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Working Group on Effects

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DYNAMIC MODELLING*

Report by the Co-Chairs of the Joint Expert Group on Dynamic Modelling

1. This report describes the results of the sixth meeting of the Joint Expert Group on Dynamic Modelling, held on 28 October 2005 in Brighton (United Kingdom) and a workshop on nitrogen processes and dynamic modelling, held back to back with the Joint Expert Group meeting on 26–27 October 2005 (a report of this workshop is annexed).

2. Experts from the following Parties to the Convention attended the meeting: Austria, Canada, the Czech Republic, Denmark, Finland, Germany, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom and the United States. The International Cooperative Programme (ICP) on Integrated Monitoring, ICP Modelling and Mapping, ICP Forests and ICP

* This document was submitted on the above date because of processing delays.

Waters, as well as the Coordination Centre for Effects (CCE at the Netherlands Environmental Assessment Agency), were represented. The UNECE secretariat was also represented.

3. The meeting was co-chaired by Mr. C. Evans (United Kingdom) and Mr. F. Moldan (Sweden). It was organized by the Centre for Ecology and Hydrology (United Kingdom) and by the Swedish programme on International and National Abatement Strategies for Transboundary Air Pollution (ASTA Programme).

I. AIMS AND ORGANIZATION

4. The objectives of the Joint Expert Group meeting were to:

(a) Review the outcome of the 2004 call for dynamic model outputs;
(b) Consider the potential for using dynamic model outputs in the forthcoming review of the 1999 Gothenburg Protocol;
(c) Assess progress in linking dynamic biogeochemical models with models of biological damage and recovery;
(d) Consider the potential for model applications incorporating both climate change and emissions reduction scenarios;
(e) Review the results of the workshop on nitrogen dynamic processes;
(f) Discuss the workplan for 2006 and 2007.

II. CONCLUSIONS AND RECOMMENDATIONS

5. The Group strongly recommended that dynamic model outputs be employed in the review of the 1999 Gothenburg Protocol. This should include (a) the use of target load functions (TLFs) as a complement to critical load functions (CLFs) for acidity in integrated assessment modelling, where dynamic models have been applied, and (b) the use of dynamic models for scenario assessment.

6. There was a continuing need to communicate the potential application and importance of dynamic models in support of the review. A joint summary document by the Group and CCE was in preparation to illustrate the effects of using TLFs in place of CLFs.

7. The outcome of the 2004 call for dynamic modelling outputs represented a major breakthrough in assessing the effects of future air pollution. The Joint Expert Group acknowledged CCE’s summary of the results and report on the 2004 call for data. The joint effort of CCE and national focal centres had produced new insights into the predicted time-scales and extent of recovery from acidification.

8. The Group noted that CCE's call for data issued in 2004 had generated a response from 14 countries, providing increased coverage of Europe and therefore strengthening the results of modelling assessment. The Group also pointed out that the response to and the outcome of the call had exceeded hopes expressed at its previous meeting in 2004.

9. As hypothesized, the European map of target loads of acidity differed significantly from the map of critical loads. The target load map suggested that in many regions, deposition reductions considerably below critical loads would be required to achieve ecosystem recovery within the next 25 to 100 years. In some areas, recovery might not be possible on this timescale regardless of non-exceedance of critical loads. The Group noted these differences and recognized that the target loads map provided a more realistic and more politically relevant picture of the ecosystem response.

10. The Group agreed that once a dynamic model was calibrated to multiple sites within a country, it was relatively easy to test different deposition scenarios. Fourteen European countries were in a position to perform such scenario analysis beyond the two deposition scenarios defined in the 2004 call.

11. The Group noted that additional work had been completed in several countries since the CCE data submission deadline in March 2005. Those countries were encouraged to contact CCE to discuss whether it was still possible to accommodate these new results.

12. The Group recognized that maps in which target loads replaced critical loads in "modelled" squares presented a feasible method of representing deposition targets (for a chosen target year) at the European scale. The TLFs associated with these squares could be incorporated into integrated assessment models using methodology identical to that currently used for CLFs.

13. The Group concluded that separate presentations of dynamic modelling results for surface waters and for soils provided a more balanced and complete picture of the effects of future air pollution than presenting them in the same map.

14. The Group noted that progress had been made in developing and testing biological response models for surface waters, and it urged that this work continue.

15. The Group took note of work being conducted on the interactions of global change and deposition of sulphur (S) and nitrogen (N) compounds on ecosystems. Progress in dynamic modelling of these interactions was being made by the European Union project Eurolimpacs and other national and international research projects. There was clear potential for global change to affect the recovery of ecosystems resulting from reduced emissions of pollutants; TLF could thus be altered.

16. The Group concluded that the dynamic model calibrations produced in response to the 2004 call for data provided a basis for running climate change scenarios in conjunction with

emission scenarios. Thus it provided a means to assess the effect of climate change on damage and recovery of ecosystems.

17. The Group urged all ICPs to continue monitoring aquatic and terrestrial ecosystems in order to document the response to changing levels of S and N deposition. These data were of crucial importance in the evaluation, testing and development of dynamic models.

18. The Group noted that much of the dynamic model development and testing was being conducted under the auspices of national and international research projects, and it urged the Parties to the Convention to continue and expand support for such research.

19. The Group endorsed the conclusions of the workshop on N dynamic processes, which are reported separately in the annex. Although many issues remained to be resolved, the Group felt that considerable progress had been made in the dynamic modelling of N as a nutrient in terrestrial ecosystems.

20. The Group noted that land management had a major influence on the impact of N deposition on terrestrial ecosystems and should be considered in models of N as a nutrient. Management was highly heterogeneous across countries and habitats, however, and the Joint Expert Group did not consider that a harmonized assessment of different management scenarios between countries was appropriate.

21. The Group observed that there was increasing evidence (from North America, the United Kingdom and Norway) that N can have a significant eutrophying effect in some oligotrophic surface waters. It therefore recommended that in future the impact of N as a nutrient should be considered in dynamic model (and critical load) assessments for surface waters.

22. The Group noted the draft 2006 workplan of the Working Group on Effects. The objectives of the Joint Expert Group were to bring together experts from ICPs to share knowledge and to produce joint reports on all aspects of dynamic modelling. A central task had been to review and assess the output of the ICPs. The Joint Expert Group had provided additional guidance on nitrogen and acidity effects based on work undertaken outside the ICPs. It was agreed that the 2006 workplan items common to all ICPs required very short summaries of existing knowledge.

23. The Group took note of the following draft workplan items for 2006:

(a) Three activities common to all ICPs, the Task Force on Health and the Joint Expert Group on Dynamic Modelling:

(i) Report on support of effects-based approaches for the review and possible revision of the Convention protocols (to be defined by the Executive Body);

(ii) Summary report of current information on dose-response functions and stock at risk;
(iii) Review report of links between field observations and critical loads;

(b) Determination and evaluation of key N and heavy metal processes for dynamic modelling;
(c) Recommendations for any further calls for dynamic modelling data;
(d) Report of the 2005 workshop on nitrogen dynamic processes;
(e) Report of the sixth meeting of the Joint Expert Group to the twenty-fifth session of the Working Group on Effects;
(f) Seventh meeting of the Joint Expert Group, tentatively scheduled for autumn 2006.

24. The Joint Expert Group agreed that it was not in a position to decide on its 2007 workplan, but it identified the following requirements for its future work:

(a) Expansion and revision of existing dynamic model and target load coverage for acidity in Europe;
(b) Further development and review of progress on dynamic modelling of N as a nutrient and the development of target loads for nutrient N;
(c) Predictions of biological recovery in surface waters using empirical chemical-biological relationships, initially on a site basis;
(d) Further development of dynamic models that take into account the confounding effects of climate change.

25. The Joint Expert Group agreed that a further meeting in late 2006 would provide a good opportunity to review progress on the 2006 workplan and consider other issues in anticipation of a future call for data.

Annex

WORKSHOP ON NITROGEN PROCESSES AND DYNAMIC MODELLING

INTRODUCTION

1. The workshop on nitrogen processes and dynamic modelling was held on 26–27 October 2005 in Brighton (United Kingdom). It was organized by the Centre for Ecology and Hydrology (CEH, United Kingdom) and by the Swedish programme on International and National Abatement Strategies for Transboundary Air Pollution (ASTA Programme). Support was provided by the Department of the Environment, Food and Rural Affairs (DEFRA, United Kingdom).

2. The meeting was attended by experts from the following Parties to the Convention: Austria, Canada, the Czech Republic, Denmark, Finland, Germany, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom and the United States. The International Cooperative Programme (ICPs) on Integrated Monitoring, ICP Modelling and Mapping, ICP Forests and ICP Waters, as well as the Coordination Centre for Effects (CCE at the Netherlands Environmental Assessment Agency) were represented. The UNECE secretariat was also represented.

3. The meeting was co-chaired by Mr. C. Evans (United Kingdom) and Mr. F. Moldan (Sweden).

I. AIMS AND ORGANIZATION

4. The workshop focused on the biogeochemical modelling of nitrogen (N) and its impacts on biodiversity. The objectives of the workshop were to:

(a) Review recent developments in the science and data sets underpinning N models;
(b) Assess the N and plant biodiversity models currently in use for semi-natural ecosystems;
(c) Assess the appropriateness of the abiotic variables used to predict biodiversity response to changing ecosystem N status;
(d) Assess the ability of biogeochemical models to predict these abiotic variables;
(e) Identify the key challenges with regard to future development, testing and application of models;
(f) Consider the suitability of biodiversity effects models for application in support of the Convention.

5. Two background documents were circulated in advance of the meeting to all participants. The first document, "Model chains for assessing impacts of nitrogen on soils, waters and biodiversity: a review", was prepared by CEH and ASTA; the final version of this review is available at http://critloads.ceh.ac.uk/contract_reports.htm. The second document, "Developments in modelling critical loads and target loads of nitrogen for terrestrial ecosystems in Europe", was prepared and presented on behalf of CCE, and its final draft was to be made available at the sixteenth CCE workshop in 2006.

II. CONCLUSIONS

A. Biogeochemical modelling of nitrogen

6. The models currently available, in general, contained the key pathways and processes of N cycling in terrestrial ecosystems. However, there were several major remaining challenges concerning N accumulation and its effects.

7. All current models ultimately stored most of the added N in the soil, but the route by which this storage occurs varied between models. Some models (e.g. MAGIC, VSD) immobilized N directly into the soil. Others (e.g. ForSAFE) first routed most N through the vegetation.

8. In several currently used biogeochemical models (MAGIC, SMART2 and VSD) the carbon-nitrogen (C/N) ratio affected (or controlled) N immobilization, one of several fluxes of inorganic N. In the ForSAFE model the C/N ratio played a smaller role in predicting N processes. None of the models used C/N ratio to directly control the leaching of inorganic N, which was determined by the balance of all fluxes of inorganic N. Therefore, a simple relationship between the C/N ratio and leaching in observed data was not a prerequisite for model applicability.

9. Further model development was required in order to reliably predict future changes in soil-water and leachate inorganic N concentrations. Several enhancements to existing models were proposed which might improve model performance:

(a) Inclusion of processes other than mineralization, nitrification and denitrification, notably nitrate (NO_3) immobilization and the possibility of this being inhibited by ammonium (NH_4); dissimilatory NO_3 reduction in aerobic/anaerobic soils; and also abiotic N retention in soils;

(b) Improved quantification of the size of the active soil carbon (C) pool;

(c) Improved simulation of C dynamics, for instance, the simulation of multiple C pools within the soil, improved description of their activity and stability, and feedbacks of increased N availability on C accumulation;

(d) Better simulation of climate-change-related effects, such as direct effects of rising carbon dioxide levels;

(e) Inclusion of dissolved organic N in models, since this might be an important sink for NH_4 and NO_3 in some systems such as wetlands, and also the only source of N for some plants in low-N systems.

10. Currently used models varied in their degree of complexity, and fulfilled different roles. Historically, simple models were applied more widely because of their transparency, ease of use and relatively modest data demands. Simple models were in general also more often applied by groups outside of the model-developing team. Complex models were used for assessment in countries where both modelling expertise and data were abundant. The development of generally applicable complex models with lower data demands (i.e. more processes simulated internally) offered the potential for larger-scale application. Complex models were also of value in identifying the key processes that needed to be incorporated into simpler models.

11. With a range of different N models being used for work under the Convention, it would be beneficial to undertake comparative studies of the predictions obtained using different models at the same locations, and comparisons against long-term datasets. This would be analogous to the inter-comparison studies undertaken on acidification models in the past, and would help in achieving consistent coverage across Europe.

B. Modelling nitrogen's impacts on biodiversity

12. Three approaches for predicting N impacts on biodiversity currently exist. In order of increasing complexity, these are:

(a) Empirical critical loads, namely estimates of the N deposition flux at which biodiversity changes are expected based on results of field or mesocosm fertilization experiments;

(b) Statistical vegetation models (e.g. MOVE, GBMOVE, BERN, NTM), calibrated using large survey datasets, which predict plant species or community occurrence from soil condition. These models have no time component but can be made dynamic by linking annual outputs from biogeochemical models;

(c) Dynamic vegetation models (e.g. VEG, SUMO) which simulate vegetation change over time and are dynamically integrated with biogeochemical models.

13. Plants do not respond to a single measurable abiotic variable, and there were some problems with all variables that could potentially be used as input to the vegetation models. Those considered most useful were:

(a) Soil solution inorganic N (and possibly organic N) concentrations within the rooting zone;
(b) Nitrogen availability (N deposition plus N mineralization);
(c) Gross N mineralization/immobilization;
(d) Biomass N increment;
(e) Foliar N content;
(f) Reduced and oxidized N deposition (particularly direct deposition to the canopy for foliar effects).

14. Organic soil C/N ratio was not considered to be a direct control on plant response, but represented a readily measurable proxy for important processes (e.g. nitrification and immobilization/mineralization). It could therefore still be useful to measure it and to incorporate it into models, although the fact that the same C/N ratio might indicate different N availability in different habitats/soils might need to be considered.

15. Acute effects needed to be considered in addition to chronic effects, in particular for above-ground N uptake. Foliar uptake of N might be significant for plant-response models, particularly for lower plants whose only (or main) source of N was via foliar uptake. Direct damaging effects of NH_4 on vegetation were dependent on air concentrations and could be predicted via critical levels.

16. Vegetation models based on large-scale vegetation surveys (MOVE, NTM, BERN, GBMOVE) or experimental data (VEG) were well developed in several countries. While there were some general similarities between models (particularly those based on survey data), nevertheless some important differences could be identified. These included:

(a) Calibration to different (national) soil and vegetation data sets;
(b) Focus on different ecosystems;
(c) Prediction of individual plant species versus plant communities;
(d) Use of different abiotic variables for N (C/N, soil solution N, N availability);
(e) Use of different variables for acidity (pH, base saturation).

17. Some outstanding challenges (for some or all models) were considered to be:

(a) More extensive testing, particularly against long-term datasets;
(b) Expansion of testing and application beyond the geographical region for which model dose-response relationships had been parameterized;
(c) Prediction of rare species;
(d) Representation of lag times (e.g. due to species persistence and dispersal);
(e) Incorporation of feedbacks with biogeochemical models (e.g. changes in litter quality due to species change);
(f) Consideration of the differential effects of oxidized and reduced N.

18. The reliance on Ellenberg indicator values as a proxy for abiotic conditions in survey-based models was considered to add an additional layer of uncertainty to model predictions. However, Ellenberg values were likely to remain necessary in many areas due to the insufficient coverage of combined vegetation and soil survey data.

19. More mechanistic, linked biogeochemical-vegetation models (e.g. ForSAFE-VEG, SMART2-SUMO, HEATHSOL-UK) should provide more accurate predictions of vegetation change in some ecosystems. Testing and adaptation for other countries/ecosystems were required for larger-scale application.

20. Episodic events might be crucial drivers of species change, and include planned events (e.g. forest felling, heathland burning) as well as unplanned ones (e.g. disease outbreaks, insect attacks). Prediction of episodic damage was difficult for any individual ecosystem, but by predicting the chronic condition it was possible to estimate the risk of episodic damage and therefore regional ecosystem response.

21. The definition of reference conditions and damage thresholds for terrestrial biodiversity represented a major challenge, particularly if linked biogeochemistry-biodiversity models were to be used for target setting. Although the definition of biodiversity targets was an issue for policy-makers, dynamic models could provide valuable information on realistic reference conditions and achievable recovery targets.

22. Linked biogeochemistry-biodiversity models for N were considered to have great application potential under the Convention. At their current level of development, this application was likely to be primarily for predicting the biodiversity impacts of different emission scenarios. An important future application of this approach would be to use the linked models to define biodiversity-based target loads.

III. RECOMMENDATIONS FOR FUTURE WORK

23. Priorities for future work on the biogeochemical modelling of N included:

(a) Consideration of the relative risk of NO_3 leaching under NH_4 and NO_3 dominated deposition;
(b) Improved simulation of the links between C and N cycles;
(c) Incorporation of the effects of climate drivers within the models;
(d) Continued testing of all models, and model intercomparison studies.

24. Priorities for future work on modelling N impacts on biodiversity included:

(a) The collection of new data to identify and verify the most suitable abiotic N variables for predicting plant response;

(b) Testing and comparison of different models at the same sites;

(c) Adaptation, testing and upscaling of models for new countries/biogeographical regions (particularly areas not included in current model coverage, such as the Mediterranean and Alpine regions and Eastern Europe);

(d) Incorporation of biodiversity models within dynamic modelling work undertaken for the Convention – for instance, target loads for N as a nutrient.

25. The development and testing of both biogeochemical and biodiversity impacts models were critically dependent on long-term monitoring, long-term experimental data and large-scale survey data. The continuation of existing programmes, where possible with improved integration of biotic and abiotic measurements, was essential to the future development of this work.