APPENDIX 5b

WORKSHOP ON NITROGEN PROCESSES AND DYNAMIC MODELLING

Summary report on the meeting prepared by the organisers

I. INTRODUCTION

1. The workshop was held on 26-27 October 2005 in Brighton (United Kingdom). It was organised 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). Support was provided by the UK Department of the environment, food and rural affairs (Defra),

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

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

II. AIMS AND ORGANIZATION OF THE WORKSHOP

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

   - Review recent developments in the science and data sets underpinning N models
   - Assess the N and plant biodiversity models currently in use for semi-natural ecosystems
   - Assess the appropriateness of the abiotic variables used to predict biodiversity response to changing ecosystem N status
   - Assess ability of biogeochemical models to predict these abiotic variables
   - Identify the key challenges with regard to future development, testing and application of models
   - 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, ‘Developments in modelling critical loads and target loads of nitrogen for

terrestrial ecosystems in Europe', was prepared and presented on behalf of the CCE. The final draft was made available at the 2006 CCE Workshop, Bled.

III. CONCLUSIONS OF THE WORKSHOP

III.i Biogeochemical modelling of nitrogen

6. The models currently available do, in general, contain the key pathways and processes of N cycling in terrestrial ecosystems. However there are several major remaining challenges concerned with N accumulation and its effects (see below)

7. All current models ultimately store most of the added N in the soil, but the route by which this storage occurs varies between models. Some models (e.g. MAGIC,VSD) immobilise N directly into the soil. Others (e.g. FORSAFE) route most N through the vegetation first.

8. In several currently used biogeochemical models (MAGIC, SMART2 and VSD) the Carbon/Nitrogen (C/N) ratio affects (or controls) N immobilisation, one of several fluxes of inorganic N. C/N ratio plays a smaller role in ForSAFE in predicting N processes. In none of the models is C/N ratio used to control directly the leaching of inorganic N, which is determined by the balance of all fluxes of inorganic N. Therefore, a simple relationship between C/N ratio and leaching in observed data is not a prerequisite for model applicability.

9. Further model development is 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. These were:
   - Inclusion of processes other than mineralisation, nitrification and denitrification, notably NO_3 immobilisation and the possibility of this being inhibited by NH_4; dissimilatory nitrate reduction in aerobic/anaerobic soils; and also abiotic N retention in soils
   - Improved quantification of the size of the active soil carbon (C) pool
   - 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 carbon accumulation
   - Better simulation of climate-change related effects, such as direct effects of rising CO_2
   - Inclusion of dissolved organic N in models, since this may be an important sink for NH_4 and NO_3 in some systems such as in wetlands, and also the only source of N for some plants in low N systems

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

11. With a range of different N models being used within 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 analagous to the inter-comparison studies undertaken on acidification models in the past, and would help in achieving consistent coverage across Europe

III.i Modelling nitrogen impacts on biodiversity

12. Three approaches for predicting N impacts on biodiversity currently exist. In order of increasing complexity these are:
    - Empirical critical loads, i.e. estimates of the N deposition flux at which biodiversity changes are expected based on results of field or mesocosm fertilisation experiments.
    - 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.
    - 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 are some problems with all variables that could potentially be used as input to the vegetation models. Those considered most useful were:
    - Soil solution inorganic N (and possibly organic N) concentrations within the rooting zone
    - Nitrogen availability (N deposition plus N mineralisation)
    - Gross N mineralisation/immobilisation
    - Biomass N increment
    - Foliar %N
    - NHy and NOx deposition (particularly direct deposition to the canopy for foliar effects)

14. Organic soil C/N ratio is not considered to be a direct control on plant response, but represents a readily measurable proxy for important processes (e.g. nitrification or immobilisation/mineralisation). It can therefore still be useful to measure and to incorporate in models, although the fact that the same C/N ratio may indicate different N availability in different habitats/soils may need to be considered.

15. Acute effects need to be considered in addition to chronic effects, in particular for above-ground N uptake. Foliar uptake of N may be significant for plant-response models, particularly for lower plants whose only (or main) source of N is via foliar uptake. Direct damaging effects of NHy on vegetation are dependent on air concentrations, and can be predicted via critical levels.

16. Vegetation models based on large-scale vegetation surveys (MOVE, NTM, BERN, GBMOVE) or experimental data (VEG) are well developed in several countries. There are some general similarities between models (particularly those based on survey data) but nevertheless some important differences can be identified. These include:
    - Calibration to different (national) soil and vegetation datasets

- Focus on different ecosystems
- Prediction of individual plant species versus plant communities
- Use of different abiotic variables for N (C/N, soil solution N, N availability)
- Use of different variables for acidity (pH, base saturation)

17. Some outstanding challenges (for some or all models) were considered to be:
    - More extensive testing, particularly against long-term datasets
    - Expansion of testing and application beyond the geographical region for which model dose-response relationships have been parameterised
    - Prediction of rare species
    - Representation of lag times (e.g. due to species persistence, dispersal)
    - Incorporation of feedbacks with biogeochemical models (e.g. changes in litter quality due to species change)
    - Consideration of the differential effects of oxidised 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 are 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 are required for larger-scale application

20. Episodic events may be crucial drivers of species change, and include events that are both planned (e.g. forest felling, heathland burning) or unplanned (e.g. disease outbreak, insect attack). Prediction of episodic damage is difficult for any individual ecosystem, but by predicting the chronic condition we can estimate the risk of episodic damage and therefore regional ecosystem response.

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

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

IV. RECOMMENDATIONS FOR FUTURE WORK

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

- Consideration of the relative risk of nitrate leaching under ammonium and nitrate dominated deposition
- Improved simulation of the links between C and N cycles
- Incorporation of the effects of climate drivers within the models
- Continued testing of all models, and model inter-comparison studies

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

- The collection of new data to identify and verify the most suitable abiotic N variables for predicting plant response
- Testing and comparison of different models at the same sites
- Adaptation, testing and upscaling of models for new countries/biogeographical regions (particularly areas not included in current model coverage, such as Mediterranean and Alpine regions, and Eastern Europe)
- Incorporation of biodiversity models within dynamic modelling work undertaken for the Convention, e.g. target loads for N as a nutrient

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