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CONFERENCE ON CRITICAL LOADS: CRITICAL LOADS COPENHAGEN 1999

Summary of the report

I. INTRODUCTION

1. The conference on critical loads, Critical Loads Copenhagen 1999, was organized by the National Environmental Research Institute, Denmark, and jointly sponsored by the Nordic Council of Ministers, the Danish Environmental Protection Agency, the National Environmental Research Institute, the Danish Farmers Union and the Danish Power companies ELSAM and Elkraft. The conference took place in Copenhagen from 21 to 25 November 1999.

2. The conference was attended by 135 participants from 17 countries. The UN/ECE secretariat, the Nordic Council of Ministers Workgroup on Sea and Air, the International Cooperative Programmes (ICPs) on Waters, and on Integrated Monitoring, the Coordination Center for Effects (CCE) and the Task Force on Mapping were also represented.

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3. Science-based reduction targets have helped to formulate effective air pollution control measures on both the national and the international level, in particular under the Convention on Long-range Transboundary Air Pollution. The implementation of the Protocols to the Convention resulted in remarkable reductions in air pollution loads in Europe and North America with a positive impact on levels of acidification but, so far, a limited impact on levels of eutrophication. The realistic assessment of the related recovery of terrestrial and aquatic ecosystems is therefore becoming increasingly important, and requires reliable and representative methods and good quality data.

40 The use of soil and water chemistry models to calculate critical loads provides a practical tool for obtaining simple and operational mapping procedures useful for administrative and regulatory purposes. However, efficiently implementing the air pollution control protocols and validating environmental recovery following the emission reductions require a broader range of indicators of change in ecosystem structure and function. More attention has to be given to biological indicators and chemical changes in the environment, and, in particular in some areas, to deriving convincing cause-effect relationships.

50 The aims of the conference were:

(a) To present the actual state of the knowledge;
(b) To critically review methodologies for calculating critical loads for acidification and eutrophication;
(c) To strengthen the relationship between calculated exceedances and the observed biological and ecological effects in the field.

60 The presentation and discussion of recent advances in the field of biological responses to acidification and eutrophication should be used to develop further the critical loads approach in order to improve the relationship between calculated exceedances and the observed biological and ecological effects in the field. The purpose was to reach beyond empirical experiences; how can changes in ecosystem structure, composition and function be assessed, and how are they related to calculated exceedances. The conference dealt with methods and models in terrestrial as well as in aquatic ecosystems. In particular the issues of biological indicators, modelling and methods for validation call for attention in order to further improve and develop science-based critical loads as a tool in the abatement of long-range transboundary air pollution.

70 Keynote presentations reviewing existing knowledge and outlining innovative methods and theories were made in plenary sessions. A number of posters provided additional information. Five thematic workshops were organized to provide for in-depth discussion of the following topics:

(a) Workshop I: Criteria dealt with ecosystem state and change, and addressed a variety of criteria and their possible alternatives. The use of different criteria for different species or ecosystems was addressed;

(b) Workshop II: Methods addressed the links between chemical and biological variables, time lags and the use of dynamic modelling;

(c) Workshop III: Ecological indicators addressed ecosystem structure and function, and the selection of organisms or processes with good relationships to atmospheric deposition;

(d) Workshop IV: Validation dealt with relations between statistical large-scale field data and modelled critical loads, dynamic modelling, and extrapolation;

(e) Workshop V: Freshwater critical loads addressed a broad range of questions, in particular the links between catchment characteristics and surface waters, lake sensitivity, dose/response relationships, and chemical criteria and biological indicators.

80 The most important information on the conference and the deliberations, conclusions and recommendations of the plenary sessions as well as of the individual workshops are summarized in the conference report.[1]

II. CONCLUSIONS AND RECOMMENDATIONS OF THE WORKSHOPS

A. Workshop I: Criteria

1. Conclusions

90 The workshop discussed and proposed several criteria for assessing the effects of nitrogen and acidity on different compartments of terrestrial and aquatic ecosystems. Some of the proposed criteria require further research.

100 The workshop agreed that research was needed particularly in the following areas:

(a) Reassessment of existing limits and empirical critical loads using both old information and new data;

(b) Linking of critical limits to:
- Mycorrhizal function (trees);
- Tree species/succession (trees);

[1] Løkke, H., Bak, J., Bobbink, R., Bull, K., Curtis, C., Falkengren-Grerup, U., Forsius, M., Gundersen, P., Hornung, M., Skjelkvåle, B.L., Starr, M. & Tybirk, K. (2000): Critical Loads Copenhagen 1999. 21st B 25th November 1999. Conference Report Prepared by Members of the Conference=s Secretariat, the Scientific Committee and Chairmen and Rapporteurs of its Workshops in Consultation with the UN/ECE secretariat. Critical Loads. National Environmental Research Institute, Denmark. 48 pp. B Arbejdsrapport fra DMU nr. 121.

- Wood quality (trees);
- Plant functional types (other plants);
- Soil fauna (soil);

(c) Consideration of historical land use and management, which may have a profound effect on several ecosystem processes and vegetation;

(d) Development of risk assessment methodologies using distributions of limits, allowing probabilities of critical load exceedances to be estimated;

(e) Development of dynamic models describing recovery rates in different compartments;

(f) Development of integrated models describing plant competition, and multi-stress interactions (nitrogen compounds, acidity, water stress).

2. Recommendations

110 (a) Revise present critical load definition in order to take into account sustainability of ecosystems (changes underlined):

ACritical load means a quantitative estimate of an exposure to one or more pollutants above which significant adverse effects on specified sensitive elements of the environment may occur, according to present knowledge@;

(b) Provide better guidance in the mapping manual (UBA, 1996) on the selection of different criteria (and their ranges) in order to improve the international harmonization of critical load calculations;

(c) Further develop methodologies for dynamic risk assessment of ecosystem effects;

(d) Develop combined critical load and risk assessment procedures. Apply critical loads for verified chemical and biological indicators and criteria across specific ecosystem compartments, soils and aquatic systems and use risk assessment methodologies where parameters are adequate. Conduct further research to link soil processes to ecosystem health.

B. Workshop II: Methods

1. Conclusions

120 (a) Present methods to estimate critical loads are: empirical approaches, simple mass balance (SMB) calculations, and dynamic models;

(b) The mapping of critical loads till now has mostly been based on SMB calculations. The reduction in sulphur emissions and uncertainties in the SMB method mean that there is now a need for a reappraisal and for a higher level of accuracy;

(c) The uncertainties associated with scaling (grid sizes) in the mapping of critical loads are of particular concern;

(d) Some components of the SMB equations need more reliable input data and improved documentation;

(e) The importance of nitrogen compounds in critical loads has increased and there is an increasing amount of data available.

2. Recommendations

130 (a) In the case of terrestrial ecosystems, more emphasis should be given in the future to empirical and dynamic modelling approaches, and coupling acidification with the nitrogen cycle;

(b) There is a need for better accessibility and use of existing monitoring data on soil conditions, fluxes and biological indicators in order to improve and develop empirical relationships and models. Long-term monitoring should be secured;

(c) Uncertainty related to scale in mapping should be quantified and parameterization of the major fluxes improved, in particular weathering, base cation deposition, N immobilization in soils, and the toxicity and chemistry of aluminium;

(d) The role of land use and forest management in base cation removal at harvesting should be included in order to compare with the effects of acidification from deposition;

(e) To reflect the uncertainties, ranges and probabilities for critical loads estimates should be given. Multiple criteria (related to different receptors) should be presented;

(f) Efforts to improve the basic understanding of the nitrogen cycle in terrestrial ecosystems should be continued;

(g) An updated critical review of the evidence concerning aluminium toxicity in relation to base cations and forest ecosystem biological indicators should be made.

C. Workshop III: Ecological indicators[2]

1. Conclusions

140 It was concluded that several studies during the past 4-5 years had increased the reliability of indicators and some of the empirical critical loads for nitrogen set at the Lökeberg workshop (Grennfelt & Thörnelöf, 1992) and the 1995 Task Force on Mapping meeting held in Geneva.

150 The specific indicators discussed can be used to set critical loads for nitrogen deposition in a large range of natural and semi-natural ecosystems, including forests. The main conclusions are:

(a) Chemical composition of the shoots (N content and related factors, such as N-rich amino acids, N ratios with P, K or Mg) give a good indication of the nitrogen status of the ecosystem. The actual levels, however, depend on the ecosystem type;

(b) Vegetation composition. Changes in the abundance of key species (e.g. dominants) and/or impacts on endangered species (red listed/nutrient stress indicators/functional groups) have been identified as reliable indicators of exceedance of N critical loads;

(c) Decomposition of organic matter, including nutrient mineralization and immobilization. Changes in the rates of these indicators are clearly observed with increased nitrogen inputs;

(d) Acidification effects of N (decrease in nitrification and mineralization, changes in nitrogen form, base saturation).

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[2] The following working definition of an indicator was used: a structural or functional characteristic of an ecosystem which may be affected by changes in acidifying and eutrophying atmospheric deposition.

2. Recommendations

160 (a) The empirical critical loads should be applied with confidence in the calculation and mapping procedures of individual countries;

(b) All countries should use the empirical N critical loads approach for natural and semi-natural ecosystems in addition to the SMB models. For this, detailed maps of sensitive ecosystems at the appropriate landscape scale (10 km x 10 km, 1 km x 1 km) have to be derived;

(c) Vegetation databases should include the most important ecosystem types and should be combined with the empirical critical values for the production of critical load maps to demonstrate the probabilities of biodiversity losses more explicitly and adequately.

D. Workshop IV: Validation

1. Conclusions

170 (a) Validation is needed at all levels to gain the user=s confidence and to support the further development of the critical load programme;

(b) Some promising attempts at validation have been demonstrated in national studies;

(c) The existing European data sets cannot be used to validate the effects at particular sites;

(d) For acidification more confidence can in general be had in models and predictions for aquatic systems than in those for terrestrial systems. For the terrestrial ecosystems, indicators and criteria are probably more robust for eutrophication than for acidification;

(e) Several criteria should be used in parallel when determining critical loads. The applied indicators/criteria should match users= aims and be field-validated.

(f) As deposition declines, deposition targets based on a gap closure in the exceeded area becomes increasingly uncertain and the calculated exceeded area will tend to be underestimated;

(g) Dynamic modelling and dynamic impact evaluation of the biological responses are crucial for improving the understanding of recovery. The present understanding of biological recovery is weak.

2. Recommendations

180 (a) Maintain monitoring and increase the use of data from intensive/integrated sites. Where needed, monitoring protocols should be revised, especially for the extensive programmes;

(b) Include the assessment of uncertainty in the national reporting to the Coordination Center for Effects (CCE) on the basis of common guidelines, and use the data in the assessment of the implications for European calculations and for integrated assessment modelling. The appropriate scale for target setting should be considered;

(c) Change the emphasis of the mapping programme towards mapping of probability of exceedance and damage and include mapping of recovery. Methods may be tested on intensive sites, but the possibilities for European scale calculations with simple and generalized dynamic models should be explored.

E. Workshop V: Freshwater critical loads

1. Conclusions

190 (a) Continued work is required on the quantification of spatial, temporal and biological uncertainty in static critical loads models and exceedances;

(b) Dynamic modelling is essential for the assessment of recovery times and the relative benefits of emissions reductions at different times and different levels;

(c) Continued monitoring is essential for the assessment of effects of emission reductions and to feed back into model development and improvement;

(d) Dose-response relationships used to select the critical chemical value are not necessarily transferable between regions or types of water body.

2. Recommendations

200 Develop definitions of exceedance to include interpretations of the probability/risk of damage, the degree of damage, and the potential time lags between exceedance and damage or non-exceedance and recovery, to incorporate uncertainty;

(b) Develop methods for the quantification of spatial (site) representativeness including geographical information system (GIS) techniques to provide inventories of the population of ecosystems and to model the distribution of critical loads and exceedances amongst the whole population;

(c) Strongly encourage the wider application of freshwater models using appropriate regional dose-response relationships;

(d) Develop methods to improve the understanding and modelling of biological recovery processes.

III. OVERALL CONCLUSIONS OF THE CONFERENCE

210 The participants in the plenary sessions:

(a) Noted the important results of ongoing activities on calculating and mapping critical loads and their substantial contribution to the development and implementation of air pollution control measures under the Convention;

(b) Agreed that the dose-response relationships used to select the critical chemical value were not necessarily transferable between regions (i.e. countries) or related ecosystems (e.g. streams and lakes), so countries should be encouraged to select or develop specific criteria where possible;

(c) Suggested a shift in emphasis to identify the recovery of ecosystems following a decrease in transboundary air pollution;

(d) Identified the need to pay more attention to nitrogen processes in terrestrial and aquatic systems, because critical loads for nitrogen continued to be exceeded in large areas of Europe;

(e) Noted the need to bring together more data to describe natural variability across

Europe and North America, and to improve their accessibility;

(f) Recommended continued scientific work and monitoring to improve the methodologies and data for assessing the status of terrestrial ecosystems, soils, freshwaters and groundwater, in particular in relation to their protection from acidifying and eutrophying pollutants.

220 The participants of the conference concluded that while there was a continuing need for international cooperation and harmonization in monitoring activities and in deriving and mapping critical loads, more work was needed on:

(a) The proper use of indicators and criteria for specific receptors;
(b) Empirical approaches to critical loads for nitrogen to protect biodiversity and natural processes;
(c) Assessing critical load uncertainties at appropriate scales;
(d) Reducing uncertainties due to site conditions and history;
(e) Generating representative data;
(f) Evaluating and mapping risk assessment and recovery of ecosystems;
(g) The further elaboration and application of dynamic models;
(h) The comprehensive assessment, explanation and validation of links between critical loads exceedances, violation of criteria, and possible damage and recovery of ecosystems.

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