmers' co-operatives. The results of this group system of education have been much more encouraging than the individual holder approach. Almost all Africans like working in groups and are more afraid of public opinion than the European. The coffee farmers' groups in the Masaka district have been particularly successful. The chief dangers are that the group relies too much upon the initiative of one man, who may die or go away, or that it purchases lorries or other expensive equipment without the technical or managerial ability to run them at a profit.

In recent years the use of farm groups has been supplemented by using the enterprising farmers among them as demonstrators instead of making use of the Departmental experiment farms for this purpose. In Buganda, in particular, it is seldom difficult to persuade a few enterprising farmers to try out a new implement, new seed or a new layout. They need some encouragement in the form of loan of tools, assistance with transport or other means, but they should not normally be paid for doing the experiment. Experience has shown that the ordinary farmer takes little notice of what he sees on an experiment farm, though the latter can be used to awaken interest in new ideas. He takes much more notice of what he sees "Mr. Mukasa" or "Mr. Nsubuga" doing. If the experiment is successful on Mr. Mukasa's farm it can be used as a demonstration for other farmers' groups to visit. In Uganda such farmers are only too keen to show other farmers what they are doing.

At Ajeluk in the Teso district and Nsangi in Buganda the village-group idea was extended. Government placed staff and expended considerable sums of money to make these places model villages. Though they have proved very valuable experimentally, particularly perhaps to show the Department what not to do, they have proved failures as demonstrations. The fact that Government spent much money on them has meant that farmers have assumed that measures adopted entail more capital expenditure or labour than the ordinary man can afford.

Educational Methods of Instructing Native Populations of Africa in the Protection and More Efficient Use of Resources

J. J. DEHEYN

ABSTRACT

For the native populations of central Africa the protection and more efficient use of resources means the improvement of methods of agriculture, stockraising and forestry. To achieve it we must work both on young people and adults. Education through the schools is aimed at the whole population, and particularly at future teachers and those who will later become Government officials responsible for propaganda and educational work among the rural population.

In school syllabuses, ample provision must be made for agricultural training, in which intuitive methods and practical exercises must be used. Some of the latter must be carried out in the field.

Adult education, which cannot be neglected, calls for a large trained native staff to reach the mass of the people. It will take the form of advice, demonstrations and even, if necessary, compulsion. Above all, a special effort must be made to convince the farmers.

The effects of this propaganda must be supplemented by all possible means, including the circulation of pamphlets, press articles and instructional films.

The education of African populations in the protection and more efficient use of resources is in practice confined to agriculture, stockraising and forestry. These are the only activities controlled by natives on a large scale. Whatever the importance of mining or industrial undertakings in Africa, the indigenous population is not responsible for their management, from which it is excluded by the unavoidable need for highly-trained technicians and the large capital invested in those interprises.

On the other hand, a high proportion of agricultural activities is exclusively in the hands of natives.

To instruct natives in the protection and more efficient use of resources, we can work either through the schools or outside them. In practice the two systems are complementary and must be used in combination; in fact the one is inconceivable without the other. Action solely through the schools can hardly have immediate results and is inevitably to some extent confined to more or less theoretical subjects. On the other hand, direct action on people over school age or unable to attend school

[1]Original text: French.

requires well-trained staff, who can only be obtained from educational institutions. It must not be forgotten that any direct approach to the mass of the population is simplified and facilitated if some members of the population have already been introduced to such ideas at school.

IMPORTANCE OF INSTRUCTION IN SCHOOLS

Instruction in schools must therefore be regarded as the basis of the campaign and receive special attention.

From the elementary school up it is essential to stress questions of soil conservation, forestry and game protection, and the proper care of domestic animals.

At this stage instruction is purely educational; it is not intended as vocational training. If young pupils absorb almost unconsciously the main principles of agriculture, they will be ready to adopt these later when they are given methodical instruction in them for vocational purposes.

Even before primary school, in the kindergartens, an attempt is made to create a psychological attitude favourable to such instruction by interesting the children in garden work appropriate to their age.

In the third year of primary school, which in rural districts of the Congo begins at about 12 or 13, a complete course in agriculture and stock-raising is provided. The course is both theoretical and practical. The practical lessons must not be associated with heavy field work but must introduce the children to the concrete aspect of the problem by observation exercises and experiments to demonstrate the theory taught. These various teaching methods in fact form a single process intended to make the child understand what he sees in his environment. A special effort is made to show him the importance of improving certain techniques and the inadequacy of some traditional methods.

The official syllabuses stress that agricultural instruction must from the start bring out the importance of humus in the conservation of soil fertility.

Throughout their school life, boys and girls receive agricultural instruction centred mainly on the study of basic principles—the necessity for humus and methods of conserving it; the prevention of erosion; reforestation and the choice of better species. The instruction must be illustrated at every stage by numerous demonstrations directly connected with the principles taught.

By educating the children one acts on the rising generation, and this is undoubtedly the best means of building a better future; but it cannot be the only one. When the better management of the common heritage is at stake, we cannot afford to wait, and the adults also must be educated. This is a more difficult task, since they are much less plastic material; but the educator cannot confine himself to tasks in which success is easy.

DUTIES AND TRAINING OF TEACHERS

Thus, in addition to the training at school which is required for all, skilled persons must be trained to work on the adult population as a whole. It would be utopian to attempt to work on the whole population without having a sufficient number of agents whose function it is to lead the masses and work on them continuously.

Rural school teachers and native officials of the technical services carrying out propaganda work in tribal areas are the obvious persons for this task of education. They are ideally suited to demonstrate to the inhabitants the value of adopting methods worked out by research stations and by the competent services of the various governments concerned.

The training of teachers deserves the fullest attention, as they have a specially important influence on the whole population among which they live as well as on the children they teach. It is for this reason that agricultural training is highly developed in teachers' training schools in the Belgian Congo. In the Belgian Congo the course in agronomy and stockraising is regarded as a basic course on the same footing as the courses in the vernacular, French, mathematics and educational science. All schools training future primary-school teachers are properly equipped to provide intuitive instruction on both the theoretical and the practical level.

The vocational training of native propagandists is also a vital problem. Without their assistance it would be absolutely impossible for the European technicians to make large-scale major improvements in methods for agriculture and stockraising. The European staff is always too small in numbers to be able to reach all farmers directly. Moreover, the use of intermediaries who are well trained technically and also know the people because they belong to the people is an excellent form of co-operation.

From the early days of European colonization of Africa, use has been made of agents to serve as intermediaries between the technicians and the natives. In the early days these valuable auxiliaries were trained by the agricultural experts, forestry experts and veterinary surgeons whom they assisted. Later this work was undertaken by the stations, which trained natives selected for their keenness but generally illiterate. Later the schools were given the task of training these auxiliaries. The first school of this kind to be established in the Congo dates from 1907; it was attached to the Eala Botanical Garden and Agricultural Testing Station.

TWO TYPES OF SCHOOLS

The number of schools has grown and two different types have become necessary: schools for agricultural, veterinary or forestry assistants and schools for agricultural instructors, veterinary orderlies and wild-life wardens.

It is an interesting fact that the need to establish schools on different levels has been felt everywhere. The schools opened in tropical Africa are of two distinct types. The first are responsible for training officials of high intellectual standing whom we call "assistants" and who are intended gradually to replace the European officials; the others train assistants with less intellectual education, whom we call agricultural instructors, forest rangers or wild-life wardens. The schools of the first type are on the higher technical-education level; those of the second give purely vocational training.

In the Belgian Congo there are now three assistants' schools which have provided 167 students for various government services.

Six other schools of this type will shortly be organized.

In this way the work of the European technicians is backed by native assistants. These assistants are in turn assisted by the instructors, veterinary orderlies and wild-life wardens. There are now 6,653 instructors, orderlies and wild-life wardens in all parts of the Belgian Congo, and an ever-increasing number are being turned out by the agricultural training schools. There are ten of these schools in operation and their number is to be considerably increased; five or six new institutions of this kind will be opened in 1950.

The number of these various auxiliaries (6,820 for two million farmers) makes it possible to launch a mass propaganda campaign to improve agricultural and stock-raising practices and so increase production while at the same time taking the necessary steps for the protection and more efficient use of resources.

METHODS OF AGRICULTURAL INSTRUCTION

It is essential that the agricultural instruction given in all the schools for auxiliaries should be intuitive and backed by numerous practical demonstrations. The students must themselves carry out the various operations they will have subsequently to teach the populations. It is also important that they should go out into the field to see how the problems considered arise in practice and what must be done to find solutions adapted to the situation.

Consideration is now being given to the organization of higher agricultural and veterinary education to train, not propagandists, but assistants for research stations, schools and laboratories. The effect of such education on the more efficient use of natural resources and their protection will be indirect and will make itself felt through the propaganda and education services.

To ensure continued efficiency, it is essential that students trained by the schools should not be left to their own devices for too long. It is of primary importance that graduates of agricultural schools who are required by their duties to live in the "bush" in continual contact with a population which is by tradition, if not by nature, fatalistic, should continue to benefit from time to time from the influence of those who trained them. This can be achieved by regularly sending out tracts and pamphlets.

Nevertheless direct contact through courses and lectures will be more efficient. The Congo educational system provides refresher courses for graduates of agricultural schools. The courses are where possible held in the areas where the propagandists for whom they are intended work. These meet for a few days and attend lectures and demonstrations given by the Government officials under whose orders they work as well as by their former teachers.

During these reunions the instructors find out how well the important points of the school syllabus have been remembered. The students' attention is drawn to points of special topical interest. These courses might be supplemented by lectures by experts on soil conservation and the prevention of erosion.

Courses on these lines for rural school teachers might also have excellent results.

METHODS OF THE AGRICULTURAL PROPAGANDISTS

Having examined the way in which native propagandists are trained, let us see how they can act on the mass of the population.

The principal function of the agricultural assistants and instructors (also called demonstrators or propaganda agents) is to persuade all the farmers in a particular district to adopt the recommended methods. This work is difficult. One must not forget the lack of understanding and absence of interest of the people with whom propagandists have to deal. Moreover, the propagandists sometimes recommend operations not sanctioned by custom; and farmers' universal suspicion of new methods is well known.

The propagandists' work is frequently made possible only by an element of compulsion. This is justified by the aim of preventing impoverishment of the common heritage while improving methods of agriculture, stock-raising or forestry for the exclusive benefit of those who apply them.

The period during which compulsion is used must nevertheless be as short as possible, and one must try to obtain an acceptance arising from reasoned conviction based on reflection, or at least the adoption of methods because they have been tested and become quasi-traditional.

To obtain results, propaganda must be intensive. It is hopeless to try for rapid results by dispersing one's efforts over immense areas. It is for this reason that in the Congo, in addition to the regular activities carried on throughout the territory, certain social groups have been chosen with the complete consent of all their members to be the subject of more intensive action. Every means is used to ensure that all the members of these groups are subjected to continuous propaganda carried out carefully and simultaneously in every field—hygiene, agriculture, organization, education, production and co-operation. It is hoped in this way to secure the rapid development of these groups towards a peasant agriculture—in the form in which it is known by peoples in an advanced stage of civilization—while conserving their own social organization and traditions. These groups, known as *paysannats*, will act as the leaven in the mass, and the standard of living attained by their members will serve as an example and gradually extend over the whole territory.

The educational organization of the Congo also provides for farm schools and practical agricultural instruction centres.

FARM SCHOOLS AND PRACTICAL CENTRES OF AGRICULTURAL INSTRUCTION

The farm-schools are intended to train good farmers by academic methods by providing an apprenticeship for young people from the elementary schools. In practice it is found that only exceptional pupils are capable of benefiting from this type of education. The others become hardly better peasants than those who have not had the training. Unfortunately the farm-school idea neglects native society as a whole and deals only with individuals. The pupils trained by these schools are sooner or later faced by a dilemma: either to follow the principles they have been taught and dissociate themselves from the clan or to integrate themselves with the clan and not adopt the methods they have learnt at schools.

The farm school will not play a really useful part until it deals with a generation whose parents have already been subject to intensive propaganda. This applies to pupils in the *paysannats*.

By "practical centres of agricultural instruction" we mean lecture courses, with demonstrations, organized for farmers. This type of education has no chance of success except in populations which have reached a certain level of development.

Publications, pamphlets and Press articles are excellent adjuncts to a well-planned propaganda campaign but cannot suffice alone, in view of the state of development of the populations of Central Africa.

It is out of the question to hope for far-reaching changes in agricultural and stock-raising techniques by the use of cinema propaganda alone. Nevertheless this method must not be neglected *a priori,* and is best made an adjunct to the whole system of propaganda. The enormous distances between rural centres are not an obstacle to the use of this means of education. In the Congo, the department responsible for propaganda was able in 1948 to organize approximately 1,200 instructional film shows attended by 1,300,000 spectators. Mobile cinema units, two to a province, are now being organized, and will tour the country in order to make better contact with rural communities. There is no need to emphasize the excellent results which may be obtained with well-chosen films in these circumstances.

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Rural Education and Its Influence on the Conservation and Better Use of Natural Resources in Nigeria

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ABSTRACT

The conservation and better use of natural resources in Nigeria are closely related to the problem of rural betterment. This must ultimately be achieved by the efforts of the village people themselves, but it can be fostered by a programme of education designed for rural life. In Nigeria, a Rural Education Branch of the Education Department has been established with this object in view. Its chief work at present has been to give teachers from the primary schools special training in school-farming practice and other rural subjects. By this means it is hoped to impart a "rural idiom" to education in the villages and give practical reality to all the subjects in the school curriculum. Over 500 school farms have already been established, but the extension of this work now depends upon an increase in the staff of the Rural Education Branch and the establishment of more Rural Education Centres. Although the work is primarily concerned with education in the schools, there are signs that its influences can extend beyond the school to the village people. The village school might thus become a village community centre and bring projects for rural betterment down to the village level.

The people who live in villages—the farmers and fishermen, craftsmen and market traders—are the most numerous and the most important section of the population of Nigeria, for it is they who exploit the country's natural resources and are responsible for the production of most of the country's economic wealth. They are the people most in need of an education that will help them to conserve and make better use of their natural resources; on this account it is unfortunate that, of all sections of the community, they should be the most uneducated and the least influenced by new ideas and modern ways. The better educated classes are becoming more and more divorced from the land and estranged to village life. They entertain great hopes for the future of their country and demand that its development shall be largely in their hands. Their hopes cannot be realized, however, if they merely seek the benefits of modern civilization whilst neglecting the interests of the great mass of the peasants and villagers, who are in reality the backbone of the country. Lord Hailey has written:

"The extensive programme of development which has now become the outstanding feature of our Colonial policy has given prominence to many aspects of administration which, though by no means neglected in the past, nevertheless did not seem to make the same claim on our attention as they demand today. The expansion of labour inspectorates, the foundation of universities and technical institutions, the improvement in urban housing and sanitation, the organisation of marketing, the stimulation of secondary industries—all these are now in progress or in active contemplation. It is natural that the public of a highly industrialized country such as ours should view these matters with special interest, and it is all to the good that they should do so. But the increase of primary production still remains the basic problem in any endeavour to improve the general standard of life in the Colonies."(1)[1]

The improvement of village life and the raising of the standard of living of village people is a problem of fundamental importance, the solution of which is both difficult and urgent. In a peasant community, where new ideas do not take root very readily, progress must necessarily be slow and gradual, requiring much constant and patient endeavour on the part of those who are trying to foster it. Moreover, improvements that are to be lasting must come from the efforts of the people themselves; attempts to impose them on the people are likely to end in failure. The use of imported machetes, the development of cocoa planting and the widespread use of cassava are examples in point. These have had marked effects on standards of living in the villages and they were improvements which, though introduced by strangers were spread by local enterprise. The people are ready and willing to adopt new methods when they are convinced of their usefulness and for this reason education might play a major part in rural development by introducing new ideas and demonstrating new methods.

Unfortunately in Nigeria, as in Great Britain itself and in other British territories, traditional education did not bring to the villages the benefits that might have been expected from it; indeed, it has sometimes had adverse effects on village life and village economy. In Nigeria it was early discovered that schooling and a knowledge of English led to wage earning employment in the towns and too often the village school was regarded by parents and teachers alike as merely a means for qualifying their children for work elsewhere, preferably clerical work in a government office or with one of the trading firms. Children were deliberately sent to school to "learn book" and not to "learn work". In this way the villages were often by-passed by education. Children, whose parents could afford to send them to school, sometimes became unfitted for any useful work at home and had to seek employment elsewhere. Thus the life of the village remained untouched by education, whilst the children at school entered a strange environment of desks, books and blackboards.

For some years, both the Education Department and the Christian Mission (which are the voluntary agencies largely responsible for primary and secondary school education in Nigeria) have been fully aware of this unsatisfactory state of affairs. There has also been an increasing recognition of the part that education ought to play in rural betterment. The village schools should be closely associated with the life of the village people and should provide an education adapted to their needs. Instead of an academic or bookish curriculum, the work of the schools might be given reality and life from rural interests and activities. Village education should have a "rural idiom" described by H. M. Burton in the following terms:

[1]Numbers within parentheses refer to items in the bibliography.

"Practical tasks, familiar things, the friendly framework—they sound so easy. The search for them and the wise use of them when found are the rural teacher's constant obsession. Perhaps one of the most attractive aspects of this rural idiom is its variety, matching the infinite variety of rural life itself. There are almost as many projects, methods, adaptations and combinations of the rural idiom as there are teachers using it".(2)

It is evident also that little improvement can be expected from old-fashioned and discredited ideas or from inferior or poorly qualified teachers. Only those teachers with good qualifications, with ability and initiative and with a modern outlook towards education, are likely to be equal to this task.

In 1937 the Directors of the Agriculture and Education Departments in Nigeria appointed an Education Officer, with eight years' teaching experience in government secondary schools and with practical experience and training in agriculture, to take charge of a new scheme, which it was hoped would help to bring this rural idiom into village education. At first the scheme was experimental and limited in scope, but the success it achieved on a small scale gave promise of far-reaching results, if opportunity came for its extension. This has been long delayed by the war and at present three Rural Education Officers and a small African Staff now constitute what has come to be known as the Rural Education Branch of the Education Department.

Up to the present its work has been confined to the provision of special courses for primary school teachers in farming and elementary rural science, the object being to establish school farms in village schools throughout the country. These school farms (as distinct from farm schools) are not intended for the vocational training of farmers or agricultural workers. They are intended for use as a practical background of interesting and purposeful activities for the whole of the school curriculum. A further important consideration is that farming practice on these school farms must be based on sound principles so that soil fertility shall be maintained: otherwise the whole basis of this work would soon be jeopardized.

Before this scheme was started, there had previously been school farms attached to many of the village schools, but they were almost without exception badly managed and were usually regarded by the teachers as a means of raising food crops for their own use at the expense of the children's time and labour. The farm work was unrelated to the general work of the school, which still remained bookish and academic and, after a few years, the exhaustion of the soil by bad farming methods reduced the land to a low state of fertility. From the outset, therefore, school farming was in disrepute both with the children and with their parents.

Without special training, village teachers could hardly be expected to be competent to manage a school farm on scientific lines, or effectively make agriculture and other rural activities an integral part of the school curriculum. Two training centres (now known as Rural Education Centres) were therefore established, one at Ibadan to serve the provinces west of the Niger and one at Umuahia to serve the eastern provinces, and the Missions and Native Administrations were invited to send teachers for training. There was a tendency at first, on the part of some missions, to send only inferior teachers, on the assumption that "any fool could be a farmer", but today it is realized that only the most capable teachers can benefit fully from the courses, or become successful as rural science teachers on their return to the schools.

Each Centre can accommodate up to thirty teachers per year. They stay for the duration of the farming season lasting about eight months. They live in a model village adjacent to their farms and married men are encouraged to bring their wives and children, so that the women-folk may also benefit from instruction at the Centres. During the courses, the teachers receive practical instruction in school-farming methods on their own individual farm plots, which they work themselves. Except in busy seasons (at planting or harvest time), most of the practical work is done in the early mornings from 6:30 to 9:00 a.m. Later in the day, there are classes in agriculture, rural science, hygiene and simple economics. All instruction is built around a framework of practical activities derived from farming and gardening, the management of small livestock, village sanitation, compost making, tree planting, the processing of farm produce and marketing. Similarly, surveying and land planning, farm calculations and book-keeping, form a practical basis for school geography and mathematics. Nature study and hygiene are also based on seasonal work in the farm or village. In many ways links can be made with some form of practical activity for nearly every school subject. Education thus receives new meaning and reality for village life.

On returning to their schools to start this new project, it is only natural that teachers should encounter many difficulties. A few years ago there was a good deal of prejudice against manual work and this prejudice still persists in some areas. Local suspicions or cupidity were an obstacle to the acquisition of suitable land for the school farm. Opposition also came from members of the school staff, or from reactionary headmasters, especially when it was discovered that the school-farm produce was no longer to be their perquisite, but that strict account of its disposal was to be kept. Practical work is also more exacting and requires more careful planning and organization than teaching merely from a book. The "follow-up work" has therefore been an essential part of the work of the Rural Education Branch and now that over 500 school farms have been established, some of them in remote places and widely scattered, a great deal of travelling on the part of the Rural Education Officers and their assistants is involved. New farm plots must be planned and measured out and a suitable crop rotation suggested. The school time-table may need to be rearranged and headmasters, supervisors and school managers may have to be interviewed so that the new work can be explained and difficulties and misunderstandings removed. Whenever new school farms are started, the plans are submitted to the Department of Agriculture for approval, and indeed the success of the scheme has been largely due to the co-operation of the officers of the two Departments. Provincial Agricultural Officers as well as the Provincial Education Officers periodically visit and inspect the work of the rural science teachers, and copies of all comments and advice recorded in the school visitor's book are sent back to the Rural Education Officer. This enables a complete record of progress to be kept and conflicting advice is also avoided. Thus the programme of work laid down for each of the "approved school farms", as they are called, is understood and carried out by all concerned.

With so many school farms widely scattered over the southern provinces, it has become increasingly difficult, with such a limited staff, to carry out this follow-up work. Last year, and also in 1944 and in 1946, the course at Ibadan had to be suspended and this year at Umuahia a series of refresher courses has been substituted for the normal course, to avoid any further increase in the number of approved school farms. Until more staff is available, a policy of consolidation rather than expansion must be adopted. It is hoped, however, that before long it will be possible to establish more Rural Education Centres: one for the Cameroons, another in Warri Province to serve the creek areas and possibly one or two more in the northern provinces. This will depend upon how soon more senior service staff will be forthcoming. Two members of the African staff are now in the United Kingdom taking university courses with a view to appointment to senior service posts on their return; many more are needed. The qualifications required for a Rural Education Officer must include practical experience in farming or gardening with a university training in agriculture or some related subject and experience in teaching, or a willingness to undertake it. Unfortunately, agriculturists who have an inclination for teaching and education are not easy to find, whilst educationists are often unqualified in agriculture or rural subjects.

When new Centres have been established, a considerable expansion of the work will become possible, as well as closer supervision of existing work. Every school farm is a potential Young Farmers' Club and it is hoped that the organization of young farmers' clubs will become an important feature of the work of the Rural Education Branch. Much remains to be done to integrate more effectively practical activities with the ordinary subjects of the school curriculum. This requires constant thought and planning and the preparation of handbooks and other aids for teachers.

It may be asked in what directions this work in the schools can help the adult population of the villages. The work of the primary schools is not intended for vocational training, either in farming or in any other profession. It is considered that education based on the children's natural environment and growing out of the life and activities of the village is a fitting foundation for work of any kind either at home or abroad. It might be described as "education for life". Many children on leaving school should be able to find opportunities for useful work at home and indeed it may well be that those with the most initiative and ability will be the ones who will choose to do this. A good foundation will also have been laid for vocational training at a later stage, or for further education in a secondary school. This is looking far ahead and results in this direction can hardly be assessed at present, but it has already been found that, when the school farm is well managed and the rural science teacher is capable and enthusiastic, the children also become keenly interested in this work.

More immediate results can be noticed in the attitude of the village people towards the school. In some places the school farm has become a centre of interest and local farmers have come to the teacher in charge for advice about their own farming problems. In places where land considered unsuitable for farming was given to the school, the people have been surprised to see better crops growing on the school farm than on their own. In the eastern provinces, where the maintenance of soil fertility is one of the greatest problems, people are beginning to realize the value of manure and, after seeing the method of making compost on the school farm, are beginning to conserve their own waste materials. It may be only here and there that such effects are seen, but they are a promise of more important advances in the future if this work in the schools can be given greater emphasis. The great problem has always been how to bring new ideas and methods into the villages; the village schools might well develop into community centres and become the spear-head for projects that Government Departments and other agencies are trying to promote at village level.

Co-operative enterprise, new methods and programmes in agriculture and forestry, better health, improved diets and feeding habits and many other urgently needed developments might gain increased momentum from education designed for rural life. To expect the village school to be the focus of this education may appear to some to be impracticable; no doubt it is an ambitious programme for the schools, but its success might go far towards creating an indigenous rural culture that would in itself improve the quality of life in the villages. This has been the way of approach to rural betterment in other countries, notably in Denmark, and given sufficient staff and financial support, it might in the long run be equally successful in Nigeria.

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Importance of the Study of Agricultural Industries in an Instructional Programme Dealing with the Conservation and More Efficient Use of Natural Resources[1]

JEAN KEILLING

ABSTRACT

I. ***Agricultural industries are directly concerned with the conservation and more efficient use of natural resources:***

For such industries the problem is to ensure long-term operation and continued returns.

II. ***What action can be taken by agricultural industries with this objective in view?***

Before factory processing: by intensifying production through the promotion of better agricultural techniques so as to increase total yield per unit.

After factory processing: by utilizing or processing by-products in a rational manner.

In this field they have the advantage of being jointly interested with the farmers.

III. ***With regard to instruction on the conservation of natural resources, agricultural industries can participate in two ways:***

In the economic field: competitions and comparisons between farmers.

In the technical field: agricultural experts from the factory.

They have the necessary means for action.

Their interests should coincide with the general interest.

I. AGRICULTURAL INDUSTRIES ARE DIRECTLY CONCERNED WITH THE CONSERVATION AND MORE EFFICIENT USE OF NATURAL RESOURCES

For these industries the problem is to ensure long-term operation and continued returns.

An analogy can be drawn between mining industries and agricultural industries. The latter may be considered as exploiting, through the agency of farmers, the *fertility lode* within the area from which their supplies are derived.

In this respect agricultural industries can operate, either like a mining concern which moves on and leaves its fixed plant after exhausting the lode, or by maintaining, restoring or improving the fertility reserves of the soil by which they are fed.

In the first case the agricultural industries have to employ light equipment which is inexpensive and easy to operate and are consequently unable to settle in one place. As a result the technical work done is superficial and, very frequently, the land is exhausted and the rural economy on which agricultural industry is based declines.

In the second case the problem for the agricultural factories is how to induce farmers to achieve, both technically and economically, a balanced exploitation of the fertility of the soil, and to organize such exploitation on a permanent basis. In this case the *main object is the continuity and the intensity of cultivation:* industry creates and maintains the fertility of any given agricultural area to the same extent as it exploits it. Its prosperity goes hand in hand with the prosperity of the farmers and with the fertility of their soil. There is, obviously, a

[1]Original text: French.

common interest linking industrialists and agriculturalists as such, and this will ultimately lead to better use being made of natural resources, especially of the soil.

As soon as the idea of long-term operation is recognized as the predominant preoccupation of those in control of agricultural industries, permanent factories will be erected, their plans drawn up and all their dealings with the outside will be based on this consideration. For example, as regards the water which they utilize and pollute, it is obvious that their attitude would differ, in this instance, from what it would be if they had to move to another location after a few years. This is even more generally the case as regards all the waste-matter produced by agricultural industries.

When, strictly from the point of view of the immediate remunerativeness of agricultural industries, consideration is given to the various aspects of this problem, it will be seen that the opposition between the two tendencies can be, and very often is, a serious problem. On the one hand, inexpensive and flimsy buildings are replaced by larger and better-built factories, whilst on the other hand an increase in the size of the area from which the factory derives its supplies results in heavier transportation costs on the raw materials.

Actually, to obtain the best results from the fertility of the soil, farmers must refrain from cultivating only one type of crop; they must practice crop rotation on the same area so that the produce supplied to the factory is, for example, repeated only every three or four years. In the case of tree planting, the area must be replanted piecemeal; in this instance systematic replanting is most important to ensure regular supplies for agricultural industries.

Whether it be a question of the cultivation of annual crops or of trees which are planted at longer or shorter intervals, a factory operated strictly for extractive purposes is, obviously and as the figures will show, more profitable than a factory which concentrates on prolonging its own existence. This situation is very similar to that of timber concerns which also have to find a compromise between a policy of exploiting the forests up to the hilt and a policy of maximum prolongation of their life. The results of the necessary and desirable compromise between the two tendencies are not necessarily those which are the most beneficial, at any given moment, either to the agricultural industries or to the farmers themselves.

In so far as these two considerations can be permanently reconciled the position of an agricultural system, which supports and enables an agricultural industry to thrive just as much as the latter supports it, may be made very stable.

If an example were needed to illustrate this statement, one might well cite the sugar beet industry in northern Europe and the continuing prosperity which, since its inception, it has given the farmers in this region who, in the past century, have made steady progress.

It is not our intention to try to determine how the interests of farmers and industrial interests should be mutually adapted for the common benefit of farms and factories. However, it must be pointed out that there exists, "de facto" if not "de jure", an *economic combination "farms + factories"* which may, following the two hypotheses mentioned above, either continue over a long period and promote prosperity, fertility and population and thus help to maintain and make a rational use of natural resources, or it may last for a few years only and thereafter find that its dissolution is accompanied by a diminution of the wealth of the agricultural area in question.

II. WHAT ACTION SHOULD BE TAKEN BY AGRICULTURAL INDUSTRIES TO CONSERVE NATURAL WEALTH?

Agricultural industries may exert an influence on the conditions and trend of production either by their policy regarding the raw materials supplied to them, or by their policy regarding the by-products which they return to the soil, directly or through the farms themselves.

With regard to the produce itself, the factories lay down certain requirements as to the quantity and quality of the produce they receive, process and refine. To satisfy these requirements, which depend both on the aims of and the techniques peculiar to the industry, the factories find themselves obliged to help and advise the farmers both on how to increase their output, and how to improve or maintain its quality.

Whatever form their action takes, it always has a serious effect, since it carries the economic sanction of payment for the supplies furnished to the factory by the farms. Therefore it must be given lengthy consideration since the results, both long- and short-term, may be far-reaching. Allowance must always be made for the apparent opposition between the effort to realize a high temporary yield and the necessity, at least for the stationary farmer, of not ruining the soil of his farm.

In this matter those in control of agricultural industries bear heavy responsibilities.

As regards the restitution or disposal of industrial by-products, the problem has two aspects:

In the case of polluted water, unless precautions are taken and unless they are previously purified, the disposal of such water may endanger the biological value of rivers and the purity of drinking water. As regards the actual by-products, waste matter which is useless to the factory but can still be utilized for agricultural purposes, it is important that they should be properly processed and fairly distributed among the farms which produced them. If they are given careless treatment, they will share in the deterioration of bacteriological conditions in the locality, and their unequal distribution would inevitably result in fertility and abundance being transferred from one section to another within the area from which the factories derive their supplies. In this matter the factory would be following the example of big urban centres of population whose organic waste matter enriches the outlying countryside at the expense of distant producer countries.

Consequently, there are two lines of action which can be taken by agricultural factories:

(1) Direct action with regard to the disposal and subsequent use of polluted water;

(2) Indirect action, with regard both to products and by-products, taken through the farmers themselves.

It is more especially through such indirect action that agricultural industries can take their place and play a not insignificant role in imparting instruction about the conservation and more efficient use of natural resources.

III. THE ROLE OF AGRICULTURAL INDUSTRIES IN AN INSTRUCTIONAL PROGRAMME DEALING WITH THE CONSERVATION AND MORE EFFICIENT USE OF NATURAL RESOURCES

Agricultural industries can participate in both the preparation and the implementation of an instructional programme dealing with natural resources.

Because of all the factors previously mentioned, the preparation of a programme should be given serious consideration both by agricultural industries and by public authorities. In the interest of the economic stability of the former, the instruction and advice given to the farmers should be directed towards maintaining the agricultural scheme, towards the conservation of the existing soil, preventing its erosion and preserving its fertility, and farming methods should take account of these considerations as they affect both private persons and the general public. Agricultural industries can, at the same time, arrange for the inclusion in the educational and instructional programmes of the essential technical knowledge which helps their operations as well as their economic and technical relations with the producers, thus ensuring, indirectly, greater stability for the combination "farms + factories". Consequently, an effort must be made to strike an equitable balance between the various interests at stake: the farmers' interests, the factory's interests and the interests of the community.

Factories can co-operate in the implementation of the programmes in two different ways: (*a*) comparative and economic; (*b*) technical.

(*a*) Through their produce and through the factory where it is processed the various farms can, with an instructional objective in view, be made to compete with one another in exhibitions and competitions which would give prominence to those which are managed best from the point of view of qualitative or quantitative production. When such exhibitions, which have a great educational value, are held, stress should always be laid on results which promote the maintenance and improvement of conditions which will prolong the fertility of the soil cultivated. It would not be enough and it would even be unwise if such comparisons were to result in the emergence of farmers who beat the record for quick crops. It would be better to instil the precept of sustained longevity and fertility.

(*b*) The technical aspect of this co-operation is even more important and should be more effective. Every agricultural factory can, by making use of its financial and material resources and its scientific equipment, encourage and give effect to the idea of sending out an *agricultural expert from the factory.* He would be a link between the factory and the farms and could advise farmers on factory and technical requirements. The agricultural expert from the factory would counsel farmers so that their supplies, both as regards quantity and quality, would be used in the proper way.

While this action, if directed in the right way, can be advantageous to both sides of the combination "farms + factories", it might, if taken only with a view to obtaining an immediate maximum yield and reaping a quick profit, endanger the longevity of the combine and be detrimental to the general interest.

Hence, agricultural industries should be financially and technically associated in implementing this programme, to the extent that their directors agree to bear in mind both the general interests involved and their common interest with the farmers. With this reservation the various permanent technical resources and human elements represented by the network of agricultural industries existing on the land could be employed to greater advantage and on a wider scale.

Resource Techniques for Less-Developed Countries: A Symposium

Thursday Afternoon, 1 September 1949

Chairman:

Hernán SANTA CRUZ, Permanent Representative of Chile to the United Nations

Discussion Leader:

S. S. BHATNAGAR, F.R.S., Secretary to the Government of India, Department of Scientific Research

Discussion:

Messrs. RHOAD, CLAY, REYNA-DROUET, Sir Harold HARTLEY, CARABAÑO, Mrs. PINCHOT, Messrs. E. DE VRIES, U. BERGMANN, OROZCO, VAN TASSEL

Programme Director:

Carter GOODRICH

Programme Officer:

Alfred J. VAN TASSEL

The CHAIRMAN:[a] It is a great honour for me to have been asked to preside over one of the plenary meetings of the United Nations Scientific Conference on the Conservation and Utilization of Resources. The Conference has brought together an outstanding group of technical experts and scientists from scores of countries and its discussions have been held under the Chairmanship of persons of high renown in the world of science and politics.

It also gives me great satisfaction to be among you at your work, because it signifies the realization of an idea in the development of which it fell to me to share, as Chilean representative on the Economic and Social Council, at six sessions. And my country from the outset gave its firm support to this lofty plan.

The subject of discussion at the present meeting is "Resource Techniques for Less-Developed Countries". It was natural that this subject should figure in the Conference agenda. In a letter to the late Mr. John S. Winant, then United States representative on the Economic and Social Council, President Truman suggested that he should propose to the Council the calling of such a conference and made the following important statement: "It is my hope that such a scientific conference would bring together all the new techniques of resource conservation and utilization, particularly for the benefit of under-developed areas, since the problems of these areas represent the hopes of millions of people for freedom from starvation and for opportunity in life".

The economically under-developed nations are the ones in greatest need of technical advances in order that their national effort should yield the best results. Hence the great importance of this Conference, planned by the United Nations, and of the inclusion in its agenda of the item with which we are now concerned.

For a long time it was thought by some that the division of labour should be planned on a world scale. According to this economic theory, balanced prosperity would only be obtained by dividing countries into highly industrialized countries, producers of raw materials and agricultural countries.

The putting into effect of this idea in the technical field presents us with a world divided into two parts: on the one side an industrial and manufacturing minority whose national effort realizes a higher yield and, on the other, a large majority who lack the technical improvements and whose production capacity is socially and historically backward.

It should be remembered that any discussion on techniques has its vital human side. Any progress achieved in technique will have positive repercussions on the main objective of the United Nations, namely to ensure peace by continuously improving the standard of living of the peoples.

We might also define technique as the sum of socially utilizable knowledge at a given moment in the history of production. From that point of view, human achievement is multiplied by applying to production methods the standard of scientific knowledge existing in society at a given time. It is the progress of science which animates the productive process, and behind each advance lies the common heritage of human culture. There is nothing which belongs more properly to the international collectivity than scientific knowledge. Consequently, in spite of the secrets which a commercial structure imposes on the dissemination of technical discoveries, there exists the moral duty to give back to mankind what originally belonged to it.

If we analyse the history of technical development in relation to the industrial countries, from the building of the first loom in England to the surprising transformations of matter in contemporary chemistry, we are led to the conclusion that man's creative faculties have been applied mainly to the production of goods. The benefits have been expressed in quantity and quality. Man's productivity has been multiplied and his output raised infinitely higher by the exhaustive use of every type of fuel and means of power production. But at the same time there has been a constant discovery of new types of production, and therein lies the creative part of the process.

Greater physical quantities of goods have not led to appreciable reductions in price levels. The potential reductions in prices have been absorbed by higher salaries, by the reduction of working hours and the financing of social benefits. Technical development has enabled the national effort in those countries to obtain the highest advantage and has raised the workers' standard of welfare.

It is in the light of that dual aspect of the benefits of technical development that the social and human problem which is our deep concern should be examined.

Things have worked out differently in the under-developed countries, which include those of Latin America. No country can avoid the historical epoch in which it is destined to live. The Central and South American nations, like many others, achieved their independence in the era called the Century of the Technical Revolution. However, most of the benefits that century afforded were obtained through consumption and not production. The technical progress of the twentieth century had to come as an "import" to those countries, whose present standard of living is only understandable in terms of the nineteenth century.

Such is the problem faced by these countries and areas and it has been the main preoccupation of many of us who have striven in the national and the international fields to bring about a radical change in this state of affairs. These peoples want to live the life of the age to which they belong and to shake off a past which still conditions their present collective existence, imprisoned in its backward economic structure. Great progress has been made, but it is entirely inadequate. There is evidence of much effort to make good use of the natural agricultural resources, especially for food production. International co-operation has been active in this task and there is much ground for satisfaction, for nothing is more urgent than to satisfy this primary human need.

But the problem of which I wish to speak is a different one. In the main fields of production, the techniques which come to these countries express themselves in terms of quantity, not quality. The extraction of minerals and other raw materials has increased; foreign capital abounds and is very ready to promote this increase. The latest technological resources are used to increase the tonnage extracted and sometimes proper attention is not paid to safeguarding the reserves, in other words to the conservation of resources, one of the

[a]The Chairman spoke in Spanish.

main aims of the present Conference. And the real crux of the problem is that the techniques stop at that point. The under-developed countries, the possessors of these rich and abundant raw materials which are extracted with all the help of technical progress, have not the benefit of all the latest processes of transformation. The mining countries, for instance, do not receive equally effective assistance in the concentration, smelting, refining, rolling and manufacture of their minerals. I must confess, however, that international co-operation has begun to make its mark in this respect and Chile, for instance, has obtained the help of international and government credit institutions to develop her steel industry. But, generally speaking, all the technical processes which would affect the standard of living of the peoples of the under-developed regions do not reach those peoples and the share of prosperity which should legitimately be theirs is "exported" to other countries, without fair compensation. Consequently, this partial, limited introduction of the latest scientific processes endlessly prolongs the existence of an unacceptable standard of living in the under-developed countries. Moreover, whilst in the highly industrialized countries advantage is taken of the lower cost of production to raise the population's level of consumption, in the economically weak countries just and legitimate aspirations towards a better standard of living are often shattered on account of world prices, in the fixing of which the producing country has no part or influence. This may seem an aspect of the matter somewhat remote from the subject of this Conference but it must be kept in mind if we are to avoid being led astray by the mirage of technique for technique's sake; if we are to succeed in regarding technical progress in the light of its real ultimate purpose: the material, spiritual and moral progress of the human being. If the recent history of rubber, tin, copper, cacao, or other raw materials were written, it would reveal that technical progress in extracting or producing them is not the sole determinant of the welfare or progress of the countries from which they come. With the aid of the latest technical devices in the world, a copper-producing country, for instance, must export in 1949 550,000 tons of copper in order to be able to purchase abroad the quantity of goods (sometimes essential for its livelihood) which it bought in 1948 with 400,000 tons.

For all these reasons I think that international concern should concentrate on enabling the under-developed countries to benefit from those technical advantages which will serve to put a higher value on the work of those countries, and on enabling their peoples to obtain the greatest possible advantage from man's labour. Those countries are interested in obtaining qualitative as well as quantitative returns. They want techniques to be of assistance not only in extracting the products of the earth but also in transforming and working them up in their own countries. They want technical processes to be the principal element in the defence of their natural resources, not a factor in exhausting those resources.

I am confident that international co-operation will proceed along the lines which I have indicated.

Moreover, the bold initiative shown by President Truman in Point Four of his programme is based on these principles. His words have been clearly explained in that sense and only a few days ago his representative on the Economic and Social Council endorsed them in a speech to that great international body.

I have just mentioned the proposal of the President of the United States to promote the economic development of the under-developed areas and countries. I think it may be of interest to refer briefly to what the United Nations is doing just now to give effect to one of the main items of that proposal, namely international aid to bring modern technical developments to the under-developed countries in order to enable them to make better use of their natural resources.

It has been my function to attend and take part in the interesting discussions held during the last six weeks in the Economic and Social Council on problems related to the economic development of the under-developed countries. Taking as a basis the studies and work done both separately and jointly by the United Nations Secretary-General and the administrations of the ILO, FAO, WHO, UNESCO and the ICAO, the Economic and Social Council has drawn up its vast co-operative programme of technical aid for economic development. This programme must be approved by the General Assembly before it can be put into effect. I do not doubt that it will be approved because in my opinion the Council has risen to a level of responsibility commensurate with the breadth and quality of the proposal of the President of the United States, which has inspired their task.

Suitable machinery has been set up to guide, co-ordinate and supervise the programmes to be carried out by each of the organs and agencies in respect of their various activities: education, agriculture, health, industry, labour, etc.

An equitable distribution of the funds to be obtained during the first year has been made amongst these organs and agencies, after careful study of their programmes, keeping in mind the possibilities of putting them immediately into effect and the greater or lesser urgency of certain work. Guiding principles have been laid down for which both the agencies and the governments asking and receiving technical assistance must have due regard. And of these principles stress must be laid on those relating to the question to which I referred at the beginning of my speech, namely, that the primary purpose of any economic development, and therefore of any measure tending to encourage it, is an increase in the productivity of natural and human resources, with the purpose of contributing to the establishment of higher standards of living for the whole population.

The Economic and Social Council and the specialized agencies hope that a programme so carefully prepared will meet with an enthusiastic reception from most Members of the United Nations and of the specialized agencies, and that voluntary contributions from them, either in cash or material services, will reach a total sum of about 30 million dollars during the first year.

For my part, I think that this hope is well founded. I also believe that in the future this sum will grow to unexpected proportions. There are certain great ideas which have a dynamic force of their own, giving them a strength and a truth which carry them far beyond the limits within which they were originally conceived. This idea is something of that kind, and it will find a ready acceptance in the minds of members of governments and peoples; it will also be a forerunner of other forms of international co-operation in developing and encouraging economic progress in regions which have not yet attained an advanced stage of development.

I have ventured to speak these words before declaring the meeting open. Although I am speaking before you purely as a private individual and not as the representative of any country or organization, I have not been able to forget that I am member of an international body whose task it is to achieve economic development, by promoting the spread of technical knowledge and making it accessible to under-developed regions.

Nor have I been able to forget that I am a citizen of a country engaged in a bitter struggle to transform its economic structure and thereby to improve the standards of living of its population, and I have thought it necessary to differentiate between the conditions of technique in one type of country and another. When doing this I remember the words of President Roosevelt: "This generation has a rendezvous with destiny." As we set to work and devote our efforts in the interests of countries which are economically weak, let us not forget that this rendezvous with destiny is also a summons to make it possible that some day all peoples of the earth may be able to live through history on equal terms.

The first statement this afternoon, and that which will guide our discussion, will be made by Dr. Bhatnagar. Dr. Bhatnagar is one of the most outstanding scientists in India. He is at the same time a Professor and Secretary of the Government of India, a member of the Department of Scientific Research and Director of the Institute of Scientific Industrial Research.

Dr. BHATNAGAR: The title of the discussion assigned to me makes me feel that perhaps I am not quite a suitable choice. First of all, I am not a believer in the view that the resource techniques in developed and in undeveloped countries can be different in essential principles for any very great length of time. Secondly, India occupies the fifth or sixth position in the industrially developed nations of the world, and as such she cannot be regarded as undeveloped in every respect. In fact, no country is "less-developed" in everything, and President Truman, in his great wisdom, has used—whenever he has written or spoken of the subject—the expression "less-developed regions" or "areas" rather than "less-developed countries". For it must be admitted that even in the most developed countries there can be regions which are comparatively less developed.

Just like liberty itself, knowledge and the latest resource techniques should be available to undeveloped countries. I have not the slightest doubt in my mind that the United States and the United Nations would like to see the torch of knowledge and resource technique burning clear and strong, until the whole world is illuminated and obtains the benefits and advantages of this knowledge. The following significant lines inscribed upon the base of the Statue of Liberty, indicate the American purpose of life to any foreigner: "Give me your tired, your poor, your huddled masses yearning to be free, the wretched refuse of your teeming shore. Send these, the homeless, tempest-tossed, to me: I lift my lamp beside the golden door." I have no doubt that not only liberty but knowledge, which is an essential ingredient for world peace, will be made fully available in each and every nation under the sun. It is, however, obvious that certain resource techniques may be of special interest to undeveloped regions and they may be of less interest to fully industrialized countries.

For example, agriculture is comparatively speaking a minor industry in many industrialized countries. On the other hand, it is the major and in some cases the only industry in the less-developed countries which have very often also the biggest density of population. The conservation and utilization of land and water resources of such countries are of the utmost importance to them.

I shall naturally report on the history of resource development of India. India's prosperity has depended in the past on its agricultural operations. That is why India gave early attention to her irrigation system. India has 22 big barrages, nearly three-quarters of a mile in length, which have been constructed across rivers, carrying water volumes of 300,000 to 2 million cubic feet per second. The length of the main canal and branches comes to about 100,000 miles, the width of some of these canals being more than 200 feet. There are some 1,800 smaller barrages and other important hydraulic structures such as aquaducts and syphons. Nearly 200 dams in earth and masonry, not exceeding 230 feet in height, have been constructed, while the number of tanks and wells for irrigation purposes runs into hundreds of thousands.

Faced with the problem of building these engineering works in sandy beds and without any solid rock for foundation, India successfully developed and perfected the theory of construction of weirs in sandy foundations. India also developed a successful theory of the transportation of silt from its large rivers into canals as affecting the design of carrying canals and this has prevented these canals from being choked up. All this was good work and the technique adopted was of great benefit and immense profit to farmers, as only the minimum machinery was used and only human and animal labours were employed in the building of these inspiring structures. A resource technique based on the technology of undeveloped countries was employed, but it has to be modified now in the light of modern knowledge. The primeval flow in the streams has now been used up and all future schemes have to be based on the storage of water available during the rainy season, which up to now has gone to waste in the sea. Plenty of water for that purpose is available, and suitable sites also exist, but most of these will involve the construction of high dams as developed in some of the most advanced countries of the world and the old techniques will have to give place to modern methods as used in the most advanced countries.

This state of affairs was reached in the United States much earlier than in India, as only few streams in the United States are fed by glaciers and carry large primeval flow as opposed to the rivers of India which mostly rise in the Himalayas. Thus, though, India had a much earlier start on the diversion and canal system, the United States had to develop the technique of design and construction of high dams. Special construction machinery had to be developed partly because of the shortage of labour, partly because it was physically impossible to construct some of these items by hand. It is therefore obvious that no under-developed region can afford to ignore the experience gained by workers in the more developed regions.

I shall give as an example the construction of a 780-feet-high dam on the Kosi River. This will be the highest in the world. The site is in an earthquake area.

The river carries a high percentage of silt. Both the technique of design and construction would follow the experience gained on the Boulder dam. The construction involves 10 million cubic yards of concrete placing, and 5 million cubic yards of rock handling in a narrow and inaccessible locality. If attempted by the old methods of manual labour, not only would that work take perhaps more than a hundred years, but it might never be completed. It has therefore been imperative for India to adopt a technique altogether different from the one she employed in the past. Similarly, on the construction of high earth dams we cannot ignore the development of constructional equipment, particularly equipment for transporting, spreading and consolidating the earth. Our past experience was limited to about 100 feet of height, while earth dams are now being attempted to a height of 400 feet or so.

It may be dangerous, however, to transplant any particular construction technique, without precaution, from one country to another—particularly from a highly industrialized country to another where hand labour is cheap and plentiful. The new technique must be adapted to the education of the labour force and the relative importance of manual labour and machinery in construction work. The use of local materials such as lime in place of cement may require consideration. Shortages of iron may necessitate the use of wooden poles. Most of the sites where hydro-power can be generated are located in the Himalayas. This will involve abnormally long transmission lines for the conveyance of large blocks of electric energy to regions where it could be used. As it will become an item of very high cost in the scheme, special research will be justified to economize the cost of transmission by the use of local materials for the manufacture of insulators and other items of construction. In a developed region this may be accomplished by referring the problem of materials to an already established firm.

Among subjects of especial interest for the less-developed regions may be mentioned the following:

1. Training and acquisition of technical personnel.

2. Procurement of literature, equipment and machinery.

3. Establishment of channels which will enable foreign and indigenous capital to flow into less-developed countries without the importation of conditions which may be considered humiliating by nations wanting this help. The United Nations can direct the financial agencies to solve these intricate problems in an honourable manner.

4. The application of knowledge which already exists in order to improve the raw materials, local facilities, resources and techniques which are indigenous in less-developed regions. It must be remembered that the people honour the services of those who do not constantly ape the techniques developed in other countries, but try to improve the already existing techniques to such an extent as to produce the best possible results.

5. Progressive measures in the legal and political fields. Without this it is possible to stifle any technical or scientific activity on purely emotional grounds.

Sometimes in the less-developed regions spectacular technical developments so capture the imagination of the administrators and laymen that any systematic work, without which planned progress is impossible, is relegated to a minor position. Quoting from the experience of those entrusted with the agricultural development of our country, it is well known that the introduction of a new variety of sugar cane with better yields of sugar, or the introduction of a wheat or cereal more resistant to frost or heat, gets much closer attention from laymen than the more systematic but less spectacular work, such as soil surveys, which may be considered a luxury and a waste of money.

It should be the duty of those in authority to realize that much larger benefits are likely to accrue if their countries have useful and reliable inventories of their resources which are further classified in suitable categories according to their innate possibilities of improvement, or of saving them from damage or loss. It is thus necessary to have broad soil surveys of the reconnaissance type, utilizing all the dependable information already available, even from empirical sources. Hydrological surveys of the surface water resources, and whenever possible, of underground sources, and of drainage conditions, should also be simultaneously considered on a broad basis. Materials and machines required for the engineering techniques to be used for soil conservation will have to be purchased from outside. Local centers for the scientific study of the problems and methods for training men will have to be developed. Help from regions more developed than ourselves would be welcome.

The economic and social aspects also deserve consideration. Conservation and utilization of vegetable and animal refuse should be organized to the fullest extent, so that organic manures may be produced. Synthetic fertilizers will also have to be used, as in the more advanced countries.

Techniques for developing fishing resources in undeveloped areas have a very significant purpose. Fish is an excellent food and can be produced and multiplied at comparatively little cost. The marine fisheries of the countries in the higher latitude of the northern hemisphere are fairly well developed, but here also much further increase is possible, mostly from the herring, cod and haddock fisheries. In the tropical and subtropical waters, where the fish populations are less dense, pelagic fisheries offer the best opportunity. It has been estimated by Dr. Harold Thompson of Australia that a 20 per cent increase over the pre-war yield is probable, of which two-thirds might be expected from cold and temperate waters and one-third from tropical and subtropical waters. According to some others, more than a 20 per cent increase is easily possible. In warmer waters there is great need for sustained exploration to reveal the presence and size of fish stocks. In such works international co-operation is essential for efficiency and speed in accomplishment. For instance, India, Pakistan and Burma could combine for an investigation of the fishery resources of the Bay of Bengal. Similarly, other parts of the Indian and Pacific Oceans could be worked out jointly by the countries bordering on them. FAO is already planning to set up such international units for the development of fisheries, and one such unit, the Indo-Pacific Fisheries Council, has already been established for South-East Asia and Australia with its offices at Bangkok.

The old exploratory methods with steam vessels were slow, but now it is possible to locate the shoals of pelagic fishes through serial surveys, and of midwater fishes through the more modern technique of echo-ranging and echo-sounding devices. In warmer seas, more powered craft and refrigeration facilities are essential for any large-scale development. Technical advice on conservation and processing is necessary. The provision of harbours, cold storage and quick transport facilities are also desirable.

Fresh-water fishery resources of the tropical countries are vast and in managed pond-culture lie great possibilities of future development. Fortunately, the empirical practices in China and India enable as much as 4,000 pounds of fish to be raised annually from an acre of pond area. But these practices require review and standardization. Experiments on the cultural possibilities of the indigenous species of undeveloped areas should first be carried out before the introduction of exotic species is considered. Associations of fish will have to be determined according to their breeding and feeding habits. The problems of stocking ponds, fertilizing and harvesting them, need investigation so as to get maximum production.

Of no less interest is the mineral kingdom. In the modern exploration of minerals several new techniques are available for use. Of these the most important is applied geophysics. Gravitational, seismic, magnetic, electric and other methods have proved their utility in the field of prospecting for hidden mineral deposits. During the last few years a geophysical section has been constituted as part of the Geological Survey Organization of India while the seismic and gravitational methods have been used for over fifteen years by the oil companies operating in India. Similar explorations will be needed in other undeveloped countries.

The development of atomic energy requires mineral raw materials, for example, minerals of uranium, thorium and beryllium. In the search for the first two, gamma-ray and beta-ray counters are proving of great help. A rare-mineral unit is now functioning under the Atomic Energy Commission and Geiger counters have been constructed and used in India during the past year or two. The appraisal of reserves of various useful minerals requires that the known deposits should be proved by drilling. Arrangements are now being made for the acquisition of drills and for training personnel in drilling techniques both for petroleum and for other minerals. India is prepared to have full facilities for oil firms to export oil on reasonable terms. This is a field in which most undeveloped countries will have to seek the aid of foreign firms.

The enforcement of a programme of conservation requires the adoption of scientific and systematic mining methods and the elimination of waste at various stages in mining, handling and transport of minerals. Low-grade and some marginal deposits have to be mined and brought to the surface and made fit for use by the utilization of various processes of mineral beneficiation, such as tabling, flotation and the use of heavy media, electrostatic and electromagnetic operations, etc. And for the utilization of minerals in industry, research—both fundamental and applied—has to be undertaken.

To achieve all these ends, India has now embarked on a programme of expansion of her geological survey so that by 1952 we shall have a personnel of some 250 geologists and geophysicists; a Bureau of Mines has been set up, whose functions will include the improvement of mining, mineral beneficiation, organization of mineral industrial statistics to serve modern needs, and research on the utilization of minerals. The equipment of these organizations with modern tools for exploration and research as well as the training of personnel for manning them adequately are part of our programme. I would now like to turn to the subject of scientific and industrial research.

There is no field in which modern knowledge, acquired in the hard way, is more important than in industry. While in the modelling of an industrialized country the scientist, the layman and the capitalist or the state may retain features which are determinable by regional considerations, no industry can be successful unless it employs the most up-to-date techniques. In the less-developed regions industrial expansion is possible only if the system of transport and communication is efficient and modern. During the last war India sent out large quantities of engines, railtracks and wagons to the Middle East. After the war, industrial products and food transportation suffered heavily because of shortages. In order to replenish their depleted stocks and for building an efficient transport system, India has just received a loan from the World Bank and one can expect increased production in India as soon as her transport system improves.

Fuel and energy also occupy a very prominent position. Perhaps the next in importance are building materials, such as steel, cement, wood and concrete, and all under-developed countries have to manufacture or acquire these materials. The role of scientific and industrial research in the development of industry cannot be over-emphasized. In Germany, the petroleum shortage, for example, was overcome by the Fisher-Tropsch and other processes developed during the war based upon hydrogenation and liquefaction of coal and its by-products. As however our resources do not give us self-sufficiency in this important field the Government of India is seriously investigating the possibility of using synthetic petrol. These processes may be of great economic and strategic interest to other less-developed regions also. In this field, India has to depend upon techniques developed in Germany and the United States, although modifications in the already known processes may have to be introduced in order to utilize our raw materials and by-products and to secure other economic advantages. Here again, regional considerations may demand greater production of petrol than waxes, this procedure may be just the opposite in countries where high melting point waxes have an easy market.

It is important for under-developed regions not to neglect scientific knowledge. They should give the greatest possible attention to the development of resources by inculcating the spirit of research. It is well known that substitutes developed by the aid of science helped us greatly during the last war. Scholars therefore have to occupy positions of trust and responsibility in the regions which we are striving to develop. The existing fund of knowledge is the most easily accessible and successful bank. The less-developed regions must not only draw from it, but they should see that this bounty is constantly expanded by them as well as by those more fortunate in natural material wealth. In planning the industrial, agricultural, mineral, metallurgical and food expansion we should not forget the place and role of institutions for research and development. In India, eleven national laboratories which will deal with the specific industries, and general scientific subjects are being planned and developed on a really ambitious scale. And universities and technical institutions are being organized to give effective aid to human betterment in every field. In sending scholars for training abroad, employing foreign experts from developed countries, or exchanging professors from other countries, India has recognized that knowledge alone is the basis of professional status in all fields. Our progress can be measured accurately only in terms of the knowledge which we are able to acquire, create and apply.

In this Conference of the United Nations, which aims at bringing peace and plenty for all mankind, I cannot over-emphasize the role that knowledge will play. By the utilization of our expanding knowledge, scientists lay the foundation stone for the structure of world-wide understanding and co-operation amongst men. The responsibility for erecting this temple rests with the trustees of knowledge, namely the scholars, the engineers, the plain labouring men and the understanding financiers. It is obvious that the rate at which the less-developed regions may catch up with the developed regions will be a measure of the success of the United Nations Scientific Conference.

I am deeply grateful to the organizers of this Conference for the honour they have conferred on me by asking me to lead this discussion. There are many important speakers who will follow and we hope we shall have a very interesting discussion on the subject.

The CHAIRMAN: Professor Bhatnagar has made a very important contribution to the work of this meeting by the statement he has just made. As Chairman of this session I now call upon Professor Albert Rhoad, of the Inter-American Institute of Agricultural Science in Costa Rica, who has had a lengthy experience of under-developed countries. Professor Rhoad has taught at Cornell and also in Brazil.

Mr. RHOAD: Dr. Ralph Allee, Director of the Inter-American Institute of Agricultural Sciences, was to be here this afternoon to discuss his prepared paper on the subject of "Preparation of Scientific and Technical Personnel for the American Tropics".[b] Inasmuch as he is unable to be here, I have been asked to take up this subject matter and I will do so briefly, rather than read his rather extensive paper which is available to all of you at the Conference.

There is no need to emphasize to this gathering that to implement or to put into action the very large body of experience information that thus far has come out of this Conference will require an ever increasing number of scientists and technicians. The training of this necessary personnel is a major problem in the less-developed countries, countries which, though very often rich in natural resources, must await the technological development of their resources before an appreciable increase in the standard of living is obtained.

Training in the sciences and technology is expensive. Too expensive for many of the countries to construct, properly equipped and staffed, technical schools or institutes to meet adequately the requirements of the problems with which they are faced. How this obstacle is being met, is of interest. There are three general methods: the first is to import trained personnel to help staff schools and laboratories, such as they may be. This has given us excellent results in many instances, providing the importee, that is the expert under contract, stays long enough to train nationals in his field who can eventually replace him or her. We usually consider that it takes five to fifteen years for an expert to properly train nationals to this stage in the less-developed countries where facilities for educational purposes are not as abundant as in the higher-developed. This is true not only of those who go down to teach in the schools but also those who work under contract in the various laboratories.

I am speaking primarily of the agricultural laboratories in Latin America, with which I am most familiar. These outside experts and scientists have made and are making great contributions to the technological development of countries by training personnel in the laboratories and in the fields. That is usually the first step.

The second is to send the most capable students abroad for special advanced training. This is a method widely used at the present in Latin America. There are far more students taking advanced work here in the United States and Europe than there are technicians, from these industrialized countries, working in the agricultural schools and colleges or experimental stations of the less-developed areas.

This has its disadvantages: When the student returns to his homeland, and I refer primarily to the agricultural students, too many of them have been over-impressed with the gadgets they see, with the fine class of cattle, the wonderful breeding establishments, and so forth. Upon their return to their homeland, they are inspired to do great things, and having been greatly impressed with the things they have seen, they endeavour to apply them under their own conditions. Very frequently, this does not work out satisfactorily. There is a great deal of adjustment that a student must make when he returns to his homeland in applying what he has learned. This problem would be greatly eased, if, in our larger universities, the students from abroad were impressed with the scientific principles and practices through which our perfected state of conditions, our perfected type of animals, or agricultural practices were achieved, so that upon returning to their homeland they could apply the same principles to the crops, animals and other elements with which they must work, and with the class of animals or with other agriculture phases of work. In speaking of the American tropics, the students who go to the United States and European universities learn about and work with classes of animals and crops very distinctly different from those they must utilize when they return home. And it is no easy matter to make these adjustments.

Six years ago, the organization of American States, what was then the Pan American Union, was called upon to establish an international institute of agricultural sciences located somewheres within the American tropics, where students from this area could go and do advanced work, learn experimental techniques and

[b]Mr. Allee's paper is printed as a background paper for the next meeting (2 September).

work in a climatic environment and under the soil and vegetative conditions of their homeland. Inasmuch as a graduate school is a very expensive institution, it was visualized that this should be a co-operative, inter-American institute. In 1942 the Inter-American Institute of Agricultural Sciences was established on such a basis, by a number of the less-developed countries.

The Inter-American Institute of Agricultural Sciences is developing its program with resources from thirteen of the twenty-one Pan American countries. It is expected that within a few years the other countries will ratify the international agreement that created the Institute and thereby become an integral part of it. This Institute receives students from all over the American continent, many of them—most of them I might say—from the undeveloped countries. We feel we have been successful in developing a training program adequate to their need, and based on plants and animals with which they must work on their return to their homeland. In this way the adjustment that is so necessary when students are trained in foreign lands, under conditions not comparable to their homeland, is minimized.

The CHAIRMAN: I now call upon Mr. G. F. Clay, of the United Kingdom.

Mr. CLAY: I welcome this opportunity to take part in the discussion on resource techniques of special interest to the less-developed countries, for I believe that one of the most important contributions which this Conference can make is to obtain a clear appreciation of the conditions and problems which exist in the under-developed countries, and of the limitations, human, physical and financial, which, by the very nature of their under-development, impose severe restrictions upon the techniques and the scope of the efforts they can make in the development, conservation and utilization of their resources.

I propose to limit my observations to land resources and the development of agricultural production—that is agricultural production in its wider sense, including crop culture, animal husbandry and forestry—and in so doing to draw upon the experience of the British colonies which cover a wide range of climatic and soil conditions and contain many races of the human population in varying degrees of development, from the subsistence and tribal economy of the African peasant to the more highly developed social structure and education of the people of, say, the Mediterranean territories of Cyprus and Malta. When I say "more highly developed", however, I wish it to be realized that even in these territories the gap in the technical development in agricultural production when compared, say, with modern refinements in agricultural practice—of which we have had so many very illuminating accounts at this Conference and which are now being incorporated as standard practice in the farming economy of the Western world—is still centuries wide.

I would deal first with the problem of the education of human populations in these territories and, if I might, discuss the evolution of the educational system in the British colonies, which has its application and its lessons to be drawn, I feel, in this question of educating people to a consciousness of soil conservation and general conservation, and its application in the training of indigenous people for leadership both in science and administration. I am thinking now particularly of Africa, which I know best. It is now little more than fifty years since most of the African colonies came under our trusteeship or protection, and until the middle Twenties the educational development of those territories rested mainly in the hands of missions. At about that time, however, in the middle Twenties, there developed an urgent desire by the people themselves to surge forward and it was felt that the resources of the missions, both from the point of view of finances and personnel, could not cope with the expansion which we must envisage in the development of the educational system in the colonies.

At that stage, therefore, the state came in, in a partnership with the missions then established, and from that date we have gradually evolved a structure in the educational system which has as its basis the development of a widespread scatter of primary schools in which the education is essentially in the vernacular, with English as a subject in the two or three top classes, from there proceeding to secondary schools which in many cases, have now become the function of the missions in the educational system, and finally, the development of university colleges ultimately aiming at university status as the peak of the educational system.

I should like to pay tribute to the help in connexion with this work which we have been able to receive in the colonies from the institutions at home. For instance, in the development of university colleges and the attainment of university status of some of those colleges at later dates, we have had the full benefit of the Inter-University Council at home and have been able to draw freely upon the experience, the wisdom and the knowledge of the university authorities in the United Kingdom.

In many cases, we are developing university colleges aimed at serving regions rather than individual territories. Mr. Rhoad himself has referred to the heavy expense which is incurred in the development of training institutions for the training of scientific personnel. Our conception has been that a West Indian university, for instance, serving the territories in that area, a West African university, an East African university, and a Malayan or South-East Asian university would probably meet the needs of the colonies grouped under those categories.

Having given that brief account of the development of the educational structure in the colonies, I should now like to refer to some of the difficulties which we have found in training particularly the scientific personnel necessary to serve their own people in their own country. Originally the idea was, that in order to obtain an accelerated development of the educational leaders of the people, we should try to select limited numbers and develop the university status, rather than start at the bottom of the pyramid and work towards the top. I believe that up to a point that was necessary; and, with the assistance of the missions, it did give us quite a number of responsible indigenous people, well educated and able to exert influence on the people in general through their positions as leaders.

However, with the increase in the numbers of the personnel required to carry out modern administration and modern development, we are now experiencing difficulty in getting sufficient numbers coming through from the primary school up to the university standard. On the basis of my experience I feel that one of the essential things is to develop fully universal education, to develop fully the necessary complement of secondary schools from which to draw the personnel or the students who will come forward for university training.

Another difficulty which we have experienced, and which I think is of interest, is this: While there is no such thing, in the colonies and in under-developed countries generally, as a professional tradition—that is, there are no people whose fathers and grandfathers have been doctors or whose fathers and grandfathers have been lawyers—nevertheless we are finding it difficult to avoid the development of those special traditions and special privileges which we normally associate with certain professions in the more highly developed countries. We have therefore found—and this is probably true for financial reasons or because of the higher status in society or the easier conditions of life—that there is generally a natural tendency among the students coming forward for higher education to choose the medical profession, say, or the legal profession or the field of administration rather than the hard work and the uncomfortable conditions of travel associated with the profession of agriculturist or veterinarian or forester.

That is one of the problems we are at present concerned with. We feel, some of us, that if we are to get the full benefit of scientific training from the people, then we must obviously get the people for the universities who come from the tribes themselves. We feel, therefore, there may be a case for the inception of some form of bonded scholarships on a tribal basis which will ensure that the tribes which need this trained personnel will send forward the requisite numbers, possibly to the secondary school, and then bonded for particular professional training. But that is one of the problems which we have found difficult in our development of the training of scientific personnel.

If I may, I should like also to touch on the problem generally of education in the under-developed countries, and in so doing, possibly I might give two or three small examples of what happens in the absence of an educated people when certain agricultural developments are being pursued or attempted to be pursued. These are simple illustrations, but I believe they point to a moral and a lesson, to the great need in any conservation work to get an educated population, educated fully in the need for and appreciation of the benefits of conservation and utilization.

First, I remember years ago, in what is a fertile area of East Africa, on volcanic soil eminently fitted for the development of an economic crop, such as coffee, we established by demonstration and by experimentation that we could grow satisfactorily a mild coffee. This was an area worked solely by the indigenous people, with no non-native enterprises whatsoever. The next step was to try to demonstrate to the people the benefits of this crop. We planted demonstration plots, but the people were told by the witch doctors of that area that the coffee plants were dancing at night, that it was "white magic" and consistently and persistently these crops were uprooted and destroyed. This was done purely because of the fact that these witch doctors had instructed the people.

That is one example, and another example I might quote occurred in northern Nigeria, where I was discussing with one of the local Emirs of that area the possibility of improving the goat population, aimed at producing milk, an essential requirement in that part of the world. The reply was given that goat milk gave them smallpox.

These are purely local examples of the need for the general education of the people to a higher appreciation of the value of conservation, and I would stress that in the training of the youngsters in the villages, that in their curricula, apart from the classic subjects which were incorporated in their syllabi, we should by all means include—I said this the other day—some place for what one might call civics or better living. This could be done by talks, and by reference to what is happening in the wider field, in the other villages, even outside the country and by illustrations on the wall. By this we would inculcate in the people of the village a wider interest, a desire for improved conditions, and a suitable medium for the development of a conservation and utilization policy.

That is, briefly, the point I wanted to make on education.

Now I should like to turn briefly to the question of research, the tool which is obviously essential for the development of backward areas. I should like to make this brief point, which I think is important. We have been impressed at this Conference by the standard and the quality and the refinement of many of the research projects of which we have been informed through the admirable papers we have listened to and discussed. We, in the temperate regions in the western world, as a result of research in agriculture, have been dealing mainly with an established system of farming which has been developed ever since the days of the enclosures and the industrial revolution, a system of farming which, by empirical means, has improved many of the methods used. We have since then, by research, tried to expand and satisfactorily expand many of the systems and methods used, and we have since then by research embarked upon refinements in systems of agriculture, in systems of stock management, in breeding and feeding and so on. In the colonies and in the under-developed countries, we are dealing primarily with a people who are at a subsistence level, whose farming system is subsistence farming. We have no wealth of experience, no accumulated knowledge as a result of empirical tests on sound farms of what are reasonable systems of farming with which to raise their standards of living. I believe, therefore, that in our approach to research in under-developed countries as a resource technique, we must avoid—and I think this is Mr. Rhoad's point—bringing people back from these advanced countries and giving them the impression that they can embark immediately on the research and on refinement, and avoid doing what would be regarded in Western countries as simple, basic investigational work needed to build systems of farming fitted to their soil conditions.

For instance, I would refer to the fertility status of tropical soils; we know little of that. We know little of more optimum soil management. We know little of the status of humus in tropical soils. We know little of the composition, classification and character of the soils of these countries. Nitrogen study in tropical countries is quite different from that in temperate conditions. The maintenance of structure and the interpretation of many factors concerned in shifting cultivation, the establishment and development of better pastures, these are problems in which, in many cases, the results obtained in temperate countries have been assisted by research that cannot have any application in, and yet are vital to, the development to the full of the land resources of these territories.

Therefore, I would make a plea that the development of research and experimentation is one of the most important resource techniques, and one which must be developed on the basis of a simpler pattern than that which we have come to admire so much in more highly developed countries.

I am constantly reminded of a statement made by an old professor of mine on forestry a quarter of a century ago. This professor said to his forestry students who were going out to the colonies that they must realize that the greater part of the work of a forestry officer in the field would consist not in the management of large forests, such as they saw in Europe, but of organizing the supply of fuel and timber on a tribal basis. That, I believe, is fundamental still in many of the under-developed countries.

Another point I should like to refer to is the problem of storage. Here again, in Western agriculture we are concerned with crop driers and with grain storage and so on, whereas in the colonies and the under-developed countries we are concerned with storage under village conditions which will avoid the unnecessary losses which are such a normal feature of village economy in under-developed countries.

Then, finally, I would say that in my view we have got to develop a technique in the laying down and testing under the varying conditions of pilot areas within which we can embrace the whole of our knowledge and try to work out patterns of land use and village co-operation which can expand the standards of living and the economy of the people of the colonies.

Mr. Guillaume yesterday presented a paper dealing with many of the problems of under-developed countries, and he showed the different areas that can be handled by humans when working by hand, when working with oxen, when being assisted by mechanization, and when fully utilizing mechanization as a basis of production. These figures are significant, and in my view any attempt which we make to try and build a system of agriculture aimed at expanding the standards of living and at supporting the social structure which we wish to establish in these colonies on the basis of subsistence farming, and expanding that by cash crops in one or two places, will never reach the level we are aiming at in these under-developed countries.

I believe that by some means we have to encourage what would amount to a revolutionary change in the organization of the present producers in these under-developed countries, if we are to effect an expansion of production and proper conservation and utilization of resources in those territories. Therefore I believe that the technique of the pilot area taken to the village, rather than to the individual as a unit, is one of the most important problems which we still have to tackle.

I could say a lot more, and there is a lot more to be said on the subject of under-developed countries, but those are some of the points that I think people should bear in mind in considering the problems of conservation techniques which are to be applied in under-developed countries.

The CHAIRMAN: I now call upon Mr. Reyna-Drouet, of Equador.

Mr. REYNA-DROUET:[c] I wish to avail myself of this opportunity to speak of the economic development of the countries of South America. In the course of the meetings which have been held here, reference has been made to the cultural development necessary to develop personnel which would be useful in the economic development of our countries. In South America and, in point of fact, in other places as well, it can be said that we have received a tremendous cultural heritage from Spain. Particularly in the Colonial Ages, we founded universities and colleges. Thereby we developed certain manual arts and the art of painting. We should not forget that we also received certain elements of agricultural culture in the same way. In Ecuador, the University of Quito has prepared us for the present stage. But we also received a tradition according to which the Spanish colonizer made the natives of a country do the work. Because of this, we have been delayed in our economic development. That is also true of the remainder of South America. That is why we will have to catch up with the other countries. These peoples have a considerable cultural coefficient of a very high quality. Nevertheless, their economic development does not correspond to the cultural development of the cultural classes of the remainder of the American continent. I wish to stress again the fact that we have to catch up with the other peoples of the American continent.

In our countries it has not been possible to develop private enterprises as they have been developed in other countries. The only way in which we can proceed is by planning the economy of our countries. In Ecuador, every effort is being exerted to catch up with the other countries in elaborating such economic plans. In these under-developed countries, we must actually raise our economy by means of a total planning of our economies. Taking into account private enterprise, this could produce a type of mixed economy with the co-operation of the State. Only in this way will it be possible for us, considering and facing our own problems, to utilize fully the techniques of the more developed countries. Only in this way will we be able to come from behind from a position in which our economic status does not correspond to our cultural status. All of these countries have to face their own problems in order to catch up with the other countries.

I should like to make a few more comments in respect to personnel. Undoubtedly, the training of such personnel presents problems which will have to be resolved. They are being studied and they have been brilliantly discussed during this Conference. This is what we must do: we must find the means to ensure that this personnel will be qualified to use the tools that we have, to import in order to build the things we need to build and to reach the final objective which we have before us. Ecuador is exerting the maximum effort today, but she will have a lot to do to repair the effects of the horrible earthquake which recently took place.

[c]Mr. Reyna-Drouet spoke in Spanish.

However, we will still progress, even against nature herself.

SIR HAROLD HARTLEY: Without breaking the thread of the discussion, I should like to take up a point which Dr. Bhatnagar emphasized in his masterly survey of the resources and of the development that is taking place in India. His survey showed a wonderful grasp of all of the problems. He said that without systematic work, planned progress is impossible. He referred to soil surveys, hydrological surveys and surveys of industries connected with indigenous resources. From watching various developments, I am impressed with the need for this approach in order to develop a proper phasing. Without that, so many schemes go astray.

A remark comes to my mind which was made by a great American surgeon, Alexis Carrell. He said that one of the greatest dangers in the modern world was the specialist and that the only safety lies in a synthesis of specialists.

We have in this Conference our synthesis of specialists, but I hope you will not think it too elementary if I refer to what I call the limiting factors in agricultural production development so as to be sure that those limiting factors are all being taken into account. I list them as water, climate, soil, man-power and human skill, pests and diseases, transport, energy and power, and equipment and capital.

Water clearly comes first; it is essential to all life. I think it is not untrue to say that hydraulic engineering is the key to many, if not most, development schemes in these less-developed countries, and that the control of water needs the most skillful planning. Water control merges into these wide issues: dams, water power, irrigation, drainage, flood control, methods of cultivation to prevent erosion and afforestation.

Climate is such an obvious factor as it determines the rate of growth of plants, depending on temperature, sunshine and moisture. But there is a point here which I do not think has come up in this Conference and which has been developed by Major Markham in a remarkable book on *Climate and the Energy of Nations*. He shows from statistics how intense heat or cold makes larger demands on the human system, that man's energy is at its height in temperate regions. He poses the problem of how far science can overcome the handicap of temperature extremes by improving living conditions in order that we may get the best results in those countries which are so productive but where you meet these temperature extremes.

Soil has been dealt with at great length in the sectional meetings. It is such a complex assemblage of inorganic and organic material, both living and dead, that it presents a very intricate and difficult scientific problem. But here science is just beginning to break in and unravel the problem. New discoveries are revealing the delicate balancing factors in the top few inches of soil on which fertility depends. But Nature is a most exacting taskmistress.

As regards man-power and human skill, the problem seems to me to be threefold. First you have education, which we have heard discussed so thoroughly this afternoon. I always feel that Denmark is the outstanding example of what education can do to raise the quality of agricultural output. Her farmers believe in co-operation, which is based on their educational system. It has added greatly to their efficiency and their happiness. Then there is the very important question of incentive, on which so many of these development schemes depend. Lastly, there is health and physique.

As regards diseases and pests, we have immediate cause for optimism. The last hundred years have seen such an amazing development in the understanding of the causes of disease, particularly of the endemic diseases of tropical and subtropical countries. There again, when you interfere with nature, when you try to change her ways, you must watch her reactions very carefully. The possibilities of the adaptation of bacteria to their environment and the development of more resistant strains may mean that our present methods, however effective at the moment, will need modifications. New methods must be found to replace the old. We have embarked on new adventures, where vigilance and research will be more than ever necessary.

As regards transport, steam transport made possible the nineteenth century, and transport must always remain the key to development by making possible the exchange of commodities and the movement of individuals. The value of surplus crops and raw materials depends on the possibility and the cost of moving them. The transport engineer must find the best solution by road, rail and water, in terms of local conditions and resources. Here I think you have one of the most important factors in development, and not only in the actual development but in diversifying the life of the individual, giving him that extra incentive and those new interests without which these development schemes will not succeed.

At other plenary meetings I spoke of the importance of energy and its utilization in power and heat. The mechanization of agriculture in this century is as important as the mechanization of industry was in the nineteenth century. Energy is needed not only to produce crops but to process them. This is the new feature which is bringing farming and industry into much closer relationship.

If you take all those factors, it is clear that their interrelation makes a complicated picture, and success depends on their proper phasing in development schemes. That is why I picked up Sir Shanti's point about the need for this systematic work. The orderly solution of these development problems in any area depends on a survey of the relevant factors: the natural resources of the country, its geography, its economic structure and its capacity both for production and consumption. The limiting factors will then appear and the problems that they present can be attacked in their proper priority.

It seems to me that such surveys are a matter of major importance, and that the value of them would be much enhanced if there were some clearing house to which the results could flow and be made available so that each country might know the resources and potentialities of the others. In this way there would gradually emerge a clearer pattern of how the world resources, distributed as they are in such an accidental pattern, can best be utilized to meet its ever-growing demands.

MR. BHATNAGAR: One of the limiting factors mentioned by Sir Harold Hartley in his very interesting lecture was climate. I am reminded of a story which I think would be of interest to this audience. When plans were being made to put a steel works in India, the European experts said that it was such a hot region that it would be impossible for any man to remain alive on the furnaces and that no steel plant could therefore be erected there. However, not only does India operate one of the biggest steel plants in the British Commonwealth, but it also supplies labour to manage the furnaces of many other countries, particularly in the Navy. The humorous retort which was given to the experts by Mr. Tata was that if the climate in India was so hot as described it would be possible to make steel more cheaply because less energy would be required for its smelting.

It is not necessary therefore to put too much emphasis on climate. These things should be examined in a balanced manner. Climate is, of course, a very important factor, but this air-conditioned room shows that climate can be controlled. In the great coking plant at Pittsburgh in the United States there is hardly a man working on the furnaces. The men operate in an air-conditioned room and, as a matter of fact, the whole operation is so neat that it can be carried on in a drawing room. By the application of science, climate can be conquered to some extent and those countries which have bad climates need not feel very despondent on account of this factor.

The CHAIRMAN: I now call on Mr. H. Carabaño of Venezuela.

Mr. CARABAÑO:[d] We do not claim to give a solution to any specific problem in this statement but simply to speak of a question which we consider vital for countries which, like Venezuela, are in a state of economic under-development. After the experiences we have had, the Conference has arrived at conclusions which underline the problem and indicate what measures might be contemplated in co-operation in order to arrive at a solution, and we are convinced that our governments will try to find the best solution for the exploitation of natural resources. There is no doubt also that they will attach due importance to the techniques which have been outlined here; if the governments will follow a policy of conservation on very specific lines, there will be very little left to do.

Immediate action may meet with obstacles due to circumstances which we have to try to foresee, and there must be a sufficient foundation of technical resources to make possible the carrying out of a programme of conservation. In the United States, for instance, the co-operation of the Department of Agriculture and the help of the soil conservation services are available, but at the same time it is also necessary to train technicians and scientists. There must be enough skilled men available to carry out the developments.

This question has been discussed in earlier meetings but is even more clearly evident at the present time. It is of such importance that it is unnecessary to insist upon it; much has been said about the various aspects of education in regard to the conservation of resources but we are under the impression that perhaps the role of the universities has been forgotten in this task. In my country great efforts are being made to enable the universities to come out of their isolation and co-operate in these tasks. As proof of this we have recently set up a School of Manual Arts in Venezuela. We have introduced this attempt at specialization in an endeavour to ensure that our professional people have the necessary instruction and orientation. Without specialization it is impossible to achieve sufficient efficiency in such a very specific field.

What I have said here about the necessity of breaking through the wall of specialization must also be applied to all forms of teaching, because in our opinion conservation is not only a special subject but also a general field of knowledge which should be inculcated into the minds of children by teaching them the various possibilities of their environment. We think the universities should assist in giving the young information about their responsibilities within their environment. The subject affects the family, the country and humanity as a whole, and we must work for a realization of this in order to do away with the ignorance which prevents improvement of general standards. Men are the best means of their own development although it is the professionals who have the greatest prestige, but the importance of the role of governments has not been sufficiently stressed. Governments must be enabled to assist more efficiently in these conservation programmes. We must recommend action and specific measures to governments. If this question is to be solved for all the countries of South America it will be necessary to mobilize all efforts and we shall also need the experience of foreign countries. We hope to have the assistance of the eminent men who are gathered here to help us in our judgments for the greater benefit of all concerned.

The CHAIRMAN: I now call on Mrs. Pinchot of the United States.

Mrs. PINCHOT: On the opening day a delegate came up and congratulated me on the holding of this conference in terms of a forty-year dream come true—and suggested it might be of interest to the participants to know something of the background of how it came to be called.

Perhaps a short history may help to make clear why so many conservationists regard this particular Conference less as a dream come to fruition than as a noble opportunity side-stepped. That, in spite of the remarkable contribution it has made on the technical side.

To condense that history in as few words as possible:

In 1908, the then President, Theodore Roosevelt, called the governors of our forty-eight United States to consider the "preservation, protection and wise use of the natural resources of the nation."

He pointed out that the conservation of natural resources is one of fundamental importance and drove home the basic truth "that the planned and orderly development of the earth and all it contains is indispensable to the permanent prosperity of the human race."

This Congress set forth in impressive fashion (and it was the first national meeting in any country to do so) the idea that the "protection, preservation, and wise use of the natural resources of the earth are not a series of separate and independent tasks, but one single problem." And, to quote again, "The various uses of our natural resources, are so closely connected that they should be coordinated and should be treated as part of one coherent plan."

[d]Mr. Carabaño spoke in Spanish.

"Hitherto," said Roosevelt, " our national policy had been one of almost unrestricted destruction of natural resources," a policy that had led to the "exhaustion of these resources and unequalled opportunity for private monopoly."

"In the past," he continued, "we have admitted the right of the individual to injure the future of the Republic for his own present profit. The time has come for a change.

"The sources of national wealth exist for the benefit of the people and monopoly thereof should not be tolerated.

"We regard the monopoly of waters, and especially the monopoly of water power, as peculiarly threatening. No rights to the use of water powers and streams should hereafter be granted in perpetuity. Each grant should be conditioned upon prompt development, continued beneficial use, and the payment of proper compensation to the public for the rights enjoyed; and should be for a definite period only.

"We look upon these resources as a heritage to be made use of in establishing and promoting the comfort, the prosperity, and happiness of the American people."

And in speaking of prevention of waste in the mining and extraction of coal, oil, gas and other minerals, stress is laid upon "their wise conservation for the use of the People" (with a capital P) "and to the protection of human life in the mines."

Let me give you one instance of how the practical issue was posed in those early days. The national forests of America were being destroyed with unparalleled ruthlessness and rapidity. A large share of the blame for this condition was due to overgrazing on state forests by big absentee cattlemen whose animals destroyed the efforts of the small homesteader, who found himself helpless to make a living.

The issue, fair access by the little men to domestic natural resources, was won only after years of the hardest kind of hard fighting—fighting against every kind of pressure, financial, political, social, sometimes even physical, by the reactionaries of that period.

Always you see the emphasis laid upon protection of the rights of the people marching side by side with the technology of forest management, development of water power, flood control, extraction of minerals. Always the purpose of conservation as defined by Gifford Pinchot, "the greatest good to the greatest number for the longest time."

A later North American Conservation Congress declared that the "movement for the conservation of natural resources on the continent of North America is of such a nature and of such general importance as should become world-wide in its scope."

Then Theodore Roosevelt pushed his understanding a step further. He proclaimed that "permanent peace is impossible unless the conservation of natural resources is assured."

"No nation is self-sufficient in raw materials," he said, and continued, "the welfare of every nation depends upon access to the natural resources it lacks."

"The world is beginning to understand that, instead of its being normal in the interest of one nation to see another depressed, it is normal in the interest of each nation to see others elevated. Fair access to natural resources from other nations is therefore an indispensable condition of permanent peace."

And being a man of action, in January, 1909, a formal invitation went out from the President to fifty-eight nations to "join together in conferences on the subject of world resources and their inventory, conservation, and wise utilization."

Some thirty of the countries, including Great Britain, France, Germany, Canada, Mexico and others, accepted. Most unfortunately for the cause of peace, President Taft who succeeded Roosevelt and whose failure to support conservation precipitated a major political revolt, decided to recall the invitation. Wilson, Harding and Hoover, all three in turn, failed to act.

In 1940 the conservation of natural resources as an "essential foundation for permanent peace" was presented by Gifford Pinchot before the Eighth American Scientific Congress meeting in Washington. A resolution, passed without a dissenting vote, recommended to "the governments of the American Republic the appointment of an Inter-American Conservation Commission cooperating with the Pan-American Union and representing all the Americas." This Commission "to be charged with the duty of preparing an inventory of world natural resources, and of formulating a general policy and specific program of action to promote the mutual conservation and prudent utilization of natural resources for the welfare of all nations, in the interest of permanent peace." Unfortunately the war intervened and the resolution came to naught.

In 1944 Gifford Pinchot brought the matter up once more with President Franklin Roosevelt. He immediately grasped the significance of the movement, welcomed it with enthusiasm, and authorized Pinchot to draft a plan and work out a full agenda.

After the death of Roosevelt, President Truman put the full measure of his authority behind the plan. And so, after forty-one years, the long delayed Conference is in existence.

All of this background makes it the more amazing, the more tragic, that *Man*, for the service of whom all natural resources are developed, should not have been made the central theme around which this meeting was organized.

Every true conservationist knows that man himself is a natural resource, *the* basic resource; that without man's energy, the energy of coal, of electricity, of oil, or atomic fission itself, is inert and meaningless.

To side-step the human and political implications of conservation, to deal with it exclusively in terms of materials, matter and technical processes, is to take a long step backward from where we stood a generation ago.

Today some 600 scientists are assembled in what is perhaps the greatest scientific gathering, with the widest coverage, that has ever been held. Such a meeting, had it been permitted, might have been used as an unparalleled opportunity for a thrashing out of the social issues upon which civilization, perhaps the future of the world itself, depends.

Yet these subjects, although there have been many indirect mentions of them, have not only been rigidly excluded from the agenda, but the scientists have ar-

Labour and Public Health Techniques

Friday Afternoon, 2 September 1949

Chairman:

Enrique Rodríguez FABREGAT, Permanent Representative of Uruguay to the United Nations

Contributed Papers:

Techniques in the Recruitment and Training of Labour (for Less-Developed Countries)
Vincent C. PHELAN, Director, Canadian Branch Office, International Labour Office, Montreal, Canada

Man as a Resource: A Problem in Conservation
A. B. WOLMAN, The Johns Hopkins University, Baltimore, Maryland, U. S. A.

The Application of the Principles of Nutrition in the Use and Conservation of Natural Resources
Dr. F. W. CLEMENTS, World Health Organization

Background Papers:

The Recruitment and Training of Labour for Resource Development
International Labour Office, Geneva.

Preparation of Scientific and Technical Personnel for the American Tropics
Ralph H. ALLEE, Director, Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica

On the Training of Technical and Scientific Staff for the Conservation and Utilization of Resources in Haiti
Pierre G. SYLVAIN, Port-au-Prince, Haiti

Memorandum by the *Société haïtienne d'Etudes scientifiques*

Discussion:

Messrs. ANTUÑA, E. DE VRIES, HUDSON, VELANDER, BLONDEL, REYNA-DROUET, RANGHEL

Programme Director:

Carter GOODRICH

Programme Officer:

Herbert SCHIMMEL

Mr. Wolman's paper was presented by Dr. Clements.

The CHAIRMAN:[a] I declare open the fourteenth plenary meeting of the United Nations Conference on Conservation and Utilization of Resources.

It is a great honour for me to have been appointed to preside over this plenary meeting of the United Nations Scientific Conference on the Conservation and Utilization of Resources. In taking up this important task and in opening the meeting, I wish to express my appreciation of the work of the members of the Conference and to express my faith in the results of this work which was undertaken under the guidance of the United States of America, and which has brought about a conference in which we have gathered together so many illustrious representatives of contemporary thought. Men and women from all parts of the world have placed their hopes in this important Conference. The outcome of our work is awaited by the world.

Throughout these weeks of work, we have always been conscious of humanity's hopes which have been placed in us. Within a few days our meetings will come to an end, but the words that we have spoken will be entered in the records of human history. This Conference has brought together at Lake Success technical experts, research workers, men of science, experienced people. We have had an exchange of ideas; we have come together to share our experiences, to share the fruits of our labours in our several countries and our several domains.

Thanks to the work of the Secretary-General of the United Nations, this important Conference has been possible. It may well be that what happens in the future will add to what we have achieved in this Conference. It may be that the contact that we have established with each other will lead to a new and valuable conquest, a conquest in the field of technique, in the field of the application of methods. It may be that it will lead to an achievement with respect to the raising of the standard of living of the people, an objective to which reference is made in the Charter and in the Declaration of Human Rights.

These were the principles and objectives which the President of the United States had in mind when he first thought of this meeting and when he made it possible. When we have worked through our programme, we shall be able to affirm that a new route has been found for human progress in all sections of human activity. It is, therefore, a time of hope for all of us.

The Charter of the United Nations states these principles very clearly. It may be that friendships between the peoples of the earth involve an exchange of the information and experience which the different peoples have acquired. Millions of the children of the world are living, we are told, under very severe conditions. We have to do what we can to relieve this human suffering. In a spirit of solidarity and with foresight, we must consider the problems of the future. These values are a part of the democratic creed, the humanitarian creed in which we place our faith. Man, within the scheme of nature, is the protagonist of this great purpose of progress. It is here that we must penetrate the secret of nature; we must discover those secrets and make use of the forces of nature.

The value of this Conference has been proved by the fact that we have gone so much into this problem. We have considered the factor man in all the aspects of his life on this planet. It is man who clears the way through the shadows; thanks to the ceaseless activity of his mind, he is able to unveil the secrets of the world and to exercise his creative will over nature. It is in this way that we can find a new basis for civilization and culture. It is for us human beings so to use our minds that we can hand over to our children a torch which will cast light on the road ahead.

Our theme today, the agenda of this plenary meeting over which I have the honour to preside, is, therefore, of special importance. The speakers for this afternoon will make it much more clear than I am making it that our purpose is to relate man to nature in the proper way. This is an immense activity in which the United Nations itself is engaged through the General Assembly and through the Economic and Social Council. These bodies have adopted resolutions embodying this principle, the principle of technical assistance, particularly to the economically backward countries. This coincides with Point Four of President Truman's programme. In 1948 the General Assembly of the United Nations had approved two resolutions, one for measures to be adopted at the next session for economic development, and the other resolution dealt with the question of more favourable conditions for economic and social development.

These are among the basic objectives stated in the Charter, and now to this we have added the purpose of the Conference in which we are now engaged. We are meeting here, thanks largely to the initiative of that great leader of the American people.

Labour and social welfare are elements which cannot be separated from the development of new techniques. They are the active principles at the basis of all the new legislation dealing with social welfare, social insurance and so on. The purpose is always to provide a sense of security. Insurance and maternity leave, healthy conditions in places of employment, the employment of minors, all these fall within the general scheme of social welfare which, as well as the question of conditions of agricultural and industrial labour, have been dealt with by the Government of my country, Uruguay. I mention this as our contribution to the solution of the problems of modern society. I mention them here now only because they are a part of the general programme of which our agenda for today is also a part.

Our children must be placed in a position where these values will receive a wider recognition and a greater measure of realization than they do today. You are meeting here as representatives of contemporary thought in the social and technical field. I now declare open the fourteenth plenary meeting of the Conference.

Our first speaker will be Mr. Phelan, of the International Labour Office. The title of his speech will be "Techniques in the Recruitment and Training of Labour". Before taking up his duties in the International Labour Office, Mr. Phelan was a highly placed official in the Canadian Ministry of Labour. It is a great pleasure to me to introduce Mr. Phelan as our first speaker this afternoon.

Mr. PHELAN *delivered the following paper:*

[a]The Chairman spoke in Spanish.

Techniques in the Recruitment and Training of Labour (for Less Developed Countries)

VINCENT C. PHELAN

Today it falls to my lot to discuss before you the associated problems of the recruitment and training of workers for resource development, specifically in their application to those areas of the world which are regarded as under-developed in an industrial sense.

It is my aim to sum up, as completely as time will permit, what the International Labour Organisation has learned through its thirty years of experience in the social and labour fields, to the extent its findings may have a bearing on the case in point. I might remark that I.L.O.'s experience in these matters has, of course, been gained through its Conferences and other international meetings, through observation of the industrial scene and through the experience of its field mission contacts. The tripartite character of the Organisation—made up as it is of Government, worker and employer representatives—has greatly enhanced the opportunities presented to the International Labour Office to observe in these matters.

Perhaps the general proposition might be stated in this way: as of today, some countries, by comparison with others, are behind to a marked degree in the stage of industrial development which they have attained. These under-developed countries lag behind in the substitution of power machines for manual labour, in the application of available scientific knowledge to problems of production: this situation is generally admitted to exist in several lands.

I might just interpolate at this point that such a situation is no reflection whatsoever on these countries termed "less developed" or "under-developed". Even among the industrial nations, the industrial revolution has not always moved forward at the same pace in all countries. The standards of living attained in all industrial nations are not precisely equal. Many reasons account for this fact—but I think it would be superfluous here to explore those reasons. My point is simply that in industrial expansion, as in a good many other matters of human progress, it is too much to expect that developments in all countries will proceed at the same tempo. In other fields of human endeavour the so-called under-developed countries may proudly point out that their history bears witness to the fact that frequently their developments have stood out in front of those competitor nations now regarded as more advanced industrially.

Recognizing under-development, friendly neighbours now propose to encourage and aid an accelerated rate of development in under-developed areas, to the end that a greater national dividend in those countries will result in improvement in living standards, while an improvement in world production, an increased flow of goods internationally, will lead to better living standards in all countries: the whole process will conduce to the ultimate aim of a happier world in which to live.

To the extent that any move in the indicated direction may succeed, the common man in those nations now backward in industrialization will be deeply and personally interested in two directions: he will have a very personal interest in the resultant improvement in his standard of living; and he will have an equally personal interest in the part he must play as one of the myriad workers whose toil will be translated into the increased production which is necessary.

It is not my task to treat with any prospective improvement in the social well-being of the peoples of these less developed lands, but rather to treat with the phase of the case which I have mentioned second, namely, the anterior phase, which comprises those problems associated with bringing into the field of industrial work many scores of thousands, or even millions, of workers, most of whom are not now engaged in employment of the type to be offered by the new developments. These must be selected and trained into industry if any large scale development of resources is to be undertaken. Modern machines substitute for much manual labour. They increase the productive capacity of a given number of workers. But it is a truism to say that machines can not eliminate the need for workers, and in fact multiplication of machines will serve to increase demands for skills. Hence the relevance, hence the importance of labour planning alongside other planning for resource development.

This process of recruitment, training and subsequent employment will, of course, give rise to the same or similar problems as those traditionally associated with labour relations in areas already enjoying a high degree of industrialization. There will be found to be many characteristics in the human relations involved which are held in common as between less developed and more developed countries and their peoples. One of the plainly evident facts developed in International Labour Conferences is the large area in which spokesmen for dissimilar peoples and scattered geographical areas voice the same aspirations. In increasing the labour force in less developed countries, a narrow or short-sighted view might be that the same "headaches" will be experienced in human relations, as are so familiar in the more forward countries. But that is human nature. On the other hand, there is this advantage in the wide area of similarity of aspirations and outlook which will be found, specifically on the part of the workers: it will make it much easier to plan present developments when it can be assumed that in so many instances workers in under-developed countries will react in the same manner as their fellows in leading industrial nations. This fact validates much of the experience of older industrial countries in labour relations, as applicable to the countries of newer developments.

The International Labour Office at Geneva has made available for this Conference a paper giving much of the relevant background information upon which a program of recruitment and training for developments now to be projected must be based.

Also, there are set forth the practices and principles upon which long-term manpower planning should be founded. I might here refer directly to some of the main points brought out in the paper in question.

First of all the paper outlines the difficulties of attempting to apply precise formulas to determine labour and skill requirements, in view of the existing lack of available information on probable needs. It emphasizes the importance of establishing systems of determining what labour will be needed, and particularly what skills will be required, by areas, from time to time.

The document outlines the preferable methods of recruiting workers, whether for training or for immediate employment, and in this connection indicates the industrial and social advantages which accrue where it is found possible to channel the recruitment of workers through a well equipped and well trained public employment service. Earlier methods utilized in less developed countries are stated to have led all too frequently to exploitation of the workers, and, indeed, there is much evidence to support this statement.

Difficulties inherent in developing working forces, especially the needed groups of skilled workers, inherent in conditions frequently found in less developed lands, are gone into. Low health standards and absence of general education are cited as important difficulties. The need of developing the will to engage in wage-earning employment when that pursuit is not already a generally accepted tradition, is dealt with, as also is the necessity of workers learning to practice the voluntary self-discipline associated with industrial employment.

While pointing out difficulties, the I.L.O. does not, of course, regard them as insuperable or perpetual barriers. In fact, seeing the thousands of people in these countries who underwent induction into modern industrial employment at an earlier stage, there is excellent reason for optimism. Moreover, both machines and industrial methods may well benefit at a later stage by the fresh outlook the newly developing countries will bring to bear on industrial production.

On training, the I.L.O. points out the advantages—as well as the difficulties—of establishing technical schools to give pre-employment industrial training; of establishing sound apprenticeship systems; of establishing short courses for new employees; and of giving training within industry.

Methods of international co-operation in the recruitment and training of labour are all examined. International co-operation through permanent migration, through sending workers abroad for training, through "borrowing" workers from well developed countries: all these methods are outlined and assessed, and all are found to have application in some cases or other, and to constitute valuable aids in overcoming a shortage of skills.

International Labour Conference Conventions and Recommendations are cited, and are recommended to Governments to curb exploitation of workers, to promote good industrial relations, and as a most valuable assistance in developing effective national employment services and sound systems of technical education and other industrial training.

So much for the general principles which may (and in some cases, must) underlie any system of recruiting and training workers for developments, especially in the long view. Now, it is to examine the application of these principles, specifically in the light of immediate problems of labour supply.

Forming its opinion from such information as is available, regarding labour supply and labour demand in relation to the development of under-developed areas, the I.L.O. has reached the conclusion that there is no over-all labour shortage in the world: that is to say, that there are a sufficient number of people available to do any reasonable quantity of new work projected for at least some time to come. However—and this is a very important modification—there will be found to be shortages of skilled workers on a very broad scale. Even those countries regarded as in the forefront in industrial development have experienced shortages of skilled workers since the war, and today do not possess surpluses of craftsmen. The situation is even less favourable in under-developed areas, where large numbers never have acquired skills of the type now called for. To some extent—as in the case of South America—migration from abroad may be looked to, to fill in the gaps. In other areas—as in Asia where population is already abundant—the need of training workers into industry is clearly indicated.

I should like at this early stage to note just what under-development means in a practical way when new projects are faced with the necessity of rather rapidly assembling a suitable force of workers to undertake a new project in a land where a great part of the population has not previously been accustomed to industrial employment—in an area where the minds of a great many people have not yet been "conditioned" to industrial employment.

Those countries which have carried their industrial development the furthest have done so over a period of two centuries. Thus it was possible in these cases to expand gradually the field of employment, the proportion of the population engaged as wage-earners. The process being rather leisurely in retrospect, the problem more or less took care of itself. Gradually people from town and country were assembled in factories, where they learned by doing. Gradually existing standards controlling working conditions were built up. Trials and troubles in the process were frequent, but somehow today's standards were hammered out—and that without much advance planning.

In the under-developed countries the situation is different. There it is hoped to "catch up" within a fairly short while. Consequently, methods which were successful in other nations may not succeed in producing quick results. Therefore, planning in regard to the recruitment of workers, and their training, will be necessary on a scale not utilized in more fully developed countries—certainly not utilized in earlier stages of industrial progress.

The first point which seems to follow from these considerations is that wherever developments are being planned, a most important part of the planning should be the recruitment and training of workers.

If a new industry undertakes a development here in the United States it may be found possible that much thought to the recruitment of workers may be left over until other plans are fairly well matured, and then by dipping into the lush supply of trained workers in this country, an industry is able to start off with enough skilled workers (even if they have to be coaxed away from a competitor) without affecting the economy adversely. But in under-developed areas it will not be found possible to resort to such methods. If such methods were engaged then either the new enterprise would find itself without skilled workers, or an existing industry would be denuded—an alarming result either way.

Therefore, when, for example, surveys of known mineral deposits are being made, when thought is being given to the accumulation of machines and tools, when properties are being surveyed and buildings planned, it will be found necessary to also give thought at one and the same time to numbers and types of workers to be recruited, whence they are to come, where and how they are to be trained. If labour planning be left over to a later stage, delays in the functioning of the new project are bound to ensue, or alternative plans which might have assisted in procuring workers will have been overlooked.

Even the earliest labour planning, it will be found, must go beyond the mere mechanics of selecting and training new employees. Incentives, including rates of pay, should be plotted with a view to securing some enthusiasm for the development on the part of the men and women to be engaged in it.

Then, assuming that a considerable portion of the workers to be engaged will be entering wage employment for the first time, it will undoubtedly be found that there will be a tendency toward a high labour turnover. To the extent possible, this should be anticipated and obviated. Excessive labour turnover is always expensive to industry. In those areas where workers after receiving training are irreplaceable except by others likewise tediously trained, there is every inducement to keep labour turnover to a minimum, for constant shifts in the early days of organizing a working force will retard a project.

For instance, industrial safety is involved in labour turnover. It will be found that planning of safety measures will pay big dividends. On this continent employers have found that industrial accidents are costly to industry as well as to employees, and not infrequently increase labour turnover. In consequence employers in Canada and the United States have expended very large sums of money to reduce the toll of industrial accidents—and while I am not suggesting that employers have not had in mind at least some element of the human approach to the accident problem, they have found that accidents were just too costly to tolerate where they could be eliminated. In the under-developed areas the experience will be no different, except that it becomes doubly important in introducing large numbers of new workers into industry, to seek to impress upon them the need for working safely, and that they are being given the protection from accidents which has become commonplace in most industries in this part of the world. And then, as I remarked in introducing this topic, the elimination of accidents will have a tendency to reduce labour turnover, for those not accustomed to industry are found to be more apt to shy off from jobs where the accident toll is heavy.

Other arrangements also will facilitate recruitment and stabilize employment. Transportation, housing, recreational and educational facilities in some cases, and the other factors common or fairly common in connection with much employment in industrial countries, will be found advantageous or necessary to assist in recruiting and in stabilizing staffs, and should be introduced in relation to needs, bearing in mind the traditions and social customs of the locality.

Now for the mechanics of recruitment and training, something by way of methods to be utilized—and I wish to speak first of *industry* as distinct from *agriculture*. Also, I speak of "labour" of various categories, but not of professional or technical workers, a phase of the case reserved for separate consideration.

Plans for contemplated projects embrace irrigation for agriculture, hydro-electric and other power developments, transport and communications, mines and other basic industries, including iron and steel. All will, of course, employ large numbers of unskilled workers, but there will be a certain minimum number of operations which will require some degree of skill. This is unavoidable.

It will be found necessary that careful analyses be made of the occupations to fit into each project. Job analysis will be of more than ordinary importance. In such a country as the United States, where trade names are reasonably well standardized and understood, and the work pertaining to a given trade is fairly well standard in practice, job analysis in reference to new projects may be substituted for by the excellent work already done in that field by the United States Employment Service and other Government agencies. But where most things are new, some start will have to be made in this regard so that skilled persons who can be located and trainees may be fitted into the general pattern without waste.

I have already mentioned that there does not appear at the moment to be any inadequacy in the overall supply of available workers for new developments when world supply is considered. From the viewpoint of each country to undergo development, the problems are of a different character than quantitive. The two immediate prime problems in recruitment to be overcome are, first, location, and second, the absence of skills.

The problem of location will arise in either of two ways. Workers in ample numbers may be available within the country, but may not be near the project. In this case the problem arises of working out transportation arrangements, either on a commuting or permanent removal basis. Most countries have some experience of their own to follow, in bringing the worker to the job. If not, the experience of the United States and Canada will be found useful, for in these countries distance has had to be bridged repeatedly.

In other instances workers will be available abroad, but either permanent or temporary migration will be required. This would appear to be the situation confronting several countries in South America if projects of magnitude are undertaken. While migration presents problems all its own, these problems have been overcome repeatedly in the past, so that the trail is clearly blazed. Information reaching I.L.O. indicates no shortage of prospective immigrants for employment. In fact, as is well known, several Western countries are at present embarked upon schemes of migration for employment, including some of the countries of South America. Migration within the Western world holds this advantage for developments, that by careful selection a variety of skills may be procured amongst immigrants.

If immigrants with the precise skills needed are not available, at least persons of working experience somewhat comparable may be induced to migrate, and may be fitted into new employment with only limited training. Canada, among other countries, has had a good deal of success in this connection recently. Woodworking, boots and shoes, cotton textiles, and some other industries, to overcome labour shortages, engaged refugees specially selected in Europe. The particular refugees were selected on the basis of their experience and apparent aptitude. With less training than an ordinary beginner these people were able to acquire skill in occupations at first novel to them. On the other hand, trade tests made among refugees showed serious differences in trade methods between Central Europe and Canada, even in a common trade like bricklaying: hence the importance of job analysis.

It is much easier, of course, to select immigrants for *unskilled* work in any part of the globe. Here the important considerations reduce to physical fitness, intelligence, capacity for physical work and apparent aptitude for the task.

Of course in Asia local applicants will invariably be more than sufficient to meet unskilled labour requirements, and finding or producing the skills needed will be the task.

In fact, the crux of the entire situation is really to produce skilled workers in the numbers needed. This will be found to be universally true. No matter how adroitly projects may be organized, there will be found to be a minimum requirement of skilled workers which cannot be substituted for. The I.L.O. finds that even in the advanced countries there is no surplus of skills—in fact there is a deficiency in some countries. Therefore two steps become necessary: first, to reduce to its barest minimum the need for extensive skill (substituting partial skill), and second, to meet this minimum need by resort to one or several expedients. Difficulties will be encountered, but unless these problems are overcome, developments will be retarded if not thwarted.

I have mentioned that the planning of labour supply should be incorporated into the blue print for development at its very earliest stage. If this be not done, greater delays than necessary in building up a labour force are bound to be encountered. For instance, in the selection of machines and tools, where alternatives are available, those types should be selected for which it may be possible to find at least some workers qualified to set up, to operate or to repair. Within a project—and even within a country—there would be an advantage in standardizing on types which call for the same type of skill. This would simplify training. There would appear to be no advantage in selecting the most efficient types of machines unless it will be found possible to ensure their operation and maintenance.

The greatest body of experience in rapidly assembling groups of workers for new projects arises in World War II. Anyone faced with labour procurement for new developments at this time could not do better than examine carefully the plans and expedients adopted in the United States, Great Britain, Canada and other Western countries during the war. With a steady draining off of skilled as well as unskilled workers for the armed forces, these countries were able to accelerate industrial production to new high levels. With little time for preparatory work, new plants were set up, and workers were trained to use machines and tools. There was no time to train large numbers of workers through the time-honoured systems. It is not suggested that all the devices put into effect in the wartime United States or Canada, for example, would work if transplanted to the Orient. It is suggested that the devices adopted here and elsewhere during the war furnish a lengthy and valuable experience, much of which could be adapted to conditions anywhere else, and some of which will have to work if skilled requirements are to be met.

Different devices which are suggested, mostly on the basis of wartime experience, include the following:

(*a*) Even in under-developed countries there are existing industrial undertakings, mechanized, and requiring a considerable variety of skills. Any study should start with an examination of any facilities they may hold to help new industries by training workers on the job for them; and also of how these plants were built up in the first instance, how they expanded later, and how they met the existing shortages of skills.

(*b*) In existing undertakings in these countries there well may be more skilled workers than are strictly necessary at the moment. For example, we found in Canada—and other Western countries had a like experience—during the war that habitually fully trained machinists (or engineers, to use the British term) were engaged on occupations where some parts of the job might, in an emergency, be done by a person of lesser skill. It was frequently possible to make arrangements to transfer some of these skilled workers to new enterprises, replacing them with quickly trained specialists. This gives a nucleus of skilled workers to the new enterprise, without interference with the older plant.

(*c*) Skilled workers who may have retired or left the trade, though still fit physically, may be induced to return. This would be a small factor in countries with a small area of mechanized industry, but no possibility can be overlooked—and these older workers make excellent trainers of trainees.

(*d*) Careful job analyses in the early stages of planning will indicate the extent to which jobs may be "broken down", so that short training courses may be given unskilled workers, specializing them in one or two operations, instead of awaiting their complete training at a trade.

(*e*) Reference has been made earlier to the possibilities of securing skilled workers permanently through migration. Where permanent migration is either not feasible or not desirable, it sometimes is possible to "borrow" skilled workers from abroad for a limited period, to operate newly introduced equipment, and to train local workers into the craft. A good part of the industry now operating in under-developed countries started in this manner.

(*f*) Short courses of training of unskilled workers, to specialize them in one or two or three operations, will be found essential in any event.

(*g*) Of course, as time permits longer processes of training will have their effect. Eventually vocational school graduates may be entered as apprentices, and after apprenticeship they will take their place in their respective national industrial life. But this is a long view proposition, and not one that can be counted upon for quick results. Nevertheless, visualizing constantly expanding economies, no time should be lost in laying the ground work for the future training of the necessary numbers of skilled workers.

(*h*) For any type of worker, whether for immediate employment or for training, it will be found most economical and practical in the long run to give due weight to the two factors of physical fitness and apparent aptitude for the job. Training costs money, and so does the introduction of a new employee into a job. To the extent that selections are limited to those who will probably "make good", costs will be reduced and projects will be speeded.

(*i*) Where an efficient public employment service exists, it is the ideal agent for selection of the new employees—and it can give much assistance in meeting shortages of skills. Where such a service does not exist, eventually it should and no doubt will be created to occupy the field. Where a public employment service is not now skilled in these matters, or where an employment service does not exist, much may be done to create an efficient institution by charging it with the responsibility for recruiting for resource development. There is much employment service experience to draw on in Britain, the United States, Canada and elsewhere.

Expedients already outlined, or comparable devices developed on the spot, will be found necessary in order to assemble the needed skilled workers, or to develop skills through rapid training. After all the job is mainly to produce skill where too little exists—and to produce skill in a hurry. Measures calculated to produce an abundance of skilled workers for five or six years hence will not aid *immediate* developments. There is no world source from which skilled workers in sufficient numbers can be drawn. Therefore, skills must be developed "on the spot" by expedients, chiefly, as suggested, by spreading out workers already skilled over as large an area of industry as possible, and by "fractionalizing" skilled tasks so that specialists may be trained quickly to take over various portions of the job. The study I.L.O. has given the subject indicates that while it involves a multitude of difficulties, the task is not impossible. What has been done before, can be done again, and perhaps with previous experience to look to, can be done to even better advantage.

Recruitment of unskilled workers should offer no serious obstacles, even if involving some work—and occasionally considerable expense.

I might just add a footnote on the factor of health as affecting all employees to be introduced into industry. Where relatively low health standards are found, it will probably be necessary to develop standards of fitness for admission to employment in an enterprise. It would be unfair to the enterprise and the employee alike were this not done. Health standards before hiring are today common enough, even in countries with reasonable averages of fitness. The introduction of health standards may reduce the available workers, but probably not embarrassingly so at first. It would be hoped that action by national governments and international organizations (and notably W.H.O.) would continue to raise standards, so that as development expands, rejection of job applicants through low fitness would diminish.

I now come to the problem of labour supply in relation to agriculture. In those countries regarded as under-developed in the older parts of the world, the two agricultural problems found most frequently appear to be an under-supply of agricultural products for the general population and an over-supply of workers—or perhaps I should say an over-supply of people trying to make a living from the land. Where this latter situation is the case, there is no problem of labour shortages: in fact, the problem is rather to find a means for some part of the present agricultural population making a livelihood in some non-agricultural pursuit. Resource development should assist in time in diminishing overpopulation on the land. The question of production, of course, is one for experts in agriculture.

In the under-developed areas, where it may now be proposed to open up new land and to develop it for agriculture, there appears to be only one answer on labour supply. Even the most modern machines will require workers, so that new land means new labour requirements. If the local available workers be inadequate in point of numbers, migration seems to be the solution—and in agriculture a not too difficult one. Canada and other countries have had considerable postwar experience in inducing workers for agriculture to immigrate—and on the whole this experience seems to have been reasonably successful. It can be intensified, in the opinion of I.L.O., to meet the problems of agriculture. In mechanized agriculture the question of mechanical skill will again arise, and so also will the question of technical agricultural knowledge. By reason of being on a much smaller scale than the comparable problem facing industrial expansion, by reason of the inducements which may be available, and by reason of a relatively greater number of trained skilled workers already present in countries with unoccupied land, generally speaking, one is led to believe that a re-distribution of workers will meet skill needs in large part. With the aid of those already trained in agriculture who may be encouraged to come as immigrants, the problem can be met.

A few general observations may be timely in conclusion:

1. Back of all these remarks is the assumption that throughout we are speaking of free and independent labour—that recruitment will always proceed by conviction and not by coercion. In the long run, coercion of workers into the job has not given results at all comparable with freedom of choice on the part of the worker. We would hope that any element of coercion is repugnant to the very idea of expanding resource development in the interests of mankind—that it would be too ironic that such a benevolent program should have as a by-product any curtailment of liberty.

2. At all stages, in putting forward any program of this nature, it must be remembered that it will be subject to adaptation to meet the traditions, whether social, economic or religious, of people affected, and only that system will work which fits in with the ideas which a people hold as part of their priceless heritage.

3. In order to secure the greatest measure of success it will be found essential at all stages that the

relevant workers' trade union (where one exists) and the employers' organizations be consulted by Governments, so that what may be decided may have the active support of the two parties at interest in industry.

4. To secure popular interest and popular support it would be well, within each jurisdiction, that as extensive publicity as local facilities may afford should be employed by Governments to educate workers into their new environment. Even in older and long established industrial economies this is found necessary. To allay prejudice and defeat false rumour, educational publicity will be found even more necessary and helpful in those countries not yet fully acquainted with the full implications of a new industrial era.

The I.L.O. is, of course, prepared to give very active assistance in these matters to its Member States who seek its help. Already some field missions to do this very job have been located by the I.L.O. in various parts of the world. In one form or another I.L.O. will make available to Member States the full value of its experience and study in these matters, and it goes without saying I.L.O. will act in closest co-operation with the United Nations and the specialized agencies in regard to the whole program of resource development.

The CHAIRMAN: We shall now open the general discussion on Mr. Phelan's paper. The first speaker in the general discussion is Mr. Santiago Antuña, of Uruguay.

Mr. ANTUÑA:[b] The progress of a nation comes fundamentally from within, and it is for the peoples themselves to conquer their own destinies. In this noble conquest it is one of the duties of governments to frame the social welfare schemes needed to equip their peoples properly for such an achievement.

When the President of the United States suggested the holding of this special international meeting for the exchange of knowledge and experience, the Scientific Conference on the Conservation and Utilization of Natural Resources convened by the United Nations, he assuredly thought that he was giving the world a wonderful and glorious opportunity for the real and effective mobilization of productive resources, and that he was thereby helping raise the standards of living of the world's peoples. Thus, Mr. Truman gave expression to the common concern of almost all the nations of the world, which are striving to produce more and better goods in order to overcome the economic insecurity caused by the disorder and confusion of these last trying years.

My distinguished colleagues will now permit me to deal with what relates more particularly to my subject today—the consideration of the problem of the human factor from the fundamental angle of agricultural development. It is in this branch of social activity that we find the most primitive conditions of human life, conditions that make rehabilitation a necessity.

As was very well said by the Chairman a few moments ago, while land is extremely important from the economic point of view, the human factor is no less important, for it is the true dynamic force which operates the process of transformation. Nature is active in germination, but man by his work can direct that function at will; the wind and the waters move freely without human intervention, but man can use these sources of energy and activity by holding them in check or unleashing them.

Consequently, one of the most vital problems of production will be the development of an able and conscientious human labour force. The solution of problems relating to individual needs and capacities is an effective means of increasing production. Improvements of the necessary machinery, and technological progress will also contribute to an expansion of production. Welfare services, which are of undeniable social importance will make production more secure. All these elements of production, however, must necessarily be supplemented by an economic and social system established and conditioned by the determination to create a society of free men living and working on terms of equality.

Among the young countries of America, Uruguay has felt that no real agrarian reform could be accomplished without stressing the essential importance of values represented by the human factor in the widest sense of the term. Often and in many places we will find agricultural communities whose members vegetate, bound hand and foot to their land or to an illusion—very often their only asset. They reject all external contacts and are unresponsive to the changes in their environment, to the hope of a prosperity which is tardy in arriving. They are communities which experience the same needs and suffer the same hardships and privations, are prone to the same doubts and, very often, fall prey to the same feelings of despair.

I do not think I need adduce more arguments to demonstrate the urgent and imperative necessity for prompt and effective action, starting from the assumption that the present may be an opportune moment for attempting to transform the peasant's psychology and for bringing men's consciences and minds together in a common desire for improvement which will ensure a better use of individual efforts.

It will be along these lines that the rural worker will achieve higher status. The agricultural worker must be made to understand how useless and misguided human efforts are when they are not directed towards a single supreme common purpose and when there is no union of all the factors directed towards achieving an identical purpose. If the agricultural worker is sure of finding the necessary assistance and advice at the right moment, a new awareness will be created within him. His vision of the problems will be widened; he will no longer live on the soil on which he works in ignorance of his country's economic development, but will deliberately adjust his efforts to the latter. We shall thus succeed in producing citizens who are perfectly identified with the progress of the country in which they live, who feel they are taking part in their own development and who understand that they are themselves responsible for their own future.

We shall then have given the human factor the special place which is its due. And we shall have forgotten the ancient error which consisted in looking at the land

[b]Mr. Antuña spoke in Spanish.

and placing man upon it as a superimposed factor. We shall then consider man as the central factor and the land as the background, the environment in which his life moves and his work develops. Let us not forget that, basically, the problem of the rehabilitation of the peasant is fundamentally an educational problem. Education given to the child and the youth will ensure them a future in which they will have a part; and education given to the agricultural worker will be an effective guarantee of agrarian reform.

The extraordinary and transcendent importance of the social, moral and health aspects of agricultural communities must not be forgotten, either. In particular, all the various economic processes of rural life are closely bound up with those of a social character. The presence in many young countries like those in our American continent of rural population centres in which development has been very precarious, where malnutrition affords a propitious breeding ground for hereditary diseases, where woman is merely a machine for the reproduction of the species and infant mortality is on the increase, really constitutes clear proof of failure to apply the means and solutions for dealing satisfactorily with these human and social problems.

In the matter of giving guidance to the agricultural worker, it must be borne in mind that it is not sufficient to talk to him about the economic or social advisability of making a change in his ways of work, his technique or the planning of his labour. The very complexity of the problem and the variety of aspects which it may offer will engender in the worker a feeling of hostility to the innovations suggested to him. It will be useless to sow seed in land that has not been properly prepared to receive and fertilize it. This has been and will be the reason for the failure of many efforts that have begun precisely at the point where they should have ended. This is one of the problems met with in some areas of this young America, which is entitled to seek the eminent place which is its due in finding a solution for this problem.

It is thus necessary to create useful employment, to extend agriculture, to place stock-breeding on a selective basis, to establish irrigation systems in as many areas as require or are capable of irrigation, and to make the country-side attractive. To achieve this, however, it is absolutely essential that the worker should stay on the land on which he works. Through an exact knowledge of all rural activities in their relationships to the various ethnic, social, agricultural and climatic factors which may decide their success or failure, the various governments in the world which are concerned for reconstruction and peace may now decide what action should be taken, so far as agriculture is concerned. Action on this level will have to be continuous, since it is absolutely necessary that knowledge should at all times have reference to actual conditions.

A plan for agriculture and stock-breeding worked out with such objectives must at the same time afford the assistance to which the rural worker is legitimately entitled, assistance which may be summarized in these four fundamental requirements:

(*a*) Attachment of the worker to the soil which he tills;

(*b*) Facilities for supplying the necessary materials for making the land which he occupies productive, and protecting his productive activities against the negative factors incidental to agriculture and stock-breeding;

(*c*) Reduction of production costs, and fair and unhampered facilities for marketing produce;

(*d*) Attention to the social, moral and health problems of the peasant family. Greater facilities for cultural and technical assistance to producers through effective scientific and practical guidance.

In view of these considerations and taking into account the importance of the human factor, particularly as it concerns those points on which it is fundamentally connected with the objectives of this Conference, I should like to suggest for future international meetings such as the present the inclusion in definite terms of problems related to the human factor, without which there can be no progress and no prosperity.

I shall transmit for the consideration of my distinguished colleagues here present and for the decision of the Secretary-General of the United Nations the point of view which we delegates of Uruguay to this Conference have emphasized in the various committees. This point of view, this proposal or, if you like, this conclusion may be summarized concretely as follows:

That the human factor, as related to the social, technical and economic aspects, is fundamental to the subject matter of any future Conference which will continue and develop the work initiated so auspiciously by the present Conference.

Perhaps I may be allowed to say that we who come from Uruguay are glad to offer the contribution of a living experience, legal and technical, theoretical and practical. It is that experience which allows us to face the future, considering the human factor to be an essential element of any plan aimed at the advancement and improvement of the living conditions of the peoples of the world.

Similarly and in conclusion I should like to draw the attention of all the organs of the United Nations connected with the preparation of these international conferences to the evident need not to overlook in any list of subjects the problem of man as an essential factor in production. It is this factor which so often evokes bitter realities, but it is on human efforts and human hopes that all possibilities for the future in the better world towards which we strive must be based.

The CHAIRMAN: I thank Mr. Antuña for his contribution to the debate. In the material submitted by Mr. Phelan and Mr. Antuña there are some points which are contradictory which we shall have to discuss. I have, however, to take note of such stern realities as the march of time and there are other speakers on the same subject on the list for today's meeting. I now call upon Professor de Vries of the Netherlands to give us the benefit of his opinion and experience.

Mr. DE VRIES: I should like to add only a very few comments to what has already been said because I am in agreement with many of the views expressed this afternoon. Pre-war experience in Indonesia showed that when an industry was established it was not difficult to recruit labour from the population, even if the individuals had not been in industry before, provided the right conditions were offered. We were able to find very good factory workers, probably because the Indonesians are very capable craftsmen by nature even when they are peasants, and they adapt themselves very readily to industrial work. In the beginning the system followed consisted of recruitment and then education in the factory itself, but in later stages we introduced vocational schools and I do not think that these can be omitted after the first start has been made. The task of the vocational schools is to give the students there an idea of the kind of work which will be expected from them in the factory. There has therefore been established a system of rather close co-operation between the schools and the factories which has proved very useful. In this system boys first attend the school, then spend a month or so in a factory and afterwards return to school. This has led to very great improvements in the practical results of the vocational schools.

In regard to agriculture, the problem is much more difficult as Mr. Antuña said. The work of a farmer cannot be specialized; it presents an integral problem in that he has to deal with a number of crops and a number of operations in regard to each crop, operations connected with soil, water and cattle. We found that agricultural schools were not a success. It has been said before in papers submitted to this Conference, but I should like to repeat that the best method of developing the knowledge of the farmer and helping him to adapt himself to changing conditions is to work mainly in the village where he lives and in the conditions under which he has to work. Our method, decided upon after much trial and error, is to work through the schoolmaster of the village elementary school. We take him from his village for some time and give him special courses in which he learns things which he can pass on subsequently to the boys and the people of the village. Thus we concentrate our efforts towards agricultural improvement particularly on the boys and girls—the latter are usually the task of the schoolmaster's wife. Young people between sixteen and twenty years old are on the threshold of independent life and have proved in Indonesia to be the best material for the promotion of developments in agriculture. This training must be on the basis of an elementary education given to them while they are young children. We found that it was difficult to give effective training without that elementary education, and to give elementary education without adult training resulted in much waste of effort. The combination, however, leads to very good results which we hope to see become more widespread in the future.

The CHAIRMAN: I thank Professor de Vries for his contribution to the debate and congratulate myself upon having offered him the opportunity to speak. I now call upon Dr. Clements, Chief of the Nutrition Section of the World Health Organization. He will submit a paper on the application of the principles of nutrition in the use and conservation of natural resources. Dr. Clements will also present a paper prepared by Dr. Wolman of Johns Hopkins University of Baltimore. Dr. Wolman is unfortunately unable to come to the meeting today. Before entering the World Health Organization Dr. Clements was Chief of the Nutrition Services of the Health Department of Australia and Director of the Australian Institute of Anatomy in Canberra. The theme of these papers is very interesting, as was the last subject. The Conference is looking at the problems of labour, whether its recruitment or its employment, from the human point of view, and in our consideration of natural resources we are now dealing with the place of man among those resources.

Mr. CLEMENTS *presented the following two prepared papers:*

Man as a Resource: A Problem in Conservation

ABEL WOLMAN

For centuries discussions on the importance of man as a natural resource have moved from philosophies of despair to unbounded enthusiasms as to his worth. Malthus was not the first to raise doubts regarding even the possibility of conserving man under the limitations of food supply which he envisioned. Many attempts have been made over these centuries to evaluate the economic significance of man in terms of dollars and cents or their universal equivalent.

To this author at least, the decision as to whether man is worth conserving would seem to be one which answers itself, in any discussion of the conservation of natural resources. How to keep him alive, happy, well fed and well sheltered must, of course, be viewed realistically in relation to the availabilities of food, industrial processes and technologic art. As a public health worker, the first objective of these varied efforts would be to reduce disease and to salvage lives. In laying out his task, however, the public health worker is immediately confronted with the issue as to whether the successful performance of this assignment will bring in its wake for the same population even greater difficulties than those from which it has temporarily escaped. With this perennial dilemma in mind, he has frequently turned to strange conversion tables by which he may assay the economic value of human life. Although reference to this conversion is made herein primarily for historical purposes, it is perhaps axiomatic to point out that, in the long run, the sole purpose of conserving and utilizing natural resources is to bring increased well-being to mankind. To assure to man the highest possible level of physical, mental and social well-being is an end which for our purposes needs no debate. It is an end which has been recognized explicitly by the constitution of the World Health Organization, for which the author now speaks, and it is implied in the basic Charter of the United Nations.

From the standpoint of this Conference, however, we should like to consider human well-being not so much as an end, but as the means by which the natural resources of the world are most likely to be conserved and developed.

THE ECONOMIC VALUE OF HUMAN LIFE

The economic value of human life was recognized very early. As Sigerist has reminded us recently, Simonds calculated as early as 1851 that sickness was costing the City of New Orleans $3,530,000 a year. A generation later, in 1873, Max von Pettenkoffer developed this argument in his lectures on "The Value of Health to a City." He pointed out that if the city of Munich were to invest what was then an enormous sum —about 7,000,000 florins—to improve its sewage-disposal and water supply, and if it thereby decreased its death rate from 33 to 30 per 1,000, the capital thus involved would yield a profitable rate of interest.

The work of urban sanitation which the early sanitary engineers achieved in Western Europe and North America has been reflected in the tremendous increase of productivity in those regions during the past century. It has led to the high standards of public health which many countries take for granted today, and has given rise to a new specialization—industrial health services. In this connexion, we must not fail to consider that the mental and social adjustment of the worker has a controlling influence both on his general well-being and on his ability as an economic producer. Modern industry is discovering the fact that wage incentives, mechanisms for collective bargaining and the like, while they increase output, do not provide a sufficient basis for human productivity, and that consideration must be given to the problems of the individual.

In the development of the modern industrial economy, the assurance of a healthy, dependable and self-reliant labour force ranks in importance with the harnessing of steam and electricity, the discoveries of modern metallurgy and chemistry, the invention of new means of transport and communications, and the devising of methods of mass production.

In less favourable environments the necessity for protecting the health of workers has been demonstrated repeatedly in situations where modern techniques have been applied for the development of natural resources.

An excellent example of the importance of protecting the health of the worker is offered in modern history by the failure of the French to build the Panama Canal, in spite of the fact that they had the enthusiasm, the technical proficiency, the housing, the necessary food and even the mechanical equipment. It is worth recalling that their defeat was by yellow fever and other diseases. When the United States of America assumed jurisdiction over the project it was able to complete the Canal at a reasonable cost. Its ability to do so, however, was conditioned primarily by its recognition of the necessity of eliminating the mosquito hazards and of providing the primary elements of environmental sanitation. The record shows that its expenditures for health work and for the prevention of disease was less than 5 per cent of the total cost of the project.

In the first seven years of the Panama Canal Project, it is estimated that some 25,000 lives were saved, even though distinguished members of the staff unfortunately were killed by disease during the same period. Without these efforts the procurement of labour and its conservation, the major essential for building the Canal, would have been impossible.

PUBLIC HEALTH AND ECONOMIC DEVELOPMENT

In spite of this record and similar ones later reported herein, the principle that the health of a people is primary in the development of resources has rarely been widely applied throughout the major sectors of the world. It is even rarer that the programmes for public health have been linked effectively with the programmes for economic development.

That such linkage is not only desirable but almost necessary in commercial and industrial enterprises is best illustrated by the experience of one of the large commercial enterprises in the Caribbean region. The Medical Director of this company stated in 1947 that the officials of the Company realized that "sick employees are unproductive and that economic advance depends upon production, and therefore they are not only agreeable to, but insistent upon, medical and sanitary standards that promote the human dignity and welfare of the labourer, protect his health, and provide optimal living conditions for himself and his family. They feel not only that it pays, but that in making these expenditures they are fulfilling a duty to their stockholders, by conducting a successful business for them."

These examples may be multiplied in a number of directions to illustrate the principles implied, even though as already stated the universal application of the axiom still remains to be accomplished. No magic wand will bring these accomplishments into being, because it must be recognized that even the most advanced techniques, modern equipment and huge capital resources are not enough to insure the success of industrial or commercial enterprises, where the natural environment is unfavourable.

Whether on the farm or in industry, the availability of a strong and reliable labour force is normally the critical factor in the success of the enterprise.

Experience has indicated the justification of the statement made by a practiced observer that "In the light of present-day knowledge and the results of past experience, when an area is to be developed, the health officer and his sanitary engineer, assisted perhaps by a psychiatrist, should move in on the heels of the prospector, and not with the fever van and the undertaker after the damage has been started, as has all too frequently been the rule. With the mechanism available today for integrated approach to development no failure to make use of this technique can be tolerated."

It is encouraging to be able to say that, when properly planned and intelligently executed, investment in the development of human resources benefits both the investor and the region where the investment is made. When that work is done by means of foreign capital such intelligently planned investment is perhaps the only field where controversy does not arise. That it is possible for such programmes to be intelligently planned and executed, as well as psychologically acceptable to the resident population, is perhaps well illustrated by the public health activities in Latin America in recent years by the Institute of Inter-American Affairs. The programmes are modest, they are not rushed into execution, they are largely manned by indigenous experts only lightly supplemented by professional advisors from outside the countries, and they are increasingly financed to a major extent by the local people. Such a pattern and its skillful and careful evolution might be studied with both interest and value by most workers in the field of public health as applied to countries other than their own. This experience indicates over and over again that it is possible to evolve ingenious techniques for salvaging lives, which are adaptable to the customs, psychologies and pocketbooks of the local people. The experience illustrates, furthermore, that the investment in the slow but effective development of a country's own human resources, provides not only for a lifting of its own standards of living, but may well be the best way of ensuring full participation by that country in the general advance toward more adequate standards of living elsewhere.

THE UNDER-DEVELOPED COUNTRIES

The examples given thus far have been drawn from experience gained by countries which possess both technical knowledge and material resources. But some 80 per cent of the world's people live in regions whose economies and social structures are only partly developed, or are undeveloped. Moreover, those same regions possess an appreciable part of the natural resources with which this symposium is concerned.

There is little accurate knowledge concerning the size and condition of the human resources of these areas. However, the principles which have been illustrated above apply with equal force to the 80 per cent of the world's population who live there. This fact has urgent implications. For example, Dr. A. Macchiavello, who has made studies of "human economics" in relation to Chile and Ecuador, states as follows:

"The conclusions might be applied to the whole continent. In this work we analyzed exhaustively the medical, social and economic causes of the wastage of human life during pregnancy, childbirth, infancy, maturity, and old age, and attempted to make approximate calculations of what these losses in biological capital mean for the national economy. The worker's low expectation of life and the high infant and general mortality rates are the worst features.

"Another uneconomic factor which has never received the consideration it deserves is the poor use made of human life. To give a simple idea of what that means we add a few calculations relating to Ecuador, expressed in dollars:

"Losses due to short duration of life, calculated on an average of two years and a wage of $3.70 (or 5 sucres a day)	$148,200,000 (Sucres 200,000,000)
"Premature loss of commercial value of human life (disablement, confinement in poor-house, insanity, lack of pension, etc.)	$74,100,000 (Sucres 100,000,000)
"Interruption of productive capacity, based on absence from work, attendance in hospitals and out-patient departments, medical expenses, etc.	$111,150,000 (Sucres 150,000,000)

"If the life of [Latin] American man were extended by five years of activity, if the general mortality rate were reduced by five per thousand and if absence from work diminished by twenty per cent—figures which could all be reached—at least $10,000,000,000 would be saved annually in Latin America, taking the average annual value of a man's work as $500."

A similar situation may be found in some parts of China. For example, the reduction in agricultural efficiency, due to hookworm disease, in certain critical parts of China has recently been set forth by Chang and his co-workers. The reduction in efficiency may vary from 50 to 90 per cent of the agricultural workers' performance. Here is an interesting example of a place where resources are available, but their use to maximum advantage is hampered seriously by a disease which establishes a vicious cycle of low efficiency, low productivity, severe malnutrition, lowered resistance to disease and continued deterioration of performance. This vicious cycle illustrating, perhaps, the entire principle of the relationship between health and economics, is a special lesson of great importance in conservation. It is superficial and inaccurate to say that in these areas people live at a starvation level because of the unavailability of land. It is equally superficial to say that the correctives are hopeless, because time, education, changes in social practice, family controls, the mental hygiene of the individual are all required for the complete result. The skilled observer is aware that all of these elements are essential for ultimate success. He is equally aware, however, that if no beginnings are made no end results are likely to ensue. He is also aware of the fact that the mere transfer of the Western World techniques, equipments and psychologies to the rest of the world, where life is cheap and starvation is common, cannot be done successfully overnight by sleight-of-hand. The translation of effective principles into equally effective results offers one of the most challenging assignments to the public health worker and to the economist that the world has ever seen.

OBSTACLES TO BE HURDLED

Perhaps the main obstacles to the conservation and use of natural resources in major regions of the world may be grouped as follows:

1. *Climate:* Heat with heavy rainfall; heat with insufficient rainfall; the effect of high altitude on human and animal life. The consequences of unfavourable climate include the presence of noxious insects, such as mosquitoes and locusts; insufficiency of water supply; imbalance of chemical elements in the soil; erosion, insufficiency of crops etc.

2. *Epidemic and endemic diseases:* Not only the pestilential diseases like plague and cholera, but other diseases which tax the strength and productive capacity of a country just as severely, for example, malaria, the enteric fevers, yaws and parasitic diseases like schistosomiasis, helminthiasis and trypanosomiasis.

3. *Conditions which are due mainly to low standards of living:* Deficiencies of nutrition, for example, scurvy, pellagra, beriberi; diseases such as leprosy, tuberculosis and syphilis; and such conditions as low expectancy of life fostered by ignorance, poverty and filth and by the attendant high rate of infant mortality.

4. *Lack of technical information and skills:* As has been stated above, there is far too little precise information on the nature and extent of the health problems and the human resources in many of the areas which we are considering. This handicap increases in importance with the shift of emphasis from foreign capital investment—which may have only a limited interest in the well-being of the community—to the effort by the countries them-

selves to develop their natural resources and provide full opportunities for all their people.

5. *Lack of personnel:* Another aspect of the same problem is the grave lack of technical personnel of all degrees of skill.

POTENTIALS OF PUBLIC HEALTH CONTROL

Climate in the general sense of the term underlies all the problems which are being discussed at this meeting, and the solutions proposed by other sections will help to increase human resources by raising the standards of living. It would be superfluous to describe here, in detail, the techniques and materials by means of which we can now solve most of the specific health problems described above. They range from spectacular new developments such as DDT and antricyde to the application of sanitary precautions which were known to the Minoan kings of Crete in the eighth century B.C. What is important is to emphasize that these techniques and materials are not too costly.

Malaria can be brought under control by residual spraying with DDT at an average cost per year of 15 to 30 cents per person. Town water supplies require capital, it is true, but safe and abundant water from a municipal system costs less than unsafe water peddled in the streets. Ordinary privies which villagers themselves can build will protect the soil and water in rural areas. Fundamental person-to-person and visual education can form habits of healthful living and support health services by effective popular demand. Such education can be carried out with a minimum of special skills and equipment.

It has been argued that the countries where the need for increased physical and social well-being is greatest must reserve all their resources for productive investment. The history of the more fortunate countries counters this argument by demonstrating that the people of a country are its most valuable resource. Investment in the health of the people is not only a prerequisite to the successful development of natural resources, it is essential to the development of the productive capacity which characterizes the advanced economies.

JOINT ACTION REQUIRED

The World Health Organization is fully aware that the isolated efforts of international bodies do not always yield the maximum benefit normally to be expected. Their very specialization creates natural limitations in the face of the complexity of the problems of modern life.

Because of these limitations and the benefits of close co-ordination of other international bodies, the World Health Organization has negotiated for the establishment of undertakings with the Food and Agriculture Organization in the areas of rural nutrition and hygiene; with the International Labour Organisation for the study of questions of industrial hygiene, tuberculosis, and health insurance; with the International Civil Aviation Organization in connexion with the various health problems of aviation; and with the United Nations Educational, Scientific and Cultural Organization on the important problems of common interest in the field of professional and public education.

The Interim Committee of the World Health Organization at its fifth session summarized the fact that co-operation with various international bodies should be continued "with special reference to the importance of emphasizing . . . that economic development without adequate health measures is necessarily incomplete, and that it is the right of people to expect that proper health measures be taken concurrently with such economic efforts."

The investments in the health of the people have always paid much higher dividends than were predicted at the initiation of those efforts. If wisely planned and conservatively extended there is no reason to believe the same results cannot be attained in many other parts of the world as have been exemplified in Western Europe and in the United States. One can be aware of both the difficulties and the obstacles in such a programme, without losing sight of the primary and lasting beneficient values for which one must strive. Negativism in attitude and in action are sometimes effective in some areas of human enterprise, but the prevention of disease and the saving of lives does not appear to be one of such areas.

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The Application of the Principles of Nutrition in the Use and Conservation of Natural Resources

DR. F. W. CLEMENTS

The previous paper in this series stressed the close relationship between a strong, healthy labour force and the successful use and conservation of natural resources of any area and gave examples of specific measures in the field of environmental sanitation that have resulted in improvement in the health and physical efficiency of labour forces. This paper deals with the place of nutrition in any programme involving the use of labour, with special reference to the tropical and subtropical areas.

Emphasis has been given to the problems of tropical and subtropical areas, as these regions are among the last remaining reservoirs of undeveloped material resources. The nutrition problems of many population groups in these areas have already been the subject of a number of international conferences, so that to-day the extent of the problems is fairly well known. The successful development of the material resources in some of these areas and, in fact, the extension and even the continuation of many existing enterprises depends, in no small measure, on the elimination of the nutrition problems.

Several specialized agencies of the United Nations are interested in the problem of "food for health". UNESCO is now sponsoring a series of round-table discussions and seminars on the topic "Food and People". FAO places the emphasis on nutrition in relation to the production, distribution and consumption of food, while in WHO emphasis is on human nutrition in relation to the maintenance of health and the prevention of disease. FAO has stimulated study of nutritional problems in a number of tropical countries and has produced several reports which incorporate the results of recent investigations. Free use has been made of FAO publications in the preparation of this paper, so that although it is presented under the aegis of WHO it is in a sense a joint contribution.

The dietary habits of a population are closely linked with the food production pattern of the area, for less than ten per cent of the food produced in the world moves in international trade and almost the whole of that flows from the New World to the congested, highly industrialized areas of Europe to assist in feeding a population which does not exceed 300 million. Indigenous populations in tropical areas are almost wholly dependent upon locally produced food.

A number of factors determine the types of food produced in any given area. These include: the traditional food habits of the population, soil fertility, climate, and population pressure on land; the last mentioned is probably the most important of all. These factors must be considered in any study of the nutritional status of a population.

FOOD CONSUMPTION PATTERNS AND THEIR NUTRITIONAL VALUE

The food production and consumption patterns of the population of tropical areas fall into three major categories, which, because they are so fundamentally different, will be considered separately.

1. *Hunting and pastoral:* These communities usually have ample land over which to hunt or to graze their flocks and for these groups there is little or no population pressure on the land. In many of the areas where hunting is the major occupation the soil and climate do not permit of extensive agriculture and animal foods are augmented by wild roots, fruits, leaves and berries gathered usually by the women. Examples of hunting communities are: the Australian aborigine, some groups of New Guinea natives, pigmies. In general, they represent an extremely primitive form of social organization which did not evolve beyond this type of economy at the same time as did other large population groups.

The dietary pattern of a hunting community is characterized by high protein intake and because of this the mineral and vitamin consumption, with the exception of vitamin C, of the adult members of the community is probably adequate. Calories for energy are obtained almost entirely from fat and protein. A clinical feature of the members of some hunting communities is the absence of subcutaneous fat, suggesting that the energy expended in walking great distances hunting for food is just balanced by the caloric intake so that a surplus of calories is not available for storage as depot fat. The infants and children of a hunting community do not as a rule receive enough calcium or vitamin C. In these communities the supply of food is dependent upon the availability of wild animals or fish so that periods of serious starvation alternate with times of plenty.

The Masai of Kenya are a pastoral tribe whose sole occupation is the tending of large herds of cattle, sheep and goats. Orr and Gilks (1)[1] studied the food patterns and physique of these people in detail and the following description is taken from their report:

"The staple articles of diet are meat, milk and blood. The blood is drawn from the living animal by puncture of the jugular vein with an arrow. Various roots and barks are used to make infusions which are used either with boiled meat or with milk. The men, while in the 'moran', or warrior class, subsist practically entirely on these articles of diet. The rest of the population, in addition to these four items, which form the main part of their food, eat also some bananas, beans, millet, arrowroot, maize, sugar and honey, as these are available. The use of maize, which was introduced only a few years ago, is increasing.

"For the greater part of the year there is no scarcity of meat, blood and milk, but in periods of severe drought, when, in spite of the large herds, the milk supply is inadequate, the consumption of these vegetable

[1]Numbers within parentheses refer to the Bibliography.

foods is increased, and even the 'moran' may be compelled to supplement their meat and milk diet.

"Berries are eaten by the warriors when on safari, i.e., on hunting or fighting expeditions. It appears also to be customary to send the pregnant women into the bush to eat berries. The berries would make an insignificant contribution to the main constituents of the diet, but it is probable that they are of considerable importance as an antiscorbutic addition."

The total number of people in the hunting and pastoral communities is small and represents but a fraction of the world's population. They have nutritional problems which, although they may not be easily solved by local measures, are capable of solution by outside help because of the smallness of the populations involved.

2. *Primitive agricultural communities:* The agricultural pattern of these communities is usually the bush-fallow rotation. In this method of farming the natural cover of the forest or grass lands is cut down and burnt and then one or two crops are planted. After these have been harvested the land is allowed to return to its former state and trees and grass grow on it again. This is the bush-fallow period, which may extend up to ten years in some localities before the land is again cleared for crops. This type of agriculture is associated with the absence of population pressure on land. Mixed crops of tubers and greens, are augmented in some places with cereals. It is not customary for these peoples to keep large numbers of domestic animals and such protein foods as are eaten are generally the product of hunting or fishing excursions. On festive occasions domesticated animals may be killed. Communities with this primitive agricultural pattern are to be found in Central and South America, parts of Africa and the Pacific Islands, in fact, in most of the undeveloped parts of the world.

Except in times of naturally occurring catastrophes, e.g., drought, ravages of insect pests, the diets are generally adequate in calories. The mixed nature of the diet, containing as it does a number of different classes of vegetable foods, augmented occasionally by foods of animal origin, suggests that it contains sufficient protein for adults. The outstanding deficiency is protein in a form easily digested and assimilated by infants and children, and the most constant clinical feature is the poor physique and lack of muscular development and poor muscle tone of the children from about six to sixteen years of age. Also the average height for age of these children is significantly less than those for children of the same age of Caucasian stock living in Europe and North America. Good muscle tone during the growing period and the attainment of the maximum body height are probably of limited clinical and economic significance but they are quantitative aspects of the protein adequacy of a diet and as such are guides to important body functions which depend upon an adequate protein diet such as growth and function of the ductless glands and the development of resistance to infection.

Deficiencies of minerals and vitamins, with the possible exception of calcium, are not usually a feature of this type of economy. Adults probably obtain enough calcium from leafy greens and other sources but it is doubtful if infants and children do, largely because they are unable to eat enough of the foods rich in calcium.

One of the most important observations of recent times is that whereas one article of diet may be the staple of this type of community, supplementary items such as leaves, berries, fruits and nuts are regularly consumed in sufficient quantities to provide a large percentage of the daily intake of minerals and vitamins. In parts of the world where the traditional diet is of the mixed variety, some employers who have provided their labour with meals have supplied the local staple foodstuff and ignored the supplementary items, generally with disastrous results. There are advantages in the use of local diets for local inhabitants but it is essential to supply all the items of the diet. This is best done by the establishment of gardens under the care of local inhabitants, with instructions to grow everything normally eaten by the labour force in the home villages. A large commercial enterprise now operating in a State in South America has followed this practice with outstanding benefit to the health of the employees and their families.

The nutrition problems of these areas vary widely from serious undernutrition, with its attendant deficiency diseases, in Africa (2) (3), to adequate calorie intakes accompanied by low protein intake in New Guinea. It is significant that frank deficiency diseases seldom occur in communities living on the traditional diet. These diseases only make their appearance when the diet is altered by impoverishment of the soil, due to the introduction of bad farming practices or by an extensive change over to cash crops, or by urbanization. In these localities the traditional mixed diet has been exchanged for one purchased from the trade store and consisting mainly of cereals and an occasional tin of meat or fish. It is no longer possible for these people to obtain supplies of fresh supplementary foods. The clinical picture in these areas is one of extensive malnutrition affecting all age groups but especially the children. In these areas there is a high incidence of kwashiorkor, a disease of infants and young children which, unless recognized early and treated, terminates in death. Dr. Cicely Williams and others who have studied the condition in detail are satisfied that it is due to general malnutrition with a marked deficiency of protein. (4) (5) (6)

Employment of the local population must be an integral part of the plans for the development of the natural resources of an area but it is essential that the diversion of some of the labour force does not impair the health and nutritional state of the whole community. In other words, the unit must be able to spare the labour diverted from the normal processes of food production and the provision of shelter. The extent to which this can be done will vary widely, for in some areas the combination of conditions is such that the daily food needs are produced and gathered with the minimum of human effort and the community has considerable leisure time. It is obvious that labour for new projects could be withdrawn from this type of community without affecting the food production programme. In other localities, often in the same political unit, up to three times as many man-hours are required to produce the same quantities of food. Much less labour and possibly none at all could be obtained from this type of community without making special provisions. If the withdrawal of manpower for labour forces will impair the food supplies of the community, the contemplated schemes must include the provision of new methods of food production which will both release the necessary labour and ensure adequate quantities of the right kind of food for all.

There are nutritional problems in many of these undeveloped areas now; whether they can be solved depends on local factors, of which soil fertility is probably the most important. Where this is still good, agricultural and educational procedures can do much. Where the fertility of the soil has been lost, as in parts of Africa, the task is more difficult and calls for comprehensive planning as is now being carried out in Gambia by the British Colonial Development Fund. (7) Whatever the local situation, it is important to appreciate that disaster can easily overtake any community in an undeveloped area if it suddenly becomes the centre of an enterprise and a careful preliminary study has not been made of the social customs and food habits of the people.

(3) *The closely settled agricultural communities of Asia:* Here population pressure over many centuries has led to monotype agriculture in which a high percentage of the arable land is used for the production of crops with a high yield of calories per unit area and hence the principal crops are cereals. Land is not available on which animals for food can be grazed. In this region up to 90 per cent of the population are peasant farmers who produce barely enough food for their own requirements and thus there is never sufficient surplus of home produced food for the urban populations. The population has been increasing so rapidly in the last three decades that it is now necessary for China and India, especially India, to import increasing quantities of food. (8)

In its fundamental essentials this type of agriculture is not dissimilar to that in many parts of Europe, but with this important difference, the relatively high standard of living of the European urban communities brings to the farmer sufficient return for his produce that he is able to import fertilizers for his land and concentrated feeding stuffs for milch cows and hogs. Even with this assistance Europe cannot produce its food needs and has to import up to 10 per cent of its requirements.

The monotype agriculture of Asia, even under the most favourable circumstances, is characterized by caloric inadequacy with a low protein intake. (9) When, however, a food shortage occurs, sources of protein are quickly reduced and a large percentage of the population is forced on to a diet consisting almost wholly of rice or millet or wheat, or other foods poor in protein. Infants and children in these communities also suffer from a chronic state of protein inadequacy with its attendant clinical manifestations. (10) (11) Mineral and vitamin intakes of large sections of these populations are well below standards considered by most authorities to be adequate. These are the regions where a disturbingly high number of cases of osteomalacia, a disease characterized by a softening of the bones, have occurred. This is primarily a disease of women who have borne many children and whose diet has not contained enough calcium to fulfil the demands of repeated pregnancies.

The monotype diet of these areas is also likely to be deficient in vitamins and it is noteworthy that in these regions a considerably high incidence of vitamin deficiency diseases occur, especially beri-beri.

THE CLINICAL AND ECONOMIC SIGNIFICANCE OF MALNUTRITION

The most frequently occurring deficiencies in the three categories of food production and consumption considered in this paper are calorie undernutrition and protein deficiency. To consider briefly the clinical features of these will repay the time spent, for it will provide a background against which to review the economic aspects of malnutrition.

The science of nutrition had its beginnings in the eighties of the last century with the investigations of Voit and Rubner into the quantitative food consumption of individuals, and from their results they calculated calorie requirements for various types of workers. At the same time the significance of protein in the diet was recognized. The discovery of vitamins at the end of the second decade of this century and the realization of the importance of minerals in nutrition were responsible for the great advances in the production and use of these substances in the following twenty years. The wheel has now turned a full cycle, for during the last five years there has been a marked increase in the study of the problems of undernutrition and of protein deficiency. In part this was stimulated by the food shortages of the war and the years since, and the reports of the horrors of concentration camps, where men, women and children were slowly starved to death. In part it was the outcome of advances in fundamental research, particularly in protein metabolism.

The description of the signs and symptoms of chronic starvation as seen and experienced in concentration and prisoner of war camps brought prominently before the world the fact that these clinical features were to be seen in varying degrees of severity in many parts of the world in times of peace; that is to say, some characteristics of the so-called normal appearance of many people in Asia, Africa and Central America were in reality signs and symptoms of chronic starvation. (12) (13) (14)

The reports from prisoner of war camps helped scientists to understand more fully the appearance and attitude to work of many people in the undernourished tropical and subtropical regions. Leyton (15) studied the changes that occurred in soldiers when taken prisoner of war and placed on a diet of 1600 calories after high calorie front line diets. The first change was loss of the natural feeling of wellbeing and an ever present hunger, with an abnormal and increasing interest in food. Then followed progressive mental and physical lethargy and an increasing disinclination to engage in physical effort. Keys has recorded that in undernutrition voluntary energy expenditure tends to be curtailed. In his experiments "the total daily energy expenditure at the end of semi-starvation was only about half that in the control period." (16)

The problem of undernutrition and its effect upon the health and wellbeing of a community is demonstrated by another example from World War II. In the pre-war years it was generally recognized that although the diet of large sections of the English people was adequate in calories, it was suboptimal in some other nutrients. It was, however, considerably better than the diet of large population groups in Asia and moreover the people and authorities accepted it as satisfactory for health. The result of food rationing in

England was to improve the nutritional value of the diet of these large sections of the population with the result that millions of people were better fed than they had ever been before and this was reflected in their general health, for of the wartime experience Magee (17) was able to write,

"One of the most conspicuous and surprising phenomena of the whole war was the way the health, vigour, and stamina of the population were maintained in spite of all the stresses of war."

Furthermore, Friend and Bransby (18) found the children of the war years grew in height and weight at a more rapid rate than the children of the same ages in the same areas in 1938 and 1939. Nor was this confined to school children, for it was also noted in England that infants in the first year of life grew more rapidly during the war than in the years before the war. Rapid rate of growth *per se* is not necessarily a desirable feature but in these circumstances it does mean that those children who grew in height more rapidly were receiving more of those nutrients essential for growth, of which protein is probably the most important. Children whose protein intake is adequate have a better chance of reaching a state of wellbeing and optional health and good nutrition.

The relationship of under-nutrition to resistance to infection is a confused picture at present and it is not possible to make firm claims that under-nutrition predisposes to infection except possibly in the field of tuberculosis. All the evidence available indicates that the nutritional state of a community is one of the most important factors in determining the tuberculosis rate. (19) It was well recognized in prisoner of war camps that tuberculosis complicated the terminal stages of chronic starvation.

The extra demands for nutrients in adolescence, a period of rapid springing up and filling out, are often not met, with adverse effects upon the general health, physique and nutritional status. This is also the time when tuberculosis first appears to any appreciable extent in the adult form. Most authorities see a close relationship between the two.

Thus far emphasis has been placed upon under-nutrition and protein inadequacy. Deficiency of other nutrients occurs in areas of semi-starvation in the tropics and subtropics. Gross deficiency leads to frank disease, which, as a rule, so incapacitates the victim that he is no longer fit for work. More important, however, are the mild or subclinical forms, for they are less obvious and more difficult to detect and the victims do not report sick but continue to work. Partial B thiamine deficiency is characterized by physical and mental apathy and considerably reduced output of work. Similarly, in the moderate stages of niacin deficiency, the victim has a greatly reduced interest in his work.

From the point of view of the employer who draws his labour force from the under-nourished areas of the tropics, it is of interest to speculate how much of the lassitude, poor workmanship and low output per man unit is due to chronic under-nutrition, including deficiencies of some of the vitamins, and how much is due to tropical laziness. Is the so-called tropical inertia really a manifestation of deficiency disease? Part of the answer to these questions is to be found in the labour efficiency of well-fed white troops in tropical areas during the war. Also, locally recruited units fed a balanced army ration, working as a labour force, were found to have a much higher output of work per unit than their civilian fellow countrymen who lived on ill-balanced diets.

Further useful information is supplied by two widely separated investigations. On the practical side there are the studies of Kraut and Muller on the output of groups of German workers during the war, while Keys and his colleagues at Minnesota, in their long-term investigations, have provided the scientific explanation for many of the observations made upon ill-fed labourers.

Kraut and Muller, working at the Kaiser-Wilhelm Institute for Industrial Physiology, were able to make a long term study of a group of German workmen who were fed entirely by their factory. (20) They were engaged in the building of an embankment and their task consisted in the dumping of debris out of railway trucks so that it was possible to make accurate measurements of the average amount of work done per man per hour. At first the workmen received rations for light labour and they dumped 1.5 tons per hour. When the rations were increased to those of heavy labourers, the output of work increased to 2.2 tons per man per hour. That is an increased output of 5 to 6 tons per man per day for an increase of 500 calories at an increased cost of less than 50 cents per man per day. During the following year, whilst the men were on the higher rations, the average gain in weight was 4 kg. per man for the year, showing that the extra rations for heavy work were not fully utilized and there was a surplus available for storage as depot fat.

Since the termination of the embankment was urgent, the men were offered a further inducement by way of cigarettes, which were then in short supply. At first, 2.5 tons per hour was the minimum production for which this premium was awarded; after several weeks the premium was graduated, the maximum being given for 3 tons and later even for 4 tons. Soon nearly every man was dumping 3 tons per hour, with the average at 3.4 tons.

It is of interest to note that in the ensuing six months the 20 workmen lost an average of 3.5 kg. of weight, showing that the energy output was not balanced by the ration for heavy work but that the morale building effect of a commodity in short supply was sufficient to call forth the maximum endeavour from the men.

From our point of view, the results of the period before the introduction of premiums are the most important; work output was proportional to food intake.

On the scientific side Keys has observed that muscular wasting is a prominent feature of under-nutrition and has suggested that it is probably due to actual shrinkage of the individual muscle fibres. It is important to appreciate that the heart muscle behaves in a similar manner to the skeletal musculature. In both acute and chronic malnutrition the heart shrinks in volume and weight, with corresponding reduction in output. As a result of these changes, motor functions deteriorate, with impairment of working capacity. Keys stressed the fact that "simple muscle strength, as measured in a single maximal exertion, declines steadily but not as dramatically as does the capacity for continued muscular exertions (endurance)."

The loss of weight of the German labourers in the period when premiums were offered was almost certainly the loss of subcutaneous and interstitial fat.

It is not enough for countries which wish to develop natural resources and reach a more advanced form of economy to concentrate their efforts upon the nutritional state of the labour force; the programme must extend throughout the whole community. The labour force forms an integral part of the community and future labour is drawn from the community. The adolescents this year are the workers next year and vigorous, healthy children can mean a vigorous, energetic labour force in the next decade. The sickly, puny children now to be seen in many villages in tropical areas will be the poor labour recruits for many enterprises in the next five to ten years.

Nutrition is, of course, not the only factor needed to ensure a healthy community. Freedom from endemic and epidemic diseases is essential, but it is equally important that good nutrition should be part of a general health programme for the whole community.

GOOD NUTRITION AS PART OF BASIC PLANNING

The solution of some, at least, of the nutrition problems of undeveloped and underdeveloped areas is essential for the successful conservative utilization of the material resources. For some areas the programmes must be long term, for they will involve changes in the agricultural pattern and food habits and customs of the people. This applies particularly to the congested areas of Asia and in the impoverished parts of Africa and Central America. In other regions where the primitive form of mixed agriculture still prevails it may be possible to bring about the desired changes in a relatively short time.

Whenever a project is to be undertaken for the conservative use of natural resources, it is essential that with the surveyors and reconnaissance party should be medical personnel capable of obtaining information on the natural food production and consumption patterns of the local population and the nutritional adequacy of the diet. The latter should be correlated with the clinical picture of the population and with statistics of infantile and maternal mortality where these are available.

The plans for the economic development of the areas must include plans for ensuring that the workers and their families obtain adequate quantities of the right kind of food. It should be accepted as the first working principle that the quantity of food provided for workers should be adequate for the type and quantity of work required; miners need more than rubber tappers. The second principle should be that the ration should be built around the local diet unless the latter is so hopelessly inadequate as to make this impossible. Importation of food does not, as a rule, provide a satisfactory long-term solution to these problems. It may, however, be necessary, at least in the beginning, to import some high-calorie-yielding foods in order to boost the calorie intake of those workers needing extra calories. This should be a short-term expedient, the long-term projects should include the local production of even this food.

The importation of large quantities of food and particularly the change-over to another dietary is not a satisfactory procedure. It tends to lead to the destruction of tribal life, as has occurred in parts of Africa, or to frank deficiency diseases, as occurred in Nauru in the Pacific Islands. The introduction of foreign foods is a strong inducement to the farmer to change to cash crops so that he too can enjoy the new foods, again, as a rule, with disastrous results. Foods purchased from the trade stores almost invariably consist of over-refined cereals, sugar and tinned meat which do not constitute a balanced diet. In general it can be accepted that a balanced diet purchasable from the trade store is beyond the purchasing power of these people.

The public health man can only point to the problems and suggest the broad general lines along which they might be solved. The actual solution will depend upon agriculturalists, technologists, social workers, etc. New crops may have to be grown and introduced to the population. Existing foodstuffs may have to be processed in a different way in order to improve their nutritional value; for example, numerous conferences have recommended that rice should be undermilled and during and since the war some countries have increased the extraction rate of flour. Or again, new foodstuffs may need to be synthesized and introduced to the population, food yeast may be but the forerunner of many similar products.

That it is possible to improve the health and nutritional status of locally recruited workers in tropical areas by local measures such as better gardens, introduction of poultry and stud stock to improve the quality of the local herds, etc., has been demonstrated many times for farsighted industrial and commercial organizations, and the satisfying thing is that economically it is a sound procedure. The essential feature is a determination on the part of the planners of the economic schemes to ensure that their efforts will result in the development of the country and not its exploitation, as has been the case too often in the past.

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The CHAIRMAN: The next speaker will be Mr. Hudson, of the Food and Agriculture Organization of the United Nations.

Mr. HUDSON: I thank the Chairman for this opportunity of referring to something which has already been mentioned in the report of the last speaker. I shall not take up more than a minute or two of your time. I simply wish to describe the combined operations which have at least reached the planning stage between the Food and Agriculture Organization and the World Health Organization.

I was given the honour of going to India recently to represent the Food and Agriculture Organization in discussing with the World Health Organization the possibilities of undertaking these joint operations. The World Health Organization is engaged in some projects there in connexion with combatting malaria by the residual DDT treatment. It seems clear that by this treatment the health of the population will be greatly improved, and therefore the possibilities of agricultural production will be similarly increased—in other words, directly as a result of the better health of the people. As a result of these preliminary studies, it is now decided, I understand, that more extensive operations of a combined nature between the World Health Organization and the Food and Agriculture Organization may be started quite soon.

I was asked to speak to you about this simply to point out one of the further examples of how important it is that a problem such as this—a problem, namely, of conservation and of improving and increasing the potentialities for production—should be attacked in a joint manner. It is not sufficient to view it as a problem of health or to view it as a problem of agriculture; it must be approached from both sides. This is just one of the many examples that could be brought to your attention of how this important problem can be approached in a collaborative spirit.

The CHAIRMAN: The next speaker will be Mr. E. Velander, of Sweden.

Mr. VELANDER: Even though time is getting short I should like to take a few minutes to discuss Dr. Clements' paper, going back to the principles of nutrition. That paper emphasized the importance of the dietary pattern which is linked to local production, and it was said that all items of the traditional diet must be included. It was even proposed—as a part of any industrialization scheme—to establish gardens for cultivating the wild plants which the natives normally eat in these under-developed countries.

I should like to ask whether there is not a more scientific alternative to this procedure. I feel that we are perhaps a little too prone to look upon food as thousands of tons of certain staple products—wheat, potatoes, meat, butter, eggs, fruits, and so on—rather than as the conveyor of certain compounds necessary for the biochemical factory in our bodies. We need about four hundred grammes of carbohydrates in a day to supply some two or three thousand calories for the machinery. The choice is a matter of economy; carbohydrates can be supplied in many ways—by bread, potatoes, tapioca, and so on. But we also need about fifty grammes of proteins, with all ten of the essential amino-acids. That is already more difficult; because the quantity is so small, the protein source must be of high quality. We need some fat to keep the tissues oiled, and as a reserve, and a dozen or so of vitamins, plus some phosphorus, calcium and so on. It is not necessary to have just so much grain, so much meat, so much fruit and vegetables, and so on. The body does not really care where it gets its material, and this is fortunate because an animal diet is very expensive. It requires about ten thousand primary calories per day from crop lands, as against about three thousand if we use the vegetary diet, because the bullock and the hog have a very poor efficiency as chemical factories. The same can be said of many plants as vitamin producers. Starving people are happy to have proteins and vitamins in any form in which they can get them, and I do not think that they will cling to their traditions if we offer them something else that can be more economically produced in less primitive ways than in a native garden or on grazing lands.

Yeast has been discussed at this Conference and it may offer real possibilities, because of its enormous productivity. Yeast products are now more expensive than vegetable protein and fat, but may soon be cheaper than animal products.

The question of totally synthetic food appears on the horizon. You all know about the German experiments during the war. They made about eight thousand pounds of totally synthetic oleomargarine a day out of carbon, water, and air. These synthetic fats are insufficiently known, but it appears that in some cases they can be absorbed by the body just as well as natural fat. And it is well known that calcium can be absorbed by the body in almost any form. The vitamins can all be synthesized nowadays, and even the "animal protein factor" mystery may soon be unveiled. That essential factor may possibly be supplied by some molds. So far, protein cannot be synthesized, but it can be produced very cheaply. Urea—a purely synthetic nitrogen compound—is used to feed cows, and it appears that they can absorb urea as a nutrient. All this indicates that we do not have to cling to traditional foodstuff sources.

Five years ago I went to Pasadena to see Dr. Henry Borsook at the California Institute of Technology. I wanted to discuss with him the vitamin retention in various types of preserved foods. I was astonished when he said, "What is the use of retaining vitamins? You can apply them afterwards for a cent a day per man, and that is much cheaper than using expensive vegetables for vitamin production and complicated processes for their retention." I was shocked, but I think that there is something to what he said. This Spring I had the privilege of meeting with Dr. Borsook again and I suggested that he should take up the matter at this Conference because I thought it was a more scientific way of solving some of the malnutrition problems. Unfortunately he is not here, since he had to be in Europe at this time. I have here, however, an issue of the California Institute of Technology publication, *Engineering and Science,* in which he has developed his ideas. He told me that this is no longer just a scientific theory but a large-scale practical experiment. It seems that Dr. Borsook has devised a concentrated, dehydrated vitamin-protein food which is very useful for correcting unbalanced diets. It is called "Multipurpose food". In Sweden we made experiments with something similar during the war. We sent hundreds of thousands of portions of dehydrated soup to Norwegian, Austrian and other children, where protein and the B-complex were supplied by yeast, and it was found to be very useful nutritionally, even though the dry-weight quantity was small. Now, Dr. Borsook's multi-purpose food is being served in millions of portions from Alaska to the tropics, with good results, by a charitable foundation called "Meals for Millions".

In his article Dr. Borsook says he makes this multipurpose food out of soy-grit, for the protein, and synthetic vitamins—except vitamin C, which is not included. It has, of course, to be combined with bread, or another carbohydrate source. It is possible that in Sweden we could find a similar cheap source of protein in the rests from our rape seed, which is quite a new oil crop. In Norway, of course, fish residues would provide a very cheap and abundant source of protein, and as I have said, the vitamin should not cost more than one cent a day. The advantages of this kind of supplementary food are that it can be easily shipped by air, and easily stored. It is very cheap—about three cents a meal—and it may be that this purely scientific application of the principles of nutrition—which tell us that the body can accept protein, vitamins and minerals in almost any form providing they are in compliance with a few simple rules—may offer a means of correcting diets which is preferable in many ways to methods for diet-correction which rely only on production in the locality in question.

The CHAIRMAN: I now call upon Mr. Blondel, of France.

Mr. BLONDEL:[c] I apologize for taking the floor after a description of such important developments. I felt however that no meeting at which population policy or work in under-developed areas was being discussed would be complete without a word from a French speaker.

My personal experience is limited, since I have only known the territories of the French Union for twenty-five years. But I have behind me all the experience of our administrators, colonists and industrialists.

Their experience can, I think, be summed up as follows:

Where human problems are concerned, there are no general rules—only special cases. It would doubtless be very convenient if everyone was five feet six in height but in that case, I should lose my head.

We must therefore take each individual case and consider how best to apply to it our ideas of the fullest possible development of life and health.

If we take the countries of the French Union, we find a wide range of development between under-populated and relatively poor countries such as Black Africa and over-populated countries which should be rich, such as the deltas of Tonkin and Cochinchina, with territories such as North Africa, where over-population is just beginning to make itself felt, in the middle of the scale. What is true of Indochina is not true of Africa.

The French Government has of course endeavoured to develop health services in all cases.

I have no need to remind you of the chain of Pasteur Institutes in French territories throughout the world, nor to tell you that these institutes have made a remarkable and sometimes vital contribution to the campaign against tropical diseases, particularly to the campaign against sleeping sickness and yellow fever.

You all know that an increasing effort has been made to study the health of the different indigenous populations over the past twenty-five or thirty years. You are also aware of the progressive development of hospitals and maternity homes, etc. Nor do I need to emphasize that educational problems have not been overlooked. Instruction was first given in the territories of the French Union by our missionaries, who have been relieved or rather "supplemented" by regular services of the administration.

I do not stress these points, since, as I will nevertheless remind you, this Conference has not been convened to study social problems. Its title is "Scientific Conference on the Conservation and Utilization of Resources" and we are therefore not concerned with social problems except in relation to the general problem before us.

How then do these social problems concern us? I should like to give a single example to indicate the need for caution in applying certain rules which we tend too readily to regard as general.

In the work of our various Sections, the need for mechanization and rationalization with a view to increasing production has been stressed. The results achieved by rationalization in this country might lead us to conclude that this method should be universally applied. I am not sure that the results achieved would be equally satisfactory in under-developed countries. In a Section meeting I gave the following examples:

In Indochina I am in charge of a coal mine, which employed 35,000 workers and produced 2,000,000 tons of coal before the war. Under pressure of events and also because the cost of labour has risen without any corresponding rise in output, we have reduced the number of workers by the use of large machines. The number of workers is now only 6,000. The local Government has asked us to discontinue this policy, in view of the problem of finding employment for the

[c]Mr. Blondel spoke in French.

workers thus released. The country has over-abundant reserves of man-power, and discharged workers are unable to find employment, particularly because there is little or no specialization and workers cannot therefore be employed in operations for which machinery can be used.

This seems to me to be a vital problem, which arises directly from those we have studied in the course of this Conference. We must bear in mind that solutions, which may be excellent in certain cases, may be the reverse in others. We are, of course, in agreement on the final objective—to ensure the highest possible standard of living for all men. But our experience in French territories leads us to ask that solutions, which other countries have tried out with success, should only be applied with the greatest caution and with particular attention to each individual case.

The CHAIRMAN: I wish to thank Mr. Blondel, and others who have spoken, for their contributions to the debate. There has been a break-down in the amplification system and it may be that those who were hoping to hear in English have heard some other language instead. During the remainder of the proceedings we shall have consecutive interpretation instead of simultaneous, so I wish once more to remind speakers of the limits on the length of speeches to which I referred in my opening remarks. I must ask speakers to be as brief as possible. They must remember that every word spoken is multiplied by two by the consecutive system of interpretation. The next speaker will be Mr. Reyna-Drouet, of Ecuador.

Mr. REYNA-DROUET *concluded his remarks on economic planning which were begun in the plenary meeting of 29 August and are reprinted in full there.*

The CHAIRMAN: I now call upon Mr. Aparicio G. Ranghel, of Colombia.

Mr. RANGHEL: I was intending to speak in my native language, but I discovered that I must speak in English. Therefore, I apologize for my imperfect English.

I am going to make a few brief remarks in regard to the question of the preservation of the principal natural resource which is man. I was very glad that Mrs. Pinchot brought this question forward yesterday as the preservation of man himself is most important. Man is really the principal and most valuable of all natural resources. I have a one-track mind, as is said in English, but my point is a practical one. It is all very well to discuss such subjects as labour, hygiene and the conservation of natural resources here, but I am a little afraid of what we are going to do in practice in our own countries. When the delegates return home from these meetings, they will have many ideas in mind.

I should like to explain briefly what we are doing to preserve man himself in Colombia, not because Colombia is my country but because this explanation might be of some use to some of the other peoples of the world. First of all, we are trying to move the hundreds of people now living in bare lands and on the slopes of the Andes to better lands. That calls for the expenditure of a lot of money, but we are doing our best.

Secondly, there is the matter of nutrition and health. In regard to nutrition we are trying to plan the grains to be used in the human diet, for example, the use of soy beans. We are trying to make the farmers and peasants throughout the country grow soy beans so that their food will be varied.

Education is very necessary for the preservation of man. We need education for the conservation of all natural resources. We are trying to educate the people, especially the future generations in the primary schools.

With regard to conservation of natural resources, it is absolutely necessary, in my opinion, to form in each one of these countries a group of men who will be able to translate into practical terms all these wonderful things which we have heard about in these meetings. We need to train engineers, agronomists and field aides who will go out to the farmers and tell them how to carry out the work. We are trying to do this now in Colombia by means of agricultural schools where we train agronomists and give them special classes in soil conservation. We have simple and very short courses, sometimes lasting for only two or three months, in which we train the field aides. These field aides are very valuable, and I believe that for every agricultural engineer or agronomist we must have a thousand field aides.

I am sorry not to be able to explain in more detail about these things, but time is short. I thank you for the opportunity you have given me to explain this much.

The CHAIRMAN: As Chairman of this plenary meeting, I wish to thank Mr. Ranghel for his contribution to this debate. With the words which we have just heard from Mr. Ranghel, we shall now end our meeting for today. I think the discussion that we have had this afternoon constitutes a very considerable headway in our work on the item which was on the programme for today. The number of suggestions that we have had put to us, the points made by the representative of the International Labour Office, the points made by Mr. Clements on behalf of the World Health Organization, all this, and the detailed debate certainly constituted a great contribution to the general work of the Conference. I would say the same of the contribution made by Mr. Antuña and by all the other members who spoke.

Before I close this meeting I would say one further word, and I do so, I think, not only in my own name but in the name of all present. I wish to express my gratitude and admiration for the work of our Director of Programmes, Mr. Carter Goodrich, and for the work of our Executive Secretary. Without these two I am sure that our work could not have been so effective, nor could it have ended so well as it is now ending. I would extend my thanks also to those who have helped us at our meeting this afternoon, and to the staff of the United Nations in general.

In closing this fourteenth plenary meeting of the Scientific Conference convened by the United Nations on the subject of natural resources I would again express my faith in the fruitful outcome of the work of the Conference. I am sure that it will give satisfaction to the hopes placed in this Conference by men and women all over the world—hopes placed in this Conference which is meeting under the auspices of the United Nations and under the skies of the Americas, which is a symbol of democracy and freedom.

The Recruitment and Training of Labour for Resource Development

INTERNATIONAL LABOUR OFFICE

ABSTRACT

1. As a first line of attack on labour supply problems associated with resource development, there is a need for more adequate information on prospective labour requirements, particularly indicating skills in demand.

2. In the recruitment of workers, measures should be taken to avoid their exploitation. The preferable system of engagement is through public employment services, which should be developed further or established, as may fit the case.

3. A thorough system of youth training should be developed, so that eventually all requirements may be met by young persons entering employment after a thorough background of instruction.

4. Initial and continuing training for adult workers is feasible and desirable.

5. All training should be aimed in the direction of specific requirements.

6. Permanent migration; or temporary migration; or the training of workers abroad, frequently may be arranged on an international basis, and may be necessary to overcome a shortage of skills.

7. The International Labour Office collects and issues much information on labour needs, especially in relation to possible migration.

8. The I.L.O. is in a position to give field assistance, where Member States so request, in devising measures to overcome labour shortages, to improve industrial training methods and to better develop employment services. A good deal of such assistance has been given or is being given currently.

9. Numerous International Labour Conference instruments and I.L.O. meeting resolutions bear on methods for recruitment and training of workers.

I. INTRODUCTION

Trained manpower is an essential component of resource development. Without labour and skill nothing can be done to turn natural resources to economic and social use. Thus, a sufficient number of workers must be available in the areas where their services are needed for resource development, and the workers must possess the proper skills for doing the work which will be required of them. This paper is concerned with techniques for recruiting and training the workers needed for resource development.

The question of the availability of suitable workers for resource development is especially acute in economically under-developed areas, which are understood to include most of Latin America, the Far East, the Near and Middle East, and Africa; certain south-eastern European countries; and non-self-governing territories. (The expression "under-developed" refers only to the economic aspect of a country's development, and does not intend any reflection on the cultural stages of development of the country in question.) Most of these areas possess resources waiting to be utilized and share a relative deficiency in the technical know-how required to make good use of them. The shortage of skill of all kinds, combined with many other factors, constantly hampers both agricultural and industrial development. Moreover, so far as many of these areas are concerned, there is a further problem. A certain amount of quantitative population redistribution is necessary in order to ensure that workers are available where they are needed.

II. EXTENT AND CHARACTER OF LABOUR AND SKILL REQUIREMENTS

Labour and skill requirements grow out of the needs of resource development and increase as development proceeds. They are determined by each country or territory and by each industry and undertaking in relation to its own development plans. Thus, the planning of resource development provides an essential basis for estimating the extent and character of manpower requirements. The more precise and concrete the plans are, the more firm is the basis for manpower planning.

Until comparatively recently, economic development can hardly be said to have been systematically planned. With one or two important exceptions, there has been a notable lack of co-ordinated advance planning for the use of natural resources in countries or areas throughout the world, whether under-developed or industrially advanced. In consequence, there has been little or no reliable information relating to the extent and character of labour and skill requirements.

During the last ten years, however, the situation has changed. Many countries have mapped out long-term development projects. Almost all the existing plans embrace agricultural irrigation, hydro-electric and other power projects, transport and communications, mining and as well other basic industries, e.g. iron and steel. The mechanization of industry and agriculture is the main emphasis of the plans. Many of the projects have gone beyond the planning stage and have been or are being successfully executed. This is the case in under-developed areas as well as in industrially more advanced areas. In fact, the emphasis on systematic planning of development is, if anything, more pronounced in under-developed areas. This is heartening, for their own need is greater and at the same time their resources are required for the raising of world living standards. Information summarized in publications of the United Nations, of the International Labour Organisation and of other specialized agencies indicates the type of development planning now being done.

So far as labour requirements are concerned, the situation varies from one area to another. In some areas, for example in large parts of Latin America, the resource development scheduled for the next few years can hardly be carried out with the labour supply available. Whatever may be done to mobilize the national labour supply, more workers will still be needed. In other areas, for example in large parts of Asia, the labour force is more than adequate for the resource development envisaged.

The fact that certain under-developed countries and areas are faced with labour shortage links the recruitment problem to world migration problems. This interrelationship is discussed in section IV. Moreover, in both types of areas (those with a sufficiency of national labour and those with a deficiency), the question of labour supply includes the problem of internal population redistribution required to mobilize the national workers for resource development in general or for the execution of particular projects. This problem, which is the essence of eliminating chronic under-employment in rural areas, must be approached primarily through recruitment policies.

On the whole, it is probably true to say that at present the numerical size of the labour supply need not in itself be a major obstacle to resource development. It may be, and in some cases has been, difficult to find a sufficient number of workers for particular projects in remote areas. Or it may be that in the near future the size of the the labour supply may limit resource development in certain countries and areas. At the moment, however, the gross number of workers available appears adequate for developments.

However, it is necessary to emphasise two factors. First, while the labour force of most under-developed territories may be numerically adequate, it is not physically adequate, owing to disease and malnutrition. Secondly, the supply of labour available for work connected with resource development depends on incentives which can be offered to induce men and women to work, to accept the habit and discipline of work, and to work regularly. Time and again, for example, it has proved impossible to obtain needed workers because it was impossible to offer them, in return for their efforts, a plentiful supply of consumers goods or other facilities or services at prices reasonable in proportion to their wages. This is a major problem of under-developed areas—and one whose solution vitally affects the supply of labour.

Moreover, the labour supply available within these limits is not adapted to the demands created by mechanized resource development. Widespread illiteracy and the absence of any minimum general education mean that the workers available lack one important prerequisite to any kind of skilled or semi-skilled employment. On the other hand, all the under-developed areas urgently require a great variety of the skills indispensable for developing their power facilities, transport, and other basic industries and for technical improvements in their agriculture and mineral resources. To define the skills needed is, in most cases, to list all the skills entering into mechanized production and organization. Most countries and areas engaged in such development indicate that they are totally lacking or very short in the supply of workers who can handle the preparation, installation, operation and maintenance and repair of machinery of every kind, whether for power projects, mining, agriculture, transport, iron and steel or other branches of economic activity. There is, in short, a notable deficiency of technical know-how in the areas planning or engaged in resource development projects.

In practice, therefore, skill requirements are almost limitless in extent. The character of the requirements reflects this fact. Workers are needed in almost all, if not all, the skills and occupational categories which make up a trained labour force in any branch of mechanized exploitation of resources. Executive and administrative staff, scientists, technicians and skilled workers are especially scarce, of course, but the needs extend on down to include the most elementary skills connected with the use of machines.

The information available to the I.L.O. on the extent and character of labour and skill requirements may be summarised in general terms:

(1) Despite a widespread advance in economic planning of resource development, information on the extent and character of labour and skill requirements is both sparse and unreliable at the present time.

(2) On the basis of the information available, it appears that—

- (*a*) Granted a mobilization of national manpower for resource development (including measures to fight disease and malnutrition, and the provision of effective incentives to work), the numerical size of the labour supply is not the major obstacle to economic development in most countries and areas at the present time;
- (*b*) The vocational adaptation of the supply of workers to the exacting requirements of mechanised resource development appears to be the urgent problem to be solved in the field of manpower;
- (*c*) Skill requirements are extensive in number, comprehensive in scope and extremely varied in character;
- (*d*) The most urgent requirements are for all kinds of workers capable of installing, operating, maintaining and repairing machinery of all kinds;
- (*e*) The most urgent skill requirements of this character are in the power, transport, mining, agricultural irrigation, construction and heavy manufacturing industries.

One general conclusion emerges from the preceding. Lack of information is a serious handicap in the planning of measures to remedy manpower and skill deficiencies. Consideration might therefore be given to the *preparation of a manpower budget for resource development.* Such an inventory of labour supply and labour requirements could be prepared by or in respect of the areas concerned, on the basis of existing economic development plans and in conformity with the industry and other classifications used in these plans, and covering periods of time corresponding to these plans. Even a simple start in this matter would be of assistance.

The other general conclusions relate primarily to the recruitment and training of workers. These questions are dealt with in the succeeding sections.

III. METHODS OF RECRUITING AND TRAINING MANPOWER

The recruiting and training of manpower for the development of natural resources must be approached in the light of the needs, traditions, and political, economic and social organization peculiar to each country or area. The techniques appropriate for solving manpower problems must arise out of this background in any given country or area or be adapted to it if they are to contribute constructively to economic development. Thus, under-developed areas are in a position not only to benefit from the cumulative experience of other parts of the world, but also themselves to develop new techniques of recruitment and training, and to enrich the world's experience while expediting their own development.

A. TECHNIQUES OF RECRUITMENT

Workers are recruited for development projects in a good many different ways, but direct recruitment by employers or their recruiting agents appears to be by far the most common. In some countries, certain trade unions act as recruiting agencies. In others, industrial or commercial guilds exercise this function. In still others, recruitment is undertaken by intermediary agents or private employment agencies who seek to bring together the employer or management needing workers and the workers looking for employment. Finally, public employment services are playing an increasingly important role in the recruitment of workers.

In non-metropolitan territories, recruiting has traditionally been carried on and in many cases still is, by professional recruiters, possessing special knowledge of the labour supply and demand in their areas. These operations have been conducted, as a rule, on a profit basis, under Government supervision in some cases. Native chiefs or other Native authorities also play an important role between the recruiters and the workers, particularly in stimulating labour supply. Moreover, recruiting by workers themselves is common in a number of non-metropolitan territories, not only because satisfied workers are the best recruiters in many cases but also because workers are designated as labour jobbers and specially remunerated for the recruiting operations they perform. There is general agreement in theory, law and practice, however, that in non-metropolitan territories these forms of recruiting often have undesirable and disruptive results, particularly in so far as forced labour is concerned. Thus, the I.L.O. Convention (No. 50) on special systems of recruiting workers laid down principles designed to obviate exploitation of workers through undesirable practices in recruitment in these territories.

In both under-developed countries and non-metropolitan territories, it is common to find workers recruited for more skilled employment and training opportunities through family groups. For example, apprenticeship and other workshop training have been traditional methods of handing down skill, and the apprentices and other trainees have tended to be the next of kin or other relatives of the craftsmen. The employer sometimes recruits his whole labour force from this source. In such cases, vocational guidance and technical selection are apt to be entirely neglected. Finally, as in all countries, workers are frequently recruited for permanent employment through the training process. They are admitted to training and advance from that status to employment after satisfactorily completing a period of institutional or plant training.

The preceding methods of recruitment, whatever may be their practical necessity, have several important defects. The facilities so provided are necessarily limited in scope. In these circumstances, neither the employer seeking labour nor the workers seeking employment are in a position to draw upon as wide an employment market as they might wish. Moreover, there is a risk, particularly in under-developed areas, of the abuses associated with unregulated recruitment operations and employment agencies conducted with a view to private profit. Finally, since each such recruiting operation is organised in a particular interest, the general interest in the orderly recruitment of workers for resource development is not adequately safeguarded. The resulting unplanned distribution of the labour supply may hamper many parts of the economy of the country or area, lead to unnecessary hardships for the workers, and fail to produce the correct number and kind of workers needed for a particular project.

The conclusion is that as soon as practical a public employment service should be developed to shoulder the burden of recruiting the workers needed for resource development, for public and private undertakings alike. This conclusion is generally accepted in under-developed areas as well as in developed areas. Substantial progress has been made in employment service organisation in Asia, Latin America and a number of non-metropolitan territories. The practical problem, however, is to build up and equip these employment services, where not now available, to carry out the rather specialized recruitment tasks imposed by large-scale development programmes. No time should be lost in providing these services with the functions, the machinery, the staff and the funds required for effective operation on the scale required by current development plans. Particular attention will have to be given to methods of operation of employment service in large and predominantly rural areas. India is experimenting with an interesting scheme for "mobile" employment offices. In certain sparsely peopled parts of Canada and the United States, experience of employment service organization would be worth analysing. The Employment Service Convention and Recommendation adopted by the 1948 Session of the International Labour Conference set forth, in some detail, the essentials of employment service organization. These standards will certainly be of practical use in countries organizing or developing their public employment service.

No discussion of techniques of recruitment would be complete without placing special emphasis on the question of incentives to labour. Compulsory labour is becoming extinct: other incentives must be found. Experience appears to indicate that higher wages are an effective incentive, even where material wants are now simple. But along with higher wages, increased supplies of consumers' goods, available at reasonable prices, are essential. The provision of attractive and suitable housing is also important, both for recruiting and retaining labour. The availability of education and training services, medical care and recreational facilities plays a large part in recruitment. Finally, the whole question of making people physically fit is a dominant element in widening the field of recruitment. The importance, purely in terms of recruitment, of solving these problems, and of working out their solutions as a co-ordinate part of recruitment, cannot be over-emphasised. The machinery of recruitment can do little unless the incentives to work are amply attractive.

B. Techniques of training

No matter how effective the techniques of recruitment, the underlying factor is the supply of skill. A recruitment policy cannot supply skill. The problem of skill is the crux of the problem of adapting human resources to the requirements of mechanized agricultural and industrial development. Education and training are the keys to the supply of skill. The techniques of skill development are thus bound up with the organization and operation of education and training schemes.

General education is the basis for any kind of vocational training. The abolition of illiteracy and a nation-wide system of compulsory free education are therefore urgent necessities in meeting the labour requirements imposed by plans for developing natural resources. Delegates to the regional conferences of Member countries of the I.L.O. have frequently called attention to the need for extending compulsory free education in Latin America, the Far East and the Near and Middle East. In all these regions and in the non-metropolitan territories, increasing efforts are being made to lay the educational foundation of technical progress. The fundamental education project of U.N.E.S.C.O. is a clear indication of the international importance attaching to the elimination of illiteracy and the provision of a minimum general education to all peoples everywhere.

The extent to which general education should include any kind of pre-vocational preparation is somewhat controversial. However, two things may be said. First, education in a general sense is an absolute prerequisite to the formation of a modern labour force; technical training is not enough and, in fact, is not possible unless the trainee has already learned to learn. Secondly, some care should be exercised not to over-do the literary side of general education, thereby creating a surplus of would-be white collar workers and also tending to attach an unfortunate stigma to manual work.

The conclusion would seem to be that pre-vocational plans should be worked out as a part of a co-ordinated educational programme. This would tend to prevent vocational emphasis from narrowing the educational horizon and to guard against premature specialization. At the same time, there would be ample lee-way for making education "practical" and "realistic", though keeping it from being perverted in a limited economic interest.

While general education is a prerequisite, the fundamental approach to the problem of skill development is the vocational training of young persons. Admittedly, present difficulties are appalling, but no emergency arrangement can fail to include the establishment of a sound scheme of youth training. The difficulties have to be faced sometime, and it is much better that this should be done sooner rather than later.

There are two basic methods of training young persons—vocational education in specialized schools or centres, and apprenticeship. The two methods are not mutually exclusive; a combination of the two may be the most practical and successful means of preparing young persons for many kinds of skilled or semi-skilled employments. In fact, the present trend in youth training is to bring institutional vocational education and the system of apprenticeship much closer together. This makes for a simpler and more practical system, able to combine the recognized advantages of both institutional and supervised on-the-job training.

A few essentials of any training scheme for young persons may be recommended on the basis of extensive international experience and of recent experience of training in under-developed countries and areas. Firstly, the principle may be accepted that all young persons up to a certain age should be regarded as trainees, regardless of whether their training is on-the-job or through a school or centre or other agency of training. Secondly, the training arrangements must be built in accordance with a systematic and co-ordinated plan, drawn up in the light of present and prospective labour and skill requirements. It is no use to plan one aspect or type of training or training for a particular project and to neglect the rest. Thirdly, public initiative on a large scale is an essential element in the planning, organization, operation and financing of any youth training programme. This is the only means of ensuring that the programme is adequate, and of safeguarding the different interests involved. Fourthly, the co-operation of employers' and workers' organizations, where such exist, must be enlisted if the programme is to be supported as it deserves to be. Fifthly, training opportunities in any one area should be developed according to the relative urgency of the needs. Subject to these priorities, the long-term aim should be to expand such opportunities on as wide and varied a scale as possible. Finally, methods of training should be decided primarily on the basis of the skill requirements of the occupations and industries for which the training is given, but also with consideration of the facilities available and the traditional methods of training customary in the different countries and areas.

In the light of these principles, the first steps in youth training programmes in under-developed areas begin to emerge more clearly. These may be stated somewhat dogmatically as follows:

(*a*) The principle should be applied that all young persons under a certain age (fixed in the light of the national circumstances) should be in training, whether in school or in a special training centre, or employed in some industrial or other undertaking as an apprentice or in any other capacity.

(*b*) Youth training should be planned on a unified basis in the light of the needs for trained manpower indicated through the manpower budget or by other means worked out in connection with the labour and skill requirements of resource development.

(*c*) Public concern with youth training should be developed, organized and made effective with adequate public funds.

(*d*) A national advisory committee and, wherever possible, local advisory committees, including representatives of economic development authorities and of employers' and workers' organizations (wherever these exist), should be established.

(*e*) The development of youth training facilities should be planned in such manner as to ensure that all young persons within a given geographic area have access to training and have reasonably varied training opportunities.

(*f*) Training schemes for individual projects, areas, industries or occupations, should be organized with primary consideration to the skill requirements to be met through training. In addition, to be practical, they must take account, especially at first, of the facilities available in or planned for the region and of the traditional methods of training workers common in those regions, industries or occupations.

In almost all the under-developed countries and areas, the organization of the training of young workers in specialized vocational and technical schools or centres in a primary preoccupation at present. Recent action in the training field has been centred on developing an organizational framework for specialized training in schools or other institutions and expanding the network of such facilities within the country or area. (So far as industrial training and apprenticeship are concerned, several of the recommendations of the 1946 American Regional Conference of the I.L.O. will be found to be generally applicable to conditions in under-developed countries.)

In addition to specialized vocational school training, and formal apprenticeship, an expansion of systematic on-the-job training of young workers entering employment in a particular undertaking is urgently necessary. The aim of such in-plant youth training is two-fold: to obtain efficient job performance and also to broaden the young person's technical understanding of the productive operations of the project and undertaking as a whole. The importance of these schemes can be readily appreciated when it is realized that the young workers affected by such training will supply an excellent source of recruitment for apprenticeship for more skilled workers or higher technical training. Morever, in-plant training of young workers tends to economize on such things as tools, machinery and materials, teaching staff, etc., and is therefore a practical form of training in countries or areas lacking adequate training facilities of other kinds. A good many of the larger undertakings in Latin America and Asian countries and non-metropolitan territories organize the training of their workers within the undertaking or in special centres directly attached to the undertaking. This may be the practice partly because there is no choice—because no other means of training are available, but it is also partly because training conducted by the undertaking for the workers recruited by it has proved to be an effective form of training. To a large extent, the employers or managements concerned will have to take responsibility for organizing this kind of training. But their task can be lightened if the Governments will provide technical and, wherever possible, financial assistance to ensure the maintenance of such training on an efficient and practical basis and on an adequate scale, and to induce employers to offer suitable opportunities for the training of their young workers.

So far as agricultural training is concerned, the primary problem at present is to develop a network of specialized agricultural training schools, adapted to the requirements of the different regions. Such schools, to be practical, must be organized on a productive basis, so far as possible, and linked with scientific agricultural stations or outposts, so that modern methods may be taught economically and through practical work. Special measures are also necessary to widen access to agricultural training schools and to encourage attendance at such courses. Initial steps include such practical measures as adequate transport arrangements for persons with the immediate area; residential units at or near each training centre; and maintenance allowances for the trainees and, in many cases, allowances to their families. Where the schools operate on a co-operative, profit-sharing basis, their work can be done more economically and larger numbers of young people from poor families can make use of the facilities.

Even these elementary parts of any programme of youth training sound ambitious in terms of the present situation, especially in under-developed countries. But they lack ambition in terms of the needs to be met. It may be suggested that they should comprise an immediate minimum programme of action of youth training related to the development and use of natural resources.

No training programme would be adequate without special arrangements for the vocational training and retraining of adult workers. This is especially true of programmes designed to meet the skill requirements of resource development in under-developed areas, where a large percentage of the adult population will be called upon to take a part in the technical process of turning natural resources to effective use. To some extent, the training of adult workers can be fitted into, or closely associated with, the arrangements for youth training. Special courses for adults are often organized in the youth training schools or centres set up by the Governments or by private undertakings, for example, and on-the-job training is probably the most common form of adult training in all countries. Evening courses and part-time technical training for employed adult workers are additional means of supplementing on-the-job training. On the whole, most under-developed countries have found that the main problem has been to promote the provision of systematic training of adults by private undertakings, and to develop adequate incentives to adult workers to take the training. This may involve technical and financial assistance from the Government. The State may then be called upon to play a more active role in ensuring training opportunities for adult workers and supervising the standards of training.

The expansion of training to enable young and adult workers to develop their skills and be promoted to higher posts is also an essential part of skill development. It is of special importance in under-developed areas where, for a variety of reasons, pre-employment training is apt to be somewhat meagre. Moreover, higher training makes it possible to fill the gaps in the national supply of technical skill; imported skills must be passed along to the local labour force through such training. Supplementary education and technical training has therefore to be made available on the widest possible scale, not only by the undertakings, which would naturally wish to develop an increasingly efficient labour force, but also by public authorities concerned with raising skill standards in general. Here again, provided there is an adequate network of youth training facilities, the provision of training for promotion (up-grading) is a relatively simple matter and can be based on the full use of existing facilities. Also, a main problem appears to be to provide incentives to the workers to take higher training. Money incentives, though important, are not always the most effective, especially in certain of the under-developed areas.

The organization of training for supervisory workmen, and especially of those instructing others, is an important part of training programmes aimed at meeting the skill requirements of resource development. Supervisory workers are in very short supply everywhere. In many under-developed countries and areas, supervisory posts have had to be filled almost exclusively by foreign recruitment. Naturally, methods of training supervisory workmen have to be closely related to the productive operations of particular undertakings. Nevertheless, the experience of France, Sweden, Switzerland, the United States and the United Kingdom is worth studying with a view to adapting it to the situation of under-developed countries. The "training within industry" method has proved practicable, with appropriate modifications, in different circumstances: the use of vocational school facilities and special training conferences for intensive training of foremen is also common. The main principle is not to neglect this specialized type of training. In a large measure, the quality of the supervisory workmen will determine the productive operations of any undertaking or project, and, in addition, there is a very great deficit of national supervisory skill in under-developed countries and areas.

Adequate training for instructors is likewise a key to the expansion of training services. Such instructors have to be recruited very largely from the skilled and experienced supervisory and other key workers in the labour force. The question of their training is thus closely linked with the arrangements made for training supervisory workmen. The outstanding current problem is to organize, on a large enough scale, systematic courses for training men to train others. In doing this, it is often possible to utilize higher technical training institutes (and it is one further reason for the development of such institutes in every country and area) and it is often necessary to borrow experienced instructional staff from abroad to help in launching the programme and training a "cadre" instructor staff.

Each resource development area and project must have its own training requirements and goals. The above minimum programme cannot be more than a yardstick against which to measure what is needed and what is done. Special problems must be met by special action. There is a vast field for initiative in training. Systematic arrangements are needed to ensure that the results of this initiative are made known to other agencies and undertakings who could profit by the experience so gained. One task of the public authorities generally responsible for training in the country or area concerned might therefore be to make this experience available in as practical and suggestive a form as possible.

Once vocational training exists, there may be a problem of allowing those trained to exercise their skills. In certain countries or areas (e.g., the Union of South Africa and Southern Rhodesia), European trade unions, fearing the competition of native skill, follow a policy which tends to restrict admission to unions and more skilled employments to persons of "European" race. In certain other countries (e.g., certain Latin American countries), higher skilled and technical jobs have, in practice, been reserved by private undertakings for foreign workers: these countries have reacted in self-defense, e.g., by erecting a number of migration barriers to the entry of technicians and other skilled personnel. These problems have to be met before training schemes can play their full part in resource development. Surely there is room for all the skill that can be developed, provided there is a planned programme of economic development. This should be one guiding principle for national and international action. The mere existence of such problems, however, re-emphasises the need for working out training schemes in close co-operation with trade unions and for basing them on a profound knowledge of national labour and skill requirements.

IV. METHODS OF INTERNATIONAL CO-OPERATION IN THE RECRUITMENT AND TRAINING OF LABOUR

The preceding section dealt with *national* policy and techniques for recruiting and training workers needed for resource development. The problems of recruiting and training labour for economic development must be attacked by each country and area: there is no substitute for such action. At the same time, *international* co-operation can greatly facilitate the solution of a number of immediate difficulties.

Systematic arrangements for the international exchange of information concerning techniques for recruiting and training workers for resource development is a first essential measure of co-operation. Such arrangements can help to overcome a lack of experience and knowledge. Through such arrangements, a practical inventory of existing techniques can be drawn up. It may be urged that such information should be collated and exchanged on a regional as well as an international basis, since the experience of one country often has special practical value for other countries and areas within the same region.

Similarly, arrangements should be developed for the international exchange of information on the extent and character of manpower requirements. In particular, this exchange of information would have to relate to skill requirements.

So far as the exchange of information on techniques of recruiting and training workers and on manpower and skill requirements is concerned, the I.L.O. is building up an international information centre at Geneva and also regional information centres (the first is being set up in the Far East) which will cover both of these subjects. The centres will be available to provide information and other assistance to Governments, international organizations and other bodies or persons concerned with recruiting and training workers. The practical influence of these centres will depend, first, on their own efficiency, secondly, on the co-operation of those Governments, international organizations, employers' and workers' organizations and individuals possessing the information required, and thirdly, on the use made of the centres by these bodies and persons.

The migration of workers from industrially advanced countries to establish themselves in under-developed areas is also a method of international co-operation for meeting manpower requirements generally and in particular for introducing into under-developed countries the new skills of mechanized production. Thus, from the standpoint of less advanced countries, immigration for settlement should be encouraged, provided that the incoming workers are able to meet the labour and skill requirements of the country concerned and provided that these workers are willing to hand down their technical knowledge to the national workers of the immigration country. Where skill is scarce all over the world, these conditions are not easy to meet. But certain industrially advanced countries, anxious to promote development in other parts of the world, are encouraging the emigration of technicians and skilled workers, even though the latter may be needed at home. This is a far-sighted policy. Though the motives behind it differ, it is a type of migration policy which can contribute to resource development, especially if it were applied more internationally among the different industrially advanced countries, on the one hand, and the less developed countries, on the other. Thus, action to break down existing barriers to the migration of skill according to manpower requirements is a means of international co-operation which will certainly facilitate better use of the world's resources, including trained manpower.

Migration surveys, technical and financial aid in economic development planning, advisory missions to study the obstacles to the immigration of the trained labour required, encouragement of consideration of the manpower requirements of resource development in bilateral or other agreements relating to migration, etc., are examples of tasks which international organizations can help to accomplish. The I.L.O., the specialized agency charged with assuming leadership on migration matters, has revised recently its Convention concerning Migration for Employment and the related Recommendations in an effort to aid needed migration. It is also preparing a Model Migration Agreement which includes detailed provisions governing the conditions and criteria of migration, the recruitment, selection, introduction and placing of immigrants, equality of treatment for migrants with nationals, etc. Taken together these two documents set forth major principles of international recruitment through migration, whose application will certainly help to solve some of the special problems of recruiting the skills for world economic development.

In countries or areas where the general level of skill for mechanized development is low, and training and migration cannot immediately meet the deficiency of skill, foreign technical assistance is an essential means of international co-operation. As a rule, foreign technicians, foremen and skilled workers are recruited from industrially advanced countries by Governments or private undertakings of less developed countries or areas to aid in introducing new machinery or methods of work, and to train nationals in these new processes, so that the latter may take over the full responsibility themselves. This method is satisfactory in spreading technical know-how. Nevertheless it has sometimes been difficult to recruit the needed experts on terms acceptable to the countries requiring their assistance, and to ensure that the technical know-how of experts is effectively imparted to the national workers. The worst disadvantages of the bilateral arrangements for technical assistance is that such assistance tends to be expensive, for public authorities at least. In consequence, few Governments can afford to "borrow" the full number and variety of technical experts needed to facilitate their economic development. This suggests that neighbouring Governments in need of foreign technical assistance of a generally similar kind or kinds might combine on a regional basis to recruit and employ pools of technical advisers and experts able to help solve common problems of economic development.

Certain organs of the United Nations and most of the specialized agencies are now in a position to co-operate in the negotiation and carrying out of such arrangements. Some of them also provide direct technical assistance through, for example, advisory missions. So far as direct assistance in the field of recruiting and training manpower is concerned, the I.L.O. is greatly expanding its practical services for this purpose.

It is often impossible, for one reason or another, to meet skill requirements through national efforts, migration or foreign technical assistance. A further practical means of developing trained manpower is through co-operative arrangements for sending abroad actual or prospective vocational instructors, foremen, skilled workers and other workers and trainees, to obtain instruction and training unavailable in their own country. Action along these lines has already been taken on a limited scale (for example, between India and the United Kingdom and between the United States and Latin American Republics). This experience has indicated that arrangements for the exchange of trainees are one of the most practical methods for accelerating training, particularly in countries lacking an adequate number and variety of training facilities. At present there is a considerable demand that such measures should be widened to promote greater opportunities (particularly for nationals of under-developed countries) to acquire abroad technical skill needed for their own economic development. The I.L.O. is therefore seeking to work out arrangements to promote the exchange of trainees. This will involve co-ordinated national and international arrangements:

(*a*) To increase the number of technicians and skilled workers sent abroad for a part of their training, or for periods of work experience; and

(*b*) To expand the types of workers and the technical and skilled trades and occupations for which training and experience abroad is considered useful and practical; and

(*c*) To develop further international assistance in the negotiation and financing of such arrangements.

The co-operation of neighbouring countries in organizing training facilities also deserves special consideration. This type of co-operation can help to overcome some of the immediate difficulties which many under-developed countries are now encountering in expanding their own training facilities. Where neighbouring countries with common resource development problems pool their assets to provide training for their nationals it may not only be financially and materially advantageous for the participating countries and more efficient so far as the training provided is concerned, but it may also lead to greater co-operation in industrial and agricultural development. In the first instance, such arrangements might be applied most practically in higher vocational and technical training institutions in neighbouring countries with a common language and somewhat similar problems of skill development. But their scope need not be limited. In the American countries, for example, regional co-operation in the organization of training facilities was emphasised at the last regional I.L.O. Conference of these countries. It was suggested that the co-operative arrangements should include regular training courses for American workers in those American countries which are more advanced in a particular type of production. The following courses were proposed to illustrate the principle involved:

(*a*) Training of workers in the cane sugar and derivative industries in Cuba;

(*b*) Training of workers in the wine industry in Chile;

(*c*) Training of railway workers in the United States;

(*d*) Training of workers in the meat industry in Argentina.

International co-operation is also necessary to overcome another bottleneck in the distribution of technical skill—the lack of machinery, tools, materials and other equipment and supplies needed for training in modern industrial and agricultural methods. It may be recommended that Governments should enter into arrangements for making available, so far as possible, the machinery and supplies (including materials) needed for increasing the number and the activities of vocational training schools and workshops, and improving their equipment and methods. Moreover it may prove useful for the Governments of under-developed countries in some regions to make arrangements on a co-operative basis either directly with the country of supply or through the intermediary of international organizations, to arrange for the procurement of "hard to get" equipment and supplies, and particularly for methods of payment.

Finally, past experience suggests that international co-operation in recruiting and training manpower for resource development could be far more effectively co-ordinated. Action taken by Governments and action taken by international organizations should form a whole, so that there are no deficiencies, gaps or overlapping in what is planned and done. The I.L.O. has taken the initiative in seeking to ensure the co-ordination of national and international effort in the manpower field. Such co-ordination is imperative to the end that in this essential field of resource development—trained manpower—no effort is wasted and progress is as rapid as possible.

Conventions and Recommendations adopted by the International Labour Conference relating to the subject matter of this paper

Vocational Education (Agriculture) Recommendation, 1921. *International Labour Code*, Art. 298.

Vocational Education (Building) Recommendation, 1937. *International Labour Code*, Art. 390. *Official Bulletin*, vol. XXII, no. 3.

Vocational Training Recommendation, 1939. *International Labour Code*, Arts. 264-283. *Official Bulletin*, vol. XXIV, no. 3.

Apprenticeship Recommendation, 1939. *International Labour Code*, Arts. 286-291. *Official Bulletin*, vol. XXIV, no. 3.

Employment Service Recommendation, 1948

Employment Service Convention, 1948

Preparation of Scientific and Technical Personnel for the American Tropics

RALPH H. ALLEE

ABSTRACT

Programmes for optimum use of our resources must be basically educational since the problem is broadly socio-economic and education of one type or another is our only approach to required changes in behaviour.

The Inter-American Institute of Agricultural Sciences of Turrialba, Costa Rica, is operated by the American States to develop a programme of research and teaching intended to reinforce and supplement national programmes of the member countries. Its programme is integrated around investigations concerning plants, animals, engineering and human relations, and functions co-operatively with national programmes.

The teaching programme is flexible in order to meet the needs of the various areas and emphasizes education either not available or not feasible to supply in national institutions, and the development of methods as well as subject matter. Study opportunities are supplied to visiting scientists, advanced graduate students and those concerned with professional improvement. A series of symposia offers opportunity to clarify fields of work and provide education. An experimental communications service is working out means of increasing the flow of the world's knowledge to colleagues in the member countries.

A proposed project is presented, the purpose of which will be to compensate to the extent possible for the disadvantages inevitably experienced by small population groups in supplying adequate scientific and technical education and training.

Optimum use of our resources must presuppose measures to promote their continual utility. This is a concept which is broader than wise husbandry. It poses an all-inclusive socio-economic problem susceptible to approach only on a broad educational basis.

When a farmer attempts to make profits or merely to feed and clothe his family under the handicaps of a primitive agriculture, he will exploit his soil. When a community attempts to meet the living standards of the twentieth century with technology and institutions adapted only to the lower consumption rates of previous generations, that community will sacrifice rational use of its resources to present necessity.

Nothing less than the application of technology to all farming and rural life problems and the use of tested techniques in bringing about more effective rural institutions will narrow the gap between consumption and sustained use of resources and also promote that faith in the achievement of higher standards which alone will permit a concern for the welfare of future generations. Wise use and conservation must be a process spreading through all activities.

We are concerned here with the role of the educational programme in stimulating changes in human behaviour, related to use of resources—a basic consideration since our programmes must succeed or fail in proportion to the skill, the appreciation, and the devotion applied to them by those by whom and for whom they are organized. Furthermore, the educational programme, whether it be centered on the student in an institution or on people in their communities, is one of the few manageable instruments of society. Basically, we have no other means of bringing about lasting changes.

To limit our discussion still further, we shall treat with those aspects of educational programmes which appear to present most promise for dealing with agricultural and rural life problems from the standpoint of an international organization. The background and educational approach of the Inter-American Institute of Agricultural Sciences will be outlined. Following this, a project will be presented representing differing approaches to education for use of resources.

International civil servants in general are starting down a road on which the signposts are of their own erecting. When this Institute was established a half dozen years ago, there was no readily available precedent for a research and educational centre operated by a group of countries for their mutual benefit. The field in which the Institute was to operate was as untilled as was much of the fertile 2,500 acres donated for the Institute's purposes to the American States by the Republic of Costa Rica.

International organizations are, like all institutions, mechanisms erected by people to serve their ends. They will be effective to the extent that they discover that which is appropriate to their capacities.

Much of the background of social and economic problems is woven into the matrix of local and national cultures. Unfortunately we find few miracles of change ready for bringing about by the wave of a hand—even though that hand be guided by the accumulated wisdom of the ages concentrated in an international organization.

From its inception in the deliberations of the Eighth Inter-American Science Conference in 1940, the legitimate scope of the Institute has been studied. Initially the relationship to national and bilateral programmes was emphasized. With the rise of the United Nations, there has been a natural concern for effective co-operation with specialized programmes of world-wide scope. The Institute, an autonomous entity reporting directly to the Council of the Organization of the American States, is *ipso facto* at a median position between the world programmes and those of purely national significance. Both its jurisdictional position and its geographic location place it outside the mold of national traditions yet within the area where a series of the world's most urgent problems occurs and where basic solutions must be sought. It should, as it has to date, maintain freedom to innovate, to cross-fertilize, and promote continuity in its field with a sense of co-ordination. Its task and hence its sphere of activity would seem to relate to cross-cultural conflict and the need for inter-human communication. In its entirety the Institute should be an experiment and a demonstration in the field of inter-human relations. Within these terms of reference, it must retain an attitude appropriate for the servant of a series of sovereign states.

Better education must come about by the efforts of those who will give it—people in their homes and communities. Here and there we can ascertain a point at which they can be aided in this process by an objective force from outside their cultures. From these points of departure, the multifold solutions required may be stimulated to develop.

The convention establishing the Institute has placed on it responsibility for developing and applying science to the welfare of agriculture and rural life. Its accepted mode of operation is through research applicable to wide areas, the training of personnel for member countries, and the promotion of that type of direct education for human well-being which has come to be called extension. The broad outlines of the job to be done are clear. The organization necessary to perform this job in a manner acceptable to the needs and desires of the people to be served must be subject to adaptation to changing potentialities within the member states and the availability of services which can be performed to an optimum advantage by other international organizations.

We are in a day of integration when disciplines must be applied as inter-reacting variables within unified problem areas. Physical, biological, and social concepts differ only in their degree of specificity—none stands alone. The universities, the privately endowed laboratories will, it is to be hoped, continue to concentrate on advancing the fringes of our basic knowledge. To do so, they will specialize and proliferate. The public institutions, particularly institutions serving groups of people, must be concerned mainly with interrelations, with composite groups of facts that have pertinence in the lives of people.

Facing this situation the early planners of the Institute realized that the pattern of organization must be such that the essential disciplines could be applied in unison. The programme was hence divided into the four realities of farming and rural life: plants, animals, engineering and human relations. To avoid tinkering at research and the following of inconsequential speculation, each research project is the concern of all four departments regardless of where leadership may be. Furthermore, each department is responsible for carrying its main projects through to a point where they have been proven or disproven under the exacting requirements of the farm or community. This process will result increasingly as the programme matures in co-operative projects with research stations, schools of agriculture, extension services, production corporations and producers' associations. Not only is it necessary to employ all the disciplines, but research, demonstration and training must enter the picture as required.

This approach precludes much of the usual curriculum building technique. It is obvious that no preconceived course will be best for all time for all students. Rather a framework of principles must be erected to which the Institute can adhere and around which it can manoeuvre with consistency of purpose and effect. Flexibility must be maintained to gear teaching to students' needs—which means to the needs of the areas from which they come—seen as functions of the students' abilities, enthusiasms and professional opportunities.

The Institute operates at the graduate level. That is to say, its educational function starts where actual or potentially feasible capacities of national institutions end. To date it has been necessary to serve several types of learners:

1. Researchers, teachers, or administrators on vacation or study-leave from their jobs come to Turrialba to learn a new technique, to improve their abilities in a general field of work, to make botanical or zoological collections, or merely to utilize the library, laboratories, the opinions of a varied group in order to mature their ideas or to prepare observations for publication. They come from many countries and bring a variety of experience and abilities to the Institute community.

2. Graduate students enrolled in universities come to Turrialba to conduct research for their doctoral dissertations. These are usually students who, because of the nature of their specialization or because of the conditions for which they are preparing, require facilities, supervision, and equatorial surroundings in order to execute a research problem valid to their life work. They usually serve as graduate assistants and add materially to the research and teaching potential of the Institute.

3. Since few of the national institutions have sufficient demand for specialized training to justify maintaining a graduate school, there is a definite need for a centralized institution to prepare professionals in the various fields of agriculture and rural life. The Institute offers for this purpose a series of opportunities for recent graduates or those in service who desire to spend from one to two years in concentrated study aimed at achieving greater professional competence, a broadened concept of their responsibilities, and personal advancement. Such students should have their basic undergraduate preparation completed. However, it is necessary to complete this preparation in some cases. The most successful method encountered to date has been to send the student to another institution where such studies are already highly developed. This process of managing the common use of existing educational facilities holds such promise that a projected programme for broadening its use will be presented at the end of this paper.

Supervised work in field or laboratory, library study, and seminar discussions largely replace customary formal courses. However, a composite series of discussions and problems on scientific methods and a course in statistics are given by a social scientist and a geneticist, with collaboration from other members of the staff. All students, regardless of their previous preparation, appear to require a further grounding in ecology. Most of them also need opportunity to study a foreign language since no American will be able to consider himself educated in the future until he is competent in at least two of the four main languages of the Americas. Such competence is rare among university graduates.

4. Although the symposium is not usually considered as a teaching device, its educational potential is great. Aside from deriving principles of procedure and promoting co-operation, the groups of men of like minds who meet at Turrialba teach each other. Limited experience indicates that a series of symposia supplied with able consultants, meeting in places where creative work can be observed, adequately prepared for and followed up, may be of definitive importance in raising the competence of our scientists and technicians. Such symposia may, furthermore, tend to replace the larger, more general, and less effective regional or subject matter conferences.

In addition to the above, the Turrialba programme is experimenting with the training of rural leaders of lower than university graduate level. Many rural programmes require the use of staff less well trained than they will eventually require. These aids should be trained close to the area where they will work. The Institute is concerned with developing methodology for the use of others and with the training of supervisory personnel.

During the current year, there is being added to the Turrialba programme a scientific communications service. This is an experimental programme to find out the most effective means of acquainting scientists, teachers and rural workers in general with the scholarly output of the world and of facilitating their obtaining material strategic to their work. By use of the *Turrialba Journal* and other existing outlets, colleagues in the member countries will be kept advised of the availability of information most likely to serve their needs. Measures will then be taken to fulfil their requests by photocopies and otherwise. Theoretically, a central service of this kind could assure that all the world's knowledge would become available to every worker. How nearly one can approach this in practice will be determined.

The above programme with such modifications as experience may dictate and with a reasonable amount of expansion will, it is believed, satisfy the need for centralized services in the field of graduate and specialized education. It does not provide sufficiently for service to the broader and important fields of undergraduate and vocational education necessary to the improvement of agriculture and the well-being of rural peoples.

Most will agree that the type of education which is intimately related to the lives of people must be carried out close to where they live. Agricultural education is of this nature at least through the undergraduate period. For instance, those living in the tropics may well seek the major portion of their more academic graduate education in temperate zone institutions. However, undergraduate education loses its efficacy if removed from the physiographic region or from the social situation in which the student must work and live. Vocational education, if the experience of countries in which it has been most effective can be followed, tends to be more productive when the trainee continues to live in his home during training.

It is no accident that areas most in need of applying skill and knowledge to the use of their resources are also the least well equipped with educational facilities. We are faced with a woeful hen-before-the-egg complex which stands squarely in the road of any programme which may be devised. No amount of foreign specialists or commissions of experts can substitute for training and education in the areas where competent manpower is needed.

From such data as are available it would appear that fifteen of the American countries are able to supply university education to less than one per cent of the age group between 18 and 21. Their secondary schools enroll less than five per cent of those between 14 and 17 years of age. As is the case in most areas of the world, the position of rural and agricultural education is even less favourable than these general statistics indicate. In this group of countries aggregating nearly 50 million people, we have not more than 1,000 students receiving university education in agriculture during a given year. The number attending schools with largely vocational objectives is somewhat higher.

If complete statistics were available they would probably prove that the educational effort measured in relative percentages expended is as high in these countries as in those that supply secondary education to 30 per cent of their youth and university experience for 5 to 10 per cent of their young men and young women. It is an inescapable fact that small countries with relatively low *per capita* incomes cannot supply the education requisite to their needs. The solutions to this problem are being given earnest consideration by all the countries concerned and will involve many factors outside the scope of this paper. It is appropriate to present an approach to the supply of scientific and technical personnel which has been under discussion at Turrialba and elsewhere in the inter-American system. As we proceed to implement our plans, the counsel of those throughout the world who may have faced similar problems will be invaluable.

Integration of effort will be necessary. Otherwise our resources will not support the facilities required. This will imply some means of pooling our planning, organizing, and supervisory talents as well as common use of a few well-supported institutions by groups of countries with reasonably similar conditions and needs. None of us is ready to say that we know even the broad outlines of how such a pooling of resources can be effected. However, there is an established tradition for working together created by six decades of experience in the Pan American Union. Discussion of the problem with educators from several countries also has emphasized several factors likely to be involved.

It is believed that, for some time at least, existing institutions can be used, thus avoiding the complex process of creating a new institution. Most countries will prefer to instruct the Inter-American Institute of Agricultural Sciences to supply additional services rather than impose on their neighbours. On the other hand, we must avoid developing at Turrialba undergraduate teaching which might even impede the process of supplying an essentially national type of education. No doubt the Turrialba function would be confined to the pilot type of course purely for the purpose of training leaders and establishing method plus some expansion in the present process of routing students to institutions where particular competency in a given field or fields exists or can be fostered advantageously.

This programme, like all activities in the new field of international collaboration, must be conducted on an experimental basis. Continual study and evaluation of comparative results obtained by following our initial hypotheses will define our educational needs and indicate developments which should and could take place in the various countries for mutual benefit.

Such an educational programme will be the subject of a symposium at Turrialba during the current year at which these plans will be made more concrete. It is now assumed that, until experience indicated changes, the initial project would have the following characteristics:

1. Students would be registered in the Agricultural Education Service of the Institute. They would be required to have the academic qualifications necessary for entrance into the institutions to which they were to be sent for undergraduate education. They would in most cases already have positions in an agricultural programme and be assured a reasonable opportunity to return to their work at an increased salary grade. They would be above average in scholarship and professional abilities and, generally, would be sufficiently advanced to be able to complete undergraduate work in less than the usual number of years.

2. They would receive a period of orientation and testing at the Institute. In some cases this period could be minimized. In other cases the student would require a period of six months or more devoted to some or all of the following:

(*a*) Concentrated practice of farm skills required in his field.

(*b*) Learning to appreciate the relationship between skills and knowledge.

(*c*) Learning to use a library.

(*d*) Concentrated work on language (when necessary)—usually English.

(*e*) Assuring the Institute authorities that they could recommend the student to a co-operating institution and providing opportunity for a systematic diagnosis for the guidance of the student, his instructors, and employers.

3. During vacation periods the student would return to work on the farms or research projects of the Institute, with the programme to which he will return eventually, or at another more adequate job opportunity found for him.

4. After completion of undergraduate work most students would return to their jobs permanently or for a period before continuing with graduate work.

5. The students would be followed up both to assist them in adjustment to their work and to evaluate the success of the training programme.

On the Training of Technical and Scientific Staff for the Conservation and Utilization of Resources in Haiti[1]

PIERRE G. SYLVAIN

ABSTRACT

The National School of Agriculture is the principal Haitian institution connected with the subject of this Conference.

There are at present 49 students attending the School, all of whom were admitted on the basis of a competitive examination, having previously passed the first part of their baccalaureate. The course of study is of three years' duration and corresponds to approximately 210 United States University term "credits".

The principal problems with which the School is confronted are those arising from inadequate laboratory work and reference material, and certain other factors which hinder the improvement of teaching staff. Among these factors may be mentioned political influence in regard to the appointment, promotion and dismissal of professors, and the lack or insufficiency of research work undertaken by these technicians.

In order to improve teaching at the School, it is suggested that closer collaboration should be established between the various science teaching institutions in Haiti as regards sharing their facilities and in certain cases even their teachers, that repeated trainee periods should be organized, that specialists should be trained in various branches that an administrative statute should be adopted to safeguard the teaching profession and lastly, that active international co-operation should be developed to facilitate exchanges of professors and research work.

The conservation and utilization of resources is a question of particular importance in countries where demographic pressure is relatively great. When per capita resources are limited, it is evident that in order to maintain an adequate standard of living, these resources must be conserved and utilized in the most intelligent manner. Training of technical staff for the exploitation of these resources should therefore rank among the primary considerations of the Governments of such countries.

Haiti, an over-populated country, with an average of more than one hundred inhabitants per square kilometre, depends to a large extent on non-industrialized agricultural products and therefore needs a well-trained technical staff to exploit her resources.

Although Haitian journalists and statesmen had long been proclaiming the need for technicians, it was not till 1902 that an institution for the training of technical personnel was inaugurated. Due to the private initiative of a group of young people, former students of higher educational establishments abroad, this institution was founded under the name of School of Applied Sciences for the purpose of fostering in Haitian youth an interest in scientific studies and enabling them to avail themselves of their knowledge to enter the careers for which they are a prerequisite. (1)[2] Although at the outset it was only intended to train public works overseers, mechanics and agricultural experts at the School, training of this latter category of technicians was abandoned and it was not until 1924 that a Higher School of Agriculture was founded. In this report we shall confine ourselves to a discussion of the School of Agriculture, the only institution whose principal aim is to train technicians in the conservation and utilization of resources. We should nevertheless mention that the Polytechnic School offers a few courses connected with the subject of this Conference, although it does not train specialists in these branches. The other science institutions do not offer any courses bearing specifically on the conservation and utilization of resources.

STATUS OF HIGHER EDUCATION IN AGRICULTURE

The School of Agriculture referred to above is now called the National School of Agriculture and is affiliated to the University of Haiti. This institution has been through so many reorganizations since its foundation that it would be impossible for us to discuss them in the space at our disposal. We shall, however, mention the broad outlines of its development and the various names under which it has been known.

The School was established by the Law of 25 February 1924 under the name of Central School of Agriculture. It was at that time under the authority of the Technical Service of the Department of Agriculture and Labour (4), a body directed by United States technicians employed by the Government of Haiti to stimulate the agricultural and industrial development of the country. This Service was established on the same basis as similar institutions in the United States, its activities comprising experiments, teaching and agricultural expansion. (7) The initial stages were, however, difficult owing to the almost complete lack of Haitian agricultural technicians. This explains why during the early years the majority of students obtained employment before they had completed their studies. In 1928 only four students of the first batch took their diplomas.

In 1931 all but one of the United States specialists went home and the direction of the School was left entirely in Haitian hands. It was renamed Practical School of Agriculture and its curriculum was considerably modified.

In 1943 another important re-organization took place and the present name of National School of Agriculture was adopted. An Experimental Station was attached to the School which, in addition to the training of agricultural experts, undertook to conduct and direct research, experimental and extension work appropriate to a higher school of agriculture.

The National School of Agriculture was affiliated to the University of Haiti when the latter was founded in

[1]Original text: French.
[2]Numbers within parentheses refer to items in the bibliography.

1945. Since, however, agricultural teaching is supervised by the Department of Agriculture and not the Department of National Education which controls the University, relations between the two bodies have never been very close. All important directives concerning the School of Agriculture still emanate from the Department of Agriculture.

The Law of 21 December 1946 which at present governs the School again modified its status. Under this law a Service of Agricultural Technique was created, one of its functions being to train agriculture engineers. The Experimental Station is no longer attached to the School and these two bodies are theoretically independent of each other but as the Chief of the Service of Agricultural Technique is also Director of the School, this does not make much difference in practice (6).

Let us consider briefly the functioning of this institution. The School accepts only boarding students, and their fees are paid in full by the State. To-day there are 49 such students. Fresh students are not admitted each year but only every three years when a previous batch have completed their course. This rather unusual system seems to be due to the limited accommodation and the smallness of the teaching staff. The result is unfortunately that a young man wishing to take up an agricultural career may have to wait two years before entering the School. It would be desirable to admit a fresh batch each year even if the number of students is limited and if some of them have to pay their own expenses. It is unnecessary for the State to pay the fees of all future agricultural engineers whilst other higher schools do not enjoy this privilege.

Students are admitted on the basis of a competitive examination and must have previously passed the first part of their baccalaureate. The baccalaureate examination is held after twelve years of schooling or the equivalent. The diploma obtained is recognized by the French authorities as equivalent to their own. In certain years the number of candidates for admission is greatly in excess of the vacancies, and this examination constitutes a severe test.

The curriculum comprises the following subjects:

- Agronomy and Horticulture
- English
- Industrial Arts
- Bacteriology
- Botany and Plant Pathology
- Chemistry and Agrology
- Conservation of the Soil
- Rural Economy
- Entomology and Zoology
- Genetics
- Rural Engineering
- Agricultural Geology
- Rural Legislation
- Mathematics
- Meteorology
- Physics
- Veterinary Sciences
- Sylviculture
- Agricultural Statistics
- Agricultural Technology
- Zootechny (4)

Taking into consideration the number of hours devoted to lectures and laboratory work, the courses in these various subjects correspond to approximately 210 United States University term "credits". As we shall see later, however, instruction is deficient in regard to library work and the quality of laboratory work.

The teaching staff at present consists of 19 professors or lecturers of whom six hold the Master of Science degree at American universities, one is an Engineer from the Paris Agronomical Institute, one is a Doctor in Veterinary Science of the Oka Agricultural Institute (Canada), four are graduates of the Haiti School of Agriculture, four are graduates of various other specialized schools in Haiti and three have pursued advanced agricultural studies in Haiti or abroad but do not hold university degrees.

Since its foundation under the name of Central School of Agriculture the Institute has trained one hundred and five graduate agricultural engineers in addition to the large number of students who have studied at the school without graduating. Mention should also be made of the 154 graduate rural instructors trained between 1931 and 1944 at the Teachers' Training Section. This Section did not have university status, but offered a number of courses in agriculture to students during their two years' course of studies.

In spite of deficiencies and certain difficulties to which we shall allude later, the School of Agriculture has produced technicians capable of rendering useful service to the expansion of agriculture and the management of State farms. Although at first the higher administrative posts in the Department of Agriculture were usually entrusted to graduates of foreign universities, the three present chiefs of the Technical Services of the Department of Agriculture are graduates of the Haitian School and have only made short journeys of advanced study abroad.

Moreover, graduates of the School of Agriculture who have subsequently attended United States universities have frequently been admitted as graduates or have at least been treated as "seniors" or fourth year students.

Nevertheless there can be no doubt that the training of agricultural technicians in Haiti still leaves much to be desired, if only because no specialists are trained and because of the too small number of agronomists turned out by the School. Certain other defects in advanced agricultural teaching will be pointed out in a moment.

NEED AND PROBLEMS OF HIGHER AGRICULTURAL EDUCATION IN HAITI

Laboratory Work: Inadequate laboratory work is one of the weak points in the teaching at the National School of Agriculture. Most of the former students of the School who go to the United States for advanced studies although they are usually able to follow theoretical courses satisfactorily, at first encounter difficulties owing to their lack of laboratory experience. We need not emphasize here the importance of laboratory work in the training of technical personnel; it is particularly felt in Haiti where teaching has a general tendency to rely too much on book work at all stages of education. The School of Agriculture laboratories are poorly supplied and the funds allocated for their equipment and maintenance are insufficient. Budgetary appropriations for the present fiscal year only set aside an amount of 8,400 gourdes or 1,680 dollars for teaching material including the purchase and maintenance of laboratory apparatus and other school supplies. Students pay no extra fees for use of these materials, since the budgetary allocation is intended to cover all this expenditure. At present there are only 19 microscopes for 39 students, and the small number of teachers does not permit of the division of classes into too many sections.

Library: Library facilities for such an institution. The Library contains under three thousand books and about twelve thousand bulletins and periodicals. The number of works which many students can profitably consult is limited since, as Haiti is surrounded by English- and Spanish-speaking countries, most of them are in foreign languages. In the absence of accurate statistics, we do not think it would be an exaggeration to say that only one quarter of the publications are in French—the language of the country—whilst much of the stock is composed of the bulletins of the United States experimental stations and of the Department of Agriculture. Most of the professors and a number of students read English well enough to consult these works profitably but students cannot be obliged to refer to works in foreign languages.

The budget for the present fiscal year only allots 3,600 gourdes or $720.00 for the purchase and binding of books (2). This scarcity of reference material is serious since one of the aims of every higher educational institution is to teach students to work for themselves by consulting reference material likely to help them to solve the problems with which they will be faced later on in their careers.

Quality and improvement of Teaching Staff: The quality and improvement of teaching staff constitute a serious problem. It is often quite rightly said that a school is only as good as its professors.

The teaching staff of the School of Agriculture is on the whole quite well trained, many of the teachers having taken advanced courses in universities abroad in addition to their studies in Haiti. A good teacher must, however, keep abreast of progress in his field and constantly improve himself by private studies and the experience gained in the course of his work. It has to be admitted, however, that only a man of outstanding ability would be able to increase his technical qualifications in the present state of higher agricultural instruction in Haiti.

A technician's career is precarious in a country whose politics afford no security of employment to agricultural engineers and specialists, and where prospects of promotion and working conditions in general are so unattractive as to discourage the finest enthusiasm. The result is that with so uncertain a future, teachers often do not take sufficient pains to maintain the intellectual and technical standard indispensable to good teaching, and even if they concentrate all their energies in this direction, laboratory and library facilities render the task somewhat difficult.

Owing to political circumstances frequently resulting in sudden dismissals or regrettable resignations, the teaching staff is renewed too often for the smooth running of the institution. From January 1946 to date, the National School of Agriculture has had five directors, two of whom were, admittedly, only appointed on a temporary basis. Of the 19 professors and lecturers at present at the School, only five were on the staff 10 years ago.

Another factor influencing the quality of the given teaching at the National School of Agriculture is the lack or insufficiency of research work undertaken by the teachers. Anyone who has studied the question will agree, I am sure, that a good agricultural science professor should devote a certain amount of time to research which obliges him to keep abreast of the latest developments in his field and enables him to keep his hand in and to avoid the error of keeping his teaching on too theoretical a plane. Hence, although this report does not cover the question of research in the utilization and conservation of resources, we can hardly deal with the training of agricultural technicians without making a few remarks on this subject.

Apparently the organizers of the School of Agriculture always intended that teaching should be accompanied by some research work, for most of the professors were at the same time employed at the Experimental Station. These activities of the Department of Agriculture were, however, gradually abandoned and the work of the stations now consists almost exclusively in the acclimatization of foreign species or varieties, the maintenance of various nurseries, and the production of milk and animals for slaughter. Several experiments of value undertaken in the past in cotton selection, maize improvement, the physiology of coffee, entomology and vegetable pathology have now been abandoned. Public opinion does not seem to appreciate the value of research even when problems of great economic importance are at stake. Although with a limited budget a first class experimental station cannot be aimed at, it is essential that genuine research should be undertaken not only in order to solve certain problems of Haitian agriculture but also to maintain teaching standards and to instil in students a thirst for scientific knowledge.

POSSIBILITIES OF IMPROVEMENT

In the light of the foregoing remarks, we think that the training of agricultural, technical and scientific staff could be improved if the whole or part of the following programme were adopted. This programme, although planned for Haiti, could be applied to certain other countries at a similar stage of development and faced with the same type of problems.

Collaboration between the various scientific teaching establishments: The insufficiency of laboratory equipment and reference material could be more easily remedied if there were closer co-operation between the various institutions teaching science. Although the University of Haiti was to some extent created for this purpose many of the institutions which compose it do not maintain any relations with one another. An agreement should exist between the Polytechnic School, the National School of Agriculture, the Teachers' Training College and the Faculty of Medicine to pool their laboratory and Library facilities for the similar courses given by each of them. This system is in force in numerous universities with much larger budgets. The Polytechnic School and the National School of Agriculture would even benefit from being located on the same campus as this would make for closer co-operation between the two institutions. It is desirable that teachers of similar or related subjects should have the opportunity of meeting frequently to exchange ideas on their problems.

Organization of trainee periods: The majority of students entering the School of Agriculture come from urban centres and consequently have not the experience of rural matters which would enable them to become successful agricultural engineers. This gap is bridged either by a series of practical studies carried out at the School or by a single trainee period of three months. Practical work is, however, limited by the amount of time available in the curriculum and by the fact that the School is situated on flat land where many species of importance to the country cannot be cultivated and where methods of cultivation suitable to sloping ground cannot be employed. It would therefore be desirable to devote one term each year to a trainee period in agricultural undertakings situated in different parts of the country in order that students may familiarize themselves with rural life and acquire practical experience in methods of cultivation which cannot be undertaken at the Station in the neighbourhood of the School.

Training of Specialists: No effort is made to train specialists. The programme of studies is the same for all students, and the result is that the School turns out technicians with only a general agricultural knowledge since they have not been specially trained in any particular branch. The field of technical knowledge has grown to such an extent during this century that it is indispensable to train specialists if it is desired to have available technicians capable of conducting certain undertakings. Moreover, forestry and veterinary medicine are no longer considered to form part of the agricultural curriculum, but are rather taught in specialized institutions. While it may not be necessary at present to increase the number of technical schools in Haiti, it would be desirable for the National School of Agriculture to add one year's tuition at the end of the present course of studies to enable those who so desire to specialize. A new diploma could be taken at the close of this extra year.

Introduction of statutory rules of employment for teachers: In order to avoid too frequent changes in teaching personnel and to give teachers security of tenure and equitable promotion of a nature to encourage them to increase their technical knowledge, it would be desirable to introduce a body of proper administrative rules independent of all political considerations. Appointments, promotions and dismissals of teaching personnel should be based on a system similar to that employed in the United States civil service. No institution can hope to retain highly qualified persons in its service unless they can be sure that they will not be molested for political reasons or at the whim or according to the likes and dislikes of their superiors.

International Co-operation: International co-operation can and should play an important part in the training of technical and scientific personnel. We think it is necessary to lay special emphasis on this point in view of the nature of this conference.

This co-operation could be achieved principally by the granting of scholarships, exchanges of teachers, the creation of international study or research centres and the establishment by certain large institutions of branch organizations in other countries.

The granting of scholarships in certain countries, and especially in the United States, has become very widespread during recent years. It would be desirable for visits for purposes of study to be exchanged more often between certain countries, which although less advanced, possess more or less similar natural resources and have reached approximately the same stage of development: for example, technicians from the West Indies and Central America and even certain regions of Africa and tropical Asia, should be able to exchange visits.

Many of these technicians had had occasion to visit large centres in the United States and Europe but are unacquainted with countries which could perhaps provide excellent sources of inspiration in view of the similarity of their problems. Such journeys could be financed by international organizations if the institutions of the countries concerned were unable to bear the cost. Since under-developed countries are financially unable to train all the types of specialists and technicians they may need, it would be desirable for groups of nations to found jointly establishments for use as centres of teaching and research by nationals of all countries in particular geographical regions. In this connexion, we welcome the foundation of the Inter-American Institute of Agricultural Science at Turrialba, where research work is carried on which could be put to practical use in a large part of America. A small number of technicians also receive additional instruction in certain branches of agriculture at this Institute. (5). We hope that the countries concerned will decide to increase their contributions in order that this Institute may expand and extend its activities.

International co-operation in the training of technical staff may also take the form of collaboration by the institutions of two different countries for this purpose. For example a number of United States universities give financial and technical assistance to institutions of other countries for the carrying out of a teaching or research programme in which they are interested. This is usually to the mutual benefit of each, since it enables the institution of the more advanced country to extend the scope of its activities and to discover new subjects for research, whilst the other benefits from the help of technicians often better trained or more experienced. Such an arrangement exists between the College of Agriculture of the State of Iowa and the Department of Agriculture of Guatemala which have together undertaken a series of investigations on maize improvement at the Experimental Station of Antigua.

The fact of the interdependence of peoples in the economic field having been firmly established, it is perfectly logical to ask for international co-operation to play its part in the training of technicians and specialists, one of the most important factors in the world economy.

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Memorandum by the Société haïtienne d'Etudes scientifiques[1]

From the economic point of view, a nation is nothing more than a society of producers. The most important material of a nation, the material to which it must give particular attention, is its human material, because it is on that material that all its possibilities for the future depend.

—*J. C. Dorsainvil*

The conservation and utilization of natural resources is, for a country like the Republic of Haiti, a task which is not only important but particularly difficult because of the high degree of illiteracy of the population. If they are to have results, any recommendations that may be made concerning the numerous problems involved in such an enterprise must be easily realizable, that is to say, they must be practically simple. They must also be approved and supported by the Government of the Republic; for any economically and socially backward country action by public authorities is indispensable.

Some of these problems, such as the problems of timber, erosion and water, are of primary urgency. Further, if agriculture is to be made fully productive, not only must a technique for the complete and wise utilization of natural resources be applied, but also an attempt must be made over as large an area as possible to improve the health conditions in which the populations of the rural areas live and raise their standard of living. In this connexion, we stress the importance of education from the point of view of saving natural resources and in the struggle against waste. One might go further and say that the application of modern methods for increased production is possible only in areas in which the school, the demonstration and experimental farms and the co-operatives have given the best results. Our problems are so varied and in many cases so complex that we might often be altogether discouraged if we did not know that no country has hitherto succeeded *in exploiting fully its natural resources*. On the contrary, the retarded countries benefit from the progress achieved elsewhere, and may thus make use of the latest discoveries. We must not forget that all modern methods and techniques represent nothing but an application of science.

The group meeting at Port-au-Prince is clearly conscious of present agricultural possibilities in Haiti and of the inadequacy of the material means available for the exploitation of natural resources. The information we advance here will perhaps provide material that may be useful in the discussion of similar problems arising for countries on the same social and economic level as the Republic of Haiti. Great opportunities can be offered in Haiti to capital investors interested in the operation of fisheries, the timber industry, hydro-electric power, the preparation of alcohol, the manufacture of sweet chocolate and preserves, the utilization of aloe and timber waste, the utilization of kelp and the working of lignite mines.

In order to interest the Haitian public in an understanding of these problems, the *Société haïtienne d'Etudes scientifiques* (Haitian Society for Scientific Studies) has decided to maintain a permanent committee to study them and will be glad to receive from the United Nations any documents that might facilitate the Committee's task.

Survey of the population of Haiti

About four-fifths of the population of Haiti, the exact figure for which, failing a complete census, is *unknown*, are farmers. This large, rural population, which, in addition, is very prolific, has an area of 27,700 square kilometres on which to develop. The *non-cultivable* area of the country is considerable. In certain regions, the population has been reduced to the *minimum subsistence level*, a circumstance which indicates the imminence of destitution for a large part of the inhabitants. For the Haitian, the field of emigration is not only limited, it is closed. One of the solutions of Haiti's demographic problem would be to improve the social and economic conditions for the development of the population and bring relief to the rural masses from that trio of diseases—yaws, malaria and helminthiasis. By ensuring the normal evolution of a large proportion of the population, we shall have found a remedy for production and consumption problems whose solution might largely modify the economic stagnation now threatening the condition of the Haitian; *for the Haitian crisis is a crisis caused by the progressive impoverishment of the urban and rural populations.*

The problems facing the urban populations are as serious as those of the rural masses, and *often their economic burden is heavier to bear.* The youth of this section of the population is confronted by the problem of the lack of employment opportunity for the individual.

In the towns as in the country there is a group of people economically independent of public departments who form the middle class: artisans, small and medium-scale tradesmen, grocers, commercial agents, brokers, commission agents and intermediaries, technical workers, professors, men and women teachers, advocates, medical doctors, engineers, notaries, pharmacists, dentists, midwives, nurses, hotel-keepers, restaurant-keepers, hairdressers, photographers, undertakers, garage-keepers, chauffeurs, launderers, distillery managers, goldsmiths, bakers, cabinet-makers, skilled workers, shoemakers, tailors, blacksmiths, musicians, painters, pastors and priests, accountants, farmers, stenographers, typists, and commodity speculators.

At Port-au-Prince the total number of persons belonging to that class is about 10,000. If we assume that each belongs to a family of six members, that makes about 60,000 people belonging to the middle class out of a population of 150,000.

The trade union movement, the organization of which is of recent date in this country, has a beneficent influence on the development of that class.

Medical and sanitary aspects of the question

It follows from an analysis of production factors that the whole of the Haitian economy is based on the work of the farmers. Since the great mass of our population

[1]This memorandum, prepared by Dr. Camille Lhérisson, President of the *Société*, represents the conclusions of a series of discussions in which the following took part: Catts Pressoir, Hector Paultre, Marcel Sicard, Camille Lhérisson, R. P. Bettembourg, Gérard Boucard, Félix Corneille, Parnel Marc, Ulrick Duvivier, Valéry Sicard, Lucien Hibbert, Pierre Sylvain, Pradel Pompilus, R. P. Brierre.

Original text: French.

lives in the country, the best means of attempting to raise the standard of living in Haiti and promote the country's economic recovery is, in the general interest, to improve the living condition of the agricultural worker.

Our present production is proportionally reduced by the number of sick women and men. Human pathology, as complicated by the action of other scourges like rats, insects, plant diseases, erosion and soil conditions, absorbs a high percentage of the national energy, perhaps as much as the deficiencies existing in general education, and vocational and agricultural training. It is therefore on the diffusion of a sound knowledge of public health and of the treatment to be applied for the prevention and cure of parasitic diseases that the economic recovery of our country will largely depend.

What are the diseases from which the farmers of Haiti suffer? What is their origin and how are they to be remedied? The pathology of the peasant masses varies strikingly from one country to another. Besides clothing, housing and nutrition, a considerable influence on the health of rural populations is exercised by the nature of the environment, whether low-lying or mountainous. It sometimes happens that the chief sectional administration officers fail to send declarations of deaths to the competent civil registrar, and in present conditions it is not possible to require certificates of death in certain areas. It follows that no reliable statistics relating to deaths and their causes can be given.

Our considerations are based on the general investigation carried out by the Payne Mission of the Rockefeller Foundation into the "Causes of incapacity for work in Haiti" in which we took part from 1924 to 1926, on the medical examination of several thousands of emigrants going from Port-de-Paix to Cuba, on a large number of autopsies that we conducted at the General Hospital from 1927 to 1929, on our experience of rural dispensaries at Kenskoff in 1928, Taifer-Laval-Prosy in 1929, Marché Lamarque (Nouvelle-Touraine) Berly-Laval in 1929, and on our experience of human biology in Haiti and the parasitological study of the country's main administrative departments.

The peasant's food habits have not improved since the time of slavery. Generally speaking, the peasant prefers quantity to quality in his food. While it may in some cases be said that his stomach is satisfied, the organism itself is not. An improvement in these defective health conditions will only be possible when the ignorance of the masses has been conquered. That requires the co-ordinated and rational efforts of an adequate rural public health organization. The peasant does not eat butter or drink milk, and there is insufficient protein in his diet, which is based too exclusively upon carbohydrates. The consumption of fruits varies from area to area.

While in some areas agricultural work may not in itself be the cause of occupational diseases, its duration and the overstrain that may result from it, especially in the case of women and children, induce lesions which are often very serious. Weeding under the hot summer sun, the threshing of maize, the preparation of coffee—these are laborious operations which are frequently accompanied by an acutely morbid condition characterized by attacks of fever with headaches and pains in the joints and in many cases by a localized inflammation of certain muscles in the lumbar area which is very suggestive of the clinical category of sciatica. The peasants are also exposed to traumatisms, serious prolapse, compound fractures and tetanus. Their ploughing instruments cause wounds which become infected and degenerate into enormous ulcers. Women and children are too often employed on the transport of heavy burdens in mountainous regions and along our rough country roads. They carry wood, water, the produce of their harvests and building materials: metal plates, planks and the like. Such considerable efforts cannot but affect their health. The flattening of the bones of the cranium, the exaggerated curvature of the spinal column, the lesion or prolapse of internal organs, muscular cramps, migraine—all these have harmful effects on the organism (conformation of the pelvis in women) and on the individual's capacity for work. This carrying of heavy burdens for long periods by undernourished individuals with only a few rare moments for rest exerts pressure on the back part of the thorax, impedes inspiratory dilatation, heightens susceptibility to pulmonary and cardiac diseases, reduces the oxygenation of the blood and prepares the ground for a chronic anaemia which can be corrected only with difficulty. Among women, such excessive strain often results in miscarriages. Mothers do not rest long enough after childbirth, which in many cases takes place on the public highways. It is not unusual to see them up and about the day after their delivery, which is sometimes laborious and often carried out in frightful conditions with the assistance of uneducated village women. All these causes explain the defective growth of newly-born children, their relatively feeble resistance to disease and the high rate of infant mortality in the country which, according to Payne is about 67 per thousand amongst children of between one and four and 167 per thousand amongst children of under one year of age. The same causes explain the frequency of abdominal complaints among women.

Generally speaking, agricultural work and long journeys on foot often oblige women to interrupt the breast-feeding of their children. The child is then subjected to an irrational and often inadequate feeding system which encourages digestive troubles, nutritional diseases and a cachexia which gives rise to serious organic disorders that develop slowly but are fatal to the child.

Children of school age are themselves employed on various kinds of the most urgent seasonal work.

The diseases most current among our peasants are all infectious, avoidable, and capable of treatment by collective medicine and hygiene.

The intestinal disorders observed in our country districts are especially frequent in children. Most of them result in dysentery or enteritis. Dysentery may be caused by bacilli (Flexner, Chiga). That is the epidemic form known in Haiti as *cholérine* and affecting annually almost 26 per cent of our rural population. It may be caused by an amoeba: the *Entamoeba Hystolitica,* which is fairly common in the North and affects between 10 and 20 per cent of our peasants according to area. Another form of it may be caused by an infusorium: the *Balantidium Coli* and another form by *intestinal worms*: the *Anguillulae.*

The various kinds of enteritis are less serious, but they are also widespread and are caused by species of

Monilia; by the protozoa, *Giardia, Chilomastix* and *Trichomonas;* and by intestinal worms such as the *Ancylostoma,* the *Ascaris* and the *Anguillulae.* Enteritis is sometimes brought on by an unseasonal drop in temperature, by damaged food and by alcoholism. Amongst infants it is caused by ignorance of proper feeding methods or by premature weaning. In such matters there is a great work of medical assistance to be done—that of inculcating in mothers some of the principles of child-rearing, of which they are now entirely ignorant.

Children are sometimes fond of earth, and it may be said that this habit is due to a shortage of certain food elements. The habit very often gives rise to *helminthiasis* resulting from the absorption of eggs or larvae and of worms contained in the earth. These intestinal parasites are very common among us and cause many complaints, particularly amongst children, and contribute a great deal to the enfeeblement of adults. The most common are the *Ascaris,* which often causes death by obstruction of the intestinal channels, the *Oxyuris,* the *Trichocephalus,* the *Ancylostoma,* the *Anguillulae* and the *Tenia.* In 1925, out of a population of 4,439 in the Carrefour, Rivière-Froide and Dégand districts, we find that 38 per cent of the people were infested with the *Ancylostoma,* 43 per cent with the *Ascaris* and 58 per cent with the *Trichocephalus.*

Ancylostomiasis is a disorder common in the sugar and coffee plantations, etc. The number of persons infected by it is estimated to be 26 per cent of all the Haitian population examined. The frequency and seriousness of the disease vary considerably from place to place. The Cul-de-Sac Plain is free of this disease because the larva of the *Ancylostoma* does not develop in saline ground. On the other hand, however, all our mountainous districts are infected by it. The disease was very well known in Santo Domingo under the name *"stomach disease".* The persons most exposed to it are those who have been in direct contact with warm, humid and larva-infected earth: growers of sugar cane, bananas, cacao, coffee, tobacco and rice. Levacher, in his *Guide médical des Antilles,* which appeared in 1847, says that

" . . . its appearance may be caused by the clearing of uncultivated ground, by the digging of channels, by warm and prolonged humidity . . . by bad weather and a watery and vegetable food. The slaves were infected by eating earth and they committed suicide with the slow agony of Ancylostomiasis.

"I have seen Negroes", says Levacher, "poison themselves in this way and force their children to follow their example from the sole motive of resentment and with the sole aim of harming the interests of their masters by putting themselves and their families out of condition to work."

Since that time, the extent of the inroads of Ancylostomiasis has remained unknown in Haiti, and it was only with the first attempts to penetrate our country districts by the Rockefeller Mission and the establishment of the first rural dispensaries that the Public Health Service began a campaign against one of the running wounds that impair the national energies. In order that such a campaign should be fruitful, it must be supplemented by a series of sanitary measures. The platonic advice to wear shoes is in our environment insufficient, since the larvae scattered about on the ground in excrement may infect even a person wearing shoes. The proportions of the evil attained by Ancylostomiasis will not diminish until the general conditions affecting the welfare of the populations are improved and public health system is developed.

Goitre is a common disorder in our mountain districts. *Pellagra* is sometimes encountered, but is not frequent. *Trachoma,* according to Dr. James Hooker, U.S.N., affected about 16 per cent of the children examined during the investigation conducted by the Rockefeller Foundation. *Smallpox, influenza* and *cerebrospinal meningitis* have claimed numerous victims throughout the Republic, particularly in the North.

A fairly common infection in the Despuiseau area of the great Cul-de-Sac Plain is the *Boussarole* or *Pinta.* It is characterized by the desquamation of the skin in patches, which assume various colours. Uncleanliness contributes to the development of this disease. Its cause is a *Treponema.* The disease develops slowly. The exposed parts of the body are the first to be attacked. The white and violet varieties are the most common. Several varieties may be observed on the same individual who then assumes a very curious mottled appearance. The disorder is accompanied by a disagreeable itch. The disease is not fatal, but it constitutes a very painful infirmity.

Tuberculosis is fairly frequent in our country districts. Although not a tropical disease, it develops with exceptional rapidity in our climate. In Haiti it recalls the type of the infantile tuberculosis of the temperate zones. According to information supplied by the Rockefeller Mission, its average incidence in our country districts is about 430 cases per 100,000 inhabitants. The development of the disease in our country districts may be explained by the absence of any specific immunity in the peasants, who are hence more susceptible to infection. The promiscuity of country life is another factor which plays an important part in the spread of tuberculosis.

When it is considered that a specimen of milk coming from the Taifer Rural Section contained exactly 1,600,000 bacteria per cubic centimetre, whereas no more than 10,000 of them, without any pathogenic species, should actually have been found, when one considers that the adulteration of milk with water is common in our country districts and that even the springs are sometimes polluted by all kinds of excrement, it can easily be understood that *typhoid* claims numerous victims, particularly in the cold areas, in spite of the immunity acquired by repeated minor infections. This disease often develops atypically and is usually complicated by malaria. According to Payne, there are about 180 cases per 100,000 inhabitants every year. One can therefore easily realize the importance of protecting drinking water in a district like that of Kenskoff or Rivière-Froide, for example, where many families from Port-au-Prince go to spend their country holidays.

Malaria has been known among us since the early days of the discovery of the island. Robertson and the Abbé Raynal give a very clear description of it. During his second voyage, Columbus was seized by a violent fever and remained for some time in a coma (typical symptom of malignant tertian malarial fever, caused by *Plasmodium falciparum*). It is what the doctors on Santo Domingo used to call the "pernicious cerebral intermittent fever". Tertian and double tertian fevers which are still called acclimatation fevers were frequent at that period. Today the infection is fairly widespread, and even at Port-au-Prince the number of cases has recently increased. Of 4,439 persons examined in various areas during the work of the Rockefeller Mission, 67 per cent had malarial parasites in the blood. When Wilson and Clark examined at Port-de-Paix 11,000 emigrants from various districts of the North and North-West who were going to Cuba to work in the United Fruit plantations, they found that 23.50 per cent of them were malarial cases. Of 2,007 school children examined during the same period (1927), they found that 50.52 per cent of them had malaria. Many of these individuals displayed relative immunity, that is to say that in spite of the presence of the parasite, their cases had never culminated in a crisis. It is difficult to reduce the intensity of the infection in our country areas. Without making use of larvicide fish, it will not be possible to destroy the larvae of the anopheles to any satisfactory extent. The peasants drink the water of streams and use the stagnant pools to water their animals. One cannot put poisonous substances like Paris green (composed of arsenite and copper acetate) into such pools and streams. A person living in a malarial district can only protect his dwelling by means of wire gauze and by using mosquito netting during the night. He may also take prophylactic doses of quinine in the evening at the time of going to bed. In that way the drug will have its maximum concentration in the blood at the time when the individual may incur the risk of being stung by mosquitoes.

Filariasis is encountered particularly in the Cul-de-Sac Plain and the Quartier-Morin area. Like all parasitic diseases, it may exist in relatively healthy subjects without causing them any trouble. It usually causes repeated lymphatic pressures which are more or less serious, and it sometimes results in *elephantiasis*.

A disease which is becoming a grave menace amongst us is *leprosy*. In the Artibonite district it is fairly frequent. We have hitherto been unable to take any measure to prevent its spreading. The disease is the more serious since of all the treatments hitherto advocated none has proved effective.

The commonest disease in our country districts is yaws. Of 2,564 persons examined in various districts near Port-au-Prince, the Rockefeller Mission found that 78 per cent were infected with yaws. The disease is frequent in youth. Of 3,289 cases examined by Dr. Wilson, Dr. Mathis and Dr. Lhérisson during the activity of the out-patients' clinic organized at La Nouvelle-Touraine, Berly and Bongars in 1929, 61.09 per cent were discovered to be children under ten years of age.

The disease began to appear in Haiti with the introduction of the first slaves in 1509. It was only in 1922 that a beginning was made to apply rational and intensive treatment in our country areas. The first description of the disease was given accurately by *Oviedo y Valdez* in 1526 in his *Histoire générale et naturelle des Indes.* He called it *"a terrible pustulous disease"*. Two hundred and thirty-one years ago, Father Labat wrote in his *Voyages aux Iles de l'Amérique* as follows:

"The Caribs are very susceptible to yaws. This disease is peculiar to America, where it is indigenous. All those who are born there, irrespective of sex, are attacked by it almost as soon as they come into the world and even though their fathers, mothers and nurses are very healthy, or at least appear to be so."

Since the time of Father Labat, these same conditions such as we observed in 1929 not far from Port-au-Prince have existed in our country districts. An enormous percentage of our rural population of Haiti is infected with yaws. Unfortunately, we cannot give any positive estimate of the numbers affected.

Agricultural work is undoubtedly the most rewarding of any that is available to the Republic of Haiti. The very facts of the situation compel our attention. The greater part of the population of Haiti lives on agriculture and feeds the rest on the fruits of this labour. A well planned attempt to achieve the physical improvement of the peasant will produce valuable results within a very short time. The establishment of a rural division of the public health service to combat methodically the causes of incapacity for work amongst the rural population is a necessity, for the utilization of a strong and healthy labour force is important to our economy. The mass of the rural population is still awaiting a whole series of rational measures indispensable for its development. That work of higher civilization, the medical education of the masses, giving them better production every day against empirical methods and exploitation by charlatans will bring in dividends which may change the balance of our accounts and improve the economic and financial situation of the Republic of Haiti.

"From the economic point of view, a nation is economically nothing more than a society of producers. The most important material of a nation, the resource to which it must give particular attention, is its human material, because it is on that material that all its possibilities for the future depends." (J. C. Dorsainvil: *La Crise haïtienne. La Question de la Production. Quelques Vues politiques et morales,* 1934.)

The economic equipment of a given people begins with the improvement of the physical conditions of the individuals forming it. The physiological condition of the farming population should be our primary concern, our first efforts should be directed to a study of the means of improving this condition. The peasants constitute the most numerous class, and on their health depend their mental condition and social activities. All the commercial statistics of Haiti point to the conclusion that the peasants constitute the backbone of the Haitian people.

In spite of the density of the population of Haiti, there is a labour problem—that of improving the condition of the agricultural workers and of relieving them from some of the miseries from which they suffer. The improvements that can be introduced in working conditions in agricultural undertakings form only one side of the question. We have dealt at length on the medical problem and the physical condition of the peasants. It remains for us to consider the social problems.

Our rural population is entirely ignorant on the subject of savings, and has no inkling of the possibility of independence for the individual, such as would allow him to discuss the conditions that might be imposed upon him. Consequently he is left defenceless in the hands of the manager of an agricultural undertaking. Steps should be taken to establish agricultural banks, to exempt the property of the family from distress proceedings and make it inalienable and to prohibit usurious loans. Villages must also be organized and exchange and trade facilities provided in the rural centres. Haitian capital must be induced to take an interest in the large agricultural undertakings which have hitherto been left to foreign capital.

Economic Problems—The Republic of Haiti is confronted by a certain number of economic problems which urgently require solution to enable means for social rehabilitation to be carried out. Some of those problems are the consequences of certain facts which we have mentioned and also of chronic inadequacies that have been aggravated by the international situation.

Defects in agricultural equipment and transport constitute acute problems. In certain areas the local roads and highways are in a deplorable condition. Our economic structure must be reformed if the economic development of the country, its social progress and national security are to be placed on a sound and solid foundation. The execution of such a reform involves the suppression of all factors that may hinder plans for the development of natural resources. That is to say, some diversity must be introduced in agriculture and trade; the one-crop system must be abandoned; regional industrialization must be developed. The solution of the economic problems also requires that a continuous effort should be made to effect the increasing application of technical progress in order to raise output to the maximum. The development and co-ordination of the administrative bodies responsible for carrying out all the plans for the development of natural resources are just as important; nor is the school question less important. All this shows that economic problems, which are connected with so many others in this new country, are manifold, complex and profound, and that they cover all branches of the national activity. Teams of adolescents should be constituted and made familiar with existing conditions and problems, and the financial resources should be obtained to make possible the employment of every person who has the technical ability to undertake and successfully to complete direct and positive action. The National Bank of the Republic of Haiti should be in a position to finance a programme for the utilization and conservation of natural resources. For its part, the Government should work towards the establishment of an Inter-American Bank, in accordance with the recommendations approved at the Eighth International Conference of American States in 1938. Such a bank would be able to assist in the agricultural equipment of the country. In matters of technical and scientific collaboration, American co-operation has always been generously offered to assist in attaining economic and industrial objectives. This type of co-operation has generally been provided by the despatch of technical missions, some of whose recommendations have already been applied. One of those technical organizations, the SCIPA, is at the present time rendering great services to the Republic of Haiti.

As the result of a resolution adopted at the Eighth American Scientific Congress, there now exists a Pan-American Commission on Natural Resources and Soil Conservation which has as its fundamental purpose the rational utilization of natural resources, and which is called upon to render remarkable services to the countries of America.

We might say, in conclusion, that the problems facing us in Haiti present no difficulty of an exceptionally technical kind, and that with the assistance of the United Nations and the Economic Commission for Latin America, the Republic of Haiti will be able to direct its agricultural and economic activity towards the search for practical, fertile and encouraging solutions for the future. As has been said,

"A rigid nationalism or regionalism does not contribute to strengthen the bases of collective well-being."

It is upon a sincere and loyal collaboration, implying an acceptance of the fundamental values that dominate personal advantage, the interests of groups and the requirements of the moment, that the success of the struggle for the utilization and protection of natural resources will depend.

ANNEX I

Census Bureau

***Director:* M. Raymond Doret**

Census of Port-au-Prince
24 January 1949
Population by Age Groups and Sex

Age Group	*Total*	*Men*	*Women*	*Men per 100 Women*
Total population	142,108	60,788	81,320	74.75
Under one year	3,409	1,695	1,714	98.89
1 to 4 years	11,025	5,582	5,443	102.55
5 to 9 years	14,116	6,584	7,532	87.41
10 to 14 years	16,869	7,533	9,336	80.68
10 to 11 years	*6,165*	*2,730*	*3,435*	79.47
12 to 14 years	*10,704*	*4,803*	*5,901*	81.39
15 to 19 years	16,437	6,439	9,998	64.40
20 to 24 years	17,918	6,642	11,276	58.90
20 years	*4,480*	*1,487*	*2,993*	49.68
21 to 24 years	*13,438*	*5,155*	*8,283*	62.23
25 to 29 years	15,613	6,401	9,212	69.48
30 to 34 years	10,038	4,501	5,537	81.28
35 to 39 years	10,369	4,489	5,880	76.34
40 to 44 years	7,135	3,400	3,735	91.03
45 to 49 years	5,418	2,443	2,975	82.11
50 to 54 years	3,759	1,613	2,146	75.16
55 to 59 years	2,565	1,041	1,524	68.30
60 to 64 years	2,316	840	1,476	56.91
65 to 69 years	1,713	561	1,152	48.69
70 to 74 years	1,186	315	871	36.16
75 and over	1,382	310	1,072	28.91
Age unknown	840	399	441	90.47

ANNEX II

Census of Port-au-Prince

24 January 1949

Population by Age and Sex

Age	*Total*	*Men*	*Women*
0	3,409	1,695	1,714
1	2,354	1,192	1,162
2	3,140	1,604	1,536
3	2,937	1,472	1,465
4	2,594	1,314	1,280
5	2,608	1,338	1,270
6	2,724	1,301	1,423
7	3,025	1,397	1,628
8	3,243	1,422	1,821
9	2,516	1,126	1,390
10	3,738	1,659	2,079
11	2,427	1,071	1,356
12	4,152	1,859	2,293
13	3,219	1,441	1,778
14	3,333	1,503	1,830
15	3,253	1,369	1,884
16	2,976	1,264	1,712
17	2,935	1,203	1,732
18	4,015	1,429	2,586
19	3,258	1,174	2,084
20	4,480	1,487	2,993
21	2,596	1,047	1,549
22	4,299	1,603	2,696
23	3,494	1,316	2,178
24	3,049	1,189	1,860
25	4,622	1,935	2,687
26	3,160	1,272	1,888
27	2,348	930	1,418
28	3,609	1,429	2,180
29	1,874	835	1,039
30	3,837	1,696	2,141
31	889	427	462
32	2,023	896	1,127
33	1,871	855	1,016
34	1,418	627	791
35	3,312	1,507	1,805
36	1,620	685	935
37	1,514	648	866
38	2,540	1,016	1,524
39	1,383	633	750
40	3,524	1,632	1,892
41	559	289	270
42	1,592	741	851
43	832	428	404
44	628	310	318
45	1,984	883	1,101
46	761	366	395
47	658	313	345
48	1,309	568	741
49	706	313	393
50	1,634	670	964
	129,981	56,379	73,602

ANNEX II

Census of Port-au-Prince

24 January 1949

Population by Age and Sex

Age	*Total*	*Men*	*Women*
51	304	130	174
52	866	379	487
53	446	212	234
54	509	222	287
55	935	379	556
56	463	201	262
57	337	133	204
58	506	187	319
59	324	141	183
60	1,305	447	858
61	144	65	79
62	352	137	215
63	262	95	167
64	253	96	157
65	749	230	519
66	243	87	156
67	216	77	139
68	287	98	189
69	218	69	149
70	709	182	527
71	78	23	55
72	204	53	151
73	101	33	68
74	94	24	70
75	308	78	230
76	95	23	72
77	67	25	42
78	102	23	79
79	59	17	42
80	221	40	181
81	43	14	29
82	59	10	49
83	39	9	30
84	45	8	37
85	91	13	78
86	21	3	18
87	26	7	19
88	23	2	21
89	38	7	31
90	73	16	57
91	4	1	3
92	12		12
93	5		5
94	6	3	3
95	13	2	11
96	6	2	4
97	2	1	1
98	9	1	8
99	4		4
100	11	5	6
Age unknown	840	399	441
	12,127	4,409	7,718

Total: 142,108 persons.

The Integrated Development of River Basins

The Experience of the Tennessee Valley Authority

Monday Morning, 5 September 1949

Chairman:

H. L. KEENLEYSIDE, Deputy Minister, Department of Mines and Resources, Ottawa, Canada

Contributed Papers:

The Experience of the Tennessee Valley Authority in the Comprehensive Development of a River Basin

Gordon R. CLAPP, Chairman of the Board, Tennessee Valley Authority, Knoxville, Tennessee, U. S. A.

The Decatur Story

Barrett SHELTON, Editor and Publisher, The Decatur *Daily*, Decatur, Alabama, U. S. A.

The Impact of TVA upon the Tennessee Valley Region

William E. COLE, Head, Department of Sociology, University of Tennessee, U. S. A.

Discussion:

Messrs. TUNSTELL, GOLDSCHMIDT, VAN TASSEL, ZUCKERMAN, ERSELCUK, A. CLARK, RANGHEL

Programme Director:

Carter GOODRICH

Programme Officer:

ALFRED J. VAN TASSEL

The CHAIRMAN: I declare open the fifteenth plenary meeting of the United Nations Scientific Conference on the Conservation and Utilization of Resources.

I think perhaps it would be appropriate to say first a word of congratulation to ourselves on the number of the members of the Conference that have been able to appear this morning. I was afraid that the British institution of the long weekend had made such inroads in this country that we might have found that it, combined with the fact that this is Labor Day, had resulted in a small attendance. However, I am glad to see that we have, if anything, more than usual. This is obviously a tribute to the interest of the subject and to the competence and distinction of the speakers.

This morning we are going to hear the story of one of the great economic and social experiments of our time. The fact that many of us already know a good deal about the Tennessee Valley development does not detract, but rather increases, our continuing interest in it.

Conceived in something approaching desperation, authorized as a result of political courage and imagination of the highest order, executed by the people of the Valley itself under the guidance of engineers and technicians and social scientists of unusual competence and conscience, guided from the beginning by an administration that was able to combine sound executive practices with adherence to democratic practices, the Tennessee Valley project is today a steadily increasing proof that political, social and scientific techniques can be successfully integrated for the permanent advantage of depressed humanity and the benefit of the nation.

I am sure that I shall have the approval of everyone here if I say that any discussion of the work that has been done in the Tennessee Valley should involve a reference to the man who, in my opinion at least, above all others, made these developments possible. The late Senator George W. Norris, by his courage, tenacity, intelligence and integrity, provided the framework of legislative approval and popular support without which the TVA could not have been established. He was a great and good man, and generations of Americans yet unborn will rise to call him blessed.

In the circumstances in which we are met today it is quite obvious that the Chairman has a simple and clear task. It is to open the meeting, to present the speakers in their proper sequence, to provide an opportunity for pertinent discussion and, when the time comes, to bring the meeting to a close. Difficult as adherence to this self-denying regimen may be for the Chairman of the day, I shall do my best to confine myself to it.

As you will have seen from the programme, our first speaker is a man who is eminently qualified to address us on the work of the Tennessee Valley Authority, Gordon R. Clapp. Mr. Clapp, who is the Chairman of the Board, is the fourth man to occupy that position. I think, perhaps, that it might be reasonable to refer to his three predecessors, because they were all men of distinction who contributed greatly to the work that he is now carrying on. The first, as you may remember, was Dr. Arthur Morgan; the second was Dr. H. A. Morgan; the third was David Lilienthal; and the fourth is our first speaker this morning.

Mr. Clapp came from university administration to the Tennessee Valley Authority and rose through the organization that has been set up under that Authority from one position to another, each of them representing an increase in responsibility and authority. Beginning as Director of Personnel, he then became General Manager, and now he is Chairman of the Board. I think I may say that this case is not an instance in which a man is made Chairman of the Board to get him out of the way so that someone else can act as General Manager.

As Chairman of the Board Mr. Clapp is in the most responsible position that is to be found in connexion with the whole organization, because it is the Board of three members which sets the policy under which the whole work of the TVA is carried out.

Before asking Mr. Clapp to address the Conference I think it would be appropriate to refer also to the fact that he is shortly being given leave of absence for three or four months to go to the Near East and to use some of the experience that he has gained here in an effort to advise on the solution of the problems that have developed there as the result of the great number of Arab refugees who have been displaced following the disturbances that have taken place in that part of the world. In Lebanon, Transjordan, Iraq, Syria and other countries in the Near East that problem is a very serious one, and it is hoped that Mr. Clapp, with his wisdom and experience, may find there an opportunity to provide a solution for the difficulties that have so far baffled all those who have attempted to solve them.

I think that that is all that needs to be said by way of introduction to the meeting and to the first speaker, except to add that I feel that it would be best to run the three speeches together without interruption, and to confine the submission of questions or additional statements from members of the Conference to the period following the third speech.

I call now upon Mr. Clapp.

Mr. CLAPP *delivered the following paper:*

The Experience of the Tennessee Valley Authority in the Comprehensive Development of a River Basin

GORDON R. CLAPP

ABSTRACT

The goal of TVA, a federal regional agency created in 1933, is the full development of the Tennessee Valley area. The individual functions assigned to TVA are not new to the federal government, but these functions are integrated in a single agency in a manner that represents a new approach to resource development. The inter-relationship of natural resources is matched by an administrative organization authorized to consider a river system as a whole, to develop it to control floods, to create a year-round navigation channel, to produce electricity, to conduct fertilizer experiments and demonstrations, and to integrate these activities under a broad responsibility to develop or assist in the development of all the resources of the region.

The methods of TVA are educational—not coercive. TVA relies in large part upon the cooperation of established local agencies of government. In terms of results, the integrated operations and developments have proven effective and more economical than if they had been undertaken separately.

The lessons of TVA's experience are public property the world over. As a region husbands and uses its natural resources more wisely and more efficiently, the benefits to men, women, and children run far beyond the confines of the region itself, even beyond the nation. Economic developments built from a better organization of natural and human resources by methods which emphasize decentralization of decision and action and local initiative increase human freedom.

I. INTRODUCTION

It is a privilege to report, on behalf of the TVA, the experience of the Tennessee Valley Authority to the delegates of this United Nations Conference.

This Conference dramatizes the world's renewed interest in the more efficient management of its natural resources, of energy in all its forms and manifestations. To this end the task of the TVA is to continue its study, interpretation, work and action in the Tennessee Valley for the advancement of that region. We believe that as the Tennessee Valley uses its natural resources more efficiently and by methods deliberately designed to increase the free choice of citizens having greater knowledge of the alternatives available to them, the benefits to mankind will run far beyond the Valley, far beyond the United States.

The time may come when the value of the TVA as a helpful demonstration, inspiring emulation in other river valleys of the world, will be regarded as its most important contribution to human welfare. But you will understand why that objective has not been the guiding purpose of those who established the TVA or who have had a part in its work. The goal of the TVA has been and continues to be the full development of the resources and opportunities of the Tennessee Valley. But the lessons of TVA's experience are public property the world over. There can be no effective tariffs or embargoes on the ideas, the engineering principles it illustrates, or the democratic methods it has developed and applied in everyday practice.

II. THE TWO MAJOR PROBLEMS OF THE TENNESSEE VALLEY

The TVA was expected to help the people of the Tennessee Valley bring about the full development of their natural resources for the general welfare of the region and to promote the national interest. This was to be done by correcting two fundamental errors which pervaded the physical setting, depressed the economic life of the region, and restricted the freedom of the people.

For more than a century the Tennessee River had been identified as a stream of great undeveloped and wasted power, a potential inland waterway, a destroyer of life and property as it ran in flood year after year. American capital, private and public, passed it by and chose instead to invest in other regions.

Those who urged the enactment of the TVA Act apparently believed that if the Tennessee River were conquered and its water power harnessed, the river would help transform the economic life of the region. This belief, this judgment called for investment too large and promised returns too long delayed to attract private capital; it required public funds and a faith in the human and economic values a transformed Valley would produce. Nothing less than the resources of the United States Government could reform the idleness and tame the destructive force of the river.

The second error which plagued the region was closely related to, if not part and parcel of, the wasted river. The Tennessee Valley has more rainfall than any other region in the country except the Pacific Northwest. Because of its temperate climate it has a longer growing season than most other large areas of the country. It has abundant rainfall and a growing season in more effective combination than any other region of comparable size in the country, without exception. But these priceless natural assets of moderate sunshine and abundant rain have been used too little. Sunshine, soil, water and human beings were not working together.

The agriculture of the region emphasized cultivation of row crops, principally corn and cotton. There are many reasons why this was done; one reason was the lack of soil minerals, especially phosphate, required to nourish a grass and animal agriculture. Reliance upon corn and cotton left the land idle and uncovered during what could have been a winter growing season, the period of the heavy rains. Wasted rain and wasted sunshine were serious losses in themselves. In addition, year by year, the fertility of the soil and the soil itself washed away. And the wealth of the soil captured in the corn and cotton was largely exported from the region never to return to the lands of the Valley.

The raw materials which were produced from the land and the forests were exported to other regions to be made into finished products. This arrangement brought small return to the people of the Valley. In 1933 the per capita income in the Tennessee Valley was only 40 per cent of the national average. The wealth that comes from human skills and machine production contributed to the income of other regions where the raw materials of the Valley were processed. Wasted water, wasted soil and sunshine depressed economic opportunity at home. This forced many men and women to migrate from the Tennessee Valley to work in the factories of other regions; thus much of the human resource of the Valley followed the exported raw materials their own kin had produced.

These, in brief, are some of the problems of the Tennessee Valley which led to the creation of the TVA. These problems have a long history. In view of the record of the past sixteen years since the TVA began its work, a record I shall summarize in a moment, one may ask why the TVA was not created sooner. The answer to this question reaches far back into the history of conservation policy, the evolution of engineering theory and practice applied to the resources of water and soil, the economic and political conflicts that centered around the powers of government, and the human tendency of private interests to pre-empt piecemeal values in our rivers and streams.

The TVA, as an engineering project, embraces navigation, flood control, and power. In the early days of this Republic the authority of the Federal Government to spend public funds to make rivers navigable was not recognized by the several states. Exclusive rights or franchises to make navigation improvements and operate boats were granted in some instances by the individual states to private business interests. The United States Supreme Court was called upon to settle this issue and it did so by interpreting the Constitution to grant this power over navigable streams to the United States Government. There followed a long period in which expenditures by the Federal Government for navigation improvements were made without regard to the effect of these improvements on the problems of flood control or the generation of hydroelectric power.

Large-scale expenditures by the Federal Government for the control of floods is a relatively recent development. Floods were long regarded as a matter of local concern exclusively. Experience with flood disasters and the gradual development of engineering methods to control floods eventually brought this responsibility into the hands of the Federal Government.

While these separate parts of our national policy on conservation were evolving, the place of hydroelectric power in public river developments was likewise a subject of great and prolonged controversy. The controversy persists to this day. But as long ago as 1909, a conservation committee appointed by President Theodore Roosevelt stated clearly, and prophetically, the compelling need for comprehensive and unified development of our rivers, including the development of latent water power. And for many years in the western United States power has been a common attribute of irrigation projects built and financed by the United States Government.

During the first World War, spurred by the necessities of national defense, and later in the 1920's the separate courses of public policy relating to federal responsibility and concern for navigation, flood control, and hydroelectric power began to merge. The development of engineering experience and ideas about how to get the greatest values from our streams supplied supporting fact for the farsighted vision of a long line of American pioneers in conservation.

The problems of the Tennessee Valley marked this region as a good place to apply modern engineering theories to a whole river and combine that development with the inseparable problem of conservation on the land.[1]

III. THE WORK AND PURPOSE OF THE TVA

The work of the TVA began in 1933. In May of that year the Congress of the United States enacted, and President Franklin D. Roosevelt signed, the Tennessee Valley Authority Act. This Act created a government corporation which, in the words of the Chairman of the Committee in charge of this legislation in the House of Representatives, was "charged with the duty of constantly studying the whole situation presented by the Tennessee River Valley, and the adjoining territory, with the view of encouraging and guiding in the orderly and balanced development of the diverse and rich resources of that section."

A more precise summary of the far-reaching purpose of the TVA development is found in Section 23 of the TVA Act:

"(to achieve) in said Tennessee drainage basin and adjoining territory . . . (1) the maximum amount of flood control; (2) the maximum development of said Tennessee River for navigation purposes; (3) the maximum generation of electric power consistent with flood control and navigation; (4) the proper use of marginal lands; (5) the proper method of reforestation of all lands in said drainage basin suitable for reforestation; and (6) the economic and social well-being of the people living in said river basin."

During the past sixteen years the Tennessee River has been stabilized by a system of dams to control floods, maintain navigation, and produce electricity. And on the land the people have been developing new farming systems which capitalize on this region's great asset—the partnership of sun and soil and heavy rainfall.

TVA and the river: The Tennessee River has its principal headwaters in the Appalachian Mountains of Virginia and North Carolina. It is the fourth largest river system in the United States. The main river forms at Knoxville, Tennessee, where two of its major tributaries join. Its course goes southeast through east Tennessee into the northern part of Alabama. Here it turns north and west, crosses that state and swings north through western Tennessee and Kentucky. Some

[1]For a brief but authoritative analysis of the evolution of law, engineering, and national policy in conservation of water resources, see *The Role of the Federal Government in the Conservation and Utilization of Water Resources,* by James Lawrence Fly, one time General Counsel for the TVA. An address before the American Bar Association, 1937. Reprinted in Pennsylvania Law Review, vol. 86 (January, 1938) 274-294.

630 miles from Knoxville it joins the Ohio River to flow on into the Mississippi River at Cairo, Illinois. The watershed of the Tennessee River is about 40,000 square miles. The states of Virginia, North Carolina, Georgia, Tennessee, Alabama, Mississippi, and Kentucky contribute to its waters and are in turn affected by its flow. This is the river that once wasted its great power in destruction of land, property, and human life. Today the Tennessee River is the most completely controlled major river system in the United States.

Since 1933 TVA has constructed 17 major dams and with 10 previously existing dams has integrated them into a single system (including some purchased from a private utility company and some owned by a private corporation but operated under TVA direction by agreement).

The present system of 27 dams and reservoirs provides nearly 11½ million acre-feet of storage for flood control at the beginning of the flood season each year. In the thirteen years since TVA's first constructed dam was placed in operation, the reservoir system has prevented approximately $42 million in flood damage at one city alone (Chattanooga, Tennessee). On the lower Ohio and Mississippi Rivers, the TVA system can reduce flood crests by 2½ to 3 feet, depending on the origin of the flood. This provides protection in those basins to 6 million acres of rich bottomland outside the Tennessee Valley and will lessen the frequency of flooding on another 4 million acres.

A 630-mile navigation channel has been created on which new traffic records are being set regularly. In 1948, the new channel carried more than 420 million ton-miles of freight. This was an increase of more than ten-fold compared with river traffic before TVA began to improve the river. Formerly, the major traffic consisted of sand and gravel dredged from the river bed and hauled short distances, and of forest products moved by barge, chiefly in the lower sections of the river. Now the modernized river, a chain-of-lakes joined together by single lift locks, carries products of higher value, such as coal, oil, grain, and steel, and for longer distances—frequently between the Valley and the Middle West. In addition to the substantial annual savings in transportation costs afforded by the new waterway, it proved itself to be a valuable asset in supplementing railroad facilities during the last war.

The same dams which control flood waters and provide a channel for navigation also produce hydroelectricity. The TVA electric power system now generates ten times as much electricity as the area produced in 1933—almost 16 billion kilowatt-hours of energy annually for a million consumers over a territory of 80,000 square miles.

Industries now use the power of the river anywhere within reach of a network of some 7,000 miles of high voltage transmission lines. In 1933, less than 3 per cent of the farms of the region had electricity; today more than 66 per cent are served through 144 municipal and rural electric systems publicly owned and supplied with power by the TVA. Under a system of low retail rates, individual use has increased far beyond the national average. Last year the average annual use by a residential consumer in the United States was 1,625 kwh. (kilowatt-hours); in the TVA area it was 2,725. The average rate or tariff for residential use in the United States in the same period was 2.98 cents per kwh.; in the TVA area it was 1.54 cents. The ever-expanding market for power under the stimulus of low rates and the developing economy of the region continue to require the installation of more and more hydroelectric and steam-electric generating plants in order to keep up with the growth of the region.

Thus the Tennessee is the first large river system to be completely controlled by multiple-purpose dams and reservoirs. The development was a pioneering project designed to provide more economical flood control, more economical navigation, and more economical power than could have been obtained by single-purpose developments. The investment in the river was expected to stimulate and strengthen the whole region in the mobilization and better use of its resources.

What is the result thus far?

The integrated development of the Tennessee River and its tributaries has provided cheaper flood control and more economical navigation facilities than could have been achieved by single-purpose developments. In addition, the electricity sold from the same system of dams brings the Government a return averaging more than 4 per cent annually on its investment in power facilities. Those who wish to examine the facts behind this statement may wish to refer to TVA's Annual Reports and Financial Statements. Because the power system of the TVA, the largest integrated system in the world, is an important source of revenue and earnings, a brief summary of the scope and financial results of that operation may be of interest here.

In the fiscal year 1949, the TVA power system provided net operating revenues of $21,479,999 (after depreciation, and payments in lieu of taxes to state and local governments). This amount represents a return of 5 per cent on the net average investment in power facilities. Liquidation of the power investment is assured through conservative depreciation charges included in the wholesale rates received by TVA from municipalities, rural electric cooperatives, neighboring utilities and all others to whom TVA power is sold. The return on the investment, after depreciation, certifies a financial performance well beyond the original objective of a self-liquidating power system prescribed in the TVA Act.

At the end of the fiscal year, the total fixed assets of the power program amounted to about $510,400,000 and the net investment, after depreciation, was $431,400,000. Of the total investment in plant in service, reinvested earnings represented about 25 per cent. Total earnings equal 30 per cent of the net investment in power facilities. The total investment in power facilities represents about 60 per cent of the original cost ($781 million) of the TVA multiple-purpose system devoted to navigation, flood control, and power.

Over the period 1933 through 1949, the TVA power operations have provided revenues of about $368 million. Of this amount, $156 million was paid out for operating expenses—primarily for wages, coal, and maintenance materials—and for payments in lieu of taxes to states and counties, and for payment of interest on the TVA bonds owned by the Federal Government.

The remaining $212 million—$130 million in net income; plus $82 million provisions for depreciation—represents the amount which consumers of TVA power have supplied, in addition to paying out-of-pocket operating costs, toward building the TVA power system, providing other miscellaneous assets, and repaying the United States Treasury.[2]

But the fiscal significance of TVA electricity is not entirely revealed by these figures. Electricity in greater abundance on the farms and in the homes and factories of the Tennessee Valley has helped to spark a great economic change. Per capita income in the Tennessee Valley, as one index of that change, is now 60 per cent of the national average compared with 40 per cent in 1933. Higher incomes in the Tennessee Valley have contributed to the economic life of the nation. For example, that part of the nation's total of individual federal income taxes which comes from the seven Valley states has steadily increased. The cumulative increase from 1933 to 1947 has amounted to $2 billion additional revenues to the Federal Government.

In 1933, individual income taxes from the seven states were 3.4 per cent of the total of such taxes in the nation. In 1947, they were 6.3 per cent of the total. Thus the states of which the Tennessee Valley region is a part are sharing more of the common burden of the costs of government.

Rising incomes have increased the purchasing power of the Valley people for goods made all over the country. Retail sales in the Valley, for example, increased from $272 million in 1933 to $1,405 million in 1946, an increase one-third greater than that in the entire United States.

The development of electric power in the Valley, which has multiplied four times the number of residential power consumers in the region and more than quadrupled the average use of electricity per customer, has provided an increasing market for electric appliances. In the 1949 fiscal year, consumers bought about $100 million worth of electric ranges, refrigerators, washing machines, water heaters, and other electric appliances. Most of these products are manufactured in the North and East. The average consumer invested $2 in electrical equipment for every dollar he paid for electricity during the year.

We estimate that in the past year the 144 municipal and cooperative systems which distribute TVA power invested about $50 million of their own funds during the fiscal year to expand and improve service. Much of this sum was expended for equipment manufactured outside the Valley region.

TVA funds, from appropriations and power system earnings over the past 15 years, have contributed to employment and income in every state in the Union. Of $279 million used by TVA to purchase manufactured articles, ranging from generating units to nuts and bolts, $334 million was paid outside the 80,000 square mile area comprising the Valley and the power service area.

The development of the Tennessee River, in addition to the main objective of flood control, navigation, and power, opened the way to vast recreation opportunities which the people of the region are seizing upon to their pleasure and profit. By the end of last year, the people of the region had expended more than $16 million for recreation facilities, equipment, and services on the 10 thousand miles of shoreline of the TVA reservoirs.

During the calendar year 1948 alone, TVA dams received over 5 million visitors who came from all of the 48 states in the Union and many foreign countries. Recreational use of the TVA lakes has become an important part of the other attractions in the region—mountains, national and state parks, historic sites, and scenic resources. The Valley now enjoys a recreation-travel business estimated at $175 million per year—an industry second only to its manufactures and agriculture in gross dollar volume.

More, much more, could be reported to describe the benefits and underscore the financial feasibility of the Government's creative investment in the Tennessee Valley. But it is enough to say that the Tennessee River is no longer a constant menace to the land and people of the Valley; it is an asset—a tool useful to the people. It is a source of energy to raise productivity and increase its variety—all for a higher standard of living made possible in part by an inexhaustible resource, the water power of the river that once ran to waste. Thus one of the costly errors in the organization of the region's resources is about corrected.

The TVA and the people on the land: The fundamental error in the use of the region's soils, its abundant rainfall, and life-giving sunshine is also slowly being corrected in a far-reaching program of education and experiment. In this part of the story of the Tennessee Valley, I must go back again into one of the historic events which led to the creation of the TVA.

During World War I a nitrate munitions plant was built at Muscle Shoals, Alabama, and construction of Wilson Dam was begun. This dam was to produce power and with its lock was to make navigation possible over the historic Muscle Shoals in the Tennessee River. The nitrate plants were not used during the war, and Wilson Dam was not completed until several years later. This national investment on the Tennessee River remained idle except as its existence stimulated extended controversy about the use and future development of the Tennessee River. Even before 1933 the Congress twice decided to establish a TVA over the protests of private interests which offered to buy these idle facilities. Presidential vetoes temporarily blocked the actions of the Congress. In 1933, when the TVA was established, Wilson Dam and the Muscle Shoals chemical plants formed the nucleus of the TVA program.

The TVA chemical plants at Muscle Shoals have been modernized. They contributed heavily to the requirements of the United States and its allies for munitions and other war needs during the recent war. These plants are now used, as they were before the war, to develop and produce new and improved fertilizers, mainly high-analysis phosphates and nitrates. About half a million tons of these new products of research

[2]Of this $212 million in cash, $172 million has been reinvested in the power program in accordance with section 26 of the TVA Act. This $172 million provided power facilities or other power assets which otherwise would have required funds appropriated by the Congress.

About $14 million was paid into the Treasury, directly or through the Reconstruction Finance Corporation, to retire bonds. The remaining $26 million has been paid into the United States Treasury under section 26 of the TVA Act and has been regarded by Congress, and recorded on TVA books, as an offset against appropriations previously invested in the power system.

and experimental manufacturing have been distributed to practical farmers for use in test-demonstrations throughout a large part of the Nation. A million tons of TVA fertilizer materials have been sold through farmer cooperatives at commercial prices. In addition, almost a quarter-million tons have been exported to foreign countries—under lend-lease and other arrangements—to bolster food production during and immediately after the war.

The fertilizer materials produced by TVA, made possible in part by the availability of large blocks of low-cost electric power from TVA dams, are significant for two reasons. (1) The processes by which they are produced are adding new knowledge to the technology of the fertilizer industry and pointing the way to more efficient, more highly concentrated products that cost less to transport and apply to the land. (2) The tests and demonstrations of the use of these new products on thousands of practical farms are helping farmers to build a more fertile soil under improved systems of farm management.

More than 65 thousand farmers have participated in this program over the past 16 years. Their practical experience with these new mineral fertilizers, emphasizing the use of phosphates in programs of soil improvement, is showing the way to better farm practices, greater diversification, and more soil- and water-holding cover crops. Row crops of corn, cotton, and tobacco, which leave the soil unprotected against erosion, are coming down off the slopes to the flatter lands and being replaced by pastures or close growing cover crops. More grain, more grass, and improved pastures have fostered a growing livestock agriculture that is bringing new wealth and health to whole communities.

In the 10 years ending in 1944, cover crops replaced row crops on a million acres—about one-twelfth of the Valley's agricultural land. A million acres of land were terraced. Pasture increased by 700,000 acres. There was a nine per cent increase in the number of livestock, and although the number of dairy cattle remained about the same, milk production went up 22 per cent.

At the same time, progress has been made in improving the water-holding capacity of the 14 million acres of forests and woodlands which cover more than half the Tennessee Valley area. Protection against forest fires has been extended to 7½ million acres since 1933 through the efforts of TVA, state forestry agencies, the United States Forest Service, and local groups working together. Some 140 thousand acres have been reforested, and another 60 thousand acres treated for erosion control by terracing and other engineering techniques. Over 173 million tree seedlings have been provided from TVA forest nurseries for planting on eroded and abandoned lands. Modern forestry management has been promoted by persuading private landowners to set up practical demonstrations on some 200 thousand acres, including both large commercial forest holdings and farm woodlands.

As electricity and machines have moved into the rural areas, as grass, pastures and livestock have substituted more of the sun's energies for human backbreaking toil, the land has released a new surplus of human energy. Thousands of people within the Valley have found new employment opportunities in the towns and cities. More than 2,100 manufacturing enterprises began operations in the Tennessee Valley and the TVA power service area between 1933 and 1946. These new enterprises were additions to the productive resources of the region and the Nation. Very few of these industries moved from other areas of the country to the Tennessee Valley. The rate of increase in manufacturing in the Tennessee Valley was greater than that for the seven Valley states as a whole and considerably greater than the rate of increase for the Nation.

These new private developments provided about 290,000 new jobs. This is an increase of 123 per cent in the Tennessee Valley, compared with 73 per cent in the Nation. When related to manufacturing alone, the number of jobs increased 140 per cent, compared with 98 per cent for the Nation.

More than two-thirds of these new industries process native raw materials. These new plants are widely distributed throughout the region: one-third located in cities of more than 100,000; less than one-third grew up in communities between 5,000 and 100,000; more than one-third are in towns of less than 5,000 people.

This, in brief, is the summary of physical and economic changes in the Tennessee Valley since the TVA began its work. The task of full development of the region is not finished; it is only well begun.

IV. THE TVA AS A METHOD OF INTEGRATION AND DECENTRALIZATION

The role of the TVA in Tennessee Valley development is two-fold. It has undertaken and carried out the program of physical construction and operation to put the river to work—a task of the Federal Government too great and too broad in scope to be accomplished by private organizations or by state or local agencies of government. In addition, it has provided the unifying influence, the sense of cohesion and direction essential to a comprehensive program for conservation and development of all natural resources in a region. By stimulating the interest of state and local agencies close to the people it has opened new avenues for joint action—strengthening rather than weakening state and local initiative. A brief description of TVA as an organization and its methods of work will make this clear.

In form, TVA is a Government corporation endowed with some of the flexibility of a private corporation. It is headed by a board of three directors appointed by the President and confirmed by the United States Senate. A general manager, appointed by the board, heads up the staff of the TVA, comprising civil engineers, biologists, chemical engineers, experts in public health, forestry, agriculture, etc. The individual functions assigned to the TVA are not new, but the TVA represents the first attempt in this country to integrate a concern for land, water and people into a single agency located in the region where the problems are.

The TVA is dependent upon Congress for annual appropriations required to finance activities of public benefit; these are traditional functions of the Federal Government but they do not produce revenues for the TVA. Among these non-revenue-producing activities are flood control, navigation and research, experiments and demonstrations helpful to soil fertility conservation, industrial and economic development and the fuller use of the resources of the Valley carried on in cooperation with more than a hundred state and local agencies.

As the sole source of electricity for an entire region and to assure the taxpayers a fair return on their investment the TVA is authorized by law to use its receipts from the sale of power in the conduct of its power business. This wise provision, customary in business and corporate practice, helps to make it possible for the TVA to satisfy the requirements of its contracts to supply electricity for the expanding needs of the area and to serve new loads and new customers promptly.

The TVA is fully accountable to the Congress and to the President for what it does and the way it performs its work. This accountability is achieved by full and complete audits of its financial records; by hearings each year before the Bureau of the Budget acting for the President and by hearings before the Appropriations Committees of Congress; by review and examination of all of its activities before Congressional committees and by periodic reports to Congress, the President and the public. The TVA is subject to an even more penetrating scrutiny and accountability through its day-by-day life with the people and the agencies of the state and local governments in the Valley.

The full development of a region for the benefit of human living depends as much upon the administrative or managerial resources of the region as it does upon the physical resources. The creation of the TVA established a new administrative resource in the Tennessee Valley. Our job in this respect is to see to it that the facts about the wise use of our resources of water, soil, minerals, and the factors of climate are discovered and made available to become a part of the everyday voluntary decisions of people.

Natural resources do not conform to man-made boundaries. The watershed of the Tennessee River, for example, includes parts of seven states. TVA has found the Tennessee River, and its watershed, a good developmental unit with many common problems and opportunities. The fact that much of the developmental action must come from the separate state governments or institutions in several states has not proved an insurmountable obstacle; on the contrary this circumstance is a fortunate guarantee of joint planning and consultation.

The TVA uses the specializations of experts to analyze each part of the physical environment; it uses administration placed in the midst of a river valley to translate the ideas of experts into language and operating plans which citizens and laymen can understand and appraise, accept, modify or reject. Let me explain this method by a few examples.

The operation of a water control system is a complicated assignment. A great many considerations enter into the daily, weekly and monthly decisions on the storage and release of water. The requirements of navigation may sometimes call for special water releases on short notice. Shoreline farmers, recreation interests, fish and wildlife experts, and malaria control people, all have a special concern in how water is regulated in the reservoirs. Sometimes the various uses of water and the management of reservoir levels for one objective or another seem at cross purposes; more often, the conflicts may be found upon exploration to be more apparent than real.

The TVA, charged as it is with the operation of the system as a unit, has to resolve these conflicts in the most efficient and prudent manner. It cannot escape responsibility by referring the conflict to some other agency because no other agency shares control of the river's flow; on the other hand, having a staff of experts familiar with each special phase of the problem, the TVA is equipped to make judgments on the basis of all the factors involved.

A similar problem of drawing unity from conflict arises in planning the dams. The genius of specialization lies in the precision with which a special part of a problem may be analyzed. But specialized analyses, if they are to be understood and reflected in beneficial action, must be related to the logic and workability of schemes in broad context.

The world of resources exists for people to live and grow in—not as pieces for experts and special groups to split up among themselves. A river system and the climate and terrain which give it being is a case in point. It is not difficult to imagine the confusion which would follow if one set of engineers attempted to develop a river for navigation, another set for power and a third for flood control. There would be endless competition for favorable dam sites, perpetual bickering over the storage and release of water, etc. But when one set of engineers, united under a single management, is charged with developing the river for all three purposes, plus a concern for every possible auxiliary benefit, the problem is already half solved. Management can bring the flood control engineer, the navigation expert, the power engineer and other specialists together to pool their particular talents and knowledge. By this process a system can be devised to do justice to each purpose within the limits set by the engineering facts and established public policies.

The impoundment of TVA reservoirs—changing a running stream into a series of slack-water lakes—posed a potential health hazard from the possible increase of malaria-bearing mosquitoes in an area where the disease was already common. But here again the application of expert knowledge and study to a problem involving many conflicting interests has resulted in a satisfactory solution. TVA's program of malaria control utilizes a number of methods based on combinations of biological, medical and engineering principles, including water-level fluctuation, "building out" mosquito breeding places through a process of diking and dewatering, control of vegetation along reservoir margins and the use of larvicides.

Both the incidence of malaria and the unit cost of controlling it have declined on TVA reservoirs. In 1934, before the program began, tests on individuals living along one section of the Tennessee River showed that more than a fourth had malaria, and in some communities as many as two-thirds were afflicted. In 1947 another check of more than 6,000 residents in malaria areas along TVA reservoirs showed just three cases—an incident of only five one-hundredths of one per cent.

The multi-purpose dams on the streams of the Tennessee River system and the programs of soil and forest conservation on the lands of the Tennessee Valley region provide dramatic proof of the interrelation between different aspects of resource utilization. Moreover, the experience of TVA's integrated approach to regional development demonstrates that valuable by-products can be secured if planning and labor are harmoniously joined together with the forces of nature.

In carrying out this responsibility in the Tennessee Valley the TVA has none of the powers of a unit of government except one—it can buy land by resort to judicial decision of the courts, land required in the construction and operation of its physical facilities. This power is also possessed by private utilities under our laws. The TVA has no powers of direction or supervision over states, counties, municipalities or private citizens—and it does not covet such power.

TVA constantly searches out opportunities to encourage and stimulate local leadership working for a greater economic development in and around the local community. Later today you will hear a report from a leader of one of the many growing communities in the Tennessee Valley, Mr. Barrett Shelton of Decatur, Alabama. He is an outstanding, enterprising private citizen, a newspaper publisher and a free man. I hope the TVA has stimulated him. I know he has stimulated the TVA. In that report you may learn more about TVA's methods than I could possibly tell you.

As each community moves ahead and builds a stronger economic base beneath its agriculture, its local commerce and industry, the cumulative effect will achieve success for the whole region. A stronger region adds to the strength and the priceless diversity of the whole Nation.

We view the full development of the Tennessee Valley as something more than mobilization of economic assets for the achievement of greater material rewards. The Tennessee Valley's greatest asset is its people, people who generally prefer to live there because they like its hills and valleys, its mountains and forests, its prevailing sense of community and the depth of the region's cultural roots and traditions. Characterize this as sentiment and you miss the point. Because when men and women can find productive and satisfying work and exercise their initiative freely where they *prefer* to live, the results reach far beyond the dollar value of their labor. Under these circumstances people gain a new birth of freedom and the world gains new wealth in goods, ideas and human self-respect.

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The CHAIRMAN: I wish to thank Mr. Clapp very much for his interesting and most authoritative statement. I am sure that we could have found no one else to give us such a complete and clear picture of the administrative achievements of the Valley Authority and of the Valley people. We appreciate very much his presence here today and the most valuable contribution that he has made to our discussion.

We are now to hear from a gentleman who has experienced in himself and in his private life the effect of the work that has been done by the TVA. Mr. Barrett Shelton, a graduate of the Washington and Lee University, has been for over twenty years the publisher of the *Decatur Daily* in Dacatur, Alabama, in the centre of the area in which the TVA operates. In addition to that, however, he has been a leader in public affairs in both his local community and in the state in which he resides. However, he is even more interesting from our point of view for another reason: he is a convert to the TVA idea. As you will hear from him in a few moments, he is a sinner come to repentence. I hope that we shall hear from him the story of how this conversion took place and of the good life that he has been living since.

Mr. SHELTON *delivered the following paper:*

The Decatur Story

BARRETT SHELTON

ABSTRACT

This is the story of Decatur, Alabama, a town of some 25,000 on the banks of the Tennessee River in the heart of the Tennessee Valley. It is the story of a town that was flat on its back in 1933, the year TVA was created. Decatur had one big industry, a railroad shop; it closed. Decatur's farmers grew one crop, cotton; it bled the soil and brought in only 5 cents a pound that year. Decatur's people were broke, disheartened, and all but finished.

TVA came on the scene, but the people of Decatur at first were resentful. They wanted no government agency to tell them how to run their business. But TVA did not tell them how to run their business. It simply made opportunities available, and the people of Decatur, overcoming their early suspicions, took advantage of the opportunities. TVA made the Tennessee River navigable, a low-cost artery of commerce at their front door. TVA brought cheap electricity, way below half the cost of former years. TVA and cooperating agencies all but wiped out malaria, formerly a millstone that sapped all energy. TVA and the state agricultural college preached and demonstrated diversified farming—grain, hay, cattle and swine; not just cotton.

These were the tools TVA gave the town of Decatur, as it gave them to other towns of the Valley. This is the story of how Decatur used those tools to lift itself up by its own bootstraps, to rise from the slough of despondency to the bright crests of hope, prosperity and, above all, enthusiasm for life itself.

Ladies and Gentlemen of the United Nations Conference:

I am privileged to tell you the story of Decatur, Alabama, a town that has come from "nothin' to somethin' " in fifteen years of a working partnership between the Tennessee Valley Authority and the people of my town.

It has happened to us, it can happen to you, if you have the courage, the intelligent determination and make the most of your opportunities. For TVA is not a magic wand. TVA would be helpless to activate community progress without the brains and the energies of a free people.

In the beginning I opposed TVA. I didn't know what it intended. I knew I wanted no government control of my life, nor over the lives of my people.

Throughout much of our lives the progressive citizens of Decatur had tried to better conditions. And it appeared that no matter in what direction they turned, the result was far from producing lasting good.

Then 1933. Economic depression settled down on the United States, more pronounced if possible in the Tennessee Valley and in Decatur.

The one major industry we had, which had kept 2,000 men at work, closed. This railroad shop gave way to the truck and the bus and economic conditions. Decatur lost this industry completely. Another industry, which in earlier years we had brought from New England with considerable subsidy in money, went bankrupt. A third industry, manufacturer of full-fashioned hosiery, went to the wall from poor management and bad times. Seven of eight banks in our County closed.

Our farm situation. We had only one crop in the Decatur area—cotton—and cotton was five cents a pound. Lands were selling for taxes, the people were ill-housed, ill-clothed and out of hope.

So you can see that we were not interested in saving a dollar or so on our power bill. That would solve little or nothing. We needed jobs and opportunities for our people.

Into this dismal, perplexed economic setting one late midwinter afternoon came David Lilienthal, then a member of the board of directors of the Tennessee Valley Authority. Four of our citizens who had long been hopeful of improving conditions generally met him in conference. We were almost frankly hostile, for he represented to us another way of thought and another way of life. And our conversation might be summarized in this fashion, "All right, you're here, you were not invited, but you're here. You are in command, now what are you going to do?"

Dave leaned his chair back against the wall and the twinkle of a smile came into his eyes, as he said gently and firmly, "I'm not going to do anything. You're going to do it."

He went on to tell us something we never knew before. He went on to say that TVA would provide the tools of opportunity—flood control, malaria control, navigation on the river, low-cost power, test-demonstration farming to show how our soils could be returned to fertility, a fertility lost through land erosion, another wayward child of a one-crop system. He told us the river would no longer defeat man, but would become the servant of man. "What you do with these tools," he said, "is up to you."

Dave Lilienthal had passed the task right back to us, right back to local control. He let us know that simple economics could be applied in the Tennessee Valley and that the faith, determination and sweat of the people would bring about the result we had eagerly sought for so many years.

Later, Dr. Harcourt Morgan, another member of the TVA board of directors, came to us and talked to us about lime and phosphate and legumes, and the relationship of people and land. He did not speak of great industry. Rather did he speak of the need for farm markets and farm processing plants and of increasing the value of our farm products through manufacturing processes. He opposed the tearing down of other sections of the United States by seeking their industry with subsidy, the promise of cheap electricity and poorly paid labor. He told our people the simple story of making the most of what we had, of developing our own natural resources, of putting to work the little capital that we owned, of growing our own industry based upon the resources of the land.

What was this? Dave Lilienthal and Dr. Harcourt Morgan had promised us nothing beyond the tools which were to come from the waters of the Tennessee River and the land-building and health-building practices which were included in TVA at the direction of a wise Congress when this independent corporation of the Government was created in the nation's darkest economic hour.

We decided then and there that the economic system we had followed had to be improved upon, and to improve it we had to pioneer an entirely new plan of economics.

Our townspeople needed jobs, our farm people needed month-by-month pay rolls, rather than a once-a-year income secured from the harvesting of one crop.

The old order, the old way of doing things had to change, or our people could never have the opportunities to which their efforts entitled them.

First, we had to adopt this new thought given to us by the two members of the TVA board. We had to quit thinking of reaching into other sections of the U. S. and subsidizing industry to come into our section. Second, we had to begin in a small way to build toward a diversified agriculture and a diversified industry. We could never again, if our people were to survive, allow ourselves to be dependent upon a one-industry and a one-crop system.

Our first step was to form our own Chamber of Commerce, formed at a time when most people didn't believe it could be done. There was very little money. So, with considerable struggle, we got together some cash and more pledges amounting to $3,000 for the budget the first year. A man who had lost all he had in the crash of one of the industries we had brought to Decatur with subsidy became the first secretary at a salary of $100 a month.

We then decided we were going to develop a cash market every day in the year for every farm product grown in the Decatur area. We were going to welcome industry, but not wait for it. We were going to develop our own farm processing plants.

We decided a packing plant would be the first venture and persuaded the local ice company to put in packing plant facilities when there wasn't as much as one wagon-load of hogs in our whole county. We are now producing our own livestock to meet the demands of this market.

We then turned to milk, formed a little corporation with paid-in capital of $15,000, telling every stockholder to forget his investment, that he would never receive any return from his money anyway. What we were trying to do was establish a pay roll every two weeks for the farm families of our section. The first day that plant went into operation there was a total supply of 1,800 pounds of milk. Today the production of milk pouring into this one plant peaks at 60,000 pounds and we have just started in this agricultural industry. What happened to the stockholders? Well, they never failed to receive 6 per cent annually on their money and about two months ago that little plant paid stockholders a 100 per cent dividend.

Along about that time we got some help from the outside. Navigation on the Tennessee River made it possible. Here you see is an exciting example of what can happen when a liability is changed into an asset. The Tennessee wasn't navigable before the creation of TVA, there was no opportunity for a successful flour mill operation. Low-cost power didn't attract Nebraska Consolidated Mills Company to establish the Alabama Flour Mills at Decatur. Navigable water did it, plus the possibilities that flour could be produced at a cheaper cost per barrel owing to savings on freight. The impact of this industry on our section was tremendous. Farmers could grow grains because there was now a daily cash market. They could produce corn and wheat, and all the grains with assurance that they would sell their production. They could get cash for products for which previously there had been no market.

Tennessee Valley Fertilizer Cooperative, a fertilizer mixing plant serving ten counties, was established by the people. Later, when we saw the possibility of selling seed commercially, this same organization put up a modern and efficient seed-cleaning plant.

An alfalfa-drying plant has been built, another way of keeping our pledge that markets would be established every day in the year for every product grown in the Decatur area.

These are specific illustrations of the forward-looking change which has taken place in the minds of our people. These industries, land builders and man builders, could never have been pictured in the minds of a defeated people, of a people who in the year before TVA saw an uncontrolled river flood and wash away the best soil, erode the back lands, wash crops, houses and barns down an angry stream.

You can see by now that the opportunities which were at hand in the development of the river and the region were being seized upon by our people with renewed courage and confidence. We now knew that we couldn't be licked again, that what had been preached to us by TVA was the economic truth.

A resident of a nearby town came into Decatur with an idea that he could build a market for poultry. We agreed with him and encouraged him to go forward. Today, that market though no more than three years old in our area is doing a $3 million business.

Today there is a market for cotton, corn, wheat, livestock, milk, timber, small grains, truck crops. Fifteen years ago we were dozing in the sunshine waiting for that once-a-year pay roll brought by cotton and wearing out our second finest resource, the land. Today the cash income from all farm products in the area surrounding Decatur is $43 million. Land building did it. Flood control did it. Navigation did it. Malaria control did it. TVA, with the other state and federal agricultural and health agencies, their teachings activated by an intelligent and determined people, did it.

Let's stop here for an illustration of the value of malaria control. Did you ever have malaria? I have, the majority of my people have. Do you know what you want to do when you have malaria? Nothing. You want to prop your feet on your desk, or if you are not an office man, perhaps you'll take a day or two off from your job in industry or take out of the fields, just to get a rest. Malaria is restful—and nonproductive. Soon after the creation of TVA a nationally known manufacturer of full-fashioned hosiery bought a bankrupt hosiery plant in our community. The new company introduced physical examinations for all employees and found that 35 per cent of all employees had malaria. Ten years later, after the TVA malaria control program had been in action, the figure had dropped below one per cent. Today, because malaria is completely controlled, this hosiery firm does not even require the malaria test in physical examination. And what happened to the people in that plant? Why, they out-produce the employees of three other plants of this same company. That's what defeating malaria has meant just in this one illustration of how government can be helpful to people by making it possible for them to help themselves.

Industrywise, our people have not been sleeping. Here again the pledge has been kept to never again be dependent upon any one major industry, or to seek after big industry alone. By the year 1940, there were 61 firms manufacturing a product in Decatur, Alabama, employing 2,834 people with an annual payroll of $3,159,000. By 1944 the number of industries was 68, employing 6,908 people with an annual pay roll of $12,927,000. In 1948 the number of firms making a product had reached 87 and employment, off from the war peak, was 5,204, but the annual pay roll was $12,605,000, just a quarter of a million short of the pay roll total during the war. You see, through the years we have been putting together the industrial picture in sound fashion. We had sought after diversity of industry rather than bigness.

Keeping soundness ahead of bigness in industry, you will be interested in a partial list of products now processed or manufactured in Decatur. These include: flour, brick, tile, meats, furniture, boxes, baskets, structural and ornamental iron products, tanks, skids, septic and grease traps, poultry processing, felt hats, crude cottonseed and oil, steel ships and barges, dairy products, aluminum fabricating, steel nuts and screws, concrete pipe, copper tubing fabrication, cotton and rayon tire fabric. Once, a short time ago, we were dependent on one industry.

Down through the years we have never hesitated to use the technical opportunities within TVA. In our considerations of types of industry needed in our community, we have gone to TVA repeatedly to ask that the facts concerning such projected industry be assembled. I have said before and I say now that TVA has the most capable personnel with which I have ever come in contact, either in private or public service. No matter what department we sought out for advice on industrial or agricultural matters, we have always received willing and dependable factual assistance. The people in TVA have worked weeks and months on some of our requests, and never once has there been any directive issued to us. They have always told us, "Now here are the facts, the decision on what you do with them is up to you." The decision was our own, this government corporation believes and practices community development at the local level.

Just a moment on the electric picture. Have the benefits of electricity been made widespread? In 1939 there were 3,800 customers in Decatur, in 1949 there are 6,933. In 1938 they burned 12 million kwh. annually, now they burn 120 million kwh. annually. In 1938 the average sales price to the residential customer was 3 cents per kwh. Today it is just above one cent—and our Electric Department made $182,000 net for the year closing June 30, 1949. You ask if the Electric Department pays any taxes. Well, the private company paid $7,500 annually in 1938. The municipal operations pay to the City of Decatur $28,000. Yet we have the second lowest residential rate in the U. S.

What has happened in these fifteen years in the spirit of our people? Are we confident without being over-confident? Do we look toward the future with assurance?

Let me give you three illustrations. Recently, a copper-processing plant decided to build a branch plant in the South. Two hundred seventy-four communities in eleven states were contacted. Do you know where that plant was located, an investment of $12 million? In Decatur, Alabama. Do you know what the difference was between that valued plant locating with us or elsewhere? The difference was in the spirit of the people—our confidence, our friendliness, our genuine interest in working with them on their problem, was the difference.

Or let's look at this figure to prove what's happening in Decatur, Alabama, in this partnership between the people and an independent corporation of the Government. In 1933 there were 7,000 property owners listed on the tax books of our country; today there are 11,000. The assessed valuation has grown from $15 million to $22 million. The population of our town has grown from 12,000 to 24,000, and yet, the most significant change has been in the thinking of our people. We have come from the status of a well-nigh beaten citizenship, merely existing, to a hopeful, exuberant, smilingly confident people, secure in the belief that, given the opportunities afforded through making the forces of nature the servant of man, and with intelligent determination and sound application of the principles of economics, we could rise to heights of good citizenship, limited only by our own imposed limitations.

Decatur today is a community of thirty-five churches, all instruments of a kindly Father above. Who guides and directs our every step, a young City whose people recently taxed themselves to build a new $1,500,000 high school for our boys and girls, where the hand of the future has already shown us the necessity for doubling the capacity of our water system at a cost of $1,100,000, where our electric department is just completing a $400,000 expansion program to be ready for the future, where our people are constantly at work on new plans to perfect a soundly begun economic system so that our people might have opportunities to earn better things of life.

I would like to close with this summary. Senator William Knowland, of California, who came to the Tennessee Valley to see for himself what had been accomplished since the creation of TVA, returned to tell Congress that TVA was the greatest boon to private enterprise he ever saw. Or in the words of Dr. Sen, a visitor in Decatur from the Embassy of India, who viewed TVA as an improvement in an ever-improving democracy, or in my own way of answering visitors who come into our section of the Valley and ask, "Wouldn't this all have happened without a TVA?" And my answer to one and all is, "It didn't!"

The CHAIRMAN: Thank you very much, Mr. Shelton. For reasons which I indicated at the beginning, and which your paper has aptly confirmed, we had reason to expect an interesting, and indeed a fascinating, personal report, and we have not been disappointed. Thank you most sincerely for the story that you told and particularly for the admirable way in which you told it.

We are now to hear from Dr. William E. Cole, the head of the Department of Sociology at the University of Tennessee. Dr. Cole is a graduate of Cornell University, where he received his Ph.D. In addition to his present work in the Department of Sociology at the University, he is the Chairman of the State Public Welfare Commission. As a result, he is in a position to have a peculiar knowledge of the circumstances about which he will speak, and he is equally in a position to give us an authoritative interpretation of the facts with which he is acquainted. It is a great satisfaction and pleasure to introduce to you Dr. William E. Cole.

Mr. COLE *delivered the following paper:*

The Impact of TVA upon the Tennessee Valley Region

WILLIAM E. COLE

ABSTRACT

For reasons inherent in ascribing causes to social change and because many TVA program operations are cooperative with state, local and other federal agencies, it is difficult to measure precisely the impact of a regional agency upon the development of the Tennessee Valley area. The author's appraisal is made against the background of these limitations.

TVA was established as a federal autonomous agency with authority to develop its decisions and policies within the region. This made possible first-hand understanding of regional problems and the development of machinery to deal with these problems on the ground. Much of the success of the various TVA programs has been due to this fact.

Historically, one of the great problems of the Tennessee Valley has been the various imbalances which have plagued it. Unbalanced man-land ratios, poor balances between food crops and population, between people and jobs and imbalances in agricultural production have plagued its economy for a hundred years. Probably the outstanding impact of TVA upon the economy of the region has been its contribution toward the development of an improved regional economy with an improved balance between its various elements. This contribution is evidenced today in the greater use of improved skills in resource development and utilization, in the extensive use and application of electric power, in the development of recreation as a new resource by-product on impounded waters, in a diversified and improved agriculture and in the application of technical skills to the care of forests and the rebuilding of forest resources, with the states and local governments expanding their activities to meet the problems and opportunities of the developmental program.

To the people of the Valley, TVA has come to signify the idea of progressive change toward the improvement and better utilization of resources.

The Tennessee Valley Authority is now sixteen years old. It was created in 1933 as a government corporation designed to develop or assist in the development of the resources of the Tennessee Valley. TVA shares with the social security program and with the atomic energy development the distinction of being the greatest of the enduring activities of the Federal Government having their inception in the administration of our late President, Franklin D. Roosevelt.

It was with a great deal of pleasure that I agreed to describe the impact of TVA upon the Tennessee Valley region. I must, however, recognize that I will not be able completely and satisfactorily to discharge the obligation I have undertaken.

For reasons inherent in social change itself, both in charting change and the assignment of causes to change, it is difficult to appraise the impact of developmental measures upon the people and institutions of an area.[1] To this general difficulty is added the fact that TVA's operations, aside from construction, power development and flood control in the river channel, are largely cooperative with other agencies. In these cooperative program operations, any attempt to gauge the contributions of one agency as against those of another will encounter difficulties. With the limitations in view, I can, however, address myself to the question: what has been the impact of TVA upon the Tennessee Valley, its resources, its people and their institutions?

This is not the place to review the history of the area or to indicate why the region failed for so many years to achieve a satisfactory development of its resources. It is perhaps sufficient to recall that the Valley has been on the defensive for a long time. It is a part of the region which in the 1930's was dubbed "the nation's number one economic problem" and probably rightly so. It was at that time an area where soils were being rapidly depleted; where forest resources had been largely destroyed. The river was not being utilized for navigation; it was subject to periods of disastrous floods; its potential hydroelectric power was undeveloped. Population pressure upon jobs and resources was acute, and *per capita* income was the lowest in the nation. More significant, the people and institutions of the Valley were discouraged. They were well on their way toward getting a regional inferiority complex. In this setting and in a period of general economic depression, TVA was established by the Federal Congress on the recommendation of the President of the United States.

[1]For a comprehensive discussion of this point see: MacIver, R. M., *Social Causation,* Boston: Ginn & Co., 1942.

Several things about the legislation establishing the new agency immediately attracted the attention of the people of the Valley. These unique factors have been well summarized by David E. Lilienthal, formerly Chairman of the TVA Board:

> A federal autonomous agency, with authority to make its decisions in the region.
>
> Responsibility to deal with resources, as a uniform whole, clearly fixed in the regional agency, not divided among several centralized federal agencies.
>
> A policy, fixed by law, that the federal regional agency work cooperatively with and through local and state agencies.[2]

Mr. Lilienthal went on to state:

> TVA was created for the job of developing the resources of a single region as a whole. The limits of its responsibilities were fixed by the boundaries of nature, a watershed and its adjacent area.[3]

TVA was thus in a position to understand and deal with problems of the Valley on the ground. It is still a source of pride to people of the Valley that the agency has less than a dozen employees in Washington, the rest being stationed in the area. The regional program has gained by the fact that administrative decisions are made in the Valley by persons increasingly familiar with all aspects of the regional economy. TVA was, by virtue of its organizing act, also in a position to approach one of the major problems of the area—that of a balanced resource development.

The problem of balance has long been a concern of the South.[4] Numerous writers have developed strongly the theory that regional development is the key to balance and equilibrium. They point out that balanced development is desirable not only between and among the several diversified areas of the nation or a region, but also between industry and agriculture, between urban and rural cultures, and between and among the various groups of people making up the society, since the aim of a progressive society is to offer not only each element of the population but each individual full opportunity. Students of regional problems indicate that a unified approach offers a medium and technique of total and balanced development.

The Tennessee Valley area has long suffered from unbalanced man-land ratios, a poor balance between agriculture and industry. The region, as well as the entire South, has a population age distribution which results in a relatively low ratio of producers to consumers. The imbalance in age groups, incomes, and between the carrying loads of institutions and resources, has been repeatedly pointed out as a problem of the region.[5]

The concept of balance appears to involve the development of an environment that affords the greatest use of human skills, which offers alternative opportunities and which tries to preserve and perpetuate the best of the value and cultural systems of both rural and urban peoples. If there is wide range of alternatives for choice of place to live, of jobs, of freedom to move and to adjust, people to a remarkable degree will effect an ecological balance in their activities. Balanced development of the resources of the area, through a unified approach, is both a philosophy and a technique. TVA has contributed to both as is evident when specific program activities are considered.

The dominant geographical feature of the Tennessee Valley is the Tennessee River and its tributaries. TVA has brought the river under control. It has changed it from a liability to an asset. TVA's dams control floods, make a continuous deep-water navigation channel, provide a nonexhaustible source of low-cost electric power, and create a chain of beautiful lakes that attract tourists from all over the United States. TVA, an agency of the Federal Government, provided these things; it has been up to the people of the Tennessee Valley to use them.

Electric power generated at the TVA plants is sold to the people of the Valley through agencies of their own creation. TVA does not ordinarily sell its power at retail but makes it available to local organizations which were willing and able to assume the responsibility of getting the power into the million homes, stores, churches, schools, and factories now using TVA power. In the urban centers, city governments, by choice of the electorate, buy power wholesale from TVA and distribute it to the people. In the rural areas, the people have formed cooperatives for the express purpose of distributing TVA power. These are local public and quasi-public agencies created by the people of the Tennessee Valley as home-owned business enterprises for the purpose of using the great resource tapped by TVA. They have made it their business—not left it up to the Federal Government—to get the full benefit from this phase of TVA resource development.

Has it worked? Would it have been better—faster, more efficient—for TVA to have taken complete responsibility and not only to have generated the power but to have followed through and sold it directly to every one of the million customers? That is a hypothetical question but it has a hard, factual answer. First, the people of the TVA area are using 10 times as much power as they did when TVA took over in 1933. Second, not only are there more consumers of power, but each consumer is using more; the average householder is using more than four times as much power as he did in 1933. Third, the 140 cities and cooperatives that sell TVA power showed a net return of 10 per cent on their investment in 1948.

The same dams that provided electric power make a navigable channel 9 feet deep and 630 miles long on the Tennessee River. Thus the people of the Valley have a low-cost highway for freight traffic. The channel is there. It is up to the people to use it. And they are using it. Navigation as a factor in the economic development of the Valley is just beginning to be felt. A new day has dawned for a number of river towns, as Mr. Shelton has indicated for Decatur, and important portions of the Valley's petroleum, industrial coal, and grain requirements are now moving by way of the

[2]Lilienthal, David E., *TVA: Democracy on the March,* New York: Harper & Brothers, 1944, p. 153.

[3]Lilienthal, David E., *The Tennessee Valley, A Story of Change,* 1946, p. 17 (Mimeographed).

[4]See: Odum, Howard W., and Harry E. Moore, *American Regionalism,* New York: Henry Holt & Co., 1938, pp. 3-34.

[5]This is well indicated in Vance, Rupert, *All These People,* Chapel Hill: University of North Carolina Press, 1945, pp. 472-73.

river. Four hundred and twenty million ton-miles of traffic moved on the river in 1948, which was about thirteen times the 1933 volume. Conservative estimates place the 1948 savings on this amount of traffic, over the next cheap form, at about $4 million. Estimates indicate the prospect of freight more than doubling with annual saving of $9 million.

The same dams that hold back floods, provide electric power and make an artery of commerce have brought countless hours of pleasure each year to the thousands of fishermen, swimmers, boaters, campers and just plain idlers who know the value of leaving the cares of the world behind while they lean back against the trunk of a giant oak tree, gaze across the glistening waters to the forested slopes of the opposite shore, and relax—just relax. For recreation has turned out to be the great unearned increment of TVA's river control project. It is rapidly becoming a major factor in the life and economy of the area.

At several of the earlier TVA projects, TVA built demonstration parks on the shores of the new lakes. Some of the parks were scarcely more than well-developed picnic grounds; others were complete with vacation cabins. In 1933 there was no such thing as a state park with vacation facilities in all the Tennessee Valley. In fact, several of the states had no public recreation areas at all and no agencies for developing any. TVA's demonstration parks served their purpose. They created among the people of the Valley a demand for new facilities—and the people through their state and local governments have satisfied their own demand. Today, just 15 years later, there are 30 public parks—state, county, and municipal parks—operated by the people of the Tennessee Valley on the shores of TVA lakes. In addition, there are more than 100 boat liveries operated for the public by private businessmen; there are boy scout camps, YMCA camps, and hundreds of summer cottages. TVA did not build these. TVA simply showed the way with its small handful of public recreation areas at the start. The people saw what could be done, and they went and did it.

I don't think anyone will ever know how many thousands of fishermen have found new pleasure on TVA lakes. There was great fear when TVA first started building dams that the new environment would be fatal to the fish. In fact, several fish hatcheries were built by TVA and placed in operation to stock the TVA reservoirs. The fears proved to be groundless. Several seasons of research by TVA fisheries experts showed that instead of declining, the fish population of impounded waters was multiplying, multiplying so rapidly that stocking was unnecessary and the hatcheries were closed. TVA reported its findings to the conservation departments of the several states in the Tennessee Valley. As a result, the state conservation departments responsible to the people of the Tennessee Valley eliminated the traditional closed season on impounded waters. This is perhaps a minor story; it is certainly a detail in the over-all picture of balanced development of the resources of the Valley. Yet it is a perfect illustration of the way in which this federal agency, TVA, and the people, acting through their local agencies, can and do work together.

Similar experiences have occurred in the field of forestry. More than half the Tennessee Valley is forested. Good forest cover is excellent protection against erosion on mountain slopes and steep hillsides—and erosion is one of our major problems. Well-managed forests can provide a continuing economic base for many Valley people. There are three ways a government can see to it that forest lands are properly used. The government can own the forests, thus obtaining complete control; it can pass laws regulating use of forests; or it can educate the people to good forestry practices. In the Tennessee Valley, emphasis has been on the third method—education. I grant that it takes longer, yet I am convinced it is the most effective, most lasting way.

TVA engages in a number of activities aimed at conserving and developing the forest resources, but let me illustrate the impact of TVA on the Valley in just one phase, fire protection. Fire is our worst forest enemy in the Tennessee Valley. Most fires are caused by careless people and by ignorant people. They can be prevented and they will be prevented if the people learn it is to their advantage to do so. One device TVA uses—and I suppose it is used elsewhere too—is the fire-damage demonstration plot, a small area of woodland purposely burned over each year to demonstrate the contrast with an adjacent unburned area. TVA, working with state foresters, encourages local organizations of farmers and timbermen to maintain such fire-damage demonstration plots throughout the Valley. This is education on the spot. It is much more effective than a textbook or a law telling a man "You can't do that."

Nearly all heavily forested areas of the Tennessee Valley now have locally organized fire-fighting brigades. These are local volunteers—farmers, tradesmen, woodsmen—who have organized themselves to suppress forest fires in their communities. They get some financial help from TVA and their state government. It has taken a number of years to sell some of the communities on the value of forest fire protection, much longer than if the government had set up its own trained crews in each community. But the point is, when the action was finally taken, it was taken by the people whose resources were directly affected, not by some paternal agency on their behalf. The action was taken by the people because they had come to realize for themselves that it was desirable.

Agriculture is the real backbone of the Tennessee Valley's economy. Two out of every three families live in a rural area. The main farm problem in the Tennessee Valley in 1933 was soil depletion. Erosion was taking a very heavy toll. Depletion of soil minerals by overcropping too was taking a toll. TVA and regional agricultural leaders agreed that the key to the problem was mineral plant foods, primarily phosphate. But phosphate alone, simply tons of phosphate dumped on the same eroding hillsides, was not the answer. Education in the use of phosphate fertilizer, in the use of the fertilizer in a revised system of farming, was needed.

The device selected by TVA and the state agricultural colleges to bridge the gap between scientific research and practical application, between the public experimental farm and the dirt farmer himself, is what we call the test-demonstration farm. We have thousands of test-demonstration farms in the Tennessee Valley; about one out of every ten farms is a test demonstration farm. These are not publicly owned farms but are normal, going farms owned and operated by typical farmers of the region. Their purpose is two-fold: first, to test the effectiveness of new kinds of fertilizers being developed by TVA; second, to demonstrate the proper use of the proper kinds of fertilizers in soil- and water-conserving systems of farming. The test-demonstration farmers are selected by their neighbors, not appointed by the government. Notice that in this activity too, the emphasis is on education and on action by the people of the region.

Are test-demonstration farms effective? Does the device work? Yes. Practices first tried out at state experiment stations and then tested and demonstrated on a large scale on the test-demonstration farms are being adopted generally by the other farmers of the Tennessee Valley. A primary need of agriculture in the Tennessee Valley is diversification. For generation after generation, farm after farm grew cotton, or corn, or tobacco—all row crops—little else. It was a one-crop system and it was mining the soil. The test-demonstration program has preached and demonstrated diversification. According to the United States census of agriculture, land in row crops in the Tennessee Valley decreased 19 per cent between the census years of 1935 and 1945 while land in row crops in the United States as a whole was increasing. That is but a single index and I shall not bother you with more figures. It is a fact, however, that more and more land in the Valley is being put into pasture. Beef cattle and milch cows now graze in knee-deep pastures that but a few years ago were cotton patches. More and more fertilizer is being used. Sales of commercial fertilizers in the Valley have increased much more than in adjoining areas. We are far from solving our agricultural problem in the Tennessee Valley, but by now we do know in what direction the solution lies and, more important, we have a firm belief in our ability to achieve it.

The states and local government have expanded their activities in order to meet the problems and opportunities of the developmental program. New agencies, such as departments of conservation, have appeared on the state level. Some sixty or seventy communities have organized local planning commissions, which are being assisted by well-staffed state commissions. The universities of the area have expanded their research programs in many fields relating to resource development, sometimes with TVA assistance in the initial stages of expansion, often without such assistance. The region has made a start in promoting resource-use education in the schools and colleges. As a result of this expansion of functions and agencies, TVA has had as its partners in developmental activities such diverse institutions as the state universities and the land-grant colleges, the agricultural experiment stations, the engineering experiment stations, the state extension services, library boards and libraries, teacher-training institutions; state, county and municipal departments of health, departments of conservation and park administration; state and local planning boards and commissions, municipal power boards and rural electric cooperatives. These local agencies plus a score or more of federal agencies and bureaus with their specialized services make the program truly cooperative.

Today to the people of the area the Tennessee Valley Authority has come to symbolize the idea of progressive change, a change toward the improvement and better utilization of resources, toward a better balanced economy with higher incomes from more secure sources and a higher standard of living buttressed by better tools and knowledge for making a living and for coping with the problems of the region.

This record of substantial accomplishment by an enterprise, which has its roots solidly in the area, has been a factor in bolstering the region's morale and has added a tangible element of regional identification. It constitutes a concrete demonstration that planning is compatible with our form of government; that the resources of the Valley can be developed and renewable resources rebuilt, that this can be done without destroying existing institutions, and that these may be used in the interest of the people. There is now a recognition that the Valley has many natural advantages—among which are abundant rainfall, a favorable climate, and adequate mineral and soil resources and that the production patterns of the Valley's economy can be rearranged within the framework of these factors. From the regional program has come a confidence that the job of Valley resource development is not only possible but practicable and challenging.

Identification of themselves with the regional program is particularly strong among the farmers of the Tennessee Valley and among the power consumers, power distributors and others closely associated with TVA program activities. The sense of belonging to the region, of being affected by it, of having a part in its development has been a major factor in the strength of TVA. This strength has not been confined to any single political party, or to political leadership, but is strongly embedded in the citizenship of the region.

In addition to geographical features and natural and institutional resources, it is important to regional resource development that the people have a collective consciousness necessary to sustain the individual and collective demands which are made upon them as the various aspects of the programs go forward. No matter what the potential resources of a region may be, the people must have the will to share in the development and utilization of them. The people of the Tennessee Valley feel this responsibility. It has been said that the Tennessee Valley Authority represents not government in the traditional sense of the word, but leadership. TVA has supplied the persuasive force of technical facts and technical skills. But more important, for the long-range outlook, the regional program has developed local leadership, initiative and enterprise.

In spite of many accomplishments made by TVA and its cooperating agencies, there is still, as Chairman Clapp indicates, much "unfinished business" in the Tennessee Valley. The *per capita* income of the Valley still is only about 60 per cent of the national average; there are still acute problems of soil erosion and human erosion; a substantial number of farms are still to be electrified; there is need to apply more fully and more extensively the fertilizer and agricultural test-demonstration experiences; private enterprises and business corporations need to more fully utilize the data, studies, and opportunities which are now available; the people need a better understanding of the role of natural resources in their lives, and the schools and colleges need to give more aid to the people in the form of resource use education.

The Valley has made a constructive use of the opportunity presented by the TVA program. As you consider the significance of this regional program, it is my hope that you will here find something that will be of value as you attack the resource development problems of your respective nations and regions.

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The CHAIRMAN: Dr. Cole, thank you very much for your valuable summary of the physical and human results of the work that has been done in the Tennessee Valley and of the work that still remains to be done. What you have said provides an admirable basis for discussion and we very greatly appreciate the work that you have done in preparing and presenting the paper to which we have just listened.

The meeting is now open for individual contributions and in view of the time I think it would be well if those who have questions to ask or statements to make would limit themselves to not more than three or four minutes in each case.

I call on Mr. Tunstell of Canada.

Mr. TUNSTELL: I note from the information given in these papers that the Tennessee Valley is approximately 50 per cent under forest cover. Presumably, with a territory which had sunk to a low economic level, those forests must have been sadly depleted, because in my experience with such communities, any tree that can turn in a dollar's income is going to be cut.

I also observe that a certain amount of planting has been done. Some 175 million trees have been utilized for this purpose. The figure sounds large, but in fact 175 million trees, with a thousand trees, or perhaps slightly better, per acre, works out to a rather small area. I think Mr. Clapp's paper said 140,000 acres. That reduced to miles is something like 200 square miles, which, in a total area for a valley of 40,000, is small potatoes.

I am very pleased to note the apparent progress that has been made in forest fire protection. I can readily appreciate that it would be the first problem attacked as it is the big enemy of the forest.

I am particularly interested in another remark to the effect that improvement along the lines of better forestry practices has taken the form of education. I should be very interested in hearing to what extent worthwhile results in better forest management are being achieved by the appeal along educational lines.

The CHAIRMAN: I know it is unusual for a Chairman to intervene on occasions of this kind, but I think I shall do the unusual.

Mr. Clapp stated that the Tennessee watershed covered some 40,000 square miles. At some other point, in either his paper or in the paper of one of the other speakers, the statement was made that electricity was supplied to users over an area of some 88,000 square miles. Is there any contradiction in this, or is there some explanation that is not immediately apparent?

Mr. CLAPP: There is no contradiction. The area of the watershed is about 40,000 square miles. In the Act which set up the TVA, the TVA was authorized to reach its consumers through local bodies, municipalities and rural electric co-operatives, and so on, within transmission distance of the dams. As the transmission system has been expanded to meet the expressed preferences of the communities within reach of its dams, the area served by electricity has not only included the Tennessee Valley but an area around it about again as large.

The CHAIRMAN: I now call on Mr. Goldschmidt, of the United States.

Mr. GOLDSCHMIDT: Mr. Clapp, the development of the Tennessee River has progressed to the point where that river is almost fully developed, and in that respect the Tennessee River is quite different from the other rivers in the United States, which have hardly been developed as much as 10 per cent. Could you explain what political or other reasons—since you have already explained that this was not done by dictatorial powers—made it possible for the TVA in sixteen years to develop this river so fully percentage-wise as against the relative undevelopment in other parts of the country?

Mr. CLAPP: The Act under which we have our being as a TVA is an Act of Congress. That Act authorized the TVA, so far as the law was concerned, to fully develop the river. It asked us to file a report with the Congress which would lay out a plan for the development of all of the river and its tributaries. We did that; we presented a plan. We have gone to the Congress each year requesting appropriations in the form of capital with which to build the dams that were incorporated in the plan which was developed by us.

As Mr. Goldschmidt has said, we have reached the point now where the major part of the river developments has been completed. We still have some dams to build in the future. All of the dams that the main river calls for have been built, and most of the major dams on the major tributaries have been built. There are still places where dams can be built and will constitute good additions to the system for some additional flood control and hydroelectricity.

Therefore, the specific answer to Mr. Goldschmidt's question is that we have been able to develop the river rather fully because the Congress has seen fit to honour

our recommendations and justifications for the need for it. We have been able to present them with a unified plan and programme, and we have been able to get financial and other results, as we have completed our dams in fairly quick order.

I think another reason—a more obvious one—why the Tennessee River development has progressed more rapidly is because, compared with the Columbia, for example, or the Missouri, it is a smaller system.

The total amount of money that has been put into dams, locks, powerhouses and transmission lines as original cost is about 750 million dollars, while I do not believe that a 90 per cent development of the Columbia River can be accomplished for any such small amount of money. I think that another and, perhaps, the most important reason why this has progressed as rapidly as it has is that once the people of the Tennessee Valley began to understand what this agency was about and saw that there was no attempt on the part of the agency to push them around, and when they began to see the benefits that can accrue from this kind of a unified development, very little controversy about the desirability, advisability and feasibility of going forward with the physical development of the river arose within the Valley. The Valley presented a united front in its requests for authorizations and funds from Congress to invest in the development of the River, and the Tennessee Valley Authority was able to present a unified programme from which each project for which funds were needed could be selected and its relationship to the whole understood by those who were going to appropriate the money.

The CHAIRMAN: Those present who have taken part in the formal or informal discussions on valley developments during the period of this Conference know that, from time to time, the view has been expressed that the Tennessee Valley Authority and the general arrangements that have been made in the Tennessee Valley are open to criticism on the ground of their authoritarian character. I wonder whether, in the light of what has been said this morning—particularly by Mr. Shelton and Dr. Cole—there is any continuance of that view and, if so, whether those who hold it would like to express their opinions.

In the absence of any response I take it that everyone has been converted.

I now call upon the Executive Secretary of the Conference, Mr. Alfred J. Van Tassel.

Mr. VAN TASSEL: The Tennessee Valley, I understand, comprises some seven states and involves the co-ordination of the legislation of the peoples of those states—particularly, I think, of their legislatures. It has been suggested that this experience of the Tennessee Valley Authority is peculiar and applicable only to the United States, and that in general the problem is not met elsewhere. I should like to ask Mr. Clapp if he feels that the experience of the Tennessee Valley Authority in co-ordinating the activities of the several States concerned has an international application to other river basins of the world?

Mr. CLAPP: That is a difficult question, and two weeks ago I might have thought it more or less an abstract one, but in view of the fact that I have committed myself to a temporary assignment in another part of the world it ceases to be at all abstract with me. I do not like to generalize on the subject or on the question. I do think that the experience of the Tennessee Valley Authority in looking at water resources as a whole, and in following water where it flows to assess its potential assets without regard to man-made boundaries, is an approach which in other river valleys will produce or create values which would otherwise be lost if those water resources were looked at piece by piece in unrelated parts. I think, too, that in the experience of the Tennessee Valley in relating water to land and in relating both to the greatest possible benefit that can come to human living, there is certainly something which can be applied in the approach that is made to resource development in other river valleys of the world.

However, for myself at least, I should not want to advocate carbon copies. I should not want to urge or even suggest that administrative forms be too precisely copied or considered. Let the administrative forms be developed to ensure unified study—unified analysis of resources and unified administration of them through whatever agencies may be most effective in the peculiar settings in which such an approach may be made. When one comes to international boundaries I think the question needs a great deal of study as to the precise application or adaptation which could be made of the Tennessee Valley Authority idea.

What I am trying to say is that there is certainly no wisdom, in my judgment, in being doctrinaire on this subject. We must cut and try, but we must devise methods which will give us a unified look, a comprehensive look at all related resources, and our administrative methods must not violate the integration of those resources. Our administrative methods should and, in my judgment, can only succeed if they rely primarily and heavily on the administrative capacities of existing institutions which are indigenous to the regions and under control in those regions.

The CHAIRMAN: I think we have time for one or two more brief interventions. I call now upon Mr. Zuckerman, from the United Kingdom.

Mr. ZUCKERMAN: It is not unusual for publicists to contrast the virtues or vices of planning with the benefits which are brought by private enterprise. For example, some of you may have read that, in part, the economic difficulties in which we in Britain find ourselves at present are the result of some of the planning to which we have been subjected. I would, therefore, say that it has been particularly interesting to me, as a member of the British delegation, to hear today that individual enterprise can flourish, thrive and grow under the rigours of the planning of the Tennessee Valley Authority. And may I also say that it gives me great pleasure to discover such a magnificent example of planning in a country so full of private enterprise?

The CHAIRMAN: I shall now call upon Mr. Erselcuk, of Purdue University.

Mr. ERSELCUK: I understand that, in the year 1948, TVA made about $21,479,000. Is it possible for the TVA administration to make use of these funds in the expansion of power facilities other than hydroelectric? In other words, is it possible for TVA to build steam plants without asking permission from the Congress, so that it will be possible in the future to have a better power system in the area?

Mr. CLAPP: It is possible, but not probable. It is a possibility under our law to use our earnings to build steam plants. But because it has involved major questions of public policy, and because it also takes a lot of money, we have gone to the Congress in times past in order to have the money appropriated, and Congress has appropriated money for the construction of steam plants. We are now building a large steam plant, we also built one during the recent war, and I suspect that we shall be building more steam plants as time goes on with moneys appropriated to us for that purpose by the Congress.

The CHAIRMAN: I now call on Mr. A. Clark, of Rutgers University.

Mr. A. CLARK: I am quite interested in the possibility that some of the ideas that have been developed in the TVA might be applied to a Missouri Valley Authority or a Columbia Valley Authority or other valley authority. I should like to direct this question to Professor Cole. Have any studies been prepared which in any way represent generalizations which are applicable to other areas in terms of what might be called human or social engineering or adjustment, or must we in each case face a separate and unique problem in that regard?

Mr. COLE: I think that in each instance the studies have to be made, and I do not see that you can apply the generalizations from studies made in the Tennessee Valley. I believe that Feiner, in his book on the international implications of TVA, did one of the best jobs—not relating it to regions in the United States, but to other regions generally. I think that perhaps is the best source for application by a person who was looking not only at prospective valley authorities in this country, but also outside this country.

The CHAIRMAN: As we have not yet had an opportunity to hear from any of our friends from Latin America, I think we should make time for one question by Dr. Ranghel, of Colombia.

Mr. RANGHEL: I was filled with admiration in hearing the statements by Mr. Clapp and Mr. Shelton. I certainly believe that the Tennessee Valley Authority is at present one of the greatest achievements of mankind. I should like to ask Mr. Shelton to explain to us a little further how they developed an interest on the part of the people in Decatur and how they developed the people's appreciation of the opportunities given to them by the TVA. In many of the countries of the world, especially in the under-developed countries, one of our problems is to develop an interest on the part of the people. Most of the people expect that everything will be done by the government. I should very much appreciate an explanation by Mr. Shelton.

Mr. SHELTON: In the first place, the question is being asked of a newspaperman—and a newspaperman is a promoter by trade. One way of keeping the public interested in the various problems as they arise is simply to print the facts and keep them before the people. Of course, we have our own organizations that go over these questions—and in the United States, I imagine, there are more committees than anything else. It is through means of that sort that we keep interest alive in the problems with which all of the people are directly concerned.

Mr. COLE: Would you tell us just a bit about your planning organization, Mr. Shelton?

Mr. SHELTON: We have had a city planning organization for several years. We are not trying to be a big town, we are trying to be a good town and a sound town. We have our zoning laws which state how the waterfront can be used, and certain areas devoted to agriculture, certain areas to commerce and certain areas to industry. Our planning board meets about once a month, unless there is a special meeting of some kind.

The CHAIRMAN: I think that in view of the importunities of the clock, we must now bring this meeting to a close. It will be recalled that this afternoon the same general subject is to be continued as a basis for discussion.

The Integrated Development of River Basins

A Symposium on Public Policy

Monday Afternoon, 5 September 1949

Chairman:

Abdel Amir AL-UZRI, Director-General of Irrigation, Baghdad, Iraq

Discussion Leader:

Gilbert WHITE, President, Haverford College, Haverford, Pennsylvania, U. S. A.

Discussants:

Messrs. AUBERT, EL SAMNY, E. DE VRIES, GOLDSCHMIDT, KRUG, RAVER, BLOCH, HATHAWAY, KARPOV, RINGERS, SZYFRES, SAIN, WARNE, F. C. RODRÍGUEZ, MENHINICK, ANGUS, SANGUINETTI, HAMID, STROME, WEBER, GUILLAUME, KALINSKI

The CHAIRMAN: I declare open the sixteenth plenary meeting of the United Nations Scientific Conference on the Conservation and Utilization of Resources.

In this plenary meeting we will continue the discussion of the integrated development of river basins.

I will ask Dr. Gilbert White to introduce the subject for the symposium.

Mr. WHITE: The symposium this afternoon is to be devoted to the problem of public policy in comprehensive river basin development. It is intended to be a free exchange of experience and opinion among the many experts in the field of natural resources who are gathered together in this Conference. No formal papers will be presented and no definite programme of discussion has been planned. For the most part, the men who are sitting around this table have participated in the eight preceding Section meetings which have dealt with the problem of water resources development. In those Section meetings, these men have recognized in various ways the tremendous opportunities for the development of water resources from the rivers of the world for the welfare of the entire populations involved.

Their discussions have revealed, I think, the great complexity of designing any plan for a river basin development. It is an extremely difficult and delicate technical as well as a social operation to take full account of the many possible uses and controls of water in even a small basin. All of us who were present at the discussion on the TVA development this morning have seen something of that complexity and difficulty.

The uses which have been considered in connexion with promoting the healthy economic life of a region are navigation, irrigation, flood control, drainage, hydroelectric power, municipal and domestic water supplies, wild life conservation and recreation. There have been many plans submitted at the preceding meetings for land reclamation by flood control and drainage, and all of them have been examined in some detail. By way of initiating this round-table discussion, it is my duty to see if there are not some broad generalizations we can draw from the experience that we have reviewed in the preceding meetings, and then to outline for the participants two questions which have seemed to those we have consulted as being especially basic questions of public policy.

I think if we were to draw any single generalization from what the water and related land people have been discussing during the last two weeks, it would be this: That the idea of a multiple-purpose project, the kind of project which was described in the discussion on the TVA this morning, is widely approved and increasingly is being applied in the world today. It is, chronologically speaking, a relatively new idea, and it now finds wide acceptance. We can say that the plans for the use and control of waters are being prepared more and more frequently so as to take account of all related purposes. The fact that electric power production can be combined with navigation and flood control and irrigation in a single dam, such as the Hoover Dam on the Colorado and the Genissiat Dam on the upper Rhône, is now well established. To design and construct dams which do not serve multiple purposes where practicable would, I think most of us agree, be a public waste. It is an irreparable waste, often, to construct a project which does not serve this multiple purpose at the beginning. Once a site has been used, it may be destroyed for the larger purposes.

The second generalization that I suggest we might draw is this: That increasingly resource technicians are recognizing that new water projects must be planned as part of a unified programme for entire drainage basins or regions, if the maximum public good is to result. That is, we are moving beyond the stage where we can be satisfied with undertaking one project on, say the Indus or on the Rhine without knowing its relation to other possible projects. During our meetings, the participants have developed a sort of non-Aristotelian logic in which they maintain that the sum of the individual parts is less than the whole in river basin development; that only as we undertake basin development on a unified basis do we get maximum results for the whole region.

A third generalization which we may draw is that increasingly technicians concerned with resources are recognizing the many inseparable links between the development of water and the development of other natural resources. The extension of irrigated acreage in Indonesia, for example, is recognized as only part of the complex problem of land-use adjustment in that area of great population pressure. The generation of hydro-electric power in Western Europe is seen as subsidiary to the whole issue of competing fuels and of economic stability in that region. Torrent and avalanche control in the Mediterranean area is seen as being part forestry and part grassland management and part water engineering, and not wholly one. In this complex web of resource utilization, the persistent thoughtful pursuit of any one strand seems to lead inevitably to crossing and consideration of the other interwoven strands. And so drainage basin development, which we begin by considering solely from the standpoint of ordering more properly the flow of water in a stream, branches out and takes in problems of land use, mineral conservation and fuel conservation.

We have seen from a number of the reports which have been presented here a great many projects which are in progress or in prospect, in river basins across the world from the Yellow River down through the Ganges, the Tigris-Euphrates, the Nile, the Rhône, the Rhine, and the great rivers of the United States and South America.

But it would be a mistake to think that these developments, about which we have heard a good deal, are certain to go forward either rapidly or on a very wide front. There are a number of obstacles. There is first of all the simple fact which has been noted here a number of times, that we do not know enough about basic phenomena of rainfall and stream flow and quality of water and the flow of silt in streams to be able to make really complete plans in many areas.

There is the obstacle that so many of the comprehensive programmes which lie ahead are in regions in which it is now financially impossible for the populations involved to finance large-scale development, and it is unlikely that they will go forward without outside help. Some of our friends here may have more to say about that later on.

Finally, there is the whole obstacle of the social reorganization and political education required to supplement the construction measures which, by comparison with these problems of social engineering seem relatively simple. We have seen, for example, how the very elementary problem of overdrawing groundwater resources in areas such as Southern California or in the London basin of the Thames are allowed to assume very acute proportions before the governments and populations involved are moved to take necessary regulatory and remedial steps.

These are all obstacles—lack of data, the volume of capital required, the problem of social organization—but I would submit that there are two issues which are even more important in considering future development of drainage basins across the world. One of those issues is this: how do we gauge the value of river development? What estimate do we place on the effect, on the benefit to the community, whether the community be a restricted one of a town like Decatur, or the United States, or the great community of the world, as resulting from developing a given river? That is one issue about which there is no unanimity of thinking among either policy makers or technicians of these United Nations.

The second issue is one that came forward very clearly this morning: can we carry out a unified programme of river basin development of which we have been talking unless we have a unified administration? Is it possible, is it practicable either to plan or to construct or to operate a unified resources programme unless there is a unified administrative agency to see that it is done? Will it materialize if the responsibility is divided among a number of agencies? That is an acute problem in most of the nations which are represented around this table. It is an even more acute problem if we think of the great rivers which cross national boundaries. Later on we shall see a map which shows the extent of those rivers that are international in scope. Can we think realistically of comprehensive river basin development on international streams unless we have some sort of administrative unity on an international level?

The two questions which are being proposed for discussion as being, in the opinion of some of us, the most important growing out of the whole series of water sections are, first, how should we gauge the public value of comprehensive river basin development; and second, can we develop unified basin programmes without having unified administration?

We shall consider the first question and move on from that to the second one when we feel we have explored it with some care.

I may say that we have around the table men who speak from experience in Israel, the United States, Canada, India, the United Kingdom; our Chairman speaks from very intimate experience with the problems in Iraq on the Tigris-Euphrates; from France, the overseas colonies of France, Indonesia, Egypt, Pakistan and the Netherlands. Facing across I see a representative from Greece and a number who were with us this morning to discuss the TVA. All of them have special experience and ideas to contribute.

I should like to open for your consideration the question of how we should gauge the public value of comprehensive river basin development.

I ask Professor Jean Aubert, of France, to open the discussion.

Mr. Aubert:[a] I think that the programme which had just been outlined by Dr. White is a logical and natural corollary to the discussions which have been conducted on the technical level for two weeks. It had been finally stated that the financial aspect played a paramount part, and that if suitable financial arrangements could not be found, it would be very difficult to proceed. In a sense, financial considerations were paramount.

Therefore, I shall bring forth a few financial considerations bearing mainly on the *Compagnie nationale du Rhône,* while drawing at the same time on the excellent example of the Tennessee Valley Authority whereon important and interesting points were raised this morning.

Two very different things were noticed about the Tennessee Valley Authority.

In the first place there was the technical element. The work that was carried out in the Tennessee Valley again showed that dams could be made to serve several purposes. As Dr. White pointed out a few minutes ago, it would be unreasonable to build dams today for a single purpose.

Nevertheless I would like to make a point on this subject: namely, that when a comprehensive project is being considered, one should strive to achieve a maximum in the field of production of power, navigation, irrigation etc. However one cannot achieve the maximum objective in all fields at the same time. For instance, electric power could be developed to the maximum point, but some sacrifice would be entailed in the field of irrigation, or vice versa.

This was very important from the financial point of view which was currently being considered. There were several alternative solutions to the development of the basin, and geographical and financial considerations had to be taken into account. If, for instance, a country was financially poor, it might find it convenient to develop certain sections which would yield immediate revenue. This is a question which depends on local conditions. In any case, it will be seen that from the very beginning, men concerned with its financing will have their say. I will not say that these men should have the final word, but their point of view should be made known to give a better balance to the programme from its very beginning so that it can be orientated in one direction or another.

This leads me to the second element of the example of the Tennessee Valley Authority, which is certainly the most original and interesting element, namely the agricultural and human benefits which were derived from it.

All that was said this morning about the human achievements was of great interest to us. I recall a visit I made in 1936 to the Tennessee Valley, and I can pay personal homage to the excellent methods that were applied, even at that time, to make the population understand the value of the project and to achieve that without coercion. Since human elements have a special priority in this field, we should pay a special tribute to the Tennessee Valley Authority administration for having understood so well and carried out that human element.

[a]Mr. Aubert spoke in French.

Moreover, the success of that endeavour depended on a certain number of elements. I cannot consider them all and so will limit my comments to its financial aspect.

In the case of the Tennessee Valley, the State (the Federal Government) furnished the necessary funds for the project. I am convinced that the Federal Government will derive interest on the money invested from various sources. I will not dwell on that point, I will say simply that in order to incur expenses it is necessary to have the money. The Federal Government could not have undertaken such a project unless it had the means at hand and this is interesting for other countries which may not possess the same financial resources. It is not always possible for a government to derive the sums necessary for the execution of a project from taxation. It is likewise not always possible for the government to find somebody willing to lend that money.

What is to be done when there is a lack of funds, since that is the problem, in my opinion, is of practical interest to a number of countries?

It is in that light that I would like to say a few words with regard to our French experiment of developing the Rhone basin, which will demonstrate to you that it is possible to use a different type of financing and to resort to private funds, even for a comprehensive project carried out by an organization which is, to a certain extent, under the control of the State.

France intended to develop the Rhône basin without spending money and without taxing the Public Treasury to the extent of a single franc. The starting point of that project is the law passed in 1919, which is therefore not recent in date, and which combined three different aspects: navigation, power and irrigation.

Although the principle of that law had been established in 1919, when the idea of a comprehensive project first originated in France, for various reasons, the implementation of that project did not begin until much later. It was only in 1934, fifteen years ago, that the *Compagnie nationale du Rhône* undertook the project.

What, then, was the financial principle on which that project was based? The financial principle was that in a comprehensive project, certain parts yield revenue, whereas others, on the contrary, involve expenditure. The sale of electric power yields revenue, whereas the development of navigation and, at least in the initial stages, that of irrigation, involves expenditure. The principle was that electricity, or in other words kilowatt-hours, would be produced, and that they would be sold, not at low prices, as in the case of the TVA—and I admit that that policy is preferable—but at the market price, because if it is impossible to sell at low prices, then of necessity one sells at the market price.

Consequently, from the initial stages, the *Compagnie nationale du Rhône* had decided that it would sell kilowatt-hours at the market price, that is to say, at the highest possible price, in order to obtain revenues for carrying out navigation and irrigation projects.

In order to ensure the success of that plan, it had been necessary to draw up successive programmes each one of which was well balanced from the financial viewpoint.

The first programme carried out by the *Compagnie nationale du Rhône* covered the Genissiat Dam and various navigation projects, since irrigation was not an urgent problem at that time. The programme was drawn up in such a way as to convince private investors that the whole project was capable, in itself, of yielding revenue. And the fact was that the banks and the general public considered that the first programme was a paying project; the public bought the shares and paid money to the *Compagnie nationale du Rhône*.

The navigation projects were started as soon as possible, and the work on the Genissiat Dam was begun a little later. Experience has proved, now that the Genissiat Dam is functioning and the electric power there produced is being sold at a very good price, that the plans had not been too ambitious. The first programme had proved to be a paying proposition and, I would even say, a profitable one. Now that the second programme, which covers the Donzère-Montdragon Dam and which involves both navigation and irrigation, is being carried out, it is easy to find willing investors for that project.

Consequently, we can state that experience has shown our financial plan to be sound, and it will certainly be continued.

We recognize the fact that our financial method does not enable us to achieve the degree of speed which characterizes the TVA; we must go much more slowly and proceed step by step. We cannot say in how many years we shall have completed the Rhône project, but we can affirm that that comprehensive project is proceeding in a satisfactory manner, thanks to the financial method which was adopted from the beginning.

Mr. WHITE: Professor Aubert has suggested that finances command and has indicated that, in the experience of France on the Rhône, it has seemed wise in the circumstances to let the revenue from power production in effect set the rate and character of development. I think it might be interesting to shift over to the problem of development on another stream, the Nile, and to hear from one who has been concerned with that river: Dr. Ahmed El Samny El Sayed, of the University of Cairo.

Mr. EL SAMNY: I should like to give a very brief outline of the method of financing and planning basin development projects with regard to the River Nile in Egypt.

The main purpose of the national policy of the Nile basin development is to utilize the valley according to its own logic. Egypt is an agricultural country and the lands are dependent entirely on the Nile for their irrigation and fertility. The main aim is to provide adequate water during the low stage and to protect the highly developed sections of the country against high floods. Navigation, forestation and power development have been partially neglected in order to retain the water for irrigation. Although the country is trying to integrate all the water uses, yet it is impossible to obtain 100 per cent efficiency in all of them. The estimate of the benefits of all our projects has been based upon the increase in the size of the cultivated areas, which results in an increase in the country's wealth and, in turn, in our national income. However, the increase in cultivated land area has not kept pace with the increase in population, and this necessitates the use of the existing projects—for example, Aswan Dam and the barrages on the Nile—for power development, flood protection and navigation. The benefits from these projects in terms of irrigation—which was their original purpose—have been accordingly limited.

I want to comment upon the matter of having a multiple purpose served. One dam cannot be used to full efficiency for power and for flood protection, because retaining a certain head on the dam will cause silting of the reservoir, and this will prevent the lands from getting the silt, which is very useful for their fertility.

Our new policy is to consider the physical and financial aspects of the future projects to bring the water uses to the point of maximum benefit. The financing of these projects has been done by the National Government, which builds and maintains the structures. Their cost is not reimbursed in the form of extra taxes upon those who benefit directly from the projects. However, there are other benefits in the form of an increase in arable land, increased employment and the establishment of light industry, all of which serve to increase the country's wealth.

Mr. White: Dr. El Samny has pointed out that in Egypt there is a situation almost diametrically opposed to that in France: it is considered that the benefits from this irrigation development are sufficiently important so that the entire programme is financed by the Federal Government out of the Federal budget. I think it might be interesting to hear some other experience on this point, and then to invite questions and observations in regard to this situation. I should now like to call on Dr. De Vries, who is the Councillor to the Ministry of Overseas Affairs in the Netherlands.

Mr. De Vries: In Indonesia, and especially in Java, irrigation works have mostly been paid for with money from the central Government. However, the income to the Government from those developments has been assessed upon a part only of the total income if all the benefits of those works are taken into account. The benefit to the Government came mostly from increases in certain land revenue taxes which amount to about 10 or 14 per cent of the increase in crops from the land that is better irrigated. Of course, attempts were made to assess as accurately as possible what the increase in crops would be—how many more quintals or hectares of rice or other crops would be harvested.

If an undertaking had to be fully self-liquidating on the basis of this tax, it would mean that the benefit to the community as a whole would be from seven to ten times as much as the benefit to the Government, and this does not apply in a number of cases. So, by making a study of various projects and finding out the best thing to do, we decided as a practical rule that 50 per cent of the costs of the undertaking should be self-liquidating and could be placed on the capital budget of the Government. The other 50 per cent comes out of invisible benefits in the shape of higher yields by some kinds of taxation and a higher national income. The practical rule, therefore, divides on a fifty-fifty basis between direct and indirect benefits.

That was long before the economic theory of the multiplier factor of the influence of additional national income on the total national income was studied. In later years, especially in Holland, this multiplier theory was tested in a number of cases and it was found that the factor varied from 1.7 to 2.1. The multiplier factor of 2 which was accepted in Indonesia as a practical rule therefore falls within the range of the results obtained from quite a number of theoretical experiments. In future it might be wise to try to fix that multiplier factor if there are enough figures and statistics available for the purpose, but in circumstances where such data do not exist, the figure 2 might be accepted as a basis to start with. It might therefore be said that Indonesia comes between France and Egypt since we estimate it on a fifty-fifty basis.

The Chairman: I call on Mr. Goldschmidt of the United States Department of the Interior.

Mr. Goldschmidt: I wonder whether there is such a wide divergence here as a matter of practice. The Rhône development described by Professor Aubert was in fact underwritten by the people of France, both through State guarantees of the bonds and by guaranteed markets for the power. I think that point ought to be made here, because otherwise people might get notions into their heads that multiple purpose development could take place in a purely private setup when it has public responsibilities to perform. I think I am right in saying that State underwriting of the bonds and of the output made this enterprise into something of a public enterprise even though the bonds were purchased privately. In this country there are a number of public enterprises such as those of the City of Tacoma and of Memphis and a number of other cities where public undertakings are financed through private bond markets, through the sale of municipal bonds underwritten by the municipality and guaranteed by revenues from the project. I put in this caveat because I think it is important not to assume that such a large-scale undertaking as that described by Professor Aubert could be adequately developed as a private undertaking.

The Chairman: I see that the Secretary of the Interior wishes to make a statement at this point.

Mr. Krug: I had not expected to discuss this subject in view of the presence of all these experts, but having worked with experts for a long time I should like to address myself briefly to this question. Even in this country, where we think we have done a lot of work in multi-purpose development, we have not yet reached unanimity on the subject of what benefits should be counted and how they should be measured. I think that with respect to each project and each series of projects we should try to determine all the social benefits both economic and engineering and find the best possible way to measure them. We should then decide which ought to be paid for by the particular body using them, the power user or the navigator, and which ought to be paid for by the general public. The fact that honest engineers might disagree about the value of power or navigation facilities should not deter us from the attempt to measure the real benefits of these projects as best we can and then reaching a realistic determination whether a particular project should be carried out or which project should take preference over another, granting that no country in the world has enough capital to exploit all its potential projects in any given period of years.

Mr. White: How would Mr. Krug set about calculating the value of some of the benefits which engineers and economists have been accustomed to call "intangible"? I recall a paper read at one of the Section meetings about ten days ago, from a department in the United States Government, which assumed, for instance, that recreation benefits were important but could not be evaluated. If you do not assign a numerical value to such benefits in calculating the total benefits to be derived from a project, do you not in effect neglect or ignore them?

Mr. KRUG: Not necessarily. I recognize, with everyone here, that you cannot put a dollar measure on the value of a sunset over a beautiful lake. On the other hand, I think you can find ways of measuring the benefit to the people of a region in the existence of a beautiful lake to fish in and to look at, and on the shores of which cottages can be built. I think that these measures must be taken into account. I grant that in estimating values of that kind the degree of accuracy in the measure will be subject to a wide degree of judgment, and even in the case of the more concrete values the problem is not an easy one. My point is that you ought to put some kind of a tangible measurement on the benefits of a project as against its cost before going ahead with it.

The CHAIRMAN: I think it would be very timely if we could now have the views of Paul J. Raver, the Administrator of the Bonneville Power Administration in the Department of the Interior.

Mr. RAVER: It has always seemed to me that our experience in the Northwest at least has been that we have made great progress in the crisis method of approach rather than under the system of a sound determination of cost-benefit ratios. I think we are undoubtedly moving in the direction of adopting cost-benefit ratios as a basis for rational programmes, particularly in the last couple of years, but I recall that Bonneville Dam, the first unit in the Northwest, was built as a result of the crisis of unemployment in the depression of 1933. Appropriations were made on the basis of making work for people who were out of jobs. The same thing was true of Grand Coulee Dam. Following that crisis, there was the crisis of the war which stimulated the completion of those great power developments in regard to which, so far as cost-benefit ratios were concerned, the experts believed that there would never be any use for all the power they produced. The crisis of the war brought them into being and then when the war was over we had the crisis of adjustment to peacetime economy. Much to the surprise of everybody, the population of the Northwest continued to grow much more rapidly than any of the experts had predicted so that we found ourselves faced with a very severe power shortage, which still exists, and which is resulting in a tremendous speed-up in the programme of construction of dams for power to meet the present shortage. Incidentally, we had a crisis last year in the most disastrous flood that has ever hit the Northwest, and as a result there was a great scurrying around and revision of long-range plans to take care of flood control.

Out of all those crises we have learned a great many things. One of them is, since we are discussing here how we can gauge the public value of a comprehensive river basin development, that sometimes it takes a crisis to make us realize that the measure is really a national measure and that while these projects are of tremendous value locally and regionally they are also of tremendous value nationally from the point of view of security, employment or national income. If that determination can be made, and it seems that it can be made rather obviously when faced with a crisis, then the programme, it seems to me, should be considered as a sound programme. I think we have reached that point nationally. Looking at the whole Northwest development today, I am convinced that the change in attitude towards that development arose out of a national crisis which made it so apparent to everyone concerned that these river basins, and this one in particular, have such great national value from the point of view of wealth and as tools for the creation of new taxable wealth and taxable income and the creation of new job possibilities. The cost-benefit ratio is rather obvious.

Mr. KRUG: If I may interrupt, I should like to say that it is obvious to Mr. Raver, but it has not been obvious to the Congress of the United States. If it had been, we would not be behind by three dams at this point.

Mr. RAVER: I agree with that statement.

Mr. WHITE: Certainly one implication of Paul Raver's statement is that we should not lay too much stress on expert calculations of the cost-benefit ratio. In Chicago we used to have what was known as the "Iroquois Theatre Fire Theory of Social Progress". Nothing was done in regard to regulation of fire escapes and construction of buildings until a couple of hundred people lost their lives in a very tragic fire. Then they took steps. That, in effect, suggests that we correlate the undertakings of some of our major efforts with crises which make the social values perfectly clear in the public mind and that without such crises we might not be able to obtain public approval.

The CHAIRMAN: I now call on Dr. M. R. Bloch of Israel.

Mr. BLOCH: I derive some comfort from the remarks of the last speaker which indicate that a crisis might have some benefit. I come from a part of the world which is well known for crises, from the time of Sodom and Gomorrah, and I think that the Jordan Valley has reached another crisis now. But, it is a bit different from the other river basins because it has its private ocean. It might be that this type of river basin is of interest because of its possibilities for other countries as well. It could certainly only be developed under pressure of a crisis, and crises we have had.

However, I think it offers one further possibility. It offers mineral wealth through the use of sun energy. It is quite possible that, if the fresh Jordan river water should be diverted to the Negev for irrigation purposes and replaced by Mediterranean water, the Mediterranean water might be used for power production and also for the creation of a very considerable wealth which might be of importance to the whole world. This new water might bring some million tons of potash each year into the Valley. We might be able to get not only our power from it but, by the use of sun evaporation, we might also get this great mineral wealth.

We have a considerable field for the use of sun energy in the Dead Sea which, at the moment, serves as a regulator for evaporation. In a dry year the evaporation automatically decreases and in a wet year it automatically increases. The same regulation might be used for the creation of a mineral wealth many times greater than that which we obtain at the present time. Up to the present time, this has been financed by private enterprises. We have not had the benefit, as the water power users have had, of a guaranteed market. In the case of mineral wealth, there was no guaranteed market in the world. It was really a market which could not be guaranteed and will not be guaranteed. Therefore it has been left mostly to private enterprise.

I think it will be possible not only to harness the water power in the Jordan Valley but also to harness the sun power, thereby establishing a system of outgoing water and of water returning to its source, and extract mineral wealth on a large scale.

Mr. WHITE: Before calling on the next speaker, I should like to make a statement which I forgot to make at the beginning of the meeting. A number of the participants in this Section requested me to explain that they are speaking as individuals who have been invited to participate in this symposium and that their expressions of opinion on these questions are not to be considered as official statements. I apologize for having neglected that statement at the beginning of the meeting.

I call on Mr. Hathaway of the United States.

Mr. HATHAWAY: I rather gathered the impression from Dr. Raver's remarks that the construction of the Bonneville and Grand Coulee projects, which were precipitated by crises, were not economically justified on a cost-benefit ratio. I am sure that he did not intend our foreign colleagues to obtain the impression that those projects were not economically justified.

Mr. RAVER: Our net revenue, over and above all expenses including depreciation and interest, for this year was $9,800,000. We have had a surplus like that, from power operations alone, at those two dams every year of operation since the first three years. The total surplus on a cost-accounting basis is in the neighbourhood of $43,000,000. I am not trying to argue that dollars and cents form the basis of feasibility. In fact, our approach to the crisis method was the exact opposite. The broad gauge needs of a programme of this kind probably transcend the dollars and cents measurement of feasibility. However, I did not intend to imply that these two dams were not economically feasible.

Mr. KARPOV: Of course, in the United States we can go ahead on any basis we please. Firstly, we have money, and secondly, as Secretary Krug has also hinted, all one has to do is to make it obvious to Congress, then we can go ahead.

From the point of view of the representatives of other countries which have, in many instances, to get the necessary money, or at least part of the money, from the International Bank, the question raised by the Chairman is of the utmost importance. At present we have not worked out standards which the representatives of the various countries could put before the International Bank, standards on the basis of which they could insist that their project was economically sound or better than the others and, therefore, should have priority. Today, that is a question of putting all the data together and then more or less trying to compare them with the other data available. But the way we do that at present cannot be considered as being very scientific; it is more or less just a matter of putting figures together and then trying to argue around the figures. If some kind of internationally accepted standard could be developed which would enable these projects to be put in different classes so far as their desirability was concerned, that would be a very big and important practical contribution.

The CHAIRMAN: I certainly would support Mr. Raver's point of view that a crisis will enforce the execution of a project, no matter how costly it may be. In our country, we are faced with two problems—shortage of water and floods. These two problems, especially the latter, cause great damage, and public opinion has forced the government to carry out projects, which, although they are all multiple purpose, are designed firstly to deal with flood control and irrigation. The other purposes of the project are delayed until funds are available to carry them out.

Mr. KRUG: May I ask the Chairman whether in his country they promote flood control for everyone who wants it, regardless of its cost?

The CHAIRMAN: We have two rivers in my country, and once these two rivers are properly controlled we shall have solved the flood problem for the whole country. The Government has carried out one project for controlling the floods of the Euphrates, and they are going to carry out a project for controlling the floods of the Tigris.

Mr. KRUG: Will these projects prevent flooding on these rivers at all times?

The CHAIRMAN: Yes. I may add one thing, and that is that the Government is now protecting the land against floods as far as possible, and this is done at the expense of the Government.

Mr. WHITE: Dr. Ringers, formerly Minister of Reconstruction in the Netherlands, wishes to speak.

Mr. RINGERS: I have to admit that in Holland flood control has mostly been done in a crisis, the crisis of breaking dykes and so on. But, on the other hand, in working on the development of river basins, we still try to calculate the value of it, and the different figures we bear in mind are, firstly, power; secondly, irrigation; thirdly, drainage; fourthly, navigation; fifthly, water supply. Then there are a number of other figures such as flood control, sanitation and recreation. The last points cannot be so easily determined. We only calculate these if it is necessary.

For power, we have not very large demands, and irrigation is only known to us in Indonesia. I know that my Indonesian friends will tell us all we want to know. Navigation, water supplies and drainage are points which we know very well and we always try to study them and gauge the public value of the development. In the end, however, we have so much doubt as to the value of our figures that we cannot for the time being bring them to a conclusion. We come to a conclusion on the economic and social basis, but we go on calculating the values and hope that on the basis of what we have calculated in the past we shall be able to calculate for the future. I believe I can give advice to everyone here and that is try to do that, for in the end, you will be in a crisis if you always admit what everybody asks of you.

Mr. AUBERT: Mr. Goldschmidt has just made an extremely pertinent remark in saying that the money contributed by the public to the *Compagnie nationale du Rhône* was subscribed because there was a State guarantee and because, indirectly, the State was more or less financing the work on the Rhone.

I realize that the loans to the *Compagnie nationale du Rhône* were guaranteed by the State and that originally the public would probably not have lent that money in the absence of a State guarantee. Nevertheless, a very important factor is involved, namely, that the State in giving its guarantee took care that it would not be exercised. The State was willing to give the guarantee, but only with the quasi-certitude that it would never have to pay out any sums, since giving a guarantee without paying cost it nothing. Thus, the State was the first to verify that the various stages of the work of the *Compagnie nationale du Rhône* were indeed worth while.

The State bided its time, and experience had shown that the first stage will pay for itself. Thus, the State had not exercised its guarantee, and it might be said that, financially speaking, the State had spent nothing.

I would add that that was the situation when the *Compagnie nationale du Rhône* was started and that now the public has still more confidence, since it has seen that the first stage has paid for itself. The State continues to guarantee the loans, but the *Compagnie nationale du Rhône* invests them very easily, even more easily than the State. Thus, it might possibly be said that the Company is able to guarantee the loans to the State. I would not go so far as to say that, but the *Compagnie nationale du Rhône* now has its own funds, and that fact is due to its financial policy.

Mr. WHITE: Mr. Szyfres, in charge of the water and hydraulic work in Uruguay, will speak next.

Mr. SZYFRES:[b] I wanted to say a few words with regard to the use of water resources in Uruguay. The problem of the comprehensive development of river basins has been raised in the course of our meetings today. I will limit myself to my own country. In Uruguay, this subject has been studied very searchingly. We have studied very carefully the possibility of the multiple-purpose development of river basins.

Within the framework of its financial possibilities, Uruguay of late has developed the use of its various rivers for purposes of electric power production, irrigation, navigation, protection from soil erosion, etc. All these programmes were carried out by the State. However, our attention was mainly devoted to electric power and irrigation. While we did not neglect the other possibilities, we gave them secondary priority. The problem of electric power is of vital importance to my country because at present we lack solid and liquid fuel. Therefore, our energy resources are extremely important to our national well-being, and electric power produced from water was a stop-gap of the greatest importance. By resorting to this we avoided all the disadvantages involved in importing various fuels from abroad.

[b]Mr. Szyfres spoke in Spanish.

I am glad to have attended these meetings under the auspices of the United Nations, and to have participated in such an interesting exchange of views on questions of tremendous importance to my country as well as to others.

As regards Uruguay, I am unable to present details about our programmes, as it would require a great deal of time. I must indicate, first of all, that the potential resources of our rivers and river basins could reach the figure of 4 billion kilowatt-hours per year as far as the production of electric power is concerned. This figure is considerably above the figure of present production of electric power in my country. The potential resources, therefore, are far greater than the resources which are actually worked at present. For example we have the Rio Negro as one of the main possibilities. We have only two dams on this river. We could achieve a production of electric power of 500 million kilowatt-hours per year if the necessary development projects were carried out. The cost of the development project so far carried out in the Rio Negro is 27 million dollars.

We have developed along with the electric power production plant irrigation projects which permitted us to reclaim about 200,000 acres of land. At the same time we are conducting intensive studies on a system of dams and reservoirs on the Rio Negro in order to exploit all the potentialities of this river.

We try to draw as much as we can on the experience of the TVA and on all the lessons which are to be learned from the success of this great endeavour. Of course, our work will be on a smaller scale. Nevertheless, there are certain achievements of general application, and we are going to stick by them.

We have another project with a potential production of 40 million kwh. per year. Finally, we have a joint project with Argentina for the development of the Rio Grande, with the possibility of obtaining 5 billion kilowatt-hours per year. A joint technical commission with members of Uruguay and Argentina is conducting studies on the implementation of this project. I am representing Uruguay on one of these joint commissions.

We have an irrigation project in Uruguay providing for the irrigation of 15 million hectares. At the same time we are devoting considerable attention to drainage.

These data, which I am passing rapidly in review, are the main outlines of our future plans of river basin development. We feel that the tremendous achievements of the United States in this field show us the goal which may be achieved by other countries. The work which is contemplated in Uruguay in this field will also have repercussions in the field of international cooperation, as we have projects in common with Argentina. There is no doubt that such a new tempo in the field of international co-operation on this particular level will serve the cause of the United Nations.

The results achieved by Uruguay so far have permitted us to cover 70 per cent of our energy requirement by hydro–electric power. Thus we are more and more able to make up for the relative economic backwardness of our country. There is no doubt that all Latin-American countries have to depend, in the first place, on their own natural resources in the industrial field if they want to succeed in the struggle for economic development. However, while depending on our own resources, we have drawn heavily on the experience of other countries.

The CHAIRMAN: I would now like to call on Mr. Sain of India.

Mr. SAIN: How should we gauge the public value of comprehensive river basin development?

The question presumes that the economic test in gauging the public value will be applied to the complete programme and not to each of the analytically separable parts. The more profitable elements of the plan will thus contribute to the less profitable.

In my opinion, river basin projects must meet a general test of economic feasibility. This monetary check on costs and benefits is an important yardstick for selection of alternative projects, even if the rigid financial test of the past is not applied.

Such an economic test is necessary to prevent the present generation from borrowing from the future more than the project is expected to pay. The present must justify that the project will not be a burden to the future generations.

In assessing the benefits, no credit may be taken for the recreation facilities, but most others can be taken into account.

Once the minimum return on the capital is assured, the aim should not, however, be to obtain the maximum net return to the exchequer. The guiding principle in river basin developments should be the greatest good for the greatest number, irrespective of territorial boundaries within the same country or the watershed limits.

We all wish that ultimately this principle may be applied, taking this entire human race as the base, thus determining the feasibility of a project by the food and energy requirements of the whole world. Till this objective can be achieved, in the face of so many conflicting ideologies, let us be content to think that each nation develops a portion of world's resources. To confine the use of the waters of a river strictly to its own basin would fall far short of this ideal.

In the present temper of some of the countries, where ideologies sway more than economic considerations, a unified administration on an international level may only create deadlocks and delay the development, rather than help it. But a co-ordinating organization may be useful. Such an organization could not have any administrative responsibilities for developments for obvious resources.

Mr. WHITE: We ought to come to the conclusion of the first question which we posed for ourselves this afternoon—the question of how we should gauge the public value of comprehensive river development. I notice that there are several who still wish to contribute to this discussion. I propose to call first upon Mr. William Warne, Assistant Secretary of the Interior, and also to ask whether any representatives from the Tennessee Valley Authority feel that they would like to comment on this problem in the light of statements made earlier; and following that we are to hear from the representative of the Philippines.

Mr. WARNE: The question is as to how these values should be gauged. We have had a continuous and running debate in this country on that point, ranging all the way from strict dollar and cents accountability to a method which would completely submerge dollar and cents accountability in favour of some kind of social determination. It is most important, however, that we should devise a cost-benefit ratio and a method of measuring benefits because the problem of weighing the projects which are to come into construction and development in the United States is no less severe here than it is in other nations of the world.

This year we are spending somewhere between 800 million and 1 billion dollars on projects for watersheds that stretch from one coast of the United States to the other. These projects are for the most part projects that have been under way for some time; there are very few new units being begun this year. That does not mean that there are not many worthy projects that have been approved and adopted by Congress and which, presumably, may be developed some day. It does mean, however, that for the time being only enough money is being allotted out of the total national budget to satisfy the requirements of projects which are already under way and on which construction has already been begun.

The order and chronology by which new developments come into the construction programme—whether the programmes of the Department of the Interior, the Corps of Engineers, the Tennessee Valley Authority, or of any other agency—is of the utmost importance to all, it seems to me, and the problem of defining the costs and the benefits and of giving some sign or indication of how priorities will be assigned to the projects that are clamouring to enter the construction field is with us now in a form that is almost like that which Dr. Raver described as a crisis method earlier. We have proceeded to justify—and one can do it on a very sound basis, no matter how the measurement is made—a much larger volume of work than is being financed at the present time in the United States, so I doubt very much whether our problem is much different from that which has been described by some of the other representatives where they have projects which they believe are clearly justified with but insufficient means for tackling them at the present time.

We also have projects that are justified from any standards of measurement that have been devised up to this time, but are not going forward now because a limited amount of funds is available to put into them. It is for that reason, I think, that it is very important here, as well as throughout the world generally, that we should devise and adopt a standard by which the projects may be measured and their importance locally, nationally and in the entire world judged.

Mr. WHITE: We shall now hear Mr. Filemon Rodríguez, who is the manager of the National Power Corporation of the Philippines.

Mr. RODRÍGUEZ: In this discussion on gauging the benefits which will be derived from projects I should like to call attention to another factor. It is the need for developing the resources of any particular country. I should like to give as an example the development of water power in the Philippines. At this moment we are undertaking a programme of development where the value of the power which will be developed, computed on the basis of the cost of similar power generated from fuel sources, is still below the cost of developing it by such fuel sources. However, apart from the fact that the cost of the power to be generated by the hydro is lower than would be the cost if it were developed by fuel sources, there is the factor of developing our own resources. If we do not develop our water power we shall have to depend completely upon imported fuels which would have to constitute for an indefinite length of time a dollar drain on the resources of the country. By developing our water power we are conserving that foreign exchange and making it available for the acquisition of other things which the nation needs. Thereby we are contributing to the development of our resources, raising the productive capacity of the nation, and enhancing the purchasing power of the the country for goods that it needs but cannot produce.

Mr. WHITE: I think that we should move on to our other question. Mr. Clapp indicates that he does not feel that he wants to add anything more to this discussion. Mr. Menhinick of TVA, however, is prepared to speak.

Mr. MENHINICK: I should like to second the statement of Secretary Krug who said that it was highly desirable that we assign tangible figures to intangible benefits. The Tennessee Valley Authority has not done that to date. We estimate the benefits of our navigation, flood control and power programmes, and those benefits exceed the cost of the projects so that we consider the projects justified. We are interested, however, in finding a sound basis for estimating the benefit of the intangibles. We are working particularly on this matter of recreation, and we should be very happy to hear from others who are working on the same problem in the hope that we might pool our ideas and, between us perhaps, find some sound basis for estimating these intangibles.

Mr. WHITE: Water resource people certainly ought to be able to pool their ideas, ought they not? I think we should move to our second question in view of the usual hour of adjournment at 5.30. This question is one which flows naturally out of the first. Assuming that we have comprehensive basin development as our ideal and that we have what is, if not perfect, at least for the moment a satisfactory means of determining what programmes we should undertake at what time—and we have heard a good deal about the question of timing—how do we go about administering these programmes from the time of planning them, through the period of construction, and into the period of operation?

We recognize that planning, construction and operation may be carried on simultaneously in most of the great basins of the world. Can we develop unified basin programmes without having unified administration? Before calling on members of this group for comments I should like to show a slide which I think will give some weight to the international aspect of this problem, and which may interest us all in view of the very simple lesson which it gives. May we have the slide?

This slide shows a simplified map of the world in which the land masses are shown in white and all of the major rivers which cross international boundaries are shown in black. No river is shown which does not cross an international boundary. For example, we find among the major streams—and I shall not attempt to enumerate all of them—the Ganges system in India and Pakistan; the Indus system in India and Pakistan; the Tigris-Euphrates, which drains across four countries in that area; the Jordan; the Rhône; the Rhine; the Danube; the Niger; the Congo; the great rivers of South America—those draining into the River Plate; the Orinoco; the Amazon; and several of the great streams of North America—the St. Lawrence, the Rio Grande, the Colorado, the Columbia, and the Yukon.

I should like to direct your attention to the great areas drained by these streams and to the fact that, if we consider that we are seeking integrated development of each of these streams on the earth's surface, then, in very considerable measure, the problem of administration is a problem of international, as well as of national, organization for doing the job.

We shall now continue with the discussion. Dr. Ringers, would you care to begin the discussion?

Mr. RINGERS: If you ask me whether we can develop unified basin programmes without having unified administration, I should first like to separate the problem into three points and to treat each of them on two levels —(*a*) the national level, and (*b*) the international level. The three points into which the problem can be broken down are the question of planning, the question of construction and the question of management of the river basins.

As to planning, I believe I must answer your question with a definite "yes". Before doing that, however, I shall split up this question of planning into the different things which have to be done for planning. First, there is mapping; then, soil investigation; thirdly, meteorological investigation; then there are the geological features; and then comes the project, which cannot be done without a unified administration. After the project, we have to make an economic survey of the values of the country; then, an estimate of costs and benefits; and, finally, we must see where the money is coming from.

I believe that all these points require a unified administration. If you should try to accomplish them with different administrations, the plan would never reach any conclusion.

I have discussed that first point both on the national and the international level. In either case, I believe, the planning has to be unified. Without unified planning, there is no good plan.

As to the second point, the construction—and now I am dealing with the question on the national level—it is possible to develop the basin without having unified administration. This morning, we heard an excellent account of the experience of the United States; on the other hand, my own country has some knowledge of unified administration and its benefits. It is not my place to talk about the American experience. As you know, however, we were faced with the problem of the reclamation of the Zuyder Zee. Many, many administrations were working on the same plan: the provinces, the municipalities, the Catchment Boards and the Departments of Finance, the Interior and Agriculture. We worked on it, I believe, for thirty years. There were always new plans. That was not only because so many were working on it, but because it was necessary first to have good equipment in order to do the work. In any event, our government understood that we had


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to have a central service to do the job, and we have had very good experience with that.

The last point has to do with management. That depends on the particular country and on the choices that it has. In many countries, there is already a unified administration for a river basin, and then there is no question. In the old countries, however, we have many administrations, each of which does its own job the best. In Holland, after construction is finished, we have the new municipality, which does its own work; we have the Catchment Board, which does the work of drainage and pumping and protection of the dykes; we have an administration for the public land. The old service, which built the project, is eliminated from the picture and goes on to its next job.

I repeat, then, that for planning it is absolutely necessary to have a unified administration; for construction, I believe, it is the best thing; and, as far as management is concerned, we can do without it.

As far as international basins are concerned, that presents a very difficult point, because you then come to the question of the independence of all the countries. As I have already said, however, I believe that, if a river basin which goes through many countries has to be developed, the planning has to be done on an international scale by an international committee. How that committee is to be appointed is another question which has to be considered. We shall not have time to develop all the possibilities along that line, although we have some experience on that point: since 1830 we have seen the workings of the Rhine Commission, which was based on the Peace Treaty of 1815. This committee, however, had supervision over the work only to the extent that no land was to damage any other land. For instance, it had to take into consideration the height of the bridges, so that ships would have no trouble when they tried to pass under the bridges. But it had nothing to do with water pollution, water power and such matters.

This shows that the collaboration of many countries is possible. I therefore believe that it is possible for planning to be done by an international committee appointed by different countries. But there is no way of making the different countries accept this work. If the river passes through four countries and one of the four does not want to do this, we simply have to hope that many countries will come together and form some new country like the United States of America—the United States of Western Europe, for instance, or the United States of the Tigris and Euphrates—although I understand that bringing together the various States into what is now the United States of America was not so easy.

In such construction on an international basis, there must be, as I have already said, an estimating of costs and benefits. At the same time, one must decide what each country is to do and the time within which it is to do it. There must be a treaty between the countries, and there must probably be some provision to the effect that, if there is any difficulty, a country can go to an international court for a decision. In the end, the management will be conducted in the same way as in the case of the Rhine—that is, under the supervision of an international committee with members from the different countries. I say again that our experience indicates that that is possible.

In regard to a unified administration, then, I say that we should have it only for the planning; that we should be careful as far as the construction is concerned; and that we should not have it for the management, but should have only supervision.

The Chairman: Mr. Angus of the United Nations Economic Commission for Europe and a Programme Officer of the Conference has a statement.

Mr. Angus: I should like to remind Dr. Ringers that the committee he has in mind already exists. We are working on this very problem of international co-operation in the development of river basins in Geneva. I agree that the problem can be divided into three parts, a problem of planning, a problem of construction and a problem of management. So far as planning is concerned, we have already attained a remarkable degree of co-operation; that of course is fairly easy, since you can get people to agree to do things if you cannot always get them to do them.

On the constructional side the feeling so far is that the ownership of a plant should be vested in the country on whose territory the plant is constructed, but there is quite a degree of co-operation in the actual construction. For instance, there are plants under consideration in Austria which will probably be constructed internationally in that equipment will be imported from countries other than Austria, labour will come from Italy, there will be entirely necessary contributions by the International Bank in the form of dollars, and so on. On the operational side, so far as we can determine at the moment, the opinion of the delegations to the committee I have referred to is that that operation should be left to the nation on whose territory the plant is built but that there should be a board with representative members from other countries through whose territory the river passes.

One of our early difficulties in considering this problem has been the fact that so far there is no common form or common basis of international agreements for the development of rivers and lakes which cross international boundaries. During the past twelve months we in Geneva have been endeavouring to collect copies of all the agreements and conventions applicable to Europe in order to try to determine what common basis exists with a view to trying to persuade the various nations to adopt a common form for future work. If any of the delegates at this Conference are interested in the possibility of extending this basis of agreement to a wider sphere than Europe, I should be pleased to see them and discuss the point with them, or correspond with them afterwards. We are actively working on the matter and expect to place proposals in this field before the Power Committee of the Economic Commission for Europe in the near future.

Mr. Bloch: I should like to ask whether anyone has any experience, when river basins pass through different countries, of devising a procedure so that the political aspects are completely separated from the technical aspects? Is this possible, and if so how far is it possible? Can the technical people prepare the basis and make alternate plans on which afterwards the different political interests are worked out and co-ordinated?

The CHAIRMAN: I see that Mr. Raul Sanguinetti of Uruguay wishes to speak.

Mr. SANGUINETTI:[e] I should like to say a few words with regard to the way in which Uruguay and Argentina approached a joint project which they wanted to carry out. We are studying a convention which has not yet been approved by the countries concerned, but nevertheless a committee has been created in the meantime to deal only with the technical aspects of the problem. It has studied the hydraulic, topographical and geological elements of the problem and has drawn up a preliminary plan. Both countries have representatives on this committee, and once the technical plans have been drawn up they will be submitted to both governments, which will have to come to an agreement and if necessary introduce amendments into the technical plan.

Mr. WHITE: Do participants feel comfortable about the idea that it is possible to get technical men together on data and plans for international basins and that it is not necessary to have a large degree of international administration in so far as the actual management of the works is concerned? I see that Mr. Hamid of Pakistan is prepared to speak on this subject.

Mr. HAMID: In the case of international rivers where joint development is essential, the planning would have to be done jointly, and that would mean international commissions. The planning of works can be done individually according to their location in each country, but control and management is a very important matter which can only be dealt with by an international commission. No other method can be devised to ensure proper management and equitable apportionment and regulation.

The question arises in this connexion whether there should be unified administrative control within each country apart from the international commission. So far in my country it has been found that works have been progressing very well even without unified administrative control, for the simple reason that it so happened that the technical services were better developed in the various departments than the civil side controlling law and order. Generally, it has been found from experience that in the case of unified administrative controls it is the civil side which gets in first because of its political influence and because of having to deal with law and order. This has hampered progress. We, however, have been getting on well with our technical developments without unified administrative control. In the case of international rivers, where there is an international commission, it may be necessary to have unified administrative control within each country, because the problems which have to be dealt with by the commission would have to be referred to various departments if unified control did not exist and that would make things very difficult.

Mr. WARNE: Experience upon our border to the south might indicate a means of solution that could be used. Is there anyone here from the International Boundary Commission between the United States and Mexico?

Mr. WHITE: I do not see anyone from that Commission, but we have someone with experience on the other border, Mr. Strome from Canada, and with him is his American counterpart on the International Joint Commission which deals with the waters flowing across the Canadian-American border.

Mr. STROME: In making these remarks, I am speaking as an engineer who has served and is still serving on Boards under the International Commission, both in investigatory work and in actual operations. I should like at this time to repeat, and perhaps to expand briefly, an earlier statement which I made in regard to the manner in which boundary water questions are settled between the United States and Canada. The Boundary Waters Treaty between these two countries was signed in January 1909, almost fifteen years after the idea was first suggested at an International Irrigation Congress held in Denver, Colorado. The high purpose of the treaty is set out in the preamble which reads in part as follows:

"To prevent disputes regarding the use of boundary waters and to settle all questions which are now pending between the United States and the Dominion of Canada involving the rights, obligations or interests of either in relation to the other or to the inhabitants of the other along their common frontier, and to make provisions for the adjustment and settlement of all such questions as may hereafter arise."

Among the articles of the treaty is one providing for the establishment of an International Joint Commission composed of six members, three of whom are appointed by the Government of the United States and three of whom are appointed by the Government of Canada.

This Commission was organized about three years after the treaty was signed, which would have been 1912. It has jurisdiction and passes on all questions involving the use or obstruction or diversion of the boundary waters or waters crossing the boundary between the two countries. Projects which might have an injurious or detrimental effect on the nationals of either country may not be initiated until they had been referred to the Commission for investigation and report. The governments of both countries are bound by the decision of the Commission. It was at first thought that the Commission would eventually split along national lines. As a matter of fact, in the thirty-seven years in which it has been operating, it has only split along national lines on one occasion and that was over a minor question of procedure. It has never failed to reach a decision on any matter brought before it and, in practically every case, its decision has been unanimous.

Therefore, we have an example of a voluntary arrangement between two nations, one very large and one comparatively small, which puts both on a footing of absolute equality. It has been said that these two countries are joined rather than divided by the imaginary line which runs from sea to sea and across the Alaskan Peninsula, a total distance of some 4,000 miles.

In conclusion, may I quote from a statement made by the late Lord Tweedsmuir. He said:

"The International Joint Commission has, since its foundation, shown the world an example of the true machinery of peace which settles disputes before they arise and thereby perpetuates the unwritten alliance of friendship between two nations."

[e]Mr. Sanguinetti spoke in Spanish.

Mr. White: I think it would be helpful to hear now from Mr. Weber of the U. S. Army Corps of Engineers. However, before asking him to speak, I should like to pose a question. Is it possible that, while there has been amicable settlement of issues that have arisen, the machinery of settlement and of agreement is such that the volume and tempo of constructive forward development has been smaller on the international sections of the stream than in the interiors of the respective countries? One might have amicable arrangements which proceed slowly. They might proceed so slowly that you would have a great retardation of work. I was thinking, for example, of the St. Lawrence.

Mr. Weber: I shall try to cover that point as well as several others.

There are a couple of points which I think might be of interest in regard to the International Joint Commission between Canada and the United States. The first point is that it has been true in this field of water development, just as in all of our civil affairs, that when two nations wish to get together in a matter of this type they must at some point relinquish some of their national sovereignty. This, in effect, has been done in the form of the International Joint Commission. The United States and Canada have, in effect, delegated certain powers irrevocably to this Commission. Those powers have had to do with decisions on certain questions regarding the use of the boundary waters and waters crossing the boundary. The two nations which joined in the Treaty reserved to themselves certain powers, but they set up the machinery for handling any conceivable question which might arise in the use or development of boundary waters. This machinery is known as the International Joint Commission, and it can be utilized upon application of either government in regard to any question which it considers timely or desirable of solution.

There is always the question of speed to which Dr. White referred. Perhaps that is one of the most serious problems to be faced by any organization which attempts to deal with international problems. But I believe that the speed with which water resource development problems can be solved by an international commission is entirely dependent upon the spirit in which the participants face the problem. If they are unquestionably mutually desirous of reaching a prompt solution, they can reach a prompt solution by that method as quickly and as effectively as by any method that can be devised. The history of this Commission between Canada and the United States, over a period of nearly forty years, shows that most of the problems have been disposed of very promptly. Most of those problems have been relatively minor in scope. However, currently, there are several major problems facing the Commission.

One of these problems is a very broad investigation of the water resource development possibilities of the Columbia River. It will require many years of the engineering investigations necessary to form the foundation for deliberations on that question. It is proceeding with considerable despatch, and it will prove very valuable to both countries as a basis for the development of that great river for their mutual advantage.

In a question such as the one regarding the St. Lawrence, to which Dr. White referred, the situation is a bit different. A very thorough investigation was made under the auspices of this international machinery. The investigation was completed and a report with recommendations was made by the Commission to the two governments. The delays, questions and problems inherent in the St. Lawrence were not involved in the International Joint Commission's efforts but in the developments subsequent to the Commission's action and were attendant upon circumstances arising in each country in regard to the desirability of the development and so on.

Mr. White: There are several others who have indicated their desire to speak. The Chairman, I believe, wishes to say a few words on this point. We ought to recognize that while there are instruments of a certain character for international co-operation on such rivers as the Rhine and those on the Canadian-United States border, some of the great streams of the world which appeared on the map shown to us a while ago involve extremely serious problems which do not as yet have even a semblance of co-operation among the countries involved.

The Chairman: It is admitted that in studying a comprehensive plan for the development of certain rivers of an international character, the agreement of all the countries concerned should be obtained, and their interests should be taken into consideration. This is particularly important for one development of ours, that of the Euphrates, but there is another river which is adjacent to my country, and that is the Jordan. Mr. Bloch has touched upon the subject of the development of the Jordan by diverting it to the Mediterranean; that is, outside the river basin of the Jordan. I should like to point out that the Jordan also has an international character, since its basin lies within four countries. I wonder whether, when considering the diversion of this water supply outside its basin, one should not consider the interests of the other countries within the basin of that river. I know that one of these countries, Transjordan, is now studying its own scheme for the development of its own land within that basin, especially in connexion with the fact that certain Arab refugees who want to stay in that country will have to be settled there and, therefore, Transjordan would require its full share of the water of the Jordan until its schemes are developed. This shows that rivers of an international character have to be considered in the light of the full interests of all concerned, and not in the particular interest of one or two countries alone.

Mr. White: Mr. Guillaume, head of the Division of Agriculture, Pasture, Forest and Wildlife for the French Ministry of Overseas Affairs, will speak now.

Mr. Guillaume:[d] I should like to speak very briefly on the experience acquired by the Niger Office in French West Africa in connexion with the development of a river basin and, in doing so, I shall give a personal reply to the second question that is being discussed today.

The conception and organization of that Office were based on the principle of entrusting to a single administration, which is an emanation of public powers, the study and implementation of all technical, economic and social initiative involved in the development of all the

[d]Mr. Guillaume spoke in French.

agricultural and, possibly, energy resources of a vast river basin, that of the Niger.

Although the experience acquired is still fragmentary and incomplete, and cannot possibly be compared with that of the extensive TVA, it may be useful to recall it here. Nevertheless, I feel obliged to explain the nature, structure and plans of the Niger Office, before giving my fundamental conclusions on the matter.

The Niger Office is a public institution, which has its own civil status and is financially autonomous; it is financed by investments from the overseas territories and has an administrative council composed of high officials of French ministerial departments, of high officials of the general Government of French West Africa and the Government of Sudan, of experts and of representatives of the indigenous populations. It controls several services for general studies, agronomic research, new constructions, colonization, exploitation, administration and finance.

The main work of the Office, which was conceived by the great French engineer Beline, consists in the reflooding of the branches of the left bank comprising the former internal delta of the Niger, which are at present dry; the reflooding would be made possible by the construction, at the point where the branches diverge, of a large dam, which was completed in 1947 and which has raised the level of the river upstream by approximately four metres.

The rate of the work, which was begun in 1932, but which was considerably slowed down by the war, made it possible to cultivate, with the help of the neighbouring dam at Jotuba, 21,000 hectares (52,000 acres) inhabited by 24,000 people who were grouped into co-operative associations for the technical activities and into colonization centres for their political and social life.

The irrigable surface served by the dam is estimated at 450,000 hectares (over 1 million acres), with due account of the necessity of retaining a minimum flow for navigation at low water. The possibilities of rehabilitation would be considerably extended and might reach approximately 3 million acres if a vast reservoir were constructed on one of the main tributaries of the upper river (Nianda), which would make it possible to raise the level at low water.

The plan is at present being studied. It would have the following advantages, among others:

(*a*) That of providing a considerable amount of hydro-electric energy;

(*b*) That of regularizing the navigation of the river;

(*c*) That of distributing agricultural hydro-electric installations throughout the valley.

The implementation of those plans in a territory which is still under-developed, which still has a primitive economic structure, since it lacks surplus man-power, and where, in fact, everything is still to be done, could not fail to involve errors of planning and execution. Practical experience has made it possible to correct these errors gradually, and I shall now give you some essential information on the factors of efficiency and proofs of our success.

On the administrative plane, or, in other words, on the organic plane, the work to be carried out was originally dependent upon an administrative service of the Government of French West Africa. That arrangement was extremely inflexible and all action was paralysed by administrative formalities.

The establishment of the Office in 1932 remedied those deficiencies, but the centralization of the organization in Paris was excessive, and the loss of contact with the local administration gave rise to many difficulties and conflicts of authority which hampered colonization in particular, and created an unfavourable atmosphere for the institution. The organic structure laid down by the Law of 1948 seems to be satisfactory. It reintegrates the Office within the economic, political and social system of French West Africa and also serves to retain the regular institutions of public power in the areas concerned.

In the technical sphere, I may be obliged to mention several platitudes; we are, however, concerned with fundamental facts, and lack of success is often due to ignoring those facts.

River basin management has to be preceded by pedological and phytographical prospection and by extremely detailed topographical studies, the total cost of which is between 15,000 and 20,000 francs per hectare, in order to eliminate all land which does not fulfill the optimum conditions for development.

In the second place, the development of agricultural techniques should be extremely detailed and should be carried out in the place where the colonists are to settle; it is therefore essential to set up experimental stations two to four years before work can be begun in the interior.

In the third place, in order that the colonists might have an adequate income and a satisfactory standard of living, superior to that of their country of origin, the semi-mechanization of the exploitation is necessary, in order that the area worked by a family should be about a dozen hectares.

Finally, still in connexion with the technical sphere, it would seem that the industrialization of soil products on the spot is an absolute necessity, in order to set the maximum value on production and to facilitate the restitution of the by-products of the industry to the soil.

In the social sphere, the difficulties encountered in the colonization of restored land, which seemed to be unsurmountable at the outset and sometimes seemed to jeopardize the future of the Office, have been overcome. More satisfactory living conditions, respect for the manners and customs peculiar to each race, the restoration of traditional social patterns and the maintenance of relations with the countries of origin are the proofs of our success.

It is obvious that all those initiatives could not be carried out merely by co-ordinating the various services responsible for them. It seems to be absolutely necessary to provide for a joint authority and that is why I consider, for my own part, that the pattern of a single administration for the development of the Niger Valley is correct and useful. I would even say that it might be a first stage and a first step towards a wider organization, which would place the problem of the management of the Niger on an international basis.

The Chairman: I call on Mr. Alexander Kalinski of Greece.

Mr. KALINSKI: I think that all previous speakers, when they insisted on "unified administration" in river basin developments, had in mind rather a local administration for each specific river basin, like the TVA. In such a case the unified administration for the development of the water resources of a specific area is recommendable and also feasible.

But when one goes to the nation level, to the government level, the unification becomes more difficult, I dare say almost impossible.

The reason is that water enters into too many branches of the national economy, of paramount importance, like agriculture, power, transport and housing. Thus it is not possible to have a single governmental instrument to deal with all those aspects of water utilization, which are so intimately connected with the development of other resources of prime importance like soils, fuels etc., which pertain to different governmental agencies.

The problem of having a unified control on the various water uses of a whole country or nation may be solved if one uses the legal concept according to which all waters are considered as a part of the public treasure, and as such they have to be administered by the State. The establishment of a governmental agency with the sole task of administrating the waters, i.e., releasing licences to the various branches of the economy, represented by their responsible government agencies, to use a certain river, lake etc. for a specific purpose, will give the opportunity:

(*a*) Of examining in a co-ordinated way all the development possibilities.

(*b*) Of settling conflicts that may arise between various branches of the economy on the exploitation of a specific water resource.

(*c*) Of setting up limits to the activities and responsibilities of two or more governmental agencies interested in the same water for different purposes.

For the accomplishment of such a task this body should possess complete records of the water resources, which means that the National Hydrologic Service should be under its control.

Mr. SAIN: Can we develop unified basin programmes without having unified administration?

Experience in the Tennessee Valley shows clearly the advantages of entrusting the entire management to a special organization, such as TVA, giving it full powers and good financial resources.

It is not difficult to imagine the confusion which might have followed, had several sets of engineers, each responsible to a different agency, attempted to develop the river for flood control, navigation and power.

But the widespread use of TVA method may present certain serious drawbacks from the national point of view.

It is well known that Mother Nature's distribution of water does not always coincide with her children's requirements. Economic expansion of large areas may be completely dependent on imported water supplies.

The Central Valley of California and the Colorado Big Thompson projects may be cited as current cases in point in the United States. The great Missouri Basin project includes several daringly complex water transfers. Then there is the proposed Gunnison-Arkansas project, which would divert water from the tributaries of the Gunnison River through continental divide tunnels to the Upper Arkansas River.

From Australia may be cited the proposal to divert the Snowy River water into the Murray River.

In northern India, the waters of the Jhelum river were diverted into the Chenab, thus making Chenab waters available for the irrigation of lands in the basin of the Ravi river. These are similar projects in other parts of India.

If each of these river basins were administered by an autonomous authority, the waters of each river would have been jealously guarded, making such diversions very difficult.

Considering all points, the Government of India has recently sanctioned a special administration, called the Central Waterpower, Irrigation and Navigation Commission in the Ministry of Works, Mines and Powers.

Without a National Authority for the co-ordination and control of water, this important resource may not be used for the best advantage, particularly when more than one State or province are concerned. The actual execution of works is a matter which could be left to local conditions in each case.

Mr. WHITE: I think we have time to carry this question of unified administration just one step forward. I call on Mr. Goldschmidt.

Mr. GOLDSCHMIDT: With all respect to the excellent work of our colleagues around this table, I think we had better face up to the fact that as yet we have had no satisfactory solution to any international river problem. I had thought of taking you on a little travelogue around the world along those rivers on the map, but I do not think time will permit it.

I say this entirely in my personal capacity. Those rivers are not merely resources; they all represent problems. For instance, we hear about the Indus as the problem of Kashmir, but it is also a problem of developing the resources of the Indus, and particularly of those international tributaries that can create great benefits or great havoc. The Nile is an international river that affects the lives, or could affect the lives, of 18 million people. There are about 4,000 years of water data on the Nile, and as yet there is no effective international plan for its development. The Rhine River has had about 100 years of international organization, on which a great deal has been done, as Dr. Ringers has told us, and yet Dr. Ringers complains about the quality of the water he is getting in his country because of the pollution upstream on the Rhine for which this international organization is inadequate. Moreover, on the Rhine there is no way in which upstream engineering can be developed jointly or co-operatively by the various countries.

Now this problem is not only true of the Far East and Europe. Here in America we have international organization on the largest and longest undefended border in the world. Yet on the Columbia River, this country started a development that was planned without reference to Canadian waters. In fact, the engineers have told me repeatedly that if there had been a truly international plan for the Columbia, the entire structure at Grand Coulee would have been different and perhaps even located in a different place.

As regards the St. Lawrence, everyone who reads the newspapers knows that thirty-seven years of international co-operation with Canada have not yet produced a St. Lawrence development.

I am not suggesting that that was the work of the Commission, but I am merely suggesting that there are no international setups at present adequate to the task of resolving these river basin problems, and I am not going to suggest a solution to that problem. I am not suggesting international TVA's. I merely suggest that rather than justify our current international organizations for river basins, we use the same forward, bold thinking that created the TVA in this country to find a solution to this problem of international rivers.

Mr. White: Mr. Goldschmidt has not offered us any solutions. I am afraid we have drawn no clear-cut solutions from this whole discussion; but it was not intended to. It was rather intended to open up the issues and to expose great differences of approach, and also the many issues that countries share in common from one great basin to another.

Certainly we have had agreement today that in developing comprehensive basic plans an effort must be made to take into account all benefits which accrue to the population involved. We have had no agreement as to how one should go about that and how one evaluates these very difficult intangibles. In fact, we have had some doubts submitted as to the practicability or advisability of attempting these precise evaluations. The suggestion has been made that perhaps situations of crisis will dictate decisions rather than precise cost-benefit ratios.

We certainly have had no solution on the problem of administration, but there seems to run through the discussion, I would say, a recognition that some sort of unified management is desirable—whether it is the kind of unified administration which has been developed on the Niger and which hopefully may lead to some comparable international system there, or whether it is a continuation and expansion of some of the joint planning that has already taken place on certain of these international boundaries.

I think we would all recognize that our discussion this afternoon has been very largely in technical terms, but that each of us would recognize that behind the technical terms is a keen realization that it is the welfare of the people who inhabit these valleys which is our major concern, and which welfare in turn is the final gauge of feasibility and of efficient administration.

I realize there are some around this table who would have wanted to contribute at the conclusion of this discussion, but time does not permit it. With these words I should like to draw the discussion to a close and turn the meeting back to the Chairman.

The Chairman: The meeting is adjourned.

Review of the Conference—A Symposium on Future Lines of Study and Directions for Progress

Tuesday Morning, 6 September 1949

Chairman:

William BORBERG, Permanent Representative of Denmark to the United Nations

Discussion Leader:

Carter GOODRICH, Chairman of the Preparatory Committee, United Nations Scientific Conference on the Conservation and Utilization of Resources

Symposium Participants:

S. S. BHATNAGAR, F.R.S., Secretary to the Government of India, Department of Scientific Research

Miss Isabella LEITCH, Director, Commonwealth Bureau of Animal Nutrition, Rowatt Research Institute, Bucksburn, Aberdeenshire, Scotland

M. JOLAIN, *Inspecteur général des eaux et forêts,* Orléans, France

Michael GRAHAM, Fisheries Laboratory, Ministry of Agriculture and Fisheries, Lowestoft, Suffolk, England

G. C. MONTURE, Chief, Mineral Resources Division, Department of Mines and Resources, Ottawa, Canada

Pedro I. AGUERREVERE, Consulting Geologist, Caracas, Venezuela

Edy VELANDER, Director, Royal Academy of Engineering Sciences, Stockholm, Sweden

Arthur E. GOLDSCHMIDT, Special Assistant to the Secretary, United States Department of the Interior, Washington, D.C., U. S. A.

Egbert DE VRIES, Professor, Agricultural University, Wageningen. Counsellor to Ministry of Overseas Affairs, The Hague, The Netherlands

General Discussion:

Messrs. HAMMOND, BLONDEL, RAUSHENBUSH, P. F. JENSEN, SAMUEL, J. EDELMAN

Programme Officers:

Alfred J. VAN TASSEL and Herbert SCHIMMEL

The CHAIRMAN: I declare open the seventeenth plenary meeting of the United Nations Conference on Conservation and Utilization of Resources.

We have on the agenda for today "Review of the Conference—A Symposium on Future Lines of Study and Directions for Progress".

Out of respect for the work accomplished and the work you are going to do this morning, I do not intend to make any introductory speech. I shall ask our discussion leader for today, Mr. Carter Goodrich, to lead the discussion of the symposium. Nine members of the Conference have agreed to prepare statements. When they have delivered their statements, other members of the Conference who may so desire can speak. I will grant them three minutes, but my gavel will get nervous when that time is up.

I now call on Mr. Goodrich, Chairman of the Preparatory Committee.

Mr. GOODRICH: The members of this morning's symposium have the great privilege of reviewing the work of these three weeks and of attempting to draw from it indications of the most hopeful directions for progress in the wiser use of man's resources. They will try to convey something of the excitement and the human promise of the improved techniques that have been outlined here. They will examine the obstacles to the application of these methods. They will indicate what seem to them as individuals the points at which further study is most needed, and the points at which there is the most pressing necessity for positive action.

This is a large undertaking, and my colleagues wish me to say at the outset that we approach it with humility and with a full sense of our limitations. We are not and cannot claim to be the voice of the Conference. The Resources Conference has no single voice. For two good reasons it cannot have. In the first place, Mr. Chairman, you and your colleagues on the Economic and Social Council did not commission the Conference to make formal recommendations. You did not invite us to attempt to advance knowledge by voting. You did not wish the experts gathered here to squander their time in the processes of drafting and necessary compromise that go into the formulation of generalized resolutions. They have had other work to do. The second reason is more fundamental. Those who have taken part in the Conference have done so not as political representatives but as individuals chosen for their technical or administrative expertness and free to tell what they knew and what they believed. As scientists and experts, they are to be counted as belonging to that great unregimented intellectual union in which, as the humorist Mr. Dooley pointed out many years ago, "ivry mimber is a walking delegate."

But if the first characteristic of scientists is their individualism, surely the second characteristic is their co-operativeness. They are eager to share their methods and their results. This is shown wherever in the world scientists are free to co-operate. It has been richly demonstrated in these meetings. The United Nations and its specialized agencies are engaged in the organization of a program of technical assistance to the less-developed areas of the world which offers great promise for the peaceful progress of mankind. In this programme the present Conference has taken its place, not as a meeting to discuss how much aid may be rendered, but as itself a step in technical assistance. What we have been doing *is* technical assistance, but of a nature notably mutual and many-sided. The experts of every country, no matter how well equipped, have had things to learn as well as to teach; and participants from each of the fifty countries have had significant contributions to make to the pool of knowledge and experience. The world's store of technical knowledge is indeed a great human resource which grows as it is shared. This Conference is an act of sharing.

Because of the great importance for our problem of this store of knowledge, I should like to call first on a member of the panel who has direct responsibility for the fostering and application of scientific techniques in relation to programmes of economic development: Dr. Bhatnagar.

Mr. BHATNAGAR: When I was asked by the organizers of this meeting to sum up and review my impressions of this Conference, I confess, I did not feel quite at ease, for I had heard from stray laymen who have graced the Conference with their presence conflicting opinions on the various aspects of our memorable meetings.

I heard one lady for example say boldly that the Conference had been a complete failure. Fancy, she said, some hundred famous scientists of the world meeting and discussing all kinds of subjects under the earth without making any recommendations or even passing a resolution. What a waste of effort and money! I heard another lady contradicting the first one even more vehemently and saying what a wonderfully sane, well-thought-out and well-planned Conference it was; where intelligent men and women listened to and discussed subjects of the utmost importance in order to chew and digest the intellectual fare that was served and to convey to their fellow countrymen in every nation that was represented at the Conference, the gist of what the world is doing in an all-out effort to better the lot of man by the aid of science and technology. What an astounding confusion would it be if these six hundred scientists tried to draft resolutions acceptable to all of them and capable of being foisted on their respective governments and organizations. Not a single resolution would have been carried and the whole of their time would have been wasted in finding faults with the phraseology and punctuations in the many drafts which would have been framed.

Somebody complained that there were far too many papers in the sectional meetings and immediately somebody contradicted by saying that in his opinion, there were not nearly enough technical papers. But these are minor details in which people must differ. There is complete unanimity amongst all the delegations who have attended the Conference that the whole meeting has been a grand intellectual treat from which results of lasting interests to all nations are sure to accrue. I asked some over-critical and somewhat difficult-to-please friends in the Minerals Section of our Conference and they unanimously thought that this Conference has succeeded in focussing world-wide attention as no other conference had done before on many aspects of the great mineral industry so that a good deal of wastage at present going on in this industry will probably be diminished and in some cases even altogether eliminated.

World statistics of mineral resources, presented by Mr. Pehrson of the U.S. Bureau of Mines, have brought out the fact that the known reserves of copper, lead, zinc, tin and chromite will barely suffice us for forty to fifty years at the present rate of consumption. We are a little better off for aluminium and manganese ores. We have, for some time, been hearing of the fast depleting reserves of petroleum, and though new discoveries in Arabia are heartening, there is no gainsaying the fact that we are using petroleum products at an accelerating rate and that an acute shortage may be felt fifty years hence if all the world uses motorcars and aeroplanes as much as the United States does. Only in the case of iron and coal does there seem to be no danger of depletion for several centuries to come. The position with regard to the base metals is, therefore, serious and calls for the adoption of all measures to conserve supplies.

Advances in mechanization of mines and in the adoption of proper methods of working are of much importance to us. In India an average coal miner is said to produce barely ¾ ton of coal per shift as against the 6 or 7 tons in the United States. Mechanization of mining and haulage can not only eliminate a lot of unnecessary drudgery but will also contribute to the reduction of costs. We have learnt that the United States is now able to mine and beneficiate hematite ores containing 50 per cent iron whereas in India we are still using 65 per cent ore. There is a lot of low-grade manganese ore in India, analyzing around 40 per cent manganese for which there is no market, and which, if mined, is often discarded and wasted. This and other minerals of comparatively low tenor can and should be beneficiated, adopting the latest techniques of milling practised in the United States.

We have learnt in the Conference that important improvements in the metallurgy of iron and steel are taking place, in the control of slag composition, in using high blast pressure and high top-gas pressure and in enriching the blast with oxygen, these contributing to a larger output of iron and less coke consumption. The use of nearly pure oxygen for the blast, with a change in the design of the blast furnace, is a development which we shall watch with interest as a potential large producer of iron and steel.

The papers on the light metals, aluminium and magnesium, as also titanium are of great interest to many of us as the raw materials—bauxite and clay, sea water and ilmenite—are abundantly available. Aluminium and magnesium are already being used in large amounts and we have been told that in a decade titanium will also be available in large tonnages. These metals are of great interest not only to countries possessing poor resources in iron, manganese, nickel and ferro-alloy elements but also to others, since they are indispensable for the aeroplane industry and for transport in general.

Beneficiation techniques and the recovery of useful materials from flue gases and fumes show ways of recovering many useful minor materials of importance to industry. The common adoption of these all over to the world would help us in obtaining several of the less common elements and other useful products.

Our difficulties in the way of learning and adopting recent advances in technology are due to lack of equipment and personnel. We need the aid of the highly industrialized countries both for training our technicians and for giving us the equipment needed for setting up new industries and processes. It is to the interest of the whole world that the technically backward countries be helped in order that at least from now on they can adopt approved methods of conservation and utilize their mineral resources wisely and without waste.

The contacts which we have established have enabled us to know where one can tap for trained personnel and experts. Even before coming here we have been lucky in persuading some of the experts to come out and help us in India. The intimate contacts now developed have enabled us to secure many more helpers in the cause of our country's development from amongst the noted scientists of the whole world. I am sure what we have achieved already has been exceeded by other nations who may have participated in such a search for talent.

What has impressed us most in this Conference is the cordiality with which scientists exchanged their views. This has paved the way for the removal of several misconceptions and wrong ideas about the methods of development followed in different countries. For instance, it is now realized, at least so far as the development of fisheries is concerned, that different regions have their special problems and that there are no standard methods available which can be applied without a great deal of previous exploration and experimentation. In fact, it may be dangerous to generalize in this matter.

Another fact which has emerged from the discussions inside the meetings and outside them is that in any resource development technique there is great need to study the human factor at the outset. In fact, it has been felt that gradual evolution from empirical traditional methods to more advanced techniques is likely to yield better and more lasting results than the revolutionary changes unrelated to the existing economies of the nations concerned and the realities of life prevalent there. Can the other sciences suggest what methods to follow to overcome the natural inhibitions?

In the Fish Section, the representatives of various countries met for a number of days and prepared a map of the latent fishery resources of the world. Similarly another map showing the existing resources of marine algae was prepared for the sectional meeting, on 1 September. The Section also considered the various measures that should be adopted for the development of fisheries, and a statement concerning these measures was recorded. You will hear the story in detail from one who is a fish expert.

The Conference has made it possible to have a free exchange of information regarding the steps that are being taken in different countries for the conservation and utilization of land and water resources. Much of this information will be of great value to us in India and I am sure to those interested in other countries. Seldom has an opportunity been presented on such a large scale for a free and frank talk on the important subjects. Mention may be made, by way of example, of the important lead given by the main participants of this Conference on the need of organizing rural communities and interesting them in the conservation of resources and in the execution of programmes of improvement through co-operative effort. We heard masters of their subjects from every land speak on problems of soil conservation and soil fertilizing and I have heard my country's representative resolve without the need of a resolution of this Conference that when he returns to India he will see that he is able to grow two blades of grass where even one grows with difficulty. One of the most inspiring events of the Conference was the fairy story of the Tennessee Valley developments told by persons who have been personally connected with the projects. A turbulent river has been tamed for the service of man and science and technology have succeeded in transforming a curse of nature into a blessing for mankind. Some of us who had the privilege of visiting the TVA site and meeting one of its master minds, Mr. Lilienthal, were thrilled to hear the account once again as presented by Mr. Gordon R. Clapp, Mr. Barrett Shelton and Professor William E. Cole. These accounts show that a scientific application does not merely confer material benefits on man; it may profoundly affect the social and moral conditions and even alter the character of the peoples of a land.

What has been done in the Tennessee Valley can be repeated and I am sure will be repeated in many valleys and in many lands. There is little doubt that the vivid impressions created in our minds of the achievements of the Americans and other great nations will help us in quickening the pace of our progress. We hope that our Damodar Valley Authority, the D.V.A., which rhymes well with the T.V.A., will be a long poem of service and achievement just like the T.V.A. When we return to our countries we shall no doubt urge upon our governments and peoples to give science a greater and greater chance in the solution of our respective countries' economic and social problems.

While it is granted that science, philosophy and religion may manifest themselves in their highest and most meritorious forms in the individual, and science conferences of this type which we have attended can be no substitute for the real work which is carried out in the laboratories and the libraries, it will have to be conceded that congregational worship has its uses and advantages. This congregation of scientists is like a congregational worship in which not only individuals but large groups of scientists have gathered together to pray and work for the bettterment of humankind by the aid of science. Recorded resolutions are often relegated to the wastepaper baskets and to cold storage in many a government and private organization; but the resolves that we take as a result of personal contacts and convictions based upon knowledge are remembered, go deeper home and bear good fruits in time. Let us hope and pray that the lessons that we learned here at this Conference will be of lasting benefit to our countries and to humanity.

Mr. Goodrich: One of the most challenging statements made at any meeting of this Conference was that of the delegate who remarked that he was the only man trained in methods of soil conservation in a nation of three and a half million people, most of whom make their living from the soil. Nothing in the Conference has been more encouraging than the reports from your country, Dr. Bhatnagar, and from many other countries, of the rapid progress that is being made in the training of technicians in the various fields of resource work.

This is a Conference of many diverse techniques. One purpose of this morning's meeting is to bring to the Conference as a whole the most significant results of the sectional meetings in which so much of the work has been done. You will have recognized that the speakers grouped around the table have played their parts in the various Sections. I call now on one who has been active in the Land Section: Dr. Isabella Leitch, of the United Kingdom.

Miss Leitch: I esteem it a great honour to be asked to have one of the last words here on behalf of the Land Section.

First, I should like to say a word about the somewhat controversial subject, the design of the Conference. In the Section meetings, we have taken it as implicit in the work of the United Nations that the aim is the betterment of the lot of all men. We have not thought it necessary to elaborate that aim anew. We have not wasted time confessing our sins or those of our fathers, although we have not been unconscious of them. We have said, here is the present position, what is it best to do now? And we have sat down in our several groups to consider those things that lie to our hands to be done.

Reviewing the work of the Land Section with the future in mind, I should say that the two main lessons of the Conference are the need for co-operative effort and the need to suit the end to the means as well as the means to the end.

The good farmer must begin with a knowledge of his means, of what the climate, the water supply and the soil will permit him to do in the way of growing crops. So the water expert, the soil surveyors and the soil chemists should literally be first in the field. When they have given him his basic data, he must then plan his cropping system. There he needs the help of the forester, the agronomist and the plant breeder to make sure that he knows how to make the best use of his land; with the economist, these same experts will advise him about the most profitable of the possible alternatives in crop growing, and when he has decided what he would like to do, they will have further advice to give him about implements, fertilizers and seeds.

I am very much content to leave all questions of the supply of the raw materials for the implements and the machinery, of the provision of oil or other source of power, where that is appropriate to drive them, and of the sources of supply and fertilizers in the hands of other Sections. But I must, on behalf of the Land Section, enter a plea for help with the design and production of simple farm implements. The agricultural implement maker must unbend from the combine harvester and other elaborate machinery which can be standardized through large-scale farming. He must diversify his interests and meet the needs of the small farmer who tills the soil under more difficult and more complicated conditions.

At this point, we have to ask the farmer whether he has decided, in consultation with his advisers, to produce only plant crops, or whether he will also carry animal stock. If he has decided in favour of animals, he still needs the help of the animal feeder and the animal breeder. I have deliberately put "feeder" before "breeder" because just as the soil scientist and the agronomist map out the land for the plant breeder, so the man with a knowledge of the nutritional requirements of animals must come with, or just a step ahead of, the animal breeder. Genes for high production are of no use to plants or animals without food for high production. In the animals it is like trying to fuel an aeroplane with low-grade fuel oil. The crops a farm can carry will largely determine the stock it can carry. At this stage, you might think that the farmer was ready to launch a programme of production but nature is not beneficient. It is reared in tooth and claw, and help is still needed if maximum production is to be achieved and the control of worms that infest the soil, of weeds that choke the crops, and parasites and insects that prey upon them, and no less in the control of the endless diseases that menace the productive capacity and the life of farm animals. And even then, when the entomologist, the parasitologist, the bacteriologist and the chemist have provided the necessary dusts and sprays and drugs, it may be apparent that production might have been still better if the forester had been called in to provide shelter belts against cold and wind or against heat and sun. There is, I believe, a great need for co-operation there.

Then, all these things having been done, we come in due season to the harvest, and because it is in due season, we come to fresh problems. All agricultural production is to some extent seasonal, and the level of consumption that is ultimately attained depends greatly on being able to outwit nature, to stretch the cropping and breeding season and to spread the food supplies over the year. When the farmer has done his best, the expert in food conservation either comes to his help or takes over from him altogether.

I can pay only a passing tribute to the food technologist for the canning and drying of the seasonal surpluses of fruits, milk, meat and fish and for the conservation of residues like blood-meal, fish-meal and oil seeds.

The problems of long-distance transport of foods and the provisioning of large cities are well in hand, but a plea must be made for better means to conserve the hard-won produce of the farm on the farm. As an illustration, contrast the grain elevators which take charge of the very small proportions of all grain that moves into international trade with losses of perhaps only 1 per cent or 2 per cent with the wicker basket of the African peasant and the rough crate or bin which together hold perhaps 90 per cent of the world's total grain harvest and in which the loss may be 25 per cent or more.

The wolves at the small farmer's door are the rat, the weevil and the moth, and they must be kept at bay.

There is room for more research in every field and sometimes for more imaginative experiments. We need more skilled helpers everywhere. The worker must be kept informed of what is being done in other areas. There is need for more co-operation all along the line, but there is urgent need at the same time for a temporary return to apparently simple problems, those of the small farmer who still tills a large part of the total farm land of the world.

On the way to this Conference, a friend of mine who is an oil refiner, said he could see no point in bringing together so many diverse interests as have met here. Before I left, he came to me and said, "I can now see the connexion between my oil refining and your 'bigger and better babies'." And yet, as far as I know, not even in the Land Section have we actually talked of "bigger and better babies".

Mr. Goodrich: The last speaker has said that we need the aid of the forest. Let us call at once on the forest for its aid. I take great pleasure in introducing Mr. Jolain, of France.

Mr. Jolain:[a] I think the main points resulting from the declarations and discussions we had in the Forestry Section of the Conference are the following:

The forest is, with agriculture, one of the basic riches of a country. Soil conservation against erosion and the conservation of water in the soil are closely linked with the existence of the forest.

Soil conservation against erosion is a fact known the world over. In many countries, either in mountains or in plains, various dispositions have been taken either to fight the existing erosion or to prevent eventual erosion.

The conservation of water in the soil by means of the forest has been the object of many studies and also controversies, some people considering that the forest could consume more water than it retained. Whatever the truth might be, there is no doubt that the forest normally constituted, and especially the leafy forest, is an admirable water level regulator.

This is why there must be equilibrium in a given country and also in the various districts of a country between forest and agricultural land. In countries of ancient development like France, the classification of soils into forest land and agricultural land was gradually carried out in the course of centuries. Each one occupies more or less the place it should, taking into account fluctuations due to economic, social, demographic or other causes.

Yet, one must consider that even in this case, the balance is not and will never be achieved completely for the reason that these causes vary so much.

In countries in full development, one is even further away from this state of equilibrium.

Furthermore, it looks as if certain regions of the globe, and I am thinking specially of the equatorial forest, are destined to be the world's forestry reserves and should be treated as such.

We are thus led to formulate a first principle:

1. There exists for each region considered individually an equilibrium between forests and agricultural land and the aim of each country must be to realize it effectively.

A country must know how to make the best possible use of its resources. To do this, it must first know them, then know how to utilize them—in short, manage them.

This management, in its broadest meaning, implies a complete and precise inventory of the various plantations, a study of the laws of growth, of the means to improve production in order to obtain constantly as good a production as possible in goods and money, not only without damaging the productive capital represented by the forest, but while trying to increase it

[a] Mr. Jolain spoke in French.

within the limits permitted by the plantations and the ecological conditions to which they are submitted.

A serious difficulty arises from the fact that, in forestry, capital and income are amalgamated. The income is obtained after a more or less long interval and most of the time not by the generations which helped to produce it. This has often been the cause of harmful abuses in exploitation.

A country concerned with a good administration of its forest resources must observe the essential principle of the separation of capital and income by means of a comprehensive forestry policy and appropriate legislation.

We can therefore say:

2. A country must manage its forests; that is to say, after having surveyed its resources, it must choose, and decide upon, the methods which will enable it, while increasing its capital, to obtain the best possible regular income and it must adopt the policy which will enable it to obtain and maintain such results.

The farmer having a yearly harvest can, up to a certain point, modify his farming policy, if he thinks it useful for economic reasons.

This possibility does not seem to exist in the case of forests because of their very nature. Yet it does exist. The plantation cannot of course be modified but, in the course of formation, the production can be modified in order to obtain certain categories of products which appear more readily salable at present or in the near future.

It is also possible, when creating new forests, to plant varieties whose products are in special demand. In such a case, the part played by the government is paramount. It must give the necessary directives and encouragements.

In tropical or equatorial forests, the problem is different. The extensive exploitation of some rare species sparsely distributed must be replaced by a more concentrated exploitation based on the utilization of new varieties. This represents vast possibilities linked with the discovery of new outlets and the creation, on the spot, of processing industries.

It is also very important to recognize that wood industry and production are closely interdependent. Production must cover the needs of industry which in turn must utilize the products in the most complete and rational manner. Some progress has been accomplished in this respect but much remains to be done: 50 per cent of the wood exploited is not utilized and a greater proportion is even not exploited. One can say without fear of error that the world wood production would be more than sufficient if it were rationally utilized.

We can therefore say:

3. Production must take into account the essential economic needs of the country as far as wood is concerned and must be carried out accordingly, taking into account the composition and condition of plantations. Research must aim at the fullest possible utilization of wood.

It is not enough to manage a forest; it must also be protected against destruction, the principal cause of which is fire. Excellent things have been written and said here on protection against fire. Considerable work has been done in this respect all over the world and especially in this country. There is a great store of experience from which everyone can benefit.

Let us simply take note of the fact that the necessity of organization appears to each one of us with a frightening clarity, but that, in most cases, its development is conditioned by financial considerations. Protection against forest fire is expensive, but it is even more costly to repair the damages. Above all, protection is essential because fires systematically and repeatedly destroy the forests.

Organization for fire protection must be sought by all possible means such as: research, expansion of the detection and fighting methods, propaganda to educate public opinion in mediterranean and tropical countries, changes in the customs and in the grazing methods.

This direct and immediate action must be supplemented by long-term measures. We could call these biological measures. They consist in creating in the specially vulnerable big forest areas either a single climax community for the whole region, or else a series of smaller "compartmented" climax communities scattered throughout the larger area. This can be done by introducing those species which are more highly resistant to fire and the ravages of insects, a factor which should not be minimized.

Mr. Goodrich: We shall continue on the side of organic resources. I ask the next speaker to discuss the problems of wildlife and fish. I call on Dr. M. Graham, of the United Kingdom.

Mr. Graham: I suppose that whenever people meet from all over the world—certainly it was so in the Fish and Wildlife Section of this meeting—what strikes them most is the *unity* of their problems. The conservation of game, mammals and birds passes through the same stages, sooner or later, in the New World as in the Old. So, on 26 August we have Dr. Edward Graham considering ownership of game for the croplands of the United States. Ownership has been good for game in Great Britain, as Mr. A. D. Middleton's paper showed. Then there are National Parks, needed as a final refuge of the larger animals, some of them dangerous; but the National Park is only an extreme example of a chosen best level of balance—an equilibrium point—one of many possible ones—between the natural pressure exerted by the animals and the pressure exerted by man. You can arrange to have all men and no game or vice versa, or you can have a balance at any intermediate level.

To know how to achieve the balance you have to study the animal population, its rates of reproduction, of growth and of mortality, both natural mortality and man-made. Dr. Leopold's paper made that point. In all our organic resources, it is these processes, reproduction, growth and mortality, that need to be studied and assessed, if the resources are to be rightly used. That is the central technical problem of all wildlife management, and it applies, in slightly different form perhaps, to soil, forests and farm animals. Tidy thinking is along these lines.

But life does not stand still while specialists put their minds in order. And the last few decades have seen the slough of despond caused by over-exploitation engulfing many of the finest of our natural resources. Particularly is this so in fisheries, where an over-fished stock by its property of giving, after a year or two, no greater yield—or less—for greater effort, or for new inventions, indeed for everything that is classed as intrinsically efficient—drives the heart out of the industry—and discourages youngsters from joining it. To agitate, to study and to contend against over-fishing comes naturally to men engaged in fishery research. This is our Dust Bowl—but it is technically much easier to restore than a Dust Bowl. We have to join together to restore over-fished areas. That is all. If we cannot do that, posterity will not think much of us.

In the Section there was no dispute about the necessity of dealing with over-fishing; but we worked more on the expansion of fisheries, such as the cultivation of fresh and brackish water fish in warm climates. Here there is room for very great expansion. And, what is more, it is almost on the door-step of many millions of people in tropical countries who are at present protein-starved. In some areas, such as the rice country, they can hardly hope ever to obtain flesh because the land is taken up for rice. The greatest skill in this art of pond-culture lies traditionally in China, secondly in India, and the first aim is to spread their methods round the world, with suitable local modifications. We should build on what we have. But new possibilities, such as the greater use of the various species of the fish called Tilapia, were also mentioned. It was the manifest opinion of the meeting on 24 August, that the possibilities for human betterment, by the increase of tropical pond-culture, could hardly be exaggerated. At the same time we realized that success would depend on human cunning and tact in dealing with all the variety of ponds and lakes and lagoons and watercourses. Our skill must be no less subtle, though more scientific, than the traditional fine discrimination of the Chinese masters of the art.

We would build on ancient skill but spread by scientific understanding.

There is no doubt at all that another fruit of the section's labours could not have formed without this meeting at Lake Success, I mean this lantern slide. One of the virtues of this long-drawn-out Conference was that there was plenty of time for conversation outside the sessions, and indeed before they began, during which we conjured up something that we could hardly have created individually. Dr. Harold Thompson, who could not get here, had boldly but carefully, perhaps too carefully, assessed the world's under-fished stocks. Out of conversations about his paper arose the plan to make, while we were all together, this chart on which the major under-fished stocks, those of which we know, could be indicated, so as to show their probable extent, and their magnitude, roughly of course. The meeting on 25 August estimated the present world yield of marine fisheries at 20 million tons per annum, and we know that, because of its high quality, fish is of more value than the mere weight tells. Our estimates of the potential yield of the under-fished stocks varied, from Thompson's cautious 22 per cent increase of annual yield, within measurable time, to a 100 per cent or more. Of course, the sources need more surveying, as, by the way, do the substantial resources of the seaweeds.

Now, of course, these stocks are not available for the mere taking. They would not be "latent" if they could easily be caught and marketed; and the meeting on 2 September discussed the main difficulties.

Among technical methods to reduce the difficulties, pressing on with echo-research is perhaps the most important. But the main difficulties are not technical but human. Consumption research is urgently needed, in order that the product may suit the folk who need it, of which the womenfolk have more to say than the men. That is one end of the stick. And the enterprising, skilled fisherman at the other end, is an absolute necessity, to be fostered by development of methods that fishermen like and to which they are attracted by a good profit. The world needs that every master fisherman can see his way to a satisfactory way of life: there are all too few of them, in some of the vigorous fishing nations, after the despondency induced by over-fishing.

Indeed, in fishing, as in the whole of our life, a new pattern is needed. And here is a unity wider than the one with which I started. Dr. Detlev Bronk, in the opening meeting, spoke of Lewis Mumford's diagnosis: that society, to survive, must work to the pattern of nature, not against it, and fishery research workers of the last decade or two have often wanted to exclaim "but I am not talking only about fish". In fisheries, modern inventiveness has brought us near to the end of our tether. Unco-ordinated, unseeing, not understanding, we can go no farther. The motives for our past activities are *obsolete,* for the future we can only hope to survive—let alone progress—if, with full understanding, we meet human needs in the pattern of nature. From our failure to do so we have plainly reached the state of the Roman Empire as Gibbon summed it up, when he found four main causes for its decline: that is, with the exhaustion and misuse of natural resources, entwined with other evil symptoms, such as senseless strife within the body politic, and a rigidity that could not stand up to either the attacks of barbarians or the impact of natural catastrophes. The connexion is easy to see: greed and grab naturally lead straight to quarrelling.

To my mind the problem of fisheries is part of the general problem this Conference was called to face, and the problem of this Conference is part of the problem facing a precariously poised civilization. The right use of resources will perhaps form the greatest part of the new pattern that is *due* to take the place of our obsolete greed-society.

Mr. GOODRICH: Thank you, Dr. Graham. Dr. Graham has stressed, as have others, the unity of the problem of resources with which the Conference is dealing. We are reaching, perhaps, a harder test of that unity as we move from the organic to the inorganic resources. I call on Mr. Monture, of Canada, whose work has been mainly in the Section on Minerals.

Mr. MONTURE: In the brief time alloted it is obviously impossible for me to review in detail the deliberations of the Minerals Section embracing as they did some sixty-two papers and covering such a wide range of subjects as:

Appraisal of world reserves and possible future requirements of mineral resources.

Methods of mineral extraction, including the most efficient mining methods.

Methods of processing ores for the best recovery of the valuable metal and mineral products.

Conservation by preventing wastage of metals in use from corrosion.

Conservation by substitution and the use of metals in comparatively abundant supply for the more scarce metals.

As a result of discussion, the following salient points emerged, which, although perhaps well known to many present, will bear repeating.

1. Metals and minerals are irreplaceable natural resources.

2. Consumption is increasing and will continue to increase as the world's population increases and the world's demands for higher standards of living increases and so long as the need for national security continues,

3. Insufficient knowledge exists on which to base a realistic estimate of the world's reserves of minerals. However, the general consensus was that given a world at peace and general price levels remaining as they are at present, no imminent shortages are anticipated. However, because of the irregular geographical distribution of mineral deposits no nation is capable of supplying all of its requirements of the many diverse metals and minerals used in modern industry. There is therefore the greatest need for recognition of the necessity for freedom from artificial barriers of trade in these commodities, and every encouragement should be given to the search for new deposits.

4. Advances in mineral technology have been increased resources and reduced costs of production. The application of scientific knowledge has brought about many improvements. To enumerate a few, prospecting has been facilitated by the increase in geological knowledge and geophysical equipment. Improvements in explosives and the rock drill have greatly decreased mining costs.

5. Improved technology has improved the purity and quality of metals and has also furnished additional new metals and alloys.

6. It was generally agreed that the era of easy and accessible discoveries was virtually over. Future discoveries would more and more depend upon the application of scientific methods of prospecting coupled with detailed geological studies and research. However, an optimistic note was sounded as to the outlook for future discovery since there are still large areas of the world which, from the mining point of view, are only partially explored or mapped geologically.

7. Generally speaking the grade of ore mined is decreasing. This is due in part to improved processes and methods that permit reduction costs. On the other hand discoveries of high-grade deposits are relatively rare. Cost of production is one of the more important factors in conservation and the increasing of our minable reserves. Methods of reducing costs are therefore important and among these increasing mechanization in mining and improved methods of processing ores are of paramount importance. However, since the efficient operation of many of these methods requires skilled operators, a warning was sounded that mechanization should be undertaken only after a careful examination of conditions since, owing to their high capital costs, they must be operated continuously. This warning particularly applied to those areas where the worker was not as yet sufficiently educated to acquire mechanical skills.

8. Direct losses of metal due to corrosion and other deterioration cannot be directly assessed. However, indirect losses caused by corrosion undoubtedly reach astounding figures. For this reason prevention of corrosion is highly important in any program of conservation. Considerable progress had been made in developing protective coatings and corrosion-resistant metal.

9. In the field of substitution the use of the light metals, aluminium and magnesium, is steadily increasing. Because for many uses these metals possess physical characteristics that make them highly desirable for certain purposes it might be more correct to call them replacement metals. Titanium, although not yet produced in commercial quantities, possesses qualities that would enable it to be used as a replacement of stainless steels thus conserving the more scarce metals, chrome, nickel, etc. However, considerable research will be required before its ultimate future will be known.

In conclusion, although considerable information is available regarding methods of mining, processing, and smelting of ores, methods of manufacture, etc., no reliable or accurate estimate is possible regarding world reserves of mineral resources either actual or potential. The difficulty of making such estimate is only too well realized. Since cost of production and market price determine whether the ore shall be mined or considered rock, any change in either of these factors may increase or decrease such an estimate greatly. Technological advances in mining or treatment directly affect these costs as will national political policies of taxation on profits or proved reserves, the latter tending to discourage development and the proving up of reserves.

Finally, mining is a highly speculative venture involving huge expenditures of capital. Political stabilities and national policy are often determining factors in the exploitation and development of mineral areas. Moreover, since the refining of metals requires huge quantities of fuel or electric energy as well as skilled labour, refineries are often erected where these are available and the ore shipped to these points for treatment. This fact poses a question as to the future development and exploitation of mineral deposits in certain of the now under-developed areas. Is duplication of presently existing plants justified solely for nationalistic reasons?

Nevertheless in spite of the difficulty of making an inventory of world reserves it is evident that the time has come when such an appraisal should at least be attempted and participants at this Conference might consider urging on their respective governments the growing need for such action.

The bases of such a survey are well organized and competently staffed Departments of Geological Surveys and Mineral Resources in order that each country may at least have some idea of what potentialities for further discoveries exist within its confines. The personnel of such Departments should, in addition to making geological surveys, carry out basic and fundamental research in geology, geochemistry and geophysics and their application to scientific prospecting. Statistical studies and analyses of past rates of production, consumption and discovery might well be made.

Information concerning the results of such work should be freely exchanged and some questions for which answers might be sought are:

In the present state of knowledge what technical methods can be recommended for mineral exploration?

How can present techniques be improved?

What mineral research projects are being carried out at present in different countries and what results can be expected of them?

What are the conditions of good international co-operation in research for increasing mineral discovery?

It is not suggested that a formal organization need be set up for the exchange of information but that rather the barriers that prevent the fullest exchange of information on an informal basis be broken down.

Only when this has been accomplished will we know the ultimate wealth of poverty of our mineral resources. I suggest it is not too soon to begin such a study. It may even be later than we think it is.

During the last few decades the mineral industry in all its phases, from prospecting for ore to marketing the finished product, has made great progress. This is demonstrated by higher efficiencies, lower costs and better working conditions. It is believed that in good part this progress has been achieved by industrial research and development using, in co-operation, the advances made in many individual lines of science and engineering to further the industry as a whole. If the problems involved in the future development of the world's mineral resources can be approached in a spirit of true co-operation and partnership, the results already achieved can be surpassed and multiplied many times throughout the world for the benefit of the whole of mankind.

Mr. Goodrich: Mr. Monture has stressed the need for international action in a way which is highly appropriate to a gathering of the United Nations. The Conference has been much concerned with and much interested in the plans for economic development in a number of countries. The next speaker, Dr. Aguerrevere, of Venezuela, is one who has discussed his own country's plans before this Conference.

Mr. Aguerrevere:[b] My friends of the Venezuelan delegation and myself wish to tell all other participants in the Conference how grateful we are to them and to all those present here for this magnificent opportunity to learn the points of view of scientists and scholars from all over the world. We are also grateful for this opportunity to exchange information on technical problems, particularly as regards petroleum, which is one of the principal natural resources of my country. We wish to congratulate the planners of this Conference for their decision that no resolutions should be adopted at these meetings. We are glad that we have been able to exchange factual results of scientific research and tell each other of our experiences. Such an exchange of views and information is bound to be of value to all of us and therefore we do not need to pass resolutions.

There are certain natural resources which are obviously expendable; they are bound to run out at one time or another, such as coal, iron and petroleum, and therefore they have to be conserved. This conservation should apply not only to their extraction but also to their consumption and efficient processing so as to avoid any preventable losses by corrosion, wastage, leakage, etc. These ideas have been outlined at length at our Section meetings and it has become clear that in our efforts to conserve natural resources, at least as far as petroleum is concerned, we should not allow ourselves to be frightened by those who say that petroleum resources will be exhausted within five, ten or twenty years. That ghost has been laid; it is obvious that prospecting is finding and will continue to find ample new deposits of petroleum and other fuels adequate to fill predictable human needs for a number of years which is considerably greater than some of the pessimists believed a few years ago.

In many regions of the world, and particularly in the Tennessee Valley, new over-all plans have been put into effect for the conservation of natural resources which have impressed the whole world. Here we see the conservation of natural resources as a totality, a unity, on the basis of a regional interrelated and integrated body over which there is a semi-governmental authority which puts the over-all plan into effect within the framework of democracy. This links up directly with the question of conservation of natural resources in general and participants are probably aware of the impression that it has created all over the world.

In speaking of the conservation of natural resources, I am thinking now of the tremendous resources of natural gas which are available in Venezuela close to places of possible consumption. At present that gas is being burnt without being utilized, but we hope to be able to utilize it in the future for making electric power and as a domestic and industrial fuel. That, however, is a matter for future development.

The countries of Latin America have grown and developed by furnishing raw materials to the industrial countries of Europe. On the other hand, the United States developed its own industries, and the development of their industries came directly after the achievement of independence. The Latin American countries lagged behind; they continued their primitive economies which were based on the furnishing of raw materials, and they did not develop their own industries. We have to industrialize; that is what we are thinking of now. That is what we are working for now, but our industrialization should not be over-hasty. It ought to be progressive and well planned. We should work out those industries which are based on national raw materials and which can benefit from limited customs tariff protection. This kind of industrial development would be a natural one in our country. It would not be accompanied by any economic dislocations, and it would not constitute a blind race towards a self-sufficient autarchy. We do not want that; we are not thinking of that. We are thinking of economic interchange all over the world. We attach more importance to progress and diversification in fishing and agriculture rather than to the development of industry.

[b] Mr. Aguerrevere spoke in Spanish.

On account of these circumstances, the countries of Latin America, and Venezuela in particular, constitute a true paradise for investments. The opportunities are multiple and tremendous. A country like ours, for instance, has virtually no debts, internal or external, and taxation is at a very, very low rate. Foreign exchange is in abundance, and money can go into the country and can leave the country at the choice of its owners, as a result of the wealth of the country.

Therefore, this is a new frontier just as the Pacific Coast was one hundred years ago, the Pacific Coast of the United States which is now celebrating the one hundredth anniversary of its development.

Mr. GOODRICH: The next speaker, like the last, spent a good deal of his time in the meetings of the Fuel and Energy Section, but I know he has interests that range widely across the field of the Conference. I call on Mr. Velander, of Sweden.

Mr. VELANDER: It has been a most interesting and instructive experience to follow the discussions of this Conference. As a research man I am a sceptic but also an optimist. I have been much impressed by the tremendous need for additional data, improved methods and continued studies and better contacts which have become evident whenever interrelation and integration of resources have been discussed. We need much more knowledge before formulating resolutions. Widely diverging and even partly contradictory statements have been made by specialists of high authority in different fields. This undoubtedly is due to insufficient diffusion and assimilation of information and shows the need of intensified documentation and implicitly proves the usefulness of this great Conference as a means of promoting exchange of knowledge.

But the difference of opinion and the inconsistency of thought often depend on inaccurate definition of fundamental terms and on a lack of uniformity in methods of survey. In the Fuel Section, there were almost as many opinions in regard to the best way of defining the properties of coal as there were speakers. In the Forest Section, it became evident that rather different methods are used in different countries for computing the volume of wood in a standing forest and for estimating the annual growth, or in other words, the production in per unit area and time. It is evidently still more difficult to find uniform methods for surveying agricultural land.

Many of these problems are dealt with in specialized national and international bodies and have been studied for decades. But we cannot afford to wait for a few more decades before the specialists get all the wrinkles ironed out of the various proposals made. There is an urgent need for quick action in order to facilitate the development of new sources of production. Therefore I think it is a most important task for the United Nations, our highest authority on co-ordination, to promote quick decisions in regard to definitions and be reasonably accurate, practically useful and immediately applicable uniform methods of survey in regard to the most important natural resources.

One of the most striking effects of our discussions has been to turn the whole problem of critical commodities upside-down. We have always been worried more or less about mineral deposits, including fossil fuel getting exhausted. At this Conference, however, it has been shown that with a reasonable amount of conservative thinking and conservation by replacement these exhaustible resources may be made to last for generations. It sounds indeed as a paradox that the real crises and the critical shortages may involve not the exhaustible resources, but the renewable resources which the creative forces of nature give us again and again, year after year: I mean the products of the great biological synthesis that goes on in farm lands and gardens, in pastures and forests and, most of all, in the Seven Seas.

Again and again, it has been emphasized that, if the population of the earth continues to increase at the present rate, a critical, if not catastrophical situation will be reached in fifty or one hundred years. There is a race between two types of biological synthesis, the creation of new members of the human family, of new mouths to feed, new bodies to be clad, housed and cared for and nature's photo-biosynthesis, whereby we, in making use of the sun's energy and the biochemical forces of nature, produce food, wood, fibres and other necessities. Apart from a rational study of the increase in population, it seems to me that the most important and fundamental problem we have discussed at this Conference is the question how far and by what means we can speed up the photo-biosynthetic processes that supply us with our daily needs.

There is an enormous variation in the means of production we now employ. A bullock weighing 1,000 lb produces about 1 lb of protein and 1.5 lb of fat per twenty-four hours during his efficient period. In a vegetable crop, for instance, soy bean or rape seed which weighs, when harvested, 1,000 lb roughly 3 lb of fat and 3 lb of protein are produced per day. Therefore we cannot afford too much animal diet.

From some reports at this Conference we have learned that speed of synthesis in monocellular organisms is incomparably greater. A crop of Torula yeast weighing 1,000 lb—including 75 per cent water—yields 4,000 lb of protein in twenty-four hours. A crop of Rodhotorula yeast, cultivated for fat production and weighing 1,000 lb will give in twenty-four hours a yield of 1,000 to 2,000 lb. In both cases, there is a large production of essential vitamins and, in both cases, the necessary area is not measured in acres of farm land but in square feet. If micro-organisms can produce protein, fat and vitamins with a higher uniformity and at a higher rate than multicellular organisms, no accidental market prices can prevent those processes from ultimately taking the lead. These perspectives should be studied internationally.

It is true that the yeast needs carbohydrate as food and we come back to the question how can this carbohydrate be photosynthesized as quickly and as cheaply as possible. If you get a better synthesis of carbohydrates in a beet field than in a forest, there is no use in making sugar substitute out of wood. It may be that the green algae capable of an enormous production per unit of organic material can even beat the beets and can be used to supply yeast food in competition with conventional crops. Now, Mr. Chairman, I am aware that this manner of thinking in carbohydrates, protein, fat and vitamins, instead of bread, meat, butter and vegetables, this idea of changing our traditional methods of feeding the world's population is very shocking to many. And still, in a couple of decades, we have become quite used to having alloys replace pure metals and synthetic plastics replace wood and natural fibres. Is it too unrealistic to expect that in another few decades our very primitive methods of producing food may be supplemented by industrialized and perhaps partly purely synthetic methods?

Apart from the need for supplying fuel for human consumption, we have always been worried about the limitations of the world's supplies of industrial and domestic fuel. Hydro-electric power is an inexhaustible supply but limited in amount. Direct application of sun power seems far away. In a pinch, however, photosynthesis might be used to supply also industrial fuel. In Northern countries, forest by-products in large amounts are used as fuel. In fact, the Swedish sulphate industry now is independent of fossil fuel and the sulphite industry has cut its consumption in half by burning the organic material in the refuse liquors. It has been estimated that the corn crop in the United States contains more calories than the entire production from the coal and oil fields.

Apart from these possibilities to create fuel, however, it has been emphasized during the Conference that the world's coal resources are very large. It is true that some high-grade qualities used for the making of coke are getting scarce but, on the other hand, we have heard that a wide variety of less valuable coal types can be used to stretch the supply. The oil situation may get critical but already synthetic methods are in full-scale operation which will turn coal, and even very poor grades of coal, into high class liquid fuel. Even vegetable crop or refuse can be made into liquid fuel.

Efficient methods are being worked out for turning coal, also of lower grades, into gas which can be conveniently transported in pipelines, just as natural gas from oil fields now is transported in this country in enormous quantities. During the war some hundred thousands of motorcars were operated on built-in gasifiers. We have also learned how country-wide electric high-tension systems have grown up, capable of utilizing energy sources wherever they are located and of supplying energy wherever it is needed. In fact, you may say that while the raw calories at the mine and the kilowatt-hours at the power-station are very cheap; the main problem is to transport the energy as solid, liquid, or gaseous fuel or as electricity in the most efficient way to the point where it is best needed.

In connexion with the whole problem of less-developed as well as developed areas, I should like to draw attention to two important trends in our productive life, both accentuating the importance of transportation. One leads to concentration, one to dispersion.

Firstly, large areas are now in a state of transition from self-supporting agricultural households to highly diversified communities. We cannot afford to have hundreds of millions of small-scale farmers trying to produce just what they need themselves and always on the verge of starvation. The farmers must contribute to the economy of the community by exporting products, as is already the rule in highly developed countries and receive in exchange tools, fertilizers and seed. But this means mechanization, industrialization; concentration into bigger, more efficient units. It also increases the need of transportation.

Secondly, there is a trend in industry which is almost contrary. In the nineteenth century, industry grew up close to sources of energy, coal fields and water falls. This led to concentration and congestion with unfortunate social consequences. Now the nation-wide electric power systems make it possible to spread out industry. All over the country-side, satellite industries grow up and also rather independent units in large production chains. This leads to more transport. But heavy industries also tend to be split up into steps. Whenever great amounts of energy are required per unit product, as in metallurgy and electrochemistry, primary production units still are preferably located at coal mines and in water power regions and intermediate products are transported to localities where living conditions are better and subsequent manufacturing steps are carried out where the emphasis lies on qualified human labour rather than energy. It is a method, if you like, to transport energy by truck, railway and ship in the form of chemical energy in a product instead of electrical energy in a wire. Secondary and tertiary factories are often highly specialized, materials and parts passing in and out through numerous consecutive links of production, alternately diverging and converging until final products can be delivered to the customers. This calls for still more transportation. But transportation here is not to be looked upon as a necessary evil. Transport systems of the most varied kinds should be integrated as parts of the productive machinery. Therefore, I think, one of our conclusions should be that in planning for large-scale future development integrated transport systems should form one of the primary and fundamental factors as an indispensable means of production in agriculture as well as in industry. We have recently created in Sweden a Transport Research Commission. But that is far too big a job for a small country like ours. It is a big job even for the United Nations.

Mr. Goodrich: The work of the Water Section was brought before the Conference in the remarkable symposium held yesterday afternoon. The next speaker was a member of that symposium. He need not confine himself to its problems, but may tell us where he sees the most urgent need for action resulting from the deliberations of the Conference.

Mr. Goldschmidt: This Conference has indicated clearly to me that the job ahead of us is to bridge the gap between what we know can be done and what we are doing. To be sure, as Dr. Woodward suggested, many of our scientists will continue to widen that gap by pressing steadily forward. They should be encouraged in that because this harnessing of sea and sun, this juggling of atoms may develop into needed additional resources that will affect the living levels of the peoples of the world. But we have far better evidence from our discussions, I maintain, that within the realm of the proved and the possible we are far short of matching our knowledge to the imperatives of the situation.

Prudence dictates that we should not rely upon the vast potentialities of further scientific advancement to overcome growing deficiencies in resources upon which more and more people will have to depend. Prudence dictates that we put our present knowledge to work. While scientists seek new sources of energy let us make use of their findings of yesterday and today to put to work the vast power of the St. Lawrence, the Nile, the the Niger, the Yangtze and all of the other unharnessed rivers of the world that are wasting to the sea. While they hunt new sources of food and fibre in what Dr. Woodward has called the fertile acres of the ocean, let us put their knowledge of the land to work—in conservation farming, sustained yield forestry and cropping, and so on—to protect and build up the earth's thin skin of topsoil which is all that keeps any of us off the rocks, physically as well as financially. While they are finding substitutes for dwindling minerals, let us husband our lead, tin, zinc, copper and all the other metals, and use them wisely and equitably.

This prudent course of action is not suggested to add further to a sense of poverty, defeat and uncertainty, for we have heard in this Conference ample evidence that poverty, defeat and uncertainty are the arch enemies of conservation and wise utilization of resources. Indeed, only a strong and widely shared sense of hopefulness can form the framework in which people will build up and develop their resources rather than destroy them utterly.

Conservation calls for tools, equipment and knowledge that cost time, self-denial and energy, and in these times self-denial and energy are currencies that are not found among poor and hopeless peoples. A farmer struggling to maintain his family may not be able to afford in his individual capacity the conservation practices that his nation cannot afford to have him disregard. Similarly, a community or nation may not be able to undertake measures for resource development and education that the world cannot afford to have neglected.

In the United States the poorer and less-developed areas are those where conservation practices have lagged lamentably. So, too, throughout the world the underdeveloped areas generally present the most serious problem to proper conservation. Populations press on resources precisely in those areas here and abroad that have lacked the tools of development, and where the people are poor, hopeless and uncertain. But because the practices of conservation are less advanced in underdeveloped areas the problem is not, I suggest, one for them to undertake alone. Resource misuse resulting from low living standards anywhere is a threat to people everywhere. Insecurity and depression, like disease, do not respect man-made boundaries. The problem of raising world levels of living in the interests of those who are here now, and in the interests of conserving resources for those yet to come, must be attacked on a world basis.

Economic development, therefore, should be pushed in the hard places rather than in the easy ones—not where nature has made it profitable but, perhaps, where man has made it difficult. The results of this Conference suggest to me, further, the desirability of pin-pointing our principal efforts to specific places, of making co-ordinated and balanced attacks on the problem of an area rather than spreading thin the quite limited resources at our disposal.

This Conference has emphasized the interrelationship of resources and the need for co-ordinating attacks on resource problems. Not only must scientists and experts work together, but communities and nations must combine to advance their solution. As in the multiple-purpose development of a river, many different types of expertise must be brought to bear on this problem. Interests must be balanced in the distribution both of costs and of benefits, and differences must be compromised in favour of progressive development.

Because this uniting upon objectives must transcend national boundaries, international co-operation—which, we have demonstrated, is so familiar to the scientist—must become a similar habit with the administrator, with the man in the street and with his representative in government. Such international co-operation will depend upon a general acceptance of gauges of feasibility and project priority that are calibrated to world conditions, rather than confined to national economy. Indeed, development projects must be judged by new standards that will reflect their relative impact upon the well-being of the world.

The successful resource development programmes of the two vastly differing river valleys of this country, the Tennessee and the Columbia, have demonstrated for old and new areas, for heavily or sparsely populated ones, for wet and dry climate, that a bold programme of creating a sound balance of industry and agriculture will result in a chain reaction of development in which initial public investments are soon overshadowed by private activity.

Without setting up those necessary gauges of project priority that I suggested would be needed, let me merely suggest that the key to the solution of the Middle East problem may be found in the Nile, the Jordan and the Litany, the Tigris and the Euphrates, as perhaps the key to the New England problem may be found in the development of the Connecticut and the St. Lawrence. The scheduling of a bold programme for the comprehensive development of the valleys of the Middle East, based upon sound and well-known engineering practices, and upon the principle of spreading the benefits to the peoples of all countries and areas, raising their levels of health and education, would affect more than sixty million people directly and provide possibilities for more than half again as many more through power and irrigation and land developments, techniques known to the scientists here and now.

The governments of these areas and of the world might well invest the relatively small sums necessary to start the job, to bring hope and stability to this vast area and to other areas of similar possibilities in Asia, Africa and Latin America. It is an effort that will require the combined work of all of the United Nations and the specialized agencies particularly, and of scientists, engineers and people from all over the world. I trust that this Conference will give a further impetus to that effort and will therefore aid in the job of our generation: to make our resource practices conform to our knowledge of what can and should be done.

Mr. Goodrich: I am sure that members of the Conference will have been struck by the contrast in emphasis as the last two speakers have drawn their lessons from the Conference. Professor Velander has stressed the need to extend the boundaries of our knowledge; Mr. Goldschmidt has called for putting to use the knowledge we have. This, I think provides an appropriate setting for the contribution of the next speaker, Dr. E. De Vries of the Netherlands.

Mr. De Vries: I thank you, Mr. Goodrich, for this opportunity to say a few words at this stage of the Conference. The last two speakers have brought us back—and I am grateful for that, as it is more in my special field—to the land. I should like to add a few words on the relation between man and the land, as a further contribution to the subject on which Miss Leitch spoke to us this morning.

Humanity is indeed—at least for the time being—fully dependent on a very thin layer of topsoil in the world. I might give the Conference these few figures: We now cultivate 20 per cent of the total area of the land, with 30 per cent devoted to pasture land. Not all of this land is equally good, and much of the land is marginal. That is brought out in this figure: that at present 50 per cent of all human beings live on only 5 per cent of the land area of the world.

This might lead us to two conclusions which would be completely different. One would be that it might be very easy to extend the 5 per cent to 50 per cent, let us say, and that we then could feed ten times as many people as now. On the other hand, we might take the other conclusion, which I think we have to deny just as we have to deny the first one: that the fact that 50 per cent of humanity is living in such a small area proves that in the long course of human history, in the human ecology on a global basis, mankind has found the best places to live, those places being for the most part the great river basins of the world, that outside those areas the possibilities for humanity are probably more difficult than where people are now situated, and that therefore we are up against a very difficult problem in finding food for future generations.

I think that both conclusions would be too rash and that we can say with confidence that there is a possibility of expanding food production in the future to a large extent, but that it will not be an easy task to do that just because there are such large areas lying idle or nearly idle. We are up against nature here, and it is not easy to conquer nature and to harness it in this respect.

One of the main future resources for future development, this Conference has shown, lies in the tropics, where the agriculturist may make use of the vast area of tropical forests. But we heard from Dr. Jolain just a half hour ago that the foresters see the same area as the main reserve of the forests of the world. Here again, then, we come up against competition between agriculture and forestry as to the use of the land in the tropics. That means that we surely cannot use all of the land in the tropics for intensive agriculture; we must give some place to the forests and the forest products which we still have to use.

But the problem is much more difficult than that of a mere abstract relation between man and land. There is a concrete relation between man and land, between the farmer and the soil which he works. At this point, I believe I again have to give one or two figures: At the present time, about one and a half billion people are living on the land, and the great majority of these people live in the great countries of Asia. As has been said this morning, and as has been said almost every day during this Conference, the great majority of these farmers are on the threshold of a new era. They have been living for many long years on their land; they have developed a type of agriculture which, if we speak again in terms of human ecology, was very well adapted to the circumstances. We have heard, for example, how the Chinese farmer has worked his land for many thousands of years and has retained its fertility. But this method of agriculture was within the limits of the system, within the limits of the tools the farmer had. This resulted in a very small-scale agriculture—about two acres on good land and perhaps three or four on land that was not so good—just enough to feed the farmer's family on a low-protein basis, on a basis that is not sufficient for the full development of human beings.

These one and a half billion people, as I said, will come into a new era. They ask for development; they breed rapidly. Their first response to contact with world economy is a great increase in population; their second response is that they want development. I think that we have here a very difficult problem in human ecology. The whole world will want to give these people—and I repeat that there are about one and a half billion farmers—the opportunity to develop themselves. And as Dr. Bhatnagar said this morning, the wish is to do that in an evolutionary way, to do that without destroying many things in their own society which they want to retain. I think that science has to play a big part in bringing this about in these farmer societies, because that is my experience, and I think that most of the farmer societies in the Far East have to bring about the development of their economy.

It has been said that that must be done on a village community basis. But to give you the magnitude of this problem, there are about two million villages in the world. And even if you do it through village communities, you will have to do that through the leaders in the village and through the minds and hearts of the majority of the people in the village. I think this work can be done, but this work is a very difficult thing to do.

How are we going to proceed to bring into these regions a real balanced development? How are we going to bring in better agriculture, better nutrition and industry, to see that these people receive all they need for a decent life? I think that research is the first thing we want. This was stressed this morning by every speaker. I should like to take up some of the figures given by Dr. Velander this morning. I think, for myself, that one of the revelations of this Conference is the possibilities of that food yeast he spoke about. The tropics are very well suited to produce carbohydrates. They may produce eight tons on an acre a year. Carbohydrate is a very good food, but without protein and without vitamins it means nothing. And one of the main painstaking problems for me has always been how to provide not only for the quantity of the food but the quality of the food. We can see that chickens, if they eat cereals, produce eggs which retain only 10 per cent of the original calorie value. The best animal to do that is the dairy cow. She returns about 30 per cent of the original food in the high value of milk. But yeast can transform 60 per cent of carbohydrates into high valuable proteins. Indeed, I can see here one of very good ways to bring about better nutrition in tropical countries, and I think that we all have to be grateful for the work that has been done, in developing this technique, which I think can contribute very much toward a better life among peoples who need it so much.

So much has been said this morning about science and the necessity of more research, that I should like to pass it over and proceed along the same line as was stated by Mr. Goldschmidt, that what we also need is the application of science. There, I believe that we have to work out, among ourselves, in our national economy, in our administration and the systems of education within the nations, and by very intensive international co-operation, new means to apply science to daily life, not only for people in highly developed countries but also for people in so-called under-developed and less-developed countries.

Here again, I think that we have a very pressing problem in human ecology. If I have learned one lesson in this Conference, it is this: that what we need is very close co-operation between people in technical science and people in social science, and social engineering and education methods for the masses of the population all over the world. I think that to bring this about is one of the tasks which is really one of the biggest things for the United Nations. Personally, I am very grateful for the opportunity we have had here to see, at the horizon, the possibility of this co-operation, and I think that we ought to pledge ourselves not to let this Conference remain merely as a very valuable and very interesting stack of documents, but that we should see that it is worked out. I believe that the United Nations is already thinking about a programme to apply all we know and all which we still have to find out, into practice.

There is the question of technical assistance. I think that technical assistance in itself is a programme and a problem. We have to work on this problem and see how best we can work it out and, at the same time, we have to do the job. I think that a second large new scheme is the one which requires a bold programme of the financing of this development. We cannot envisage that every nation in itself has all the means to do all that has to be done; and it not only has to be done for the benefit of that one nation, but it has to be done for the benefit of the world as a whole. I think that the new methods of international financing, and the benefits of that financing, should be shared by the whole world, because they are things which are of the utmost importance and urgency.

I should like to repeat again that I believe the problem is of a magnitude which may baffle us, but the problem is so urgent that we have to deal with it. If I may summarize my impressions of this Conference in two words, I should say that it is to find a solution for adequate food and a decent standard of living for a new billion of people which are to be added to the two billion that we have now. That is possible, but it is very difficult. If someone were to say, on the opposing side, "It is very difficult," I should say, "It is possible and therefore we have to endeavour to do it."

Mr. Goodrich: There are two themes which I should like to recall in bringing the formal part of the symposium to a close. The first, which has been touched upon by almost every speaker, is that of the interdependence of resources. In a real sense, therefore, the resource problem is a unified one on which a common concerted attack has been made. It is one which crosses the lines of the sections and the still more numerous lines of the technical specialties represented in them. This is the theory on which the Conference has been built. If in the minds of its participants, it has succeeded—as Miss Leitch has reported—in bridging for example the gulf between oil refining and livestock nutrition, I think we can claim that it was built well.

The second theme has come out with particular clarity in the latter part of the discussion. It is this, can we so husband and so use the world's resources that the people of the world may look forward to increasing standards of living, or must we face the gloomy prospect of increasing misery because of resource depletion? The question is not rhetorical and it is not an easy one. We have been warned of the wastes, past, present and continuing, of irreplaceable materials, both in the more-developed and in the less-developed areas. We have examined the figures of current consumption. Moreover, we realize that we must face steadily mounting demands on resources both because of increases in the world's population and because of increasing pressure the world over for higher standards of consumption. Several speakers during the Conference have dealt with the problem of population. They have agreed that the prospect for the next few decades is one of substantial increase, but they have differed sharply as to the rate at which, in countries feeling the new impact of industrialization, the birth rate is likely to follow the death rate downwards towards some sort of equilibrium. Less has been said of the increase of consumption standards. No conservationist would wish every item in the present standard of living in the United States—our extravagant use of woodpulp, for example—to be copied the world over. But no conservationist and no humanist could deny or would wish to deny, the reality of the surge toward higher living standards in every part of the world—an increase indeed which forms part of the stated objects of the United Nations.

Is there hope that these aspirations for higher living standards can be met? Can the books be balanced, as one speaker put it, by increasing supply assets rather than by reducing needs liabilities? Mr. Chairman, I believe the Conference has an answer to that question. In the technique, present and prospective of discovery and invention, of ingenious substitution, of the harnessing of unused power, and of placing the use of replaceable resources on a sustained yield basis, the experts present at these meetings have pointed to ways by which the world could well provide higher standards for more people. The answer of the Conference is affirmative. The technical means are at hand.

But the answer of the Conference—let me hasten to add—is also conditional. First of all it depends on the condition of peace. And second it depends on a great variety of social and economic and political conditions. Again and again discussion in sections or plenaries has reached this point. Here is the technique and here is its promise, but the obstacle to its application lies in the institutional arrangements. Its use calls for a decision by the individual farmer or the owner of a wood lot, by the village community, by a great mining corporation, by a government, by an international organization. Sometimes the improved method would benefit the individual owner even in a short run, but the obstacle lies in ignorance, or ill health or lack of training. Sometimes, as has been pointed out for Indonesia and America alike, the obstacle is poverty of the farm. In other cases the difficulty may be the failure of legal regulations to check abuses which are the communities loss although the individual's short-run gain.

Speakers have recognized that government must often act as the protector of interests of the future, as against the interests of the present. They have given, to be sure, no magic formula by which government itself is to balance present against future. But they have offered the suggestion that the rate of interest may often be the key problem to attack in resource development. Sometimes, as has been said this morning, the obstacle lies in barriers to trade, to the movement of capital, to the movement of technology. Finally, speakers have placed before us encouraging examples of great projects, that looked at piece by piece, could not have paid their way, but planned and viewed as concerted wholes, have gone on to triumphant success.

On these problems the Conference offers questions and a challenge rather than answers. As you will recognize Mr. Chairman, all of them fall within the field of interest of the Economic and Social Council at whose call we have gathered in this meeting. We hope therefore that the work begun here will continue within the framework of the United Nations as well as in daily decisions in the nations to which the members of the Conference will return. Some of it, we know will continue in the friendships of those who have worked together here.

Mr. Chairman, the scientists and the technicians have spoken soberly but they have offered much. It is for us as individuals, for our nations, and for the international organizations to make this a world that can take advantage of the promise they hold out. That promise is the wise and abundant use of the world's resources for the enrichment of the life of mankind.

The CHAIRMAN: I shall now grant three minutes to members of the Conference who wish to speak. I call first on Professor Hammond of the United Kingdom.

Mr. HAMMOND: During the discussion in the Land Section it was quite evident that a very large proportion of the land area of the world is range and grazing land, and when questions were asked during the discussion as to what could be done to increase their output, there was little information forthcoming, except the negative advice of reducing stock. That advice is not popular in large areas of the world, and there was a hint that we should go back to carbohydrates and yeast. I think that would go against the wishes of a very large proportion of the world.

A very large area of this range and grass land lies in tropical and semitropical countries, and nothing in the way of fundamental research has been done for it as has been done for the comparable area in the temperate climate. Research at stations such as Rothamsted, Beltsville and Cornell has given us a grassland husbandry which has been put into full effect in New Zealand, where the output of grass is on the whole equal to any cropping system in the way of calories and very much higher in proteins. That has come as a result of basic research on soils, manures, forage crops and animals. I think the great need at the present time is for similar research stations to be set up in tropical and semitropical areas to deal with the range grassland problem, not merely with cropping. The range problem is a wide one and a very large one, and it is only by putting first-class scientists on to the job that we can really get the fundamental principles that are necessary to develop those areas.

The CHAIRMAN: I now call on Mr. Blondel of France.

Mr. BLONDEL:[c] In the summary statements dealing with the work of the various sections, and particularly in the last statement of Mr. Goodrich, considerable stress was laid on the fact that this Conference mostly raised questions and that the answers were not always forthcoming. Therefore, it was stated that the work was bound to continue after this Conference, particularly through the exchange of views among the delegates present here and also through the influence that these delegates may exercise in their respective countries. The countries from which we come are democratic countries where public opinion plays an important part. It appears to me that the main conclusions reached here probably do not correspond with the ideas current in the public opinion in the various countries. There are often exaggerations and even errors in the statements made on the subjects about which we have spoken, and it appears to me it would be highly useful if a simple, clear and concise but precise summary of the main conclusions reached by this Conference could be distributed widely in the countries that we represent so as to permit the correction of some of the popular errors to which I have alluded. With public opinion being better informed, this would enable us to get from the national organizations the effort toward development and management that has been suggested by the delegates present.

The CHAIRMAN: I call on Mr. Raushenbush of the Preparatory Committee.

Mr. RAUSHENBUSH: It seems to me to be highly unfair to the scientists here to let the impression go out to the world that they can raise the standard of living over the next fifty years and develop the under-developed countries. It is unfair to them because there are so many factors that may prevent that from happening. It is going to be very difficult to do it. I wish to speak in that regard in relation to the under-developed areas themselves. It was my fortune over the weekend to sit with members representing private finance houses and public finance departments of this Government. They asked me the question whether the scientists now at Lake Success wanted to develop the under-developed areas. I answered in the affirmative, and they allowed themselves the privilege of patronizing me to the extent of saying: "Please do not be naive. The scientists may want the development of these under-developed areas, but it is not generally wanted by their industrialists and governments." A lively dispute ensued, and they cited five cases. If you will give me a moment, I think these five cases may rest in your minds.

They cited, first, a certain Far-Eastern country that had come over with the impression that the Western world had now come to the point where it had to export capital, and so they came with a proposal to make rayon out of rice straw without knowing whether rice straw produces rayon and with a proposal to make ceramics without knowing whether they had the clay to do that. They said that we must give. I happen to have made a

[c] Mr. Blondel spoke in French.

study of the capital needs of this country, and I want to assure one and all that this country (USA) can absorb all the capital that it can produce and save over the next thirty years and still not be adequately equipped for its own needs. But, if we want the development of under-developed countries, the impression that it is obliged to export capital must be eradicated at once.

The second thing they pointed out was that a whole string of countries insist that there must be either 51 per cent local control of capital, or no industrial companies at all. They pointed out forcibly that, since there was no local capital in those countries able to supply 51 per cent of the needed investment there would be no development. These countries, so to speak, had patriotism without development, and were going to stay in that unsatisfactory position.

I should like to point out that I am not sharing all the views of these people. I am merely describing the scepticism which is present with regard to the real desire of the under-developed countries to be developed and to create the climate in which it is possible.

Their third point dealt with an authenticated story of a large North American company engaged in an effort to secure local capital. It had adopted the principle which, in my paper presented to the plenary meeting of 26 August, I said was the great American gift to the world, that of large-scale distribution at low unit cost. It offered participation to local investment. The offered shares were thrown back. Local investors said: Your proposition is that we must wait three years and then earn 5 per cent, 6 per cent or 8 per cent; we can make 21 per cent at this moment. The local shares were turned back and the company was unable to obtain adequate local participation and start work.

Then there was also an electrical equipment company that had always had minority participation all round the world, but in Latin America their shares were turned back, because the North American company insisted on setting low prices.

The essence of the question is whether the scientists are going to be allowed to aid development. This particular group thought that, basically speaking, the scientists were not going to be allowed to have the necessary local conditions to assist economic development. They thought that the conditions described by Mr. De Vries, Mr. Goldschmidt and Mr. Goodrich would not be possible. They thought that basically there would be no local effort to change a certain feudal relationship regarding the distribution of income from any industrial development in certain countries.

Finally, they cited something that is disturbing to so many people. They cited the fact that industrialization in very small amounts simply lowers the standard of living by inducing the rapid increase of population.

Those were the five points. In fairness to the scientists, the laymen of the world should thoroughly understand that while everyone here is agreed that the experts here have the techniques and methods to give all the people of the world a high standard of living, you may not be able to give your great gift to society over the next period of years because of unfavourable local economic and social institutions.

The CHAIRMAN: Mr. P. F. Jensen of Denmark wishes to speak.

Mr. JENSEN: Several times during the Conference, the fact that we scientists are here as private individuals and with no responsibility has been emphasized. Therefore, I should like to briefly summarize my impressions of this Conference as a private individual who has been attending the meetings for three weeks.

This Conference has proved, I think, that there is hardly any lack of raw materials in the world. There is no lack of land to be cultivated; as a matter of fact, if all the available land the world over were cultivated with the same intensity as, for instance, the land in Mr. De Vries' native country there would, in my opinion, be such an over-production of food material that it would not be possible to get rid of it. Therefore, with proper use of the knowledge collected by scientists and technicians in the past the earth could easily support a much larger population than it supports at present and at a much higher standard of living. It is now the task of those people who have the responsibility, that is the politicians and economists, to bring that accumulated knowledge into use and in doing so raise the standard of living of hundreds of millions of people all over the world. I hope they will take the job seriously and recognize their responsibility.

The CHAIRMAN: Mr. Samuel of Israel wishes to speak.

Mr. SAMUEL: Yesterday and today I have listened to a few remarks on the development of the Jordan River. Having been familiar with this plan for a long time, I should like to state that this development, which has been known as the Jordan Valley Authority, cannot and will not be undertaken without full understanding between the State of Israel, Transjordan, Syria and the Lebanon. I express the hope that this understanding will be achieved in the near future.

The CHAIRMAN: I call next on Mr. J. Edelman of the United States.

Mr. EDELMAN: I am not here as a private individual: I have a responsibility to my organization, which is the CIO, which operates a permanent standing committee on conservation and regional development. In the last few months the work of that committee has become more widely understood among the rank and file of our unions and is perhaps exerting some slight influence. Our interest in this particular problem is two-sided. We have many unions which are directly concerned with the development of resources from the standpoint of employment, examples being the fishermen of the Pacific and boatmen on inland vessels, to say nothing of course of workers in utility industries.

On the other hand, however, our principal emphasis on this work is as consumers and as people who are interested in generally increased standards of living. In the earlier stages of the development of TVA, it was necessary, for instance, in order to get urban areas in the TVA region to use the power from TVA, to hold referenda or official elections in many of the municipalities. My union took a leading part in educational work in connexion with such referenda.

A union such as mine, which has considerable membership in the South as well as in New England, has had personal experience of the enormous social values which are, it seems to us, a well demonstrated by-product of an intelligent application of scientific methods to the problem of the conservation and development of natural resources.

In passing let me mention a project which my union is pushing legislatively, and that is to try to set aside through legislation some of the very few remaining redwood trees in California as a National Park dedicated to Franklin Delano Roosevelt.

My particular union has been obliged to concern itself, for instance, very actively with the whole question of power costs simply because of a geographical shift in location of our industry from one section of the country to another. In New England power costs are very much higher than in the South, and this becomes an economic problem for a union such as ours. However, the point I wish to make is not so much to describe the work we are doing. We are just beginning on it.

I should simply like to say one thing. I should like to put forward a very strong word of caution to the technicians and the experts here, for instance, who are offering us substitutes for conventional types of nutrition that from a political and public relations standpoint are, to put it in American slang, "dynamite". A worker would very quickly say: What do these high-brows want us to do, to produce more and not eat? Those things must be very carefully handled.

The principal point I want to make is clear, and that is that scientific and technical knowledge is always needed; more of it is always needed. We do know enough now to understand that our job is the application of what is already known. All of this extraordinary and valuable information and knowledge which has been shown here will go to nothing unless we are able to advance definitely in getting this whole problem into politics. I mean by that, not ordinary partisan politics, but simply to get the underlying population to understand what this problem is and to bring it into the general arena of public controversy so that not merely legislative advances can be made but that at the same time you can take an additional step—build up a strong emotional sense, a sort of extension of the instinct of workmanship, to create a feeling and an *esprit de corps*, as it were, against the whole popular concept of natural resources as something which should be immediately and instantly raped, something of which this country has shown some dramatic examples.

I think that ultimately meetings of this kind must extend their activities to popular education to enable the democratic peoples in each country to take effective action and to give practical expression to the scientific and technical knowledge which has been so brilliantly adumbrated at this meeting.

The CHAIRMAN: This Conference was born in a vision of service, the same vision that inspired the Marshall Plan and the bold new programme of technical assistance to under-developed countries.

Not out of a boyish desire to serve but stemming from a grown-up man's generous good will towards all mankind, we see the spirit of service and generosity so often met with in our host country. The basis is not just sentimental; it is based on the idea of help to self-help and asking the recipient to be willing to give, the donor to accept. Behind it all is the desire to introduce knowledge, "know-how", practical wisdom and applied science.

You have been listening today to a most illuminating discussion—a review of documents as well as of speeches—and I am sure that you are all grateful to those who have spoken at this morning's meeting. I congratulate you upon the work accomplished. You have given freely of your knowledge to whom it may concern. You have received new knowledge and inspiration; you have acquired new friends in many foreign countries, men and women with whom you will be able to co-operate in the future.

I congratulate you upon the spirit in which you have conducted your discussions, and from which I have noted that the nationalistic spirit has been absent. You have felt yourselves to be co-workers in a grand enterprise. I congratulate you particularly upon having been exempted from the obligation to produce recommendations and to present results before such and such a date. This Conference would have been entirely different had you been nominated as representatives of your governments, for to be the representative of a government means, first of all, to be no longer a free man. There was great wisdom in President Truman's suggestion that the Conference be not composed of government representatives, and that you should not bother about recommendations. The Economic and Social Council had no difficulty in seeing that point of view. There was behind it faith in the importance of spreading knowledge and in the value of the exchange of ideas.

You do not know how I, a representative of a government although not speaking here in that capacity—and certainly a representative of a government anxious to co-operate with all others—feel when I am listening to your discussions. You have not been concerned with national prestige. You have not been concerned about the effect on public opinion in your home countries words spoken here might have. You have not had to confess the sins of others. You have made no reservations. You have not even had to create or accept rules of procedure, and you have managed to do useful work nevertheless, for your work will stand.

In your papers I have found the word "discussant". I have never in my long service as a participant in international conferences and assemblies, at the League of Nations and at the United Nations, met that word before. It will henceforth be my secret desire that I may some day be promoted a "discussant"—that is, a man free to take part in a common endeavour to find truth and nothing but truth.

You are a lucky lot, you who have been able to work in that spirit. The United Nations would be an entirely different organization the day its conferences, councils and assemblies were meeting unhampered by national interests, or with those interests seen in the light of that greater integration which is needed and to which you have been pointing. As I say, there is a great difference between the outlook which obtained during the time of the League of Nations and that which exists now under the United Nations.

We still have an organ—a council—to look after the question of war. But I think the greatest difference is this: that the United Nations has recognized, and is increasingly recognizing, the impact of science and technology on world conditions. We have established a group of specialized agencies, and it will be found that the basic elements in them are those of science.

Your Conference has to be seen in that total setting. And I wish you could have told us, better than it was possible for you to do in the short time at your disposal, what priorities we who are working in the Economic and Social Council should give to the various problems. We have that problem of priorities over and over again. How shall we tell whether money is to be used for the fight against illiteracy or for a conference on soil questions or for a conference on health questions? We are constantly compelled to take decisions on such matters.

Some of you—perhaps all of you—have felt that the Conference could have done still better by creating some common clearing-house or clearing-houses for technical knowledge within the various fields of conservation and utilization, or by taking the initiative in regard to periodicals and other publications, or by voting resolutions. Well, if there be some pent-up energies, they are your property. Find for yourselves ways and means of giving them a proper outlet, of exercising pressure on statesmen. And let me whisper to you that recommendations may not be the way, that you may find quicker and more efficient ways and means of building what you want to build. Apply your scientific mentality to that task.

I submit to you that behind this urge is a desire for better organization of science. President Truman, in the letter in which he instructed the United States representative on the Economic and Social Council to propose the calling of this Conference, said that science itself had become one of the major resources of the world. Have you not felt that you might have liked to deal with that general question in its entirety? I make use of this opportunity, when I am Chairman of a meeting of many prominent scientists, to urge that that question be examined. I am not thinking in terms of the regimentation of science; I am asking that science should organize itself or should be organized scientifically. That is a sociological problem, and you should use what social science can be applied to that very task.

We cannot go on having the problems of the world dealt with in this way: that we in the political and diplomatic world throw the question to the experts, saying "You have the knowledge", while the experts throw it back to us, saying "You have the power". We get very little progress in that way.

The task of organizing science seems a frightful one. Still, it is coming, it is going on, you are beginning it yourself today. And one can see how very cautious they are in UNESCO, where they are trying to start it as a "liaison", and when they have created an association or a council or a scientific union or what not, they think that they have done something. But they are far from it.

The social movement among scientists must have its finishing touch in reaching out towards the scientific organization of science in the jobs of mankind, knowing that we shall never reach this goal. The approach should not be individual, national or international. What then? Scientific.

What is the vision? First, that all problems to which the scientific method, scientific mentality and scientifically acquired knowledge can be applied—that is, to which science can be applied—be treated under that angle. Second, that the question of organizing science be treated under that angle. Third, that we all, but first and foremost the scientists themselves, should have the vision of world organized science, and that they apply science to achieve that ever inspiring goal.

The United Nations aims at promoting high ideals, expressly stated in the Charter. But the United Nations is not restrictive in spirit and still less monopolistic. It wants these ideals to grow and thrive outside the United Nations as well.

Your work is now finished here, but neither the members of the Economic and Social Council nor the participants in this Conference will think that there is nothing more to be done. No. You have had your leisure now, your work begins from today. It will have to develop all over our little globe, for this Conference will remain a growing point. From this Conference will, without express recommendations, come initiative, ideas and inspiration. I trust that every one of you will act within his own field—I did not say, just within his own country—as such growing point. You will be under moral obligation to act as a sort of scientific missionaries. Every one of you must have seen the impressive possibilities which science and technology offer mankind. And please consider all countries as under-developed countries.

I have, as Chairman, been obliged to prevent resolutions and recommendations, but as a diplomat and as a Chairman I can easily circumvent that.

I express the hope, and I believe I express the hope of all of you, that this Conference one day, in the not too distant future, will be called The First United Nations Scientific Conference on the Conservation and Utilization of Resources.

I have had the last word; the meeting is adjourned.

Concluding Addresses

Tuesday Afternoon, 6 September 1949

Chairman:

Trygve LIE, Secretary-General of the United Nations

Concluding Addresses:

Vijaya Lakshmi PANDIT, Ambassador of the Government of India to the United States of America

James THORN, President, Economic and Social Council of the United Nations

Carlos G. LÓPEZ, Ecuadorian Delegation to the United Nations Scientific Conference on the Conservation and Utilization of Resources

Julius A. KRUG, Secretary of the Interior, United States of America

The CHAIRMAN: I declare open the eighteenth plenary meeting of the United Nations Conference on Conservation and Utilization of Resources.

Our first speaker this afternoon is Her Excellency, Madame V. L. Pandit, Ambassador of the Government of India to the United States. Madame Pandit does not need any specific introduction. She is, as you all know, one of the leading ladies in the world of today, and she is well known to everyone in the United Nations.

Madame PANDIT: I am deeply grateful for your kindness in asking me to speak here today. In accepting this invitation I was conscious of the fact that as a person having no knowledge of science my claim to any association with such a distinguished gathering hardly existed. This thought inevitably came in the way of preparing what I should say, but in turning over in my mind the topic of the address, I felt that the enrichment of human life was an idea so vast in its conception that it ceased to be the monopoly of the scientist, and each individual, no matter how humble, might add his small contribution.

Science today is undoubtedly everybody's business just as politics have become a part of the daily life of the individual, and unless the relationship between science and politics is correct, there may be no life left which scientific knowledge can enrich.

Man's main preoccupation through the ages has been the pursuit of happiness. Towards this end he has, at different periods, toiled, suffered and fought wars. This pursuit was not for a betterment merely in terms of physical well-being but in the creation of conditions which would enable him to fulfil the best in himself.

In ancient times men did not think in terms of improving their lot. Greek thought is pervaded by the idea of a fixed order in the universe which kept things in their place, assigning to each its proper sphere and function. This scheme of things also implied degeneration from some earlier period of a golden age. There was no question of improving material resources since the forces of nature were deemed unchangeable—subject only to the will of the gods.

With the Middle Ages the idea of an original state of felicity gained ascendancy. There was no question of making the life of man happy in *this* world. Happiness could only be secured in heaven and only a small portion of the human race was predestined to be saved for the other world.

Such views were both appropriate and relevant at a time when nature was supposed to function eternally in a particular manner, as a consequence of which the social order also conformed to a certain fixed design, but with the emergence of science the revolution in the minds of men began to take shape; and as science invaded the preserves of established ideas mankind discovered within itself the means of progress through the exploitation of natural resources.

The mechanical age which science brought into existence had, among others, two important results. (a) It gave promise of eliminating the disparity between wealth and want, and (b) it gave power to the dispossessed peoples of the world to break the bonds of slavery. The common man woke from the slumber of centuries and demanded a minimum standard of living, housing, education and security in old age. This awakening is specially visible today in Asia—the home of more than half the human race—who have not so far been enriched by any of the great discoveries of science.

The past history of mankind gives ample evidence that enduring contributions to civilization have been possible only when men have been reasonably fed and clothed and enjoyed a degree of health; as Francis Bacon pointed out long ago, man's mental and material progress are inseparably linked with one another. The most important job that lies ahead of us, therefore, is that of human emancipation—the chance of full development for every human being, the opportunity for him to share actively in past achievements and contribute toward new ones. The lack of this is the reason for the unrest in Asia and Africa. The problem these continents pose is essentially a human problem and believing as I do that the conflict between the scientific and humanist approach is purely superficial, I dare to hope that it will be possible for scientists and humanists to work together thus making possible the conservation of this vast section of humanity—our greatest source of energy—from whom we may then expect contributions for the enrichment of civilization itself.

"Probably at no time in the world's history," says Sir Edmond Mallenby, "has the average citizen of this and of most other civilized communities felt so insecure against death by violence. At no time in the world's history has the same citizen had reason to feel so secure against death by disease."

While science offers us unlimited power to create material wealth it has also given man the means of annihilating himself; and the greatest danger today, as I see it, lies in the creation of a situation which may lead to the employment of those means. The fear of war is the single most dominating characteristic of our time, and the common man judges things largely in terms of their capacity to hasten or avert war. Can we wonder that some aspects of the present situation confuse him? He interprets the duties of the scientist in terms of humanity as a whole. He is bewildered when he finds limitations being imposed on freedom of thought and investigation and is afraid that such tendencies might aid the destructive rather than the constructive aspects of science. He feels the time has come, when, in the interest of his own survival—in the interests of civilization and of humanity, science must have a moral basis.

Because of its alliance with forces which do not share its idealism, science finds itself on the horns of a dilemma. On the one hand it seeks to conserve and create, and on the other its discoveries are utilized for purposes of destruction and death. Enormous possibilities for good or evil depend upon the choice that is now made, and the peoples of the world hope that the conscience of humanity, of which, by force of events, the scientists have become custodians, will enable them to make the right choice. The great objective of feeding and clothing mankind and of raising the standard of living has to be quickly fulfilled, for time moves rapidly, and even more swift are the emotions of those who have already waited too long for the bare minimum that human decency demands and has a right to expect.

There has been and continues to be a time lag in our progress and in our thinking. In the words of Professor Zimmer: "Science has injected into the external world the dynamism of a torrent, whilst most men, in their own thinking, keep to the tempo of the glacier. The result is the maladjustment we see around us."

In the West, where science has made such rapid strides, we have to bring about an adjustment of mental attitudes, and in the East we have to remove the crying anachronism of vast populations leading lives steeped in poverty, in a world where a thousand secrets of mastering nature, of increasing productivity, of prolonging life, of liquidating want, are practised and known. It is in the fitness of things that the United Nations should now offer, as it did recently in the meeting of the Social and Economic Council which met at Ootacamund, India, for helping the economic development of South-East Asia, its scientific knowledge to the East to redress the existing world imbalance in the distribution of material goods, services and skills.

Perhaps it may not be out of place to say here that consistently with our geographical position in the Indian Ocean, we are doing as much as our resources permit —perhaps even beyond our resources—to advance the beneficent activities of science in that part of the world. The establishment of large-scale and fully equipped laboratories for the study of physics, chemistry, irrigation, electrochemical industries and technology in some of its important applications is clear proof of our determination to cultivate science both as pure knowledge and as ameliorative skill. In our plan to establish a vast network of research centres, we hope we shall have with us the good wishes and the co-operation of the scientists of the world.

Looking upon the history of scientific achievement, my faith in its service to humanity, notwithstanding recent doubts and scepticisms, is not diminished. When dogmas bound the intellect of man, science fought valiantly and suffered nobly to secure for us the precious heritage of free thought and now, when the heart of man is frozen with fear—fear of want, of insecurity, of death swooping upon him suddenly and swiftly and in ways that may be fantastic and unpredictable—science must once again lead the crusade, not only because it has the means and the ability to do so, but also because many of the spectres which haunt us today have unfortunately emanated from its own creations.

The CHAIRMAN: Madame Pandit, the audience has already thanked you, and I should like to add my personal thanks. We are very glad that you were able to come to Lake Success today. We know all the difficulties your country has to face, and on behalf of us all, I say that we are happy when we know that your country is able to overcome them, and we are happy when you are making progress in that vast part of the world for the betterment of all the people living in your country.

Our next speaker has just come from the ninth session of the Economic and Social Council of the United Nations, which session dealt with important problems on technical assistance for economic development. He served brilliantly during the past year as the President of the Economic and Social Council and as the Chairman of its meetings. It gives me great pleasure to introduce Mr. James Thorp, High Commissioner for New Zealand to the Dominion of Canada and President of the Economic and Social Council of the United Nations.

Mr. THORN: I am very glad to have this opportunity to speak before this group of distinguished scientists and resource experts drawn from all over the globe. It makes me very happy to be able to bring greetings to this Conference from the Economic and Social Council over which I have had the pleasure of presiding this past year. I only wish that it had been possible for me to be with you throughout your sessions because I think that the subject with which you have dealt is fundamental to the success of the United Nations.

The first aim of the United Nations Charter is peace or in its very words "to save succeeding generations from the scourge of war, which twice in a lifetime has brought untold sorrow to mankind". But this aim rests squarely on another major aim of the Charter, which is to promote special progress and better standards of life in larger freedom. These two aims are as dependent on one another as soil conservation and water control, as fertile soil and plant growth. Unless we can hold out to mankind, and I mean all mankind, a realistic hope of improved living standards, the world will never escape from the shadow of war. Without a sound economic base, the peace must necessarily rest on flimsy foundations.

The job you have done here is exploring the means by which mankind can wrest more things to eat and wear and use from a stubborn earth is therefore as much a part of the work of the United Nations as the deliberations of the Security Council.

I have just come from a meeting of the Economic and Social Council, which is working to promote the economic and social advancement of people all over the world.

Thus it is, that our meeting in Geneva which has been under way during your meeting at Lake Success has been a parallel attack on much the same problem. You have been discussing the ways in which mankind can secure a larger return now and tomorrow, from the earth's resources. But the development of one resource is dependent on the development of another, since one region of the world may have very different natural resources from another. Therefore, the interdependence between resources may be translated into the interdependence of regions. Each region can develop and use its resources fully only in co-operation with other regions.

This means that there must be trade between regions. To this end the Economic and Social Council has been working persistently through its various agencies to eliminate the barriers to the free flow of trade. To the extent we are successful in this sometimes disheartening task, we shall be contributing importantly to the more effective utilization of resources.

Many of the current economic problems the Council has been concerned with are of immediate relevance to your discussions of resource conservation utilization. The world has made slow, but steady progress, towards the goal of increased production and, last year, we continued generally to offset the war's devastation and reach levels surpassing those of the pre-war years. Our problem now is to make certain that we do not slip back, but rather that we continue this progress in the years to come.

This means, among other things, that we must take steps to conserve our resources and not only in the long run, but in the immediate future. For example, much of the increased lumber production of recent years was won at the expense of the future productivity of the world's forests. We must start now to adjust our rate of cutting to the rate of growth of our forests. But the world still needs large amounts of wood products. If total production is to be maintained without impairing the future yield of the forests, we must open up new forests and cut in all forests, old and new, at a yearly rate equal to annual growth.

Along the same lines, soil scientists tell us that the contribution of some areas to recent record food outputs has meant "mining" the soil in those areas, robbing it of its fertility for the sake of current yields. But if we cannot continue to get food in the same volume from one area, we are going to have to open new lands to cultivation since there is no indication of any slackening in the world's need for food.

We must also guard against those cyclic swings from boom to bust which have interrupted our efforts to increase production in the past and which have had such disastrous effects on the adoption of sound conservation practices.

In the past boom times, for example, many farmers planted wheat on land that should have been left in grass. This resulted in destroying the fertility of the land and starting erosion. Then, in the depressions following such booms, many of these farmers found that they lacked enough funds to undo the harm and restore fertility to the land. Dust bowls and wastelands were often the result of such practices. And what was worse, the cycle of boom and bust thus wasted those very resources which were necessary to increase production and raise standards of living.

Perhaps no question so graphically underscores the one world concept as the problem of the conservation and utilization of the earth's resources. Wherever there are miners and minerals to be wrested from the earth, wherever there are farmers and tillable land, wherever there are floods, dust bowls and forest fires—there are basic struggles and problems common to all. If cattle disease runs rampant in Argentina, part of Europe may have to ration meat. And if wind erosion destroys the wheat fields of Australia this is equally a problem with repercussions in other parts of the world.

The problem of resource use and conservation is one that crosses the frontiers of ideologies. The United States and the Soviet Union are both, in their different ways, committed to and embarked on extensive programs of soil conservation.

We in the Economic and Social Council are striving persistently, if not always with full success, to establish through the tools of diplomacy the sort of world in which the talents of you scientists and experts may be put to the fullest use. But we know that at every stage, we cannot go far without your help. I think there is fairly general agreement on this point. I think the best testimony that the United Nations is on the right track is the fact that we saw need of bringing you men and women together in this Conference. I am indeed very proud that this Conference was called, in response to a resolution of the Economic and Social Council.

Certainly we will need the ideas, the aid and assistance of the men of science if we are to realize the aims of the Charter. We can scarcely hope to achieve "better standards of life in larger freedom" without intensive use of all we know about using the world's resources. It will be a herculean task to raise the standards of living of the vast masses of people of Asia, Latin America and Africa. In terms of what we now know, it would strain our present resources to the utmost to achieve even a modest increase in living standards for those people.

But we cannot be assured of even our present resource base for this job in view of the steady depletion of resources. Even before we get fairly started on the job of raising standards in the less-developed countries, we are losing ground daily.

Every acre of land that is washed or blown away, every mile of forest destroyed by fire or wasteful cutting, every water power site rendered unusable by siltation, every ton of minerals dissipated or left in the ground by wasteful methods, each cubic foot of natural gas that might be used for productive purposes allowed to disappear into the air—each of these wastes sets us back in our drive to raise standards of living throughout the world.

We know how much ground we are losing in this way in the highly developed countries. For example, there are good estimates of the losses due to soil erosion, in such countries as the United States and Australia to cite two countries where this is a problem. But we have no such information for many of the less-developed countries. We do not know how fast unsuitable farming methods are destroying the best farm lands of Latin America, although soil scientists assure us that the rate of loss in that continent is high. The point is that we cannot afford to assume that a less-developed country is one whose natural resources are somehow more nearly intact and less depleted.

Conservation, therefore, does not mean the hoarding of resources. It means the application of practices of wise utilization which you have been discussing here. It is now a wall set up for static defence against distant and doubtful dangers. A man who sees his house which represents the dream of a lifetime disappearing in smoke knows he needs a fire engine. Now, similarly for us, the Charter's pledge of increased living standards may disappear in a muddy stream unless we realize the immediate and burning need for conservation.

But conservation, however, necessary, is not enough. We need to find ways and means of getting more from the world's resources. Many scientists have emphasized the importance of ecology—of the relationship of living things to their environment. Man, it is said, has increased resource depletion by violating the laws of his environment, by destroying the balance of nature. I do not question the validity of many of the illustrations of this thesis, but it seems to me there has been one important item left out of this analysis—namely, that man is the one living thing that has the capacity to do something about his environment.

Man's intervention destroys the balance of nature, true enough. But man is able to study the world and determine the means of returning a livable balance. Moreover, there are no fixed and limited sums of resources available to him to increase the world's output of goods and services. New horizons in the world supply of energy were lifted by the atomic chain reactor. Experimental developments, no less exciting, give hope of vastly increasing the amount of food that an acre of land can produce.

Modern advances in science supply the big new factor in the relation of man to his environment. It is a factor that can refute the gloomy forebodings about man's inability to feed himself and increase the production of other goods. But science is no such factor if it is left in the laboratory, or worse still, in the textbook.

A new era of peace and prosperity awaits mankind if modern techniques and science are applied to resources. The earth can be made to yield vast stores of new wealth so that man can be provided with higher standards of living if waste of resources is halted and science and technology applied.

The scope of this problem is international. This means widespread sharing of scientific and engineering knowledge so that such capital expenditures will be put to the best possible use. It is this second job of spreading scientific and technical knowledge which is the primary job of your experts gathered here. We in the United Nations have a special name for this sharing of "know-how" to aid in economic development; we call it "technical assistance" or sometimes "technical assistance to the less-developed countries".

We have been debating this question in the session of the Economic and Social Council which has just concluded. We have planned an expanded programme of technical assistance through the United Nations and its specialized agencies to encourage the flow on a systematic basis of technical "know-how" to and between the less-developed countries.

In a very real sense this Conference is technical assistance. The exchange of technical information has, I am sure, been of value to participants from all countries. But I know that you have placed special emphasis on the problems of the less-developed countries and on the aid which the results of the Conference might be to them.

At the same time, I am sure that participants from the more economically advanced countries have been able to learn much from their colleagues in the less-developed countries. But the less-developed countries have bigger jobs ahead of them because there is further to go to achieve a more adequate standard of living. This means that the scientists and engineers of the less-developed countries have heavier demands placed upon them in relation to their number than their more numerous colleagues in the industrialized or economically advanced countries. Thus, the many excellent scientists and engineers of the less-developed countries are still too few in relation to the need for their services.

Accordingly, the scientists and engineers of the less-developed countries were among the first to hail the entrance of the United Nations into the technical assistance field. They, more than anyone else, appreciate the value of receiving from their colleagues in the more economically advanced countries the results of work in larger and better equipped laboratories, and of more extensive engineering undertakings.

At the same time, they know that substantial modifications may be necessary before techniques developed in industrialized countries can be transplanted to their own. One set of obvious differences may be those arising from differences in climate and topography. Others may derive from such differences as the extent of transport facilities or a trained working force.

The scientists and engineers from the highly developed countries will face fresh and exciting problems as they enter new lands with their knowledge and methods. The scientists and engineers of the less-developed countries will have, in a sense, a big educational job to do in acquainting their colleagues from abroad with the unique conditions which may make it essential to revise earlier conclusions.

I am sure that the more frequent collaboration you will engage in under an expanded United Nations programme of technical assistance will be pleasant and stimulating. I trust that this Conference makes such a hope a realistic one.

It seems to me that many of the scientific papers discussed at UNSCCUR provide a set of preliminary, working blueprints for working out certain vital phases of the United Nations programme of technical aid to under-developed countries.

This Conference is of course one of the first and most important steps in such an expanded programme of technical assistance. I was pleased to learn that fifteen senior scientists and engineers from less-developed countries are commencing their studies under the United Nations technical assistance fellowship programme at this Conference. It is a great pleasure to extend the welcome of the Economic and Social Council together with our best wishes for a successful and profitable visit. I am sure that it should be very profitable.

One of the unique aspects of this Conference has been the exchange of ideas and experiences between men of different countries and fields of specialization. And of course this exchange has been wider than the attendance at this Conference because you have had the benefit of papers received in advance from many authors who were unable to attend the Conference.

Your contributions also have been oriented solidly in the direction of the practical economies involved. How much do air surveys cost relative to those carried out entirely on the ground? How much return in terms of increased yield can be obtained by using a new hybrid? What is the value of future returns to be expected from the use of sound soil conservation practices? You may not have been able to get definite and quantitative answers to such questions in all or even most cases. But, with your discussions oriented in such a direction I am sure that your results will be of great practical value to the programme of technical assistance of the United Nations.

Yes, I think that without resolutions or majority and minority reports, you may be sure that your meeting will have a very important impact on the work of the United Nations and particularly on its programme of technical assistance for many years to come.

First, the proceedings of your Conference will be a major source of information on the techniques of resource conservation and utilization and in the relations between them. These proceedings will be used by the scores of administrators and experts in your countries who for one reason or another were unable to attend this Conference. They will constitute a monumental addition to the printed knowledge of those questions.

Second, you have gotten to know each other, you have reached across boundaries of countries and specialties for the better understanding of one another's problems. These are important benefits for you and the future work of the United Nations. But after all this is not precisely a peculiar contribution of this Conference. You scientists were among the first internationalists, among the first to realize that man's hope lay in free interchange of ideas between countries rather than conflict. The proceedings of such broad and splendid organizations as the World Power Conference and the various publications of the Food and Agriculture Organization are no less important contributions to the technical assistance programme of the United Nations.

No, I think the most important aspect of this Conference for the future work of the United Nations is that you scientists and we of the United Nations itself and its specialized agencies have gotten to know each other as workers in this common project at United Nations headquarters. Every participant in these meetings, every author of a paper has contributed as directly to the future of the United Nations as a representative on the Security Council.

I know this is not an entirely new experience to many of you who have contributed your time and talents to the success of projects of such specialized agencies as the FAO and UNESCO, and I am sure, too, that all of you as citizens have felt deep concern for the course of the United Nations through the stormy seas of recent years, have read with alternating hope and fear of the successes and setbacks of our organization. But now I fancy that you will follow the United Nations efforts to settle the clashes that disturb the peace with a more personal interest.

Now, for better or worse, you know and must feel more deeply that we are members of the same family, players on the same team. Having carried on your debates in Council chambers at Lake Success and the committee rooms of the General Assembly, you are less likely to dismiss the debates of this great forum of the nations as unrewarding chatter from a somewhat different world.

On the part of the officials of the United Nations, I hope that the echo of your constructive debates will lead the members of the political councils and commissions to seek more earnestly for wider areas of agreement.

The Conference itself, the activities of the specialized agencies and of other organs of the Economic and Social Council have demonstrated that there is much more to the work of the United Nations than the more widely publicized clashes of the Security Council.

But this is of course only one step along a long road. There is still a tremendous job to do to realize the aims of the Charter for economic and social advancement. You men and women and your colleagues are the trustees of human knowledge in many fields fundamental to victory in such a campaign.

I am glad that we have gotten to know you and you may be sure that now that you have become more intimate members of the family we shall not readily let you go. I think it was Shakespeare who advised that having found good friends "to grapple them to thy soul with hoops of steel". Now that we know you and know where to come for expert knowledge, I think you must face the fact that you are in for it. In the great jobs that lie ahead, we will have many occasions to call on you for your help. This Conference leaves no room for doubt what the response will be.

The CHAIRMAN: Mr. Carlos G. López, of Ecuador, has asked to be heard. He has just a few remarks to make.

Mr. LÓPEZ: I have taken the liberty of asking the Chairman for a few minutes time to express on behalf of the Ecuadorian delegation two specific points before the closing of this most important Scientific Conference on the Conservation of Natural Resources.

The first point has to do with the impressions we shall take with us of the importance of the Section and plenary meetings. Our attention has been directed mainly to the learning aspect through listening to what has been said by members from the United States, from Europe, from Asia, as well as from the other countries of Latin America that are more highly developed than our own.

The limited possibilities in Ecuador have allowed our delegation, or the present delegate at least, to make only a limited contribution to the Conference. However, we feel that we have learned a great deal of the necessity of conserving resources, which should be further accentuated in the future. Not only should we try for a more efficient development and utilization of our possibilities, but we should try to co-operate and co-ordinate to the utmost with what is being done and will be done in the future by the rest of the countries throughout the world.

The second point deals with the gratitude our delegation wishes to set forth in connexion with the most generous contributions made by the majority of the countries of the Americas towards relief in the greatest tribulation befallen Ecuador through the worst earthquake registered in its history which took place just a month ago.

I am quite sure that most of the participants here have read about and seen pictures of the great destruction and devastation that took place, but allow me to say that what you have seen is just a mild reflection of what actually happened, as three whole provinces have been affected by this terrible event leaving thousands of people homeless and without immediate means of support.

From this you may judge how welcome have been the kind contributions from the governments and peoples of the American countries, with the United States leading the benevolent action, and followed immediately by the sister Republics of our continent.

To all the citizens of the Americas we wish to express our obligation for the kindness shown in many ways so generously, I repeat, and at the same time so opportunely.

I thought that this occasion was the most appropriate for doing this, because the members here present can transmit to their own peoples the recognition of gratitude by the Ecuadorians at this Conference. We request you earnestly to make this sentiment known, and we assure you beforehand our due obligations if you kindly comply with our petition.

The CHAIRMAN: The last speaker is the very well-known friend of ours, the Secretary of the Interior of the United States, Mr. Krug. He has been with the Conference during the whole session. I know all of you will agree with me when I say that we are again happy to have Mr. Krug address the Conference.

Mr. Krug: I have enjoyed participating in this Conference. It has been an inspiring experience of what can be accomplished through a free interchange of knowledge and ideas towards the solution of the important problems of the world. We all recognize it is indeed a small start, but most important it is a start. It should encourage all of us to find the most effective plan for moving forward at an ever-accelerating pace.

Certainly our meetings have demonstrated at least three important points:

1. Interest in conservation and development of resources is confined neither geographically nor to specific resources.

2. The scientists and experts of the world have demonstrated here that it is possible to overcome differences in language and cultural background to reach a better understanding about what needs to be done to assure a decent standard of living for the people of the world.

3. The bold, new programme that President Truman is advancing for the development of the under-developed areas of the world has vast support not only in these areas but in the world generally.

We have heard alarming predictions of the increase in the world's population. We have viewed estimates of the staggering increases in food, energy and materials which will be necessary to provide for the living needs of the world's population. We have heard encouraging accounts of what can be done in the various specialized fields of resource development to meet these staggering demands. With some resources these accounts may be a little too encouraging. And so many have emphasized, these problems are not single, indivisible, world-wide problems which can be resolved on a world-wide basis. Rather, they are a host of regional and national problems and the solutions for most of them must be found by the people of individual nations or at most groups of nations.

For the most part, each nation or at best each region of the world is, and will continue to be, largely dependent upon its own resources for basic foods, materials, fuels and energy. For most things world trade can merely supplement local supplies and the economies are always weighted heavily against supplies of foods and materials that must come from abroad.

On the other hand, these meetings have clearly demonstrated that knowledge, experience and ideas can readily be interchanged among the free nations of the world. The world cannot afford monopolies of technologies which, when properly made available, can help every nation to find answers to its particular and special problems.

Therefore, I think each nation must draw upon world-wide "know-how" and information to make the very best of what it has—that is the very essence of sound conservation. This Conference has demonstrated the appalling lack of, and the compelling need for, really effective interchange of knowledge regarding resource conservation and development. It is up to all of us working through proper channels within our respective governments to find the means of assuring this effective interchange of knowledge among the nations of the world.

While we take new hope and courage from the accomplishments of these meetings, I want to re-emphasize what has been said here time and time again. There is no simple answer. No single TVA will supply desperately needed food for India or China. No newly discovered ore deposits will be the economic salvation of South America or Africa.

Resource development and conservation is the application of the detailed and specific knowledge of thousands of trained people in thousands of fields of enterprise. It is only through aggressively pushing our work in each of these interrelated fields that we can achieve the desired over-all result—a decent and secure way of living for the people of the world.

This Conference will have wide repercussions in resource work for a long time to come—you have dropped pebbles in the pool and the ever-widening circles of the ripples will affect the lives of people on every continent.

It has been said that this is a conference without resolutions and to be sure we have spent no time in chasing commas through multilingual texts. But we are not without resolutions for I am confident that each one of us has resolved to forward in his own way the great purposes of resource conservation, utilization and development which will mean so much to our people and their children.

The Chairman: Thank you for your kind words about the Secretariat and the staff of the United Nations. I know that the staff of the United Nations are happy when they know that the delegations and the delegates are satisfied. We are just doing our simple duty, but I can tell you that we are happy when a conference is over and we know that you are going home and that you are satisfied with us. That is the best honour you can pay us.

The first Scientific Conference on the Conservation and Utilization of Resources has come to an end. I was very glad that I had both the time and opportunity to come to your meeting and to preside over your closing meeting of what has been one of the most interesting and constructive sessions ever held at Lake Success. I congratulate you not only on the scope and variety of the subjects you have covered, but on the many different points of view which you have brought to bear upon them. Your proceedings have aroused great popular interest. The space which the newspapers have devoted to this Conference indicates a growing interest in the constructive long-term activities of the United Nations. In addition to the newspapers, we have supplied the radio throughout the world with scores of reports on this Conference and interviews with its participants.

I think that one of the most important results of this Conference has been to demonstrate to the peoples of the world that the United Nations is concerned with building the economic and technological foundations of international peace by enlisting the collaboration of the scientific and technical world.

This exchange of ideas and experience through the United Nations will not end with the closing of this Conference. The proceedings of this Conference will be published, and its work will be available to the specialists in the fields of development and conservation of resources all over the world who did not have the chance to attend.

One of the most important things about this Conference is that we of the United Nations and you, the scientists, have become acquainted. It is significant that Mr. Clapp was invited to speak at this Conference long before the Middle East Economic Mission was conceived and long before he was asked to head that Mission.

I am confident that as progress towards a stable peace continues an increasing proportion of our work here at the United Nations will be devoted to constructive efforts for the economic development of the world and the raising of the living standards of its peoples. This is not a task which can produce results overnight, or even in a short period of years. This task must be an example of collaboration not only between men and peoples of today, but between generations, and it must be undertaken in the broad spirit of human solidarity. In this task we shall rely to a very large extent on scientists and technicians for their help and advice, as individuals or small groups collaborating on specific projects and in conferences of broader scope such as this one. For all these reasons, we are very glad to have met so many of you here. It has been a stimulating experience and one which we intend to repeat.

I thank you for coming here and for your hard work, and I wish to welcome you either here at Lake Success or at the new headquarters in Manhattan or at the other places belonging to the United Nations and its specialized agencies where we can meet again.

LIST OF CONTRIBUTORS TO PLENARY PROCEEDINGS

Figures in italics refer to scientific papers and opening and closing remarks