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EXECUTIVE BODY FOR THE CONVENTION ON
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Working Group on Effects
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Item 5 (viii) of the provisional agenda

# JOINT EXPERT GROUP MEETING ON DYNAMIC MODELLING

Summary report on the fifth meeting prepared by the organizers

## Introduction

1. The fifth meeting of the Joint Expert Group on Dynamic Modelling took place on 28–29 October 2004 in Sitges (Spain). It was organized by the Swedish programme on International and National Abatement Strategies for Transboundary Air Pollution (ASTA programme) in cooperation with the Centre for Ecology and Hydrology (United Kingdom).

2. Twenty-one experts from the following Parties to the Convention attended the meeting: Canada, Denmark, Finland, Germany, Ireland, Norway, Poland, Sweden, Switzerland and the United Kingdom. The International Cooperative Programme (ICP) on Integrated Monitoring, ICP Modelling and Mapping and ICP Waters, as well as the Coordination Center for Effects (CCE) were represented. A Vice-Chairman of the Working Group on Effects attended and a member of the secretariat was also present.

3. The meeting was co-chaired by Mr. Alan Jenkins (United Kingdom) and Mr. Filip Moldan (Sweden).

## I. AIMS AND ORGANIZATION OF THE MEETING

4. The objectives of the meeting were to:

(a) Review the technical problems encountered with the 2003 (first) call for dynamic modelling outputs from national focal centres (NFCs) and suggest possible solutions;
(b) Consider the CCE plans for the forthcoming 2004 (second) call for dynamic modelling outputs;
(c) Review the requirements and options for providing dynamic model outputs to integrated assessment models;
(d) Assess the options for using dynamic modelling for scenario analysis and to review the status of dynamic modelling of nutrient nitrogen and heavy metals;
(e) Determine the suitability of existing models for assessing the joint impacts of emission reductions and climate change.

5. The meeting was conducted in a series of plenary sessions addressing four topics:

(a) Response to the 2003 call for data;
(b) Technical issues:

(i) Nitrogen;
(ii) Consistency with critical loads;
(iii) Coverage and representativity;
(iv) Presentation of results;

(c) Beyond the next call for data:

(i) Climate change impacts;
(ii) Dynamic modelling of nutrient nitrogen and heavy metals;
(iii) Biological responses;

(d) Future developments.

## II. CONCLUSIONS AND RECOMMENDATIONS

6. The Joint Expert Group agreed on 30 conclusions and recommendations here grouped into six sections.

## A. Response to the 2003 call for data

7. The Joint Expert Group reviewed the response to the 2003 call for data and welcomed the progress achieved. At the same time the group urged more NFCs to respond to the new (2004) call especially with respect to target load functions for surface waters.

8. The Group agreed with the proposed CCE specifications for the target load reporting planned for the call for dynamic modelling outputs in 2004.

9. The Group agreed on the use of the critical load function at sites where there were no calculated target loads. At the EMEP grid scale, combination of the two provided the best available material for the assessment of the whole area. It was, however, desirable to design a way to indicate which squares were based on target loads and which on critical loads.

10. The Group recommended the CCE call for a list of nine variables including calcium and nitrate concentrations in soils or surface waters and carbon to nitrogen ratios of humus layers in the years 1990, 2010, 2030, 2050 and 2100.

11. The Group recommended that dynamic models be run using two scenarios in the coming call for data: emissions according to the 1999 Gothenburg Protocol and “background” deposition. In the “background”, sulphur and nitrogen deposition beyond 2020 would be set to natural background levels as defined by EMEP.

12. The Group agreed that future (beyond 2020) base cation and nitrogen uptake should be assumed constant for the target load calculations. Long-term uptakes were already used for critical load calculations.

13. The Group recommended the use of present day data to identify ecosystems for which dynamic modelling was not needed in response to the call for data, because the soils or surface waters were not currently damaged with respect to the chemical target. Since agreed emission reductions to 2010 will take the pollutant deposition flux lower, these sites could be considered to be protected in the future.

14. The Group urged CCE to include scenario analyses for the two deposition scenarios in their planned report on the response to the 2004 call. The group also recommended that NFCs should further explore the dynamic modelling outputs on a national level.

15. The Group encouraged better national awareness of NFCs in individual national research project activities with associated dynamic modelling outputs that could be utilized in response to the call for data.

16. The Group urged all ICPs and their NFCs to include ICP monitoring sites when reporting critical loads and target loads to CCE for consistency checking and validation assessment.

17. The Group reminded NFCs of the requirement to use consistent models for critical loads and target loads in their response to the 2004 call.

18. The Group noted the potential of the "half-time" concept for communicating dynamic modelling results to end-users. The Group recommended all ICPs to explore further the use of the "half-time" concept to display recovery changes and to illustrate differences between scenarios.

19. The Group requested better insight into the results of dynamic modelling work done in Canada and recommended CCE to seek ways to include these in their assessment of the 2004 call for data.

## B. Modelling nitrogen dynamics

20. The Joint Expert Group welcomed the suggestion for an expert workshop on the subject of nitrogen dynamics in terrestrial systems. The workshop should include the consequences of nitrogen deposition and climate change.

21. The Group encouraged ICP Forests, ICP Vegetation, ICP Integrated Monitoring and ICP Waters to examine the results from their dynamic modelling efforts with respect to nitrogen variables and to evaluate whether these outputs were sufficient to predict the biological response with respect to nitrogen as a nutrient (eutrophication).

22. The Group acknowledged that present approaches to the representation of broad-scale nitrogen dynamics were simplifications, and urged the development of mechanistic descriptions that could be incorporated into dynamic modelling.

23. The Group recommended that each NFC contributing to the call should parameterize nitrogen dynamics in the manner each determined best suited for its country. The country-specific protocol should thus be appropriate for the ecosystems of interest, the data availability and model selected. Appropriate guidance on parameterization of nitrogen dynamics was available in the Dynamic Modelling Manual.

## C. Interactions with climate change

24. The Joint Expert Group recognized the need for developing empirical relationships between observed climate change variables and observed effects. It recommended that ICP Integrated Monitoring asseses the need for dynamic models to be revised and modified to incorporate key climate change driven processes and preferably to include internal feedbacks and dependencies.

25. The Group noted the output from the European Union project EUROLIMPACS showed that potential effects of future climate change were of the same magnitude and occurred over a similar time period as those expected in response to emission reduction agreements (e.g. the Gothenburg Protocol) and, therefore, must be considered. Potential effects of land use and management were also confounding factors potentially affecting damage and recovery from air pollutants. The synergistic and combined effect of these factors required evaluation by ICP Waters, ICP Forests, ICP Vegetation and ICP Integrated Monitoring.

26. The Group noted that whereas biogeochemical (acidity) dynamic modelling applications to date were generally on an annual time step, effects in terrestrial and aquatic ecosystems were often manifested over shorter timescales (days, weeks, months). This was particularly important for evaluation of future climate change response and such shorter-term responses would need to be considered in the future by all relevant ICPs.

27. The Group expressed concern that new information arising from ongoing climate change research might not be readily available for work with respect to dynamic modelling of impacts on acidification processes.

## D. Heavy metals

28. The Joint Expert Group agreed that soil organic matter dynamics and acidity were key to modelling heavy metals. The group concluded that the expertise existed, the databases were available and that it was feasible to do the first trials of dynamic modelling of heavy metals at least for cadmium, lead, zinc and mercury. The group highlighted that dynamic models were available and could be used to undertake scenario studies.

## E. Ecological responses and targets

29. The Joint Expert Group noted that models for nitrogen as a nutrient had been developed but their outputs needed to be checked for consistency with observed data on successional changes and loss of species. For the forthcoming call, however, there would not be sufficient

time to apply these models extensively. ICP Vegetation should consider the potential of these models for impacts evaluation.

30. The Group highlighted the importance of terrestrial biological responses in relation to the next generation of model development and, in particular, the incorporation of key feedback mechanisms that linked ecological response with biogeochemical cycling.

31. In terrestrial ecosystems, the targets for biodiversity were not explicit and did not link closely to biogeochemical model outputs. The Group encouraged ICP Vegetation and the wider scientific community to explore targets for biodiversity and the detection of change. This might be best explored by means of a workshop.

32. Recent research on aquatic ecosystems indicated that acid neutralizing capacity damage thresholds for zooplankton, phytoplankton and benthic invertebrates might be lower than those for fish. ICP Waters should give further consideration to identifying appropriate response targets for these biota and their inclusion in effects-based evaluation.

## F. General

33. The Joint Expert Group gave support to the 2004–2006 work plan of the Working Group on Effects. However, except for acidity, most of the deliverables were rather optimistic with outcome dependent on funding being available. It was noted that the Working Group included work plan elements for the Group for September 2004 to August 2005 as:

(a) Develop a method for assessing site-specific simulation results within a regional context;
(b) Formulate and evaluate an agreed description of nitrogen processes for dynamic models;
(c) Support the calculation of critical loads and simulation with dynamic models at monitoring sites of all ICPs;
(d) Develop an agreed methodology for the application of dynamic modelling in setting deposition targets;
(e) Evaluate the synergies in dynamic modelling work carried out in different ICPs.

34. The Group identified that a further meeting in 2005 would be beneficial to review the outcome of the 2004 call for data and in order to design the best strategy for further employment of dynamic models in the work of the Convention as well as for the Clean Air for Europe (CAFE) thematic strategy of the European Union. Three major areas where progress required review were the links between biological and chemical modelling, the interactions between air pollution, climate change and land use and the yet unresolved issue of future impacts of nitrogen

deposition. The Group felt that any advice from the Working Group or the Executive Body on priorities was desirable in order to share existing resources between these issues, since progress will inevitably be in proportion to the resources available.

35. The Group reviewed and proposed a short description of the potential use of dynamic modelling within the framework of the Convention (annex 1) for wide distribution to NFCs, ICPs, the Working Group on Effects, the Executive Body as well as more widely, e.g. within the CAFE programme.

36. The Group emphasized the need for better synergy between CAFE and Convention activities. The multi-pollutant and sectoral nature of CAFE resulted in a limited overlap with the work of the Convention but this should not present an obstacle in making full use of existing results of dynamic modelling in the work of both the Convention and CAFE.

# **Annex I**

## Dynamic modelling of acidification in support of the Convention

1. The link between emissions of sulphur and nitrogen and the acidification of soils and surface waters is understood. The impact of the chemical changes on biota is also sufficiently understood such that chemical targets aimed at protecting aquatic or terrestrial biota have been established as the basis for international agreements on emission reductions. These chemical targets are converted, with the aid of (steady-state) models, into critical loads. Emission reduction targets aim at reducing the level by which these critical loads are exceeded across Europe. The link between the deposition of acidifying pollutants and the loss of or damage to biota, however, is not immediate.

2. The soil cation exchange capacity (CEC) provides a buffer that delays the onset of soil and surface water acidification. Just as the damage to biota is delayed beyond the onset of acid deposition, so the recovery from acidification will also be delayed. The models used to determine critical loads consider only the steady-state condition in which the chemical and biological response to a change in deposition is complete. Dynamic models, on the other hand, attempt to estimate the time required for a new (steady) state to be achieved. These models can also provide a prediction of chemical status at any point in the future in response to any emission scenario. This note describes the possibilities and limitations of using dynamic models to define the limits and timescales of the recovery processes as an extension to the previously used static approaches (critical loads) and thus provide information on recovery times as a strategy/policy tool.

3. With critical loads (the steady-state situation) only two cases are distinguished when comparing them to deposition: (1) the deposition does not exceed the critical load; and (2) the deposition exceeds the critical load. In the first case, no problem is perceived and no reduction in deposition is necessary. In the second case there is, by definition, an increased risk of damage. In this respect, a critical load serves as a warning as long as there is exceedance, since it indicates that deposition should be reduced. This is the basis on which the 1999 Gothenburg Protocol was negotiated.

4. A conclusion often drawn from this simple analysis is that acidification of soil and surface water is fully reversible and that reducing deposition to (or below) the critical load immediately removes the risk of ‘harmful effects’. So the chemical parameter (e.g. an aluminium: base cation ratio in soils or an acid neutralizing capacity concentration (ANC) limit in surface waters) that links the critical load to the biological effect(s) immediately attains a non-critical (‘safe’) value and that there is immediate biological recovery. In reality, however, the removal of the risk of further damage does not necessarily imply that chemical or biological recovery will occur, at least not in the short term. One major reason is that the reaction to

changes in deposition is delayed by (finite) buffers, such as the CEC in catchment soils. These buffers can delay the attainment of a critical chemical parameter and it might take decades, or even centuries, before a (new) equilibrium (steady state) is reached (fig. I). These finite buffers are not included in the critical load formulation, since they do not influence the steady state. But they can influence the time to reach it. It is also likely that the desired chemical target will be achieved prior to a new steady state and so the concept of equilibrium becomes irrelevant.

5. Dynamic models are needed if we wish to estimate the times involved in attaining a certain chemical state in response to given emission scenarios. In addition to the delay in chemical recovery, there is likely to be a further delay before the 'original' biological state is reached, i.e. even if the chemical criterion is met (e.g. ANC>0), it will take time before full biological recovery is achieved, e.g. as a result of the dispersion characteristics of species. The possibility remains, however, that the original biological status will not be recovered, but this is a possibility for both steady state and dynamic approaches.

6. Given the observed delays in ecosystem responses, there are two related questions for which steady-state models provide no answer: (a) When will ecosystems recover in response to the agreed emission reductions? (b) Which deposition reductions are necessary to achieve recovery within a given time? Dynamic models can be readily used to provide an estimate of the future soil or surface water chemistry in response to existing or planned emission reductions, and thus the timing of recovery.

7. In this respect, dynamic models have been used to assess the ANC in surface waters across Europe in response to the 1999 Gothenburg Protocol scenario (fig. II).

8. Dynamic models can also be used to answer the second question regarding ecosystem response within a given time frame to define the concept of a target load. Target loads depend on the characteristics of the ecosystem like critical loads but they also depend on the timetable for deposition reductions (the target year) and thus are not unique for a given ecosystem. Because of their explicit dependence on time, only dynamic models can produce such target loads.

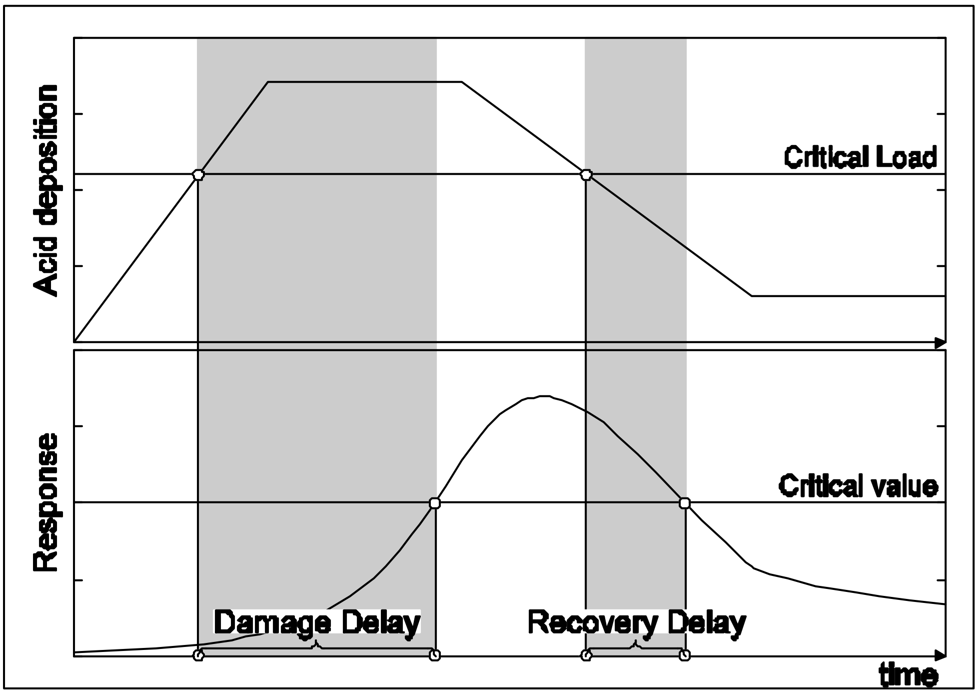


**Figure I.** Typical past and future development of the acid deposition effects on a soil/lake (chemical or biological) variable in comparison to the critical values of this variable and the critical load derived from it. The delays between the (non) exceedance of the critical load and the (non) violation of the criterion are indicated in grey

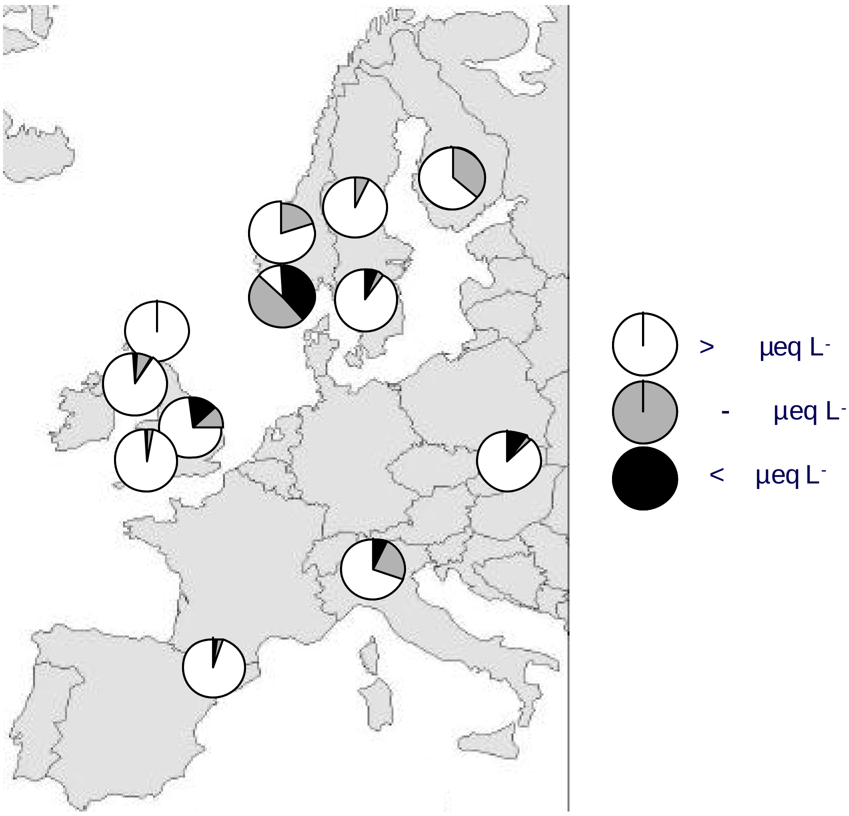


**Figure II.** Predicted surface water ANC concentration for 2016 in acid sensitive regions under currently agreed deposition reductions expressed in three ANC classes. (Source: Jenkins et al. 2003, Hydrol. Earth Syst. Sci. 7, 447–456)