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JOINT WORKING PARTY ON FOREST ECONOMICS AND STATISTICS

Ad hoc meeting to review the draft study of European timber trends and prospects (ETTS V)

Palais des Nations, Geneva, 6-8 February 1995
Starting at 10.00 a.m.

Outlook for separate parts of the sector

External influences on the sector
(Item 4 of the provisional agenda)

CHAPTER 5

This chapter has been prepared by Mr. P. Kauppi of the Finnish Forest Research Institute, consultant to the secretariat. It covers the two most doubtful and controversial external influences on the forest and forest products sector - air pollution and climate change.

In the final version of ETTS V, this material should be supplemented by discussion of (a) forest fires (b) biotic damage, including insects and game.

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CHAPTER 5

EXTERNAL INFLUENCES

Abstract

Trends in the physical and chemical environment of European forests are described. It is concluded that the adverse effects on forest biomass have been limited. Forest increment and the growing stock have developed favorably in all major regions of Europe. European forests have made a positive contribution to the global carbon budget. The favorable trends of forest increment and growing stock are likely to continue for at least 20 more years. However adverse effects of pollutants have been widespread on forest biodiversity. Not much improvement can be expected in this respect in the next 20 years.

In the long term, toward 2030 and beyond, the future interactions between forests and global change are uncertain, and very difficult to predict. For example, the observed changes in the concentrations of green house gases can bring about a climatic warming in 20-40 years, that is within the life time of most forest stands.

Assuming a climatic warming the prospects for biomass productivity are good in northern Europe, moderate in central Europe, and uncertain in southern Europe in the long term. The prospects for forest biodiversity are essentially less good in all regions.

Forestry can be further developed to cope with changes in the physical and chemical environment. Sustainable management and forest conservation can make contributions to mitigation of global change.

5.1. Introduction

1. A forest is an ecosystem. It can offer biodiversity, industrial wood, biomass energy, game, and other goods. It can also create landscape elements, protect the quality of ground water and surface water, provide protection against avalanches, and generate other services. The different goods and services must be taken into account in a balanced fashion. The objective of forestry is to develop and share forest lands and forest productivity, to take into account the different goods and services, and to create optimal beneficial impacts. Forestry is a sustainable, long term business where the needs of future generations are taken into account.

2. The impacts of air pollution must be assessed in a multi-objective,long term perspective. Such a broad scope is here adopted which is in accordance with the definition of global change as applied within the International Geosphere-Biosphere Program (IGBP). The definition includes three driving forces of change: land use, atmospheric chemistry, and climate. The objective of this chapter is, first, to describe relevant changes of forest indicators over time, and then to create a professional view on the impacts of global change on European forest ecosystems, as evaluated based on the observed trends of global change. The effects of forests on global change are also briefly assessed. The view is extended beyond 2005.

5.2. Trends in Global Change

3. In the next paragraphs, the trends in land use, atmospheric chemistry and climate are briefly described. Such trends serve as a basis for forestry assessments.

5.2.1. Land Use

4. Changes in land use have impacts on forest management and conservation. For example, land cover can change from non-forest to forest, and from exploitable forest to protection forest. Also within a land cover class, like exploitable forest, changes can occur in land management such as an introduction of new silvicultural methods.

5.2.1.1. Land Cover

5. The total area set aside for nature protection has increased, and was about 500 000 km2 in 1990, according to recent IUCN statistics, about 10.2% of Europe, (excluding such large countries as, for example, Belarus, Russia and Ukraine (IUCN 1994). These statistics do not cover only forested land but also other land. The protected areas are of particular interest because of their landscape value and biodiversity.

6. In 1990, the area of forest and other wooded land in Europe was about 195 million hectares. In the past 30 years it increased by about ten percent. This has been due to afforestation and the abandonment of agricultural land in south western and in Atlantic Europe, and similar changes elsewhere.

5.2.1.2. Wood Resources

7. Since 1960 removals have increased in Europe, but forest increment has accelerated even faster. The gap between forest increment and forest removals has grown steadily (Fig. 1). Average tree mortality has been low. As the result, the growing stock has been accumulating at an accelerating rate (Fig. 2). The impact of

increment has more than compensated for the effects of removals and mortality. The increase of wood biomass in the past 30 years has been about 40% that is, much larger than the corresponding increase in forested land cover. Also the forest increment has increased by about 40%.

Figure 1

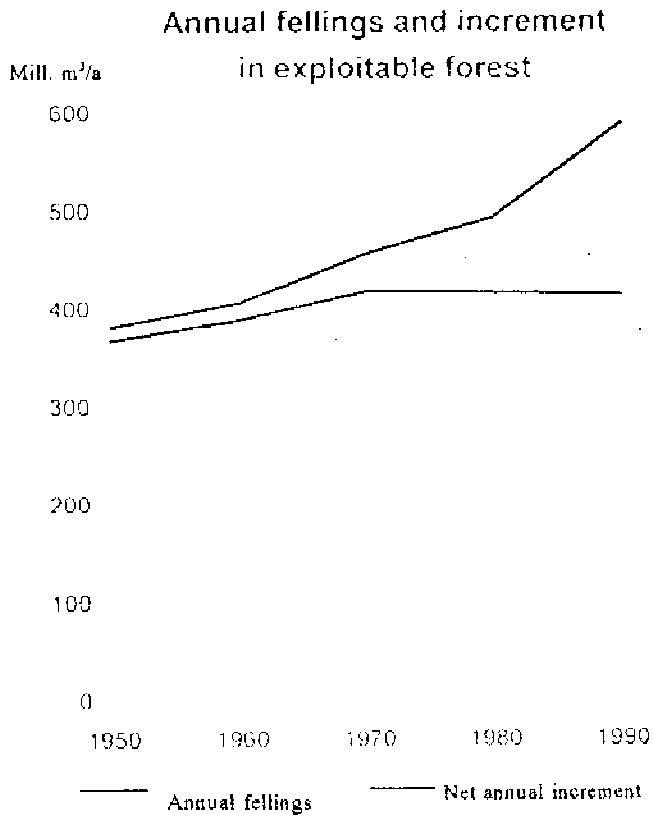
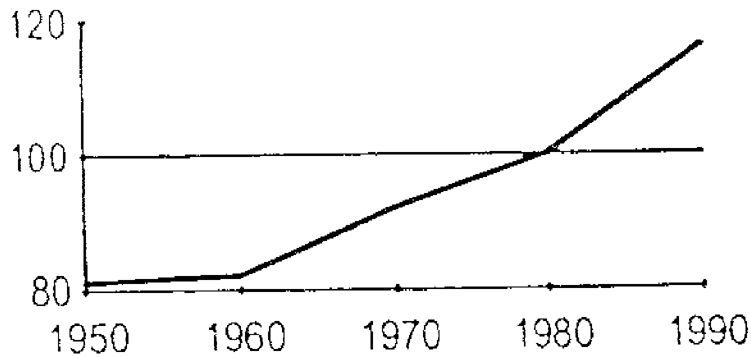


Figure 2



8. The patterns of substantially increasing forest increment, slightly increasing or almost unchanged removals and mortality, and increasing growing stock as a consequence, have been universal in Europe. In 1970-1990, the growing stock increased in all European countries where statistics have been available.

9. Between 1980 and 1990, the growing stock increased by 8%,7%, and 19% in eastern Germany (former GDR), Czechoslovakia and Poland, respectively. The reported 100% increase in western Germany was however due mostly to severe underestimation of growing stock for 1980. A statistically representative forest inventory was carried out in western Germany in the end of 1980s. The estimate of 1990 was based on these new measurements. Although there are problems with the statistics, it is an established fact that the growing stock (national total) has not declined, not even in countries where air pollution has been a problem.

5.2.2. Atmospheric Chemistry

10. Air quality has changed in Europe over the past 30 years and will keep changing into the 21st century. Sulfur dioxide emissions have decreased and will most likely continue to decrease as a result of environmental protection policies (Fig. 3). Ambient levels of sulfur dioxide and sulfate are decreasing accordingly. Ammonium emissions and concentrations follow a similar pattern, while nitrogen oxide emissions have not started decreasing in Europe, with the exception of some countries like Germany (Fig. 4). The nitrogen loading of forest ecosystems is unlikely to decrease essentially by 2005.

Figure 3

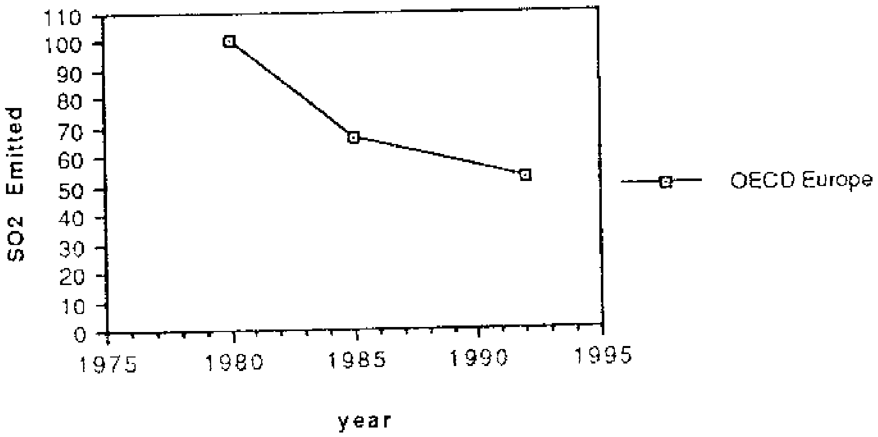
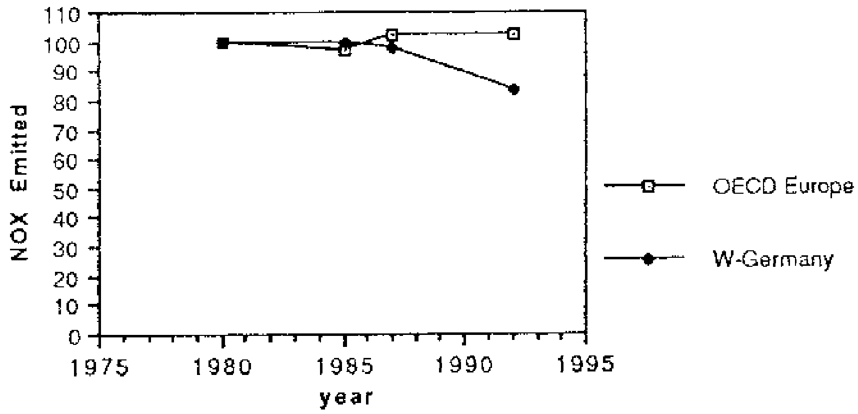


Figure 4



11. Tropospheric ozone concentrations have steadily increased in Europe since 1960. The ozone chemistry is complicated, and it is uncertain how the concentrations will respond to changes of the emissions of ozone precursors. It is likely that the ozone concentrations will increase in some areas and decrease in others. The upper atmosphere may have changed over Europe since 1960 and affected the total amount of solar irradiance and its spectral quality. However, there are little quantitative estimates of such changes.

12. The best recorded and most obvious change of atmospheric chemistry is the increase of carbon dioxide concentration from about 280 parts per million (ppm) in 1850 to 317 ppm in 1960, and further to 355 ppm in 1990. The change in the past 30 years was about 12%. Additional 10-20 ppm units will be observed in the atmosphere by 2005, since the main driving force (fossil fuel consumption) is so powerful that it is unrealistic to anticipate changes in the consumption patterns before 2005. It is feasible that the carbon dioxide concentration will continue increasing beyond 2005.

13. The concentrations of other green house gases such as methane, nitrous oxide and the CFCs have also increased in the air in Europe in the same way as in the other parts of the world. However, unlike the carbon dioxide concentration, they may start decreasing before 2005.

5.2.3. Climate

14. The variability of climate has not changed in Europe since 1960 to the extent that one would speak of a new climatic pattern. There have been a few unusually warm years recently, but no convincing proofs of a change due to the green house effect. The eventual green house warming is relevant mainly beyond the year 2005 and, in particular, beyond 2020. However, given the tradition of forestry as a term business the issue is highly relevant. Most of the forest stands existing today will have to cope with whatever the environment is beyond 2005, and even beyond 2020.

5.3. Impacts of Global Change on Forest Ecosystems

5.3.1. Past

15. Carbon dioxide concentration in the atmosphere and nitrogen pollution have increased. The productivity of ecosystems has increased as a consequence (Kenk and Fischer 1988; Luxmoore et al. 1993; Johnson et al. 1994). In the Netherlands and parts of Germany nitrogen deposition can be as high as 50 to 70 kg N per hectare and year.

16. The recorded changes in atmospheric chemistry have not been the only reason, and not even the main reason for the recorded change of forest increment by +40% since 1960. Firstly, the increasing growing stock has provided the basis for a higher increment (effect of a higher "wood capital"). Secondly, silviculture has improved. However, these changes alone, although very important, cannot explain the observed increase of productivity in repeated measurements from given forest ecosystems (e.g. Kenk and Fischer 1988). A part of the observed increase of biomass productivity has been due due to increasing availability of carbon dioxide and nitrogen that is, due to the eutrophication effect. The changes of atmospheric chemistry have contributed to an increase and not to a decrease of the forest biomass on average in Europe.

17. Stand decline has occurred in different parts of Germany, Poland, the Czech Republic, Russia, Ukraine, and other countries. These impacts have been due to severe pollution mainly by sulfur and heavy metal

compounds, and in some cases also due to excess nitrogen pollution.

18. Forest biodiversity has been affected by air pollution. A large amount of observations is available from the Netherlands, Sweden, Finland and elsewhere on changes in forest vegetation. Eutrophication has acted in favour of nitrophilous plant species. The species composition of lichen vegetation has changed in Finland, probably due to a combined effect of sulfur and nitrogen on the survival and the competitive advantage of the different species. Changes have been observed also in the ground cover vegetation.

19. In summary, the main adverse effects on the European scale have been those on forest biodiversity. Biomass production has declined only in small areas. This effect has been more than compensated for by a substantial average increase of forest increment all over Europe.

20. Adverse effects have been observed on forest service functions. Pollution has deteriorated the ability of forests to improve the quality of ground water and surface water. Decreasing visibility of the ambient air has deteriorated the role of forests as landscape elements. Visibility is affected by sulfur particles, and the decreasing trend of sulfur pollution is expected to improve future visibility.

5.3.2. Future Scenarios of Impacts

21. The achieved and anticipated improvements in air quality contribute to combatting adverse effects on forests. For example, the prospects for conserving the pristine environment of protected forests are improving as the sulfur pollution load is decreasing. However, nitrogen deposition has not decreased, and the concentration of atmospheric carbon dioxide continue increasing.

22. The concept of "critical load" refers to the highest deposition of pollutants which does not cause harmful effects to ecosystems. The concept "critical level" refers to air concentrations of in an analogous way. It has not been easy to determine such critical indicators of air pollution levels and loads, although much emphasis has been given to this important task. It is very difficult, almost impossible scientifically, to determine such indicators, since it is the combination of environmental factors, and not one factor in isolation that determines the productivity and biodiversity of a forest ecosystem. Moreover, different forests respond in different ways. For example, it has been observed that planted conifer forests at high altitudes in mountains are particularly sensitive to air pollution damage, especially if the trees are genetically of a wrong origln.

23. It is not certain that when critical loads or levels are exceeded, there will be ecological damage. Neither is it certain that if emissions are reduced, and the critical loads and levels are no longer exceeded, the risk of damage completely disappears. The concepts of critical loads and levels represent a compromise between scientific accuracy and precision, and the requirement for simple environmental guidelines.

24. The favorable trends for forest biomass and forest increment in the past 30 years have been so strong that they can hardly change abruptly in the next 20 years. In the longer term, the development depends on environmental policy measures. The greatest long term uncertainty is due to a possible climatic change, and maybe to changes in the environment that have not yet been recognized adequately such as the pollution from industrial organic chemicals.

25. The development of climate is a critical and uncertain issue regarding the impacts of global change on forests. In a positive scenario, the climate remains unchanged, or changes very little. The current structures of the forest sector would be able to develop gradually and smoothly.

26. In a negative scenario, the development for green house gases translates into a significant climatic warming and eventual changes in rainfall patterns. The climatic change would be a global phenomenon, affecting the forest sector worldwide. There would be second order and third order effects due to changes in agricultural land use and in global trade patters. The subsequent impacts on the European forest sector are very difficult to predict.

27. The growing stock and forest increment in northern Europe might not decline, not even in the negative scenario. The ecosystems in that region are less vulnerable to climatic warming than to climatic cooling. In fact, a warming of the annual average temperature by 2-5 degrees Celsius in 50-100 years would increase the forest increment, and probably would not threaten the survival of the trees. In southern Europe such a substantial warming, associated with an increase of severe drought periods would probably decrease the forest increment. The risk of forest fires would increase. The biodiversity would be negatively affected in all European regions.

28. It must be emphasized that this scenario is prepared from a narrow perspective. It omits the second order and third order effects, and does not address the full array of objectives for long-term forestry. Improving and stabilizing the air quality would contribute to the predictability of forest ecosystems, an essential basis for long-term sustainable forestry. Reducing pollutant emissions would be a superior environmental policy from the perspective of sustainable management and conservation of European forests.

5.4. Impacts of forests on global change

29. Trees, the conifers in particular, filter pollutants such as sulfur and nitrogen compounds from the atmosphere into the ecosystem, and improve the air quality down wind. This is to the benefit of the down wind ecosystem, although it adds to the burden on the ecosystem itself. Afforestation on acid soils can contribute to surface water acidification. Clearly, not all the impacts of forests on global change are positive, but many of them are.

30. Increasing forest biomass sequesters carbon dioxide from the atmosphere. The concepts "sink" and "source" refer to changes in the carbon reservoir of forest ecosystems. An increasing reservoir is a sink, and a decreasing reservoir is a source. The two main reservoirs are carbon in the soil, and carbon in forestvegetation. An additional, essentially smaller reservoir is the carbon in forest products.

5.4.1 Past

31. In the past the area of forested land and forest biomass diminished in Europe. The forests were a source of carbon dioxide into the atmosphere until the late 1 9th century. Since then, European forests have been a sink for atmospheric carbon dioxide. Also the soils have been a sink, yet the best information is available on forest vegetation and forest products reservoirs.

32. Based on growing stock and wood products statistics it has been estimated that European forests were an annual sink of 85-120 million tons of carbon in 19711990. The forests controlled the rise of the carbon dioxide concentration in the air and contributed to the carbon budget by absorbing about 5 % of the carbon dioxide emitted in Europe in fossil fuel use.

33. About 70-105 million tons of the sink was due to the increase of growing stock, and an additional 15 million tons due to a build up of the stock of forest products (sawnwood and panels). Because the gap between

forest increment and forest removal has increased, the sink impact has also increased (see Fig. 1). The ratio of wood removals to forest increment has declined to 0.7-0.8 in most European countries. This is the main reason for the sink effect.

5.4.2. Future Scenarios of the Carbon Budget

34. In the near term, the development of sink/source will depend mainly on the ratio of forest increment to forest removals: The lower the ratio, the larger the sink. As the increasing trend of the growing stock has been so universal and consistent in the different European countries, the current sink effect is likely to persist at least 15-20 more years. In the longer term, the low ratio of removals to forest increment -- the main reason to the current sink effect -- cannot be sustained. Three scenarios of the carbon budget can be developed for the period beyond 2010-2015.

35. Firstly, the demand of the current forest products and eventual new products could increase. As a result the forest removals would increase and approach the level of forest increment. Subsequently, the current carbon sink would weaken, approach zero, and the current mitigating effect of European forests on the global carbon budget would essentially be lost. The full impact of fossil emissions in Europe would be realized as an increasing tendency of the concentration of carbon dioxide in the atmosphere. However, the increasing removals would generate an increasing flux of wood, a renewable material, which eventually would make a contribution to sustainable development in Europe notably by replacing non renewable raw materials.

36. Secondly, the removals could remain at the current low level, or be further reduced. The growing stock would continue accumulating at the current rate, or even faster in the first phase. In the second phase, most forest stands would become mature. The carbon reservoir in vegetation would approach saturation. The current sink effect would be lost and the forest increment would decline. The flux of wood, a renewable material, would decrease which could contribute to an increasing consumption of non-renewable raw materials.

37. Thirdly, a new forest policy could be developed which would adopt a long term perspective to carbon mitigation and find an acceptable balance between the different forestry objectives. New areas would be established in different parts of Europe for nature protection, and the carbon reservoir of forests would grow larger. Converting non-forest to forest would also contribute to the increase of the carbon reservoirs in vegetation and soils in the long term. Wood removals would grow as a result of afforestation, improved forest management, and closing the current gap between removals and increment in exploitable forests. An increased flux of forestry products would be used to substitute other, ecologically less sustainable products. Forests and forest management would make a positive contribution to the global carbon budget in both short and long term.

38. These three scenarios are future visions rather than predictions. The forestry objectives may well change substantially in the next 30-60 years as they have changed earlier, making these scenarios worthless. A whole new array of uncertainties emerges, if one assumes a change in climate. The mechanisms controlling the reservoirs and fluxes of carbon in forest ecosystems are sensitive to climate, particularly to temperature. Obviously, it is very difficult to make any quantitative forecasts of the sink effects beyond 2020. Until then, European forests will most likely continue acting as a carbon sink.

5.5. Discussion

39. The impacts of global change on forests, and the impacts of forests on global change must be assessed from the perspective of long term, multi-objective forestry. From this perspective it would be of utmost

importance to try to stabilize the atmospheric environment as much as possible, in order to improve the predictability of forest ecosystems. If the predictability is lost, there will be no basis for long-term forestry policies. For example, the current uncertainty regarding the climate beyond 2010-2020 is an obstacle for developing multi-objective forestry in all regions in Europe. Even such a basic matter as applying the forest yield tables is at risk, if the yield tables are no longer reliable because of changes in the atmospheric environment. In the meantime, as the atmospheric environment has not been stabilized, it is important to record and analyse the trends of the environment, and try to cope with changes as they occur.

40. While forests have been, and have been viewed, as victims of air pollutants, forestry can also contribute to the solutions regarding air pollution. Forests filter pollutants and shorten the life time of sulfur, heavy metals, nitrogen, and other types of pollutants in the atmosphere. Maintaining and creating forests serves the filtering purposes. Planting more shade trees in southern Europe could contribute to home energy efficiency by alleviating the need to develop air conditioning, thus lessening energy emissions in the same way as has been reported from North America. In particular, forests can make a positive contribution to the global carbon budget and help alleviating the risk of an enhancement of the green house effect. New objectives are thus emerging for contemporary forestry.

41. In summary, the current situation and the near term prospects are very good in Europe in terms of biomass productivity and biomass reserves. For conserving the biological diversity, and regarding other ecosystem functions such as watershed and groundwater protection, the recent history and the near term prospects are not as good. The pollution levels of sulfur and nitrogen compounds are high in Europe. Although the deposition of sulfur and some heavy metals have started decreasing in large areas in Europe, the flux of nitrogen deposition is still not decreasing, and the concentration of carbon dioxide in the atmosphere is increasing. A transient change of biological diversity has been observed in favour of nitrogen demanding (nitrophilous) species. The development extends to nature conservation areas.

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Luxmoore RJ, Wullschleger SD, Hanson PJ (1993) Forest Responses to CO2 Enrichment and Climate Warming. Water, Soil, and Air Pollution 70: 309-323.

OECD Core Set of Environmental Indicators (1994), Publications Service, OECD, Paris.

Figure Captions:

Figure 1. Forest increment and forest removals in Europe.

Figure 2. Growing stock of exploitable forests in Europe (index 1980=100).

Figure 3. Sulphur dioxide emissions in OECD Europe (index 1980=100; OECD 1994).

Figure 4. Nitrogen oxide emissions in OECD Europe and in western parts of Germany (index 1980=100; OECD 1994).