UNITED NATIONS **E**

Economic and Social Council

Distr.
GENERAL

EB.AIR/WG.1/2001/13
19 June 2001

Original: ENGLISH

ECONOMIC COMMISSION FOR EUROPE

EXECUTIVE BODY FOR THE CONVENTION ON
LONG-RANGE TRANSBOUNDARY AIR POLLUTION

Working Group on Effects
(Twentieth session, Geneva, 29-31 August 2001)
Item 7 (c) of the provisional agenda

WORKSHOP ON CHEMICAL CRITERIA AND CRITICAL LIMITS

Summary report prepared by the organizers

Introduction

1. The workshop on chemical criteria and critical limits took place under the auspices of the Working Group on Effects. It was organized by the United Kingdom's National Focal Centre (NFC) as a contribution in kind to the activities of the International Cooperative Programme on Mapping Critical Levels and Loads, as agreed by the programme's Task Force at its sixteenth meeting in 2000.

2. The meeting took place from 19 to 21 March 2001 in York (United Kingdom). It was attended by 33 experts from the following Parties to the Convention: Canada, Czech Republic, Germany, Netherlands, Norway, Sweden, Switzerland and the United Kingdom. The International Cooperative Programme on Mapping Critical Levels and Loads (ICP Mapping) and the Coordination Center for Effects (CCE at the National Institute of Public Health and the Environment (RIVM), Bilthoven, Netherlands) were represented.

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3. The workshop was chaired by Ms. Jane Hall (United Kingdom).

I. AIMS AND ORGANIZATION OF THE WORKSHOP

4. The aims of the workshop were:

(a) To examine the chemical criteria and critical limits currently used for acidification and eutrophication critical loads models (steady-state and dynamic);

(b) To consider new or alternative chemical criteria and critical limits;

(c) To consider what guidance is needed in their application;

(d) To draw up conclusions and recommendations to be presented for consideration at the meeting of the Task Force on ICP Mapping (7-9 May 2001, Bratislava).

5. The meeting began with a series of plenary presentations to provide background information on the issues and promote discussion:

(a) The validity of the chemical criteria and limits for emission control in Europe, considering the questions: (i) do the criteria and limits provide a fair method of sharing the burden of emission control; (ii) will they in fact lead to the desired outcomes? (Richard Skeffington, United Kingdom);

(b) Observations on acidity effects in Swiss forests. (Sabine Braun, Switzerland);

(c) Nitrogen effects on forest ecosystems from the viewpoint of critical loads. (Walter Fluckiger, Switzerland);

(d) The relationship between Norway Spruce status and soil water base cations/aluminium ratios (BC/Al) in the Czech Republic. (Jakub Hruska, Czech Republic);

(e) The temporal behaviour of BC/Al in soil solution of forest soils. (Rock Ouimet, Canada);

(f) The use of the sodium dominance index for predicting weathering rates and critical loads for soils and waters. (Malcolm Cresser, United Kingdom);

(g) Chemical criterion for salmon: Acid neutralizing capacity (ANC), Al or pH? (Frode Kroglund, Norway);

(h) Critical ANC – some experiences with its application to Scottish freshwaters. (Ron Harriman, United Kingdom);

(i) Base saturation as a critical limit – the link to dynamic models. (Max Posch, Netherlands);

(j) Limits for soils and for freshwaters and the way forward with dynamic modelling. (Harald Sverdrup, Sweden).

6. On the second day of the meeting work continued in three discussion groups:

(a) Acidity - Terrestrial Ecosystems (chaired by Richard Skeffington, United Kingdom);

(b) Acidity - Freshwaters Ecosystems (chaired by Chris Curtis, United Kingdom); and

(c) Eutrophication - Terrestrial Ecosystems (chaired by Mike Ashmore, United Kingdom).

7. The discussion groups were asked to consider two sets of questions:

(a) Criteria and limits:
  (i) Do they represent a chemical dose to biological response?
  (ii) Are they appropriate, or in need of revision?
  (iii) Are there any new ones that should be considered?

(b) Mapping Manual:
  (i) What are the implications of these discussions on criteria and limits?
  (ii) Are revisions to the Mapping Manual necessary?

II. CONCLUSIONS AND RECOMMENDATIONS

8. The workshop agreed upon a number of conclusions and recommendations. These are listed below separately for each discussion group topic.

A. Acidity – Terrestrial Ecosystems

9. The discussion group on acidity – terrestrial ecosystems considered each criterion and related conclusions and recommendations for revisions to the Mapping Manual separately.

10. Critical molar base cation to aluminium ([BC/Al]) ratio. The group agreed that it was time to update the review of underpinning scientific experimental data relating [BC/Al] to damage. It suggested the following revisions to the Mapping Manual:

(a) To report that the base case of [BC/Al] = 1 is ecosystem-specific (coniferous forest);

(b) To include a table of tree, moorland and grass species with suggested [BC/Al] ratios, together with a "reliability rating" for each;

(c) To tabulate the limitations and advantages of applying [BC/Al] on a horizon basis (such as in the PROFILE model) versus a "mixed-tank" single horizon (such as in the Simple Mass Balance equation);

(d) To report that further research is needed to look at the short-term temporal fluctuations in [BC/Al] and how they may be related to adverse effects. For example, are the trees/plants responding to average or extreme [BC/Al] values? Dynamic modelling needs to consider this.

11. The gibbsite equilibrium constant (K_{gibb}) was also discussed. It was concluded that the Mapping Manual should:

(a) Recommend the use of K_{gibb} as a default, with the value set according to the percentage of organic matter in the soil as defined in the table in the Mapping Manual;

(b) Include the option for calculating the critical aluminium concentration ($[Al^{3+}]_{crit}$) by methods other than the gibbsite equilibrium constant (K_{gibb}). For example, the use of models (e.g.

Windermere Humic Aqueous Model), or if there are good empirical field data to represent the relationship between H^+ and Al^{3+}, these should be used in preference to K_{gibb}.

12. Critical pH ($[H^+]$). The group agreed that:

(a) Countries should consider the use of critical pH or ΔpH (i.e. acceptable change in pH) as a criterion;

(b) Existing data on pH dose-response needed to be compiled and synthesized and indicator species (i.e. species that may be adversely effected) needed to be identified;

(c) pH should be related to heavy metal dissolution (link this area of work to heavy metal investigations).

13. It suggested that the Mapping Manual should include:

(a) A recommendation that critical pH is the most appropriate criterion for organic soils;

(b) A table of plant growth effects versus pH and soil fauna effects versus pH to help in the selection of appropriate limits.

14. Critical molar base cation to hydrogen ([BC/H]) ratio. The group agreed that there was a need for a review and further investigation to improve the database on the [BC/H] dose-response to biological effects.

15. Critical aluminium concentration ($[Al^{3+}]$). No actions were identified.

16. Aluminium weathering greater than aluminium leaching ($Al_w \geq Al_{le}$). No actions were identified.

17. Percentage base saturation (%BS). The percentage base saturation was introduced as a potential new criterion; it was also considered to be a good criterion for dynamic modelling. It was agreed that:

(a) There was a need to promulgate the relevant equations for use in critical load calculations;

(b) A protocol was required for the measurement of %BS, perhaps involving ICP Forests;

(c) Research was needed to set appropriate %BS limits and to link them to other criteria.

18. It was suggested that the Mapping Manual should include %BS as a potential new criterion for linking steady-state models to dynamic models.

B. Acidity – Freshwater Ecosystems

19. The discussion group on acidity – freshwater ecosystems concluded that:

(a) There were relationships for pH and Al with biological response, but the relationship with ANC was best;

(b) There was a need to define dose-response functions on a regional basis to account for regional differences in, for example, organic acidity or strain-dependent sensitivity of species;

(c) There was a need to define separate dose-response functions for lakes and streams to account for differences in episodic acidification;

(d) More work was needed on the definition of chemical targets for biological recovery in dynamic modelling, given hysteresis in both chemical and biological recovery processes which could lead to changing dose-response (ANC/species) relationships;

(e) There was a need for a forum for data and information exchange between countries, preferably web-based. It was suggested that perhaps ICP Waters could be involved in this development since they already had a web site.

20. The group recommended the following revisions to the Mapping Manual:

(a) To recommend the use of ANC as a criterion for lakes and streams (although the limit values may be different);

(b) To recommend that for international comparisons, there is a need to standardize the indicator (brown trout) and the required probability of damage (using regional dose-response relationships);

(c) To standardize the definitions for ANC and labile aluminium;

(d) To include a comment about how countries should treat naturally acid lakes (i.e. ANC ~ 10 μeq/l) and whether in these situations zero critical loads are acceptable;

(e) To include a reference to the forum for data exchange, proposed in the conclusions above.

21. The Acidity Terrestrial Group and the Acidity Freshwaters Group together drew up a table of confidence ratings for different acidity criteria which is attached to this document.

C. Eutrophication – Terrestrial Ecosystems

22. The discussion group on eutrophication – terrestrial ecosystems aimed to review both the current effects criteria, taking into account the recommendations from the Copenhagen Conference (1999), and the empirical critical load values considering whether new evidence had become available since 1995. However, it should be noted that its assessment of new evidence was not comprehensive. The group examined the criteria and critical loads on an ecosystem basis.

23. Criteria for forests:

(a) Soil fauna. There appeared to be a lack of data on soil fauna, although some data exist for Sweden. It was felt that these data on soil fauna needed to be reviewed and considered as

a potential indicator or criterion;

(b) Pathogens/pests. Some new data were presented on nitrogen-pathogen interactions and useful chemical criteria identified. The new data suggest that critical loads would need to be lowered. A review of the literature on the potential use as indicators is needed to understand the interactions between fauna, insect attack and phenolics as driven by nitrogen;

(c) Frost/drought. These criteria need reviewing. However, frost damage was regarded as probably not important. Drought is believed to play a role in damage as a consequence of increased growth and higher water demand;

(d) Root/shoot ratio. Many studies demonstrate changes to this ratio. It was considered useful for pot experiments but would be difficult to apply in the field. The usefulness of the root/shoot ratio as a criterion was therefore questioned;

(e) Nutrient imbalances. There was concern about the use of this criterion with respect to the empirical critical loads approach. It was agreed that nutrient imbalances should be regarded in mass balance models, which may require development. A further review is required;

(f) Nitrogen leaching. A lot of good new data are available. This criterion could be applied to all forest types based on throughfall; a critical throughfall could be used as a useful indicator of effects;

(g) Ground flora. There was a lack of good new data to consider. The ranges of empirical critical loads given in the Mapping Manual to protect from changes in ground flora should be used more explicitly. The possibility of shifting to high/medium/low parts of the range to allow for altitude, base cation availability and temperature should be emphasized. The effects on bryophytes and lichens should probably be considered separately from those for other ground flora.

24. Critical loads for wetlands:

(a) Ombrotrophic bogs. While it was agreed that the empirical critical load should remain in the range of 5 -10 kg N/ha/year, there were new experimental data to support a change in the reliability score given in the Mapping Manual, from “quite reliable” (#) to “reliable” (##);

(b) Mesotrophic fens. There are no new data available at present, but experiments are under way, so a review of new data should be possible in 3-4 years’ time;

(c) Shallow soft-water bodies. New modelling data support the existing empirical critical loads range (5-10 kg N/ha/year) given in the Mapping Manual.

25. Criteria and critical loads for heathlands:

(a) Nitrogen leaching. This criterion was not thought to be important for heathlands, but should be considered for peat systems. Clarification of some of the nomenclature in the Mapping Manual is needed, for example, the difference between the ecosystems named “upland Calluna heath” and “moor”;

(b) Role of management. The Mapping Manual needs to make the role of management in heathlands more explicit by including (model-derived) estimates of the impact of alternative management regimes on the critical loads;

(c) Arctic heathlands. New experimental data for arctic heaths strongly suggest a change in the empirical critical load in the Mapping Manual from 5-15 kg N/ha/year (reliability

score: quite reliable (#)) to 5-10 kg N/ha/year (reliability score: reliable (##)). However, a brief review of the data is required to support this proposed change.

26. Critical loads for grasslands:

(a) Dune grasslands. It was suggested that dune grasslands should be introduced as a new habitat in the Mapping Manual table of empirical critical loads. New data are available to support an empirical critical load in the range of 10-20 kg N/ha/year (reliability score: quite reliable (#));

(b) Calcareous grasslands. New data support changing the empirical critical load in the Mapping Manual from 15-35 kg N/ha/year (reliability score: quite reliable (#)) to 15-25 kg N/ha/year (reliability score: quite reliable (#));

(c) Montane-subalpine grasslands. No new data are available at present, so the empirical critical load should not be changed from that given in the Mapping Manual;

(d) Neutral-acid grasslands. Although there are few data available, it was thought that the critical load for this grassland type could be lowered (15-25 kg N/ha/year). However, there is not enough evidence to support this new value at present.

27. The discussion group on eutrophication – terrestrial ecosytems also concluded that:

(a) There was a need for a workshop to revise the empirical critical loads for nutrient nitrogen (autumn 2002 was suggested);

(b) There was a need to agree the mechanisms to produce the background review documents to prepare for the above workshop;

(c) There was a need to identify all sections of the Mapping Manual relating to eutrophication and the setting of empirical nutrient nitrogen critical loads that needed revising;

(d) Use should be made of the experiences of countries which had already applied empirical critical loads;

(e) Empirical critical loads were important, both for biodiversity and forest sustainability, and more countries should be encouraged to use them.

III. SUMMARY CONCLUSIONS FROM THE WORKSHOP

28. The workshop on chemical criteria and critical limits concluded that:

(a) The criteria and limits being used did represent dose-response relationships;

(b) There were, however, criteria and limits that needed revising;

(c) There were potential new criteria, for example, percentage base saturation.

29. The workshop proposed:

(a) New empirical nutrient nitrogen critical loads;

(b) To organize (preferably in autumn 2002) a workshop to formally review empirical nutrient nitrogen critical loads.

30. The workshop also identified:

(a) Areas requiring further research and/or review;
(b) Required revisions to the Mapping Manual.

IV. PROCEEDINGS OF THE MEETING

31. The proceedings of the meeting, containing discussion group reports and abstracts of the presentations, as well as the conclusions and recommendations, will be available in a full workshop report from the United Kingdom National Focal Centre. While only a limited number of hard copies will be produced, the full report will be made available via the United Kingdom National Focal Centre web site (http://critloads.ceh.ac.uk) in downloadable format.

Table. Confidence ratings for the different criteria used to calculate acidity critical loads

Criterion	Biological effect	Confidence rating
pH	Soil fauna and microorganisms Plant growth in organic soils	high high
$[Al^{3+}]$	Surface water and shallow ground waters	low
[BC/Al]	Tree stability (windthrow) Inhibition of root growth	low high
[BC/H]	Plant growth in organic soils	low
$Al_w > Al_{le}$	Soil stability	low
%BS	Loss of nutrient capital Physical stability for vegetation and soils	low low
ANC	Damage to fish species	high