UNITED
NATIONS

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Economic and Social Council

Distr.
RESTRICTED

EB.AIR/WG.1/R.121
23 April 1996

Original: ENGLISH

ECONOMIC COMMISSION FOR EUROPE

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

Working Group on Effects
(Fifteenth session, Geneva, 3-5 July 1996)
Item 5 (e) of the provisional agenda

DYNAMIC MODELLING AND ASSESSMENT OF ECOSYSTEMS EFFECTS

Progress report by the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems (ICP IM)

I. INTRODUCTION

1. Since the fourteenth session of the Working Group on Effects the Programme Centre of ICP IM and collaborating institutes have carried out a number of different assessments, which are described in detail in the 1996 Annual Report of the programme. Pursuant to a decision of the Executive Body for the Convention at its thirteenth session (ECE/EB.AIR/46, annex I, section 3.6), the present report summarizes the main conclusions from these assessments.

GE.96-30764

II. DYNAMIC MODELLING

2. The Working Group on Effects, at its twelfth session in 1994, considered dynamic modelling to be a key element in the further development of the effect-oriented activities under the Convention. It was proposed that the dynamic modelling activities should be carried out on two different levels/scales of coverage:

(a) ICP-IM in cooperation with national data centres and invited modelling experts would be responsible for the application of dynamic modelling at selected sites; and

(b) The Coordination Center for Effects (CCE/RIVM) would take the responsibility for the model applications on a regional basis.

3. Three well-known process-oriented dynamic models (MAGIC, SAFE, and SMART) have been calibrated with data from five selected ICP IM sites. The main aim of the project has been to assess the dynamic response to different deposition scenarios, including the effects of the implementation of the Protocol on Further Reduction of Sulphur Emissions (SP2), a scenario for maximum feasible reductions (MFR), and two scenarios for NOx emissions. The deposition was calculated with the EMEP transfer matrices and current reduction plans as officially reported to UN/ECE for the target years 2000, 2005 and 2010. The three scenario combinations used for the assessment are shown in the table below and an example of the model results from the Norwegian IM site Birkenes are shown in the figure below.

Table The three scenarios used for the dynamic model runs, representing possible ranges of future deposition.

Scenario label	SO_2	NO_x	NH_y
(A) best prediction	SP2	present level	present level
(B) lower limit	MFR	-30%	present level
(C) upper limit	present level	present level	present level

4. The site-specific model applications also provide a reality check for the regional-scale modelling exercise coordinated by the Coordination Center for Effects (CCE/RIVM). This project has been funded by the Nordic Council of Ministers and carried out as a joint project between the ICP IM Programme Centre at the Finnish Environment Institute, Helsinki, Finland, and four modelling centres (CCE/RIVM, Bilthoven, Netherlands; Institute of Hydrology, Wallingford, United Kingdom; Lund University, Lund, Sweden; and Norwegian Institute for Water Research, Oslo, Norway).

5. The five selected sites receive varying deposition loads and have different catchment characteristics. These sites therefore represent a wide range of possible future responses to the atmospheric loadings. The main conclusions derived from the results of the project (presented in the ICP IM Annual Report 1996 (Forsius et al.)) are as follows:

(a) Dynamic models can be successfully applied to data from ICP IM sites;

(b) Catchments/plots respond in a dynamic way to changes in emissions/deposition. The deposition load which any site can tolerate therefore depends on the length of time taken for a response to occur. Dynamic models are therefore needed as a valuable complement to steady-state techniques, provided that adequate data are available;

(c) The three models (MAGIC, SAFE, and SMART) applied in this study yielded generally consistent results, which gives confidence in the scenario assessment;

(d) The "Best Prediction" scenario (including the effects of the second sulphur protocol and present level for NOx emissions), resulted in many cases in a stabilization of soil acidification, although significant improvements did not always show;

(e) The models should be applied to more ICP IM sites to increase the sensitivity gradient and geographical coverage;

(f) More work is needed to improve the description of nitrogen processes in the dynamic models.

III. ASSESSMENT OF THE EFFECTS OF NITROGEN DEPOSITION

6. The work on the assessment of the effects of nitrogen deposition on ecosystems has been carried out by the Programme Centre and the first results were presented in the Annual Report 1995. The main aim has been to derive empirical critical thresholds for N deposition, and to identify different ecosystem variables associated with N saturation and leaching. There is a great potential for linking such intensive studies with regional monitoring data in order to link process level data to regional-scale questions. The results from the calculations have been presented in the Annual Report 1996.

7. Input-output budgets were calculated separately on plot- and catchment-scale. Both bulk and throughfall deposition measurements were used in order to obtain the best possible estimate of total N deposition. A correlation analysis was performed between the N output and other ecosystem fluxes and pools of nitrogen. For the statistical analysis, data from two ecosystem experiments, EXMAN and NITREX (Tietema and Beier, 1995; Wright and Tietema, 1995), were also included in order to increase the number of observations and the gradient of N deposition.

8. The main conclusions of the assessment were:

(a) A critical deposition threshold of about 9-10 kg N/ha/a was generally indicated by the input-output budgets, and comparable results have been obtained in several previous assessments. It should be recognized, however, that the systems considered are not necessarily in a steady-state, and even low-deposition sites may eventually become saturated unless nitrogen is removed from the system;

(b) The output flux of nitrogen is strongly correlated with key ecosystem variables like N deposition, N concentration in organic matter and current year needles, and N flux in litterfall. Similar results were obtained in the EXMAN and NITREX studies (Tietema and Beier, 1995; Wright and Tietema, 1995);

(c) There is a great potential for using such statistical relationships from intensively studied sites in conjunction with regional monitoring data (e.g. ICP Forests and ICP Waters data) in order to link process level data with regional-scale questions;

(d) A continuous effort should be devoted to improving the collection and reporting of data within the ICP IM framework, in order to increase the number of sites with sufficient data for detailed effects assessments.

IV. TESTING OF THE EDACS DEPOSITION MODEL

9. The EDACS model (Estimation of Deposition of Acidifying Components on a small scale in Europe) is used for deriving deposition estimates for the calculations of critical loads on the European scale. In EDACS dry deposition is estimated with the inference method (i.e. inferred from the concentration and deposition velocity). The performance of the EDACS model was evaluated using throughfall data from ICP IM sites and other sites in Europe. The model testing and development have been carried out at the RIVM in the Netherlands (van Leeuwen et al.). A summary of the results is presented in the Annual Report 1996. The main conclusions were:

(a) Significant relationships were found between modelled dry deposition and dry deposition and deposition estimated from throughfall and bulk precipitation measurements. However, especially for SOx and NOx the scatter was considerable. This was assumed to be due to a large extent to the lower spatial resolution of the EMEP model, which calculates the air concentration values used in EDACS;

(b) For NHx, Ca and K, the model seems to underestimate dry deposition at higher deposition levels, probably because 'background' air concentrations are used while additional input by local sources may occur;

(c) If only ICP IM data were considered, significant relationships between modelled and measured dry deposition were found for all components except NHx;

(d) The largest uncertainty in wet deposition was estimated in areas with low measurement density, leading to relatively large interpolation errors (i.e. in southern and eastern Europe).

V. EVALUATION OF EFFECTS OF N AND S DEPOSITION ON VEGETATION

10. The evaluation of N and S deposition effects on vegetation was carried out at the Department of Environmental Assessment, SLU, Sweden. The effects of pollutant deposition on natural vegetation, including both trees and understorey vegetation, is one of the central concerns in the impact assessment and prediction. The main aims of the project were to examine: (i) the validity of the ICP IM data for assessing the effects on vegetation; and (ii) the current state of vegetation at the ICP IM sites in relation to environmental conditions and pollutant deposition. Correlation and regression techniques were used. The results are summarized in the Annual Report 1996 and the main conclusions were:

(a) Epiphytic lichen species composition on tree stems varied among the sites, especially between the northern countries and central Europe. The mean sensitity index of epiphytic lichens on tree stems was well correlated to the observed deposition gradient;

(b) Understorey vegetation naturally varied greatly among the ICP IM areas in the different countries. The mean acid-intolerance score and the mean nitrogen-demand score were correlated to N and S concentrations in soil water, but not to those in deposition;

(c) The relation between S and N was linear in atmospheric deposition. This relation was changed in soil water at the nutrient-poor sites mainly in northern coniferous forests, but remained linear at the nutrient-rich sites mainly in central Europe. The change may have been caused by the vegetation, due to its role in biogeochemical processes;

(d) Vegetation monitoring is useful in reflecting the effects of atmospheric deposition and soil water chemistry, especially regarding S and N, and can be used in impact assessement. With improvements in the ICP IM data reporting and in the combination of different subprogrammes carried out at the sites, the power of vegetation monitoring would increase considerably.

References */

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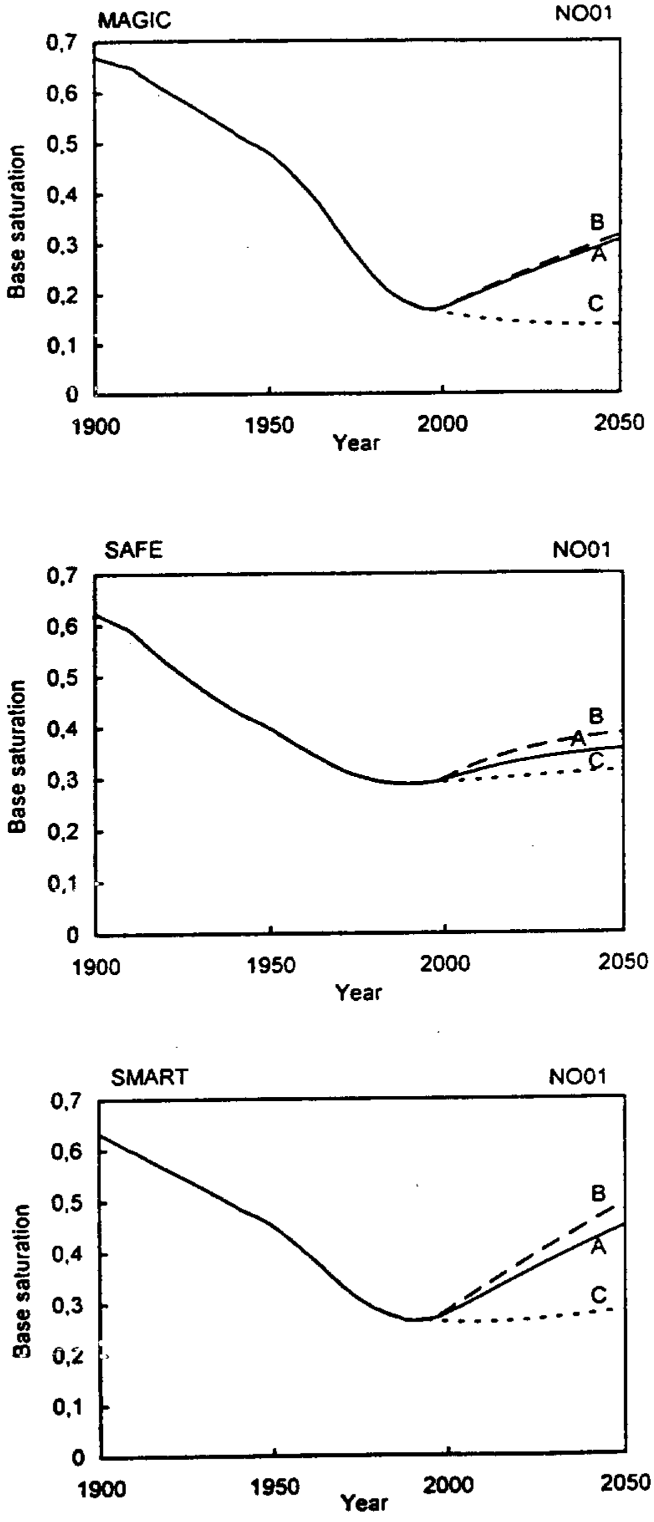

Figure Simulated soil base saturation (fraction) for the ICP IM site Birkenes (Norway) using three different dynamic models and deposition scenarios A-C (see table).