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Working Group on Effects

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RECENT RESULTS AND UPDATING OF SCIENTIFIC AND TECHNICAL KNOWLEDGE

MODELLING NITROGEN EFFECTS IN TERRESTRIAL ECOSYSTEMS, INCLUDING BIODIVERSITY

Report by the Coordination Centre for Effects and the Task Force of the International Cooperative Programme on the Modelling and Mapping of Critical Levels and Loads and Air Pollution Effects, Risks and Trends

INTRODUCTION

1. The Working Group on Effects, at its twenty-sixth session, approved the proposal of of the International Cooperative Programme on the Modelling and Mapping of Critical Levels and Loads and Air Pollution Effects, Risks and Trends (ICP Modelling and Mapping) to request its Coordination Centre for Effects (CCE) to make a call for data on empirical and computed critical loads for nitrogen (N) and dynamic modelling parameters, in preparation for use in a possible

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revision of the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (ECE/EB.AIR/WG.1/2007/2, para. 12 (j)). The results are presented here in accordance with item 3.7 of the 2008 workplan for the implementation of the Convention (ECE/EB.AIR/91/Add.2) adopted by the Executive Body at its twenty-fifth session.

2. CCE issued a call for critical loads data on 11 November 2007, after an early notification to the national focal centres (NFCs) of ICP Modelling and Mapping in June 2007. The deadline for data submission was 10 March 2008. The call took into account lessons learned from the call for voluntary data issued in 2006, which was designed to allow NFCs to test new scientific and technical knowledge and reported in the *CCE Progress Report 2007* (CCE 2007) and in document ECE/EB.AIR/WG.1/2007/11.

3. In support of the call, CCE had:

(a) Finalized a harmonized land cover database in collaboration with the Stockholm Environment Institute. The database covered the modelling domain of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants (EMEP);

(b) Produced an updated version of the very simple dynamic (VSD) model;

(c) Established deposition trends in Europe for use in dynamic modelling by NFCs. The periods included were 1880–2010 using historic emissions and 2010–2100 using two national emission scenarios: “current legislation” (CLE) and “maximum feasible reductions” (MFR). The scenarios were prepared in collaboration with the Centre for Integrated Assessment Modelling (CIAM) in November 2007. These scenarios could also be used by CCE to interpolate conclusions for other emission scenarios, e.g. regarding dynamic modelling of aspirational targets that might be formulated by the Working Group on Strategies and Review and the Task Force on Integrated Assessment Modelling;

(d) Finalized comprehensive software, interactive database management queries and instructions to assist NFCs in their response to the call for data.

3. NFCs were requested to participate in the application of:

(a) A broad range of critical limits in simple mass balance calculations to address biodiversity, as proposed in Alterra/CCE (2007);

(b) Empirical critical loads for all ecosystems for which NFCs provided computed critical loads, including Natura 2000 ecosystems of the European Union (EU). The ecosystems were classified following the European Nature Information System (EUNIS, http://eunis.eea.europa.eu);

(c) Dynamic modelling of acidification and eutrophication.

I. DATA REVIEW BY THE TASK FORCE

4. The response by NFCs to the 2007/2008 call for data is presented in the table below. Romania submitted data for the first time. Not all Parties submitted reports to substantiate their results.

Table. Data submissions from countries (denoted with "x") as a response to the 2007/2008 call for data.

COUNTRY	Critical loads			Dynamic modelling
	Acidity	Nutrient nitrogen (empirical)	Nutrient nitrogen (modelled)	
Austria	x	x	x	x
Belarus[1]	x		x	
Belgium	x		x	x
Bulgaria	x	x	x	
Canada	x			
Switzerland	x	x	x	x
Germany	x	x	x	x
Finland	x	x	x	
France	x	x	x	x
Great Britain	x	x	x	x
Ireland	x	x	x	x
Italy	x		x	
Netherlands	x	x	x	x
Norway	x	x	x	x
Poland	x		x	x
Romania	x		x	
Russian Federation	x		x	
Sweden	x	x	x	x
Slovenia	x	x	x	x
Ukraine[2]	x		x	
Total	20	12	19	12

[1] Preliminary data requiring further clarification.

[2] Data for the Crimea only; data requiring further clarification.

5. The updated European critical load maps and data statistics were presented at the eighteenth CCE workshop held from 21 to 23 April 2008 in Berne, and the twenty-fourth meeting of the Task Force of ICP Modelling and Mapping held on 24 and 25 April 2008 in Berne. In comparison to the European critical load database of 2006, which was used for the review of the Gothenburg Protocol, more and improved information became available to support effects-oriented integrated assessments under the Task Force on Integrated Assessment Modelling and the Working Group on Strategies and Review. This included information on critical loads for Natura 2000 areas and – in the CCE background database – also for semi-natural vegetation.

6. The United Kingdom and Sweden provided a list to CCE with EUNIS codes following the suggestion made by the Task Force of ICP Modelling and Mapping to its NFCs. These codes denoted ecosystems for which empirical critical loads should be included in the 2008 European critical loads database, which would be used by the Task Force on Integrated Assessment Modelling.

7. The Task Force of ICP Modelling and Mapping:

(a) Approved the results of the 2007/2008 call for data and recommended the Working Group on Effects to use the data for the work on the revision of the Gothenburg Protocol. Countries that did not submit data in 2008 will have their data replaced by the CCE background database, i.e. the data submitted in 2006 would not be used in these cases, unless the countries have specified otherwise;

(b) Requested CCE to make data available to CIAM for tentative scenario analyses as soon as possible;

(c) Requested CCE to investigate the differences between the 2006 and the 2007/2008 data and to report this to the Working Group, although it preferred that all European air pollution policy frameworks would use identical critical load data.

8. The Task Force of ICP Modelling and Mapping:

(a) Thanked those NFCs which had delivered data and emphasized that corrections could be accepted only by the deadline of 13 May 2008;

(b) Thanked CCE for its considerable work regarding the 2007/2008 call for data and its progress with respect to the workplan;

(c) Noted the differences between empirical and modelled critical loads;

(d) Reiterated that critical loads for nutrient N could be related to biodiversity by comparing the computed value with appropriate ranges of empirical critical loads, as described in the *Manual on Methodologies and Criteria for Modelling and Mapping Critical Loads and Levels and Air Pollution Effects, Risks and Trends*;

(e) Encouraged NFCs to consult each other to discuss the results of empirical and calculated critical loads;

(f) Encouraged NFCs to further review the background land-cover maps available at CCE, and to communicate differences to national data to CCE.

II. RESULTS OF THE EUROPEAN CRITICAL LOADS DATABASE 2008

9. An overview of natural ecosystem areas at risk of acidification and of excessive nutrient N deposition in countries within the modelling domain of EMEP is given in annex I.

10. Results were computed using the European critical loads database of 2008. Depositions were made available by CIAM in autumn 2007. They were based on two emission scenarios: CLE in 2000, 2010 and 2020 and MFR in 2020.

11. The area at risk of acidification was computed to decrease from 11% in 2000 to 6% and 1% in 2020 for CLE and MFR, respectively. For the 25 EU Member States (EU-25), these areas were 18%, 9% and 2%, respectively. Notably, the reports available in 2006 did not yet address the EU-27. Even for MFR, 60% of the natural ecosystem area in the Netherlands was computed to be at risk of acidification in 2020. For all other Parties, the natural ecosystem areas at risk of acidification were well below 10%.

12. The area at risk of acidification computed with 2006 critical load data was similar to the results using the 2008 data. For EU-25, the area at risk was slightly lower in 2010 for CLE with the 2006 data (18%, 7% and 2%, respectively).

13. The area at risk of eutrophication was computed to decrease from 49 % in 2000 to 47 % and 17 % in 2020 for CLE and MFR, respectively. The EU-25 area at risk of eutrophication was 77%, 67% and 31%, respectively.

14. The area at risk of eutrophication computed with the 2006 critical loads database compared to the 2008 database was 3% lower in 2000, 2010 and 2020 for all scenarios. For the EU-25, the area at risk using the 2008 data was significantly higher than when using the 2006 data (65%, 56%, and 25%, respectively).

III. STATUS OF DYNAMIC MODELLING

15. Most parties submitted results on dynamic modelling using the VSD model for terrestrial ecosystems. The Netherlands included results of the application of a dynamic vegetation model on terrestrial ecosystems. Dynamic vegetation models were also being tested in Austria, Germany, Sweden, Switzerland and the United Kingdom, but results have not yet been included in the data submission. Norway, Sweden and the United Kingdom had also used a dynamic model on aquatic ecosystems.

16. Dynamic modelling data submitted by these countries, and data from the background database, enabled assessments of the occurrence of (non-)exceedance and (non-)violation of the critical limits.

17. Four cases are of combining (non-)exceedance of critical loads and (non-)violation of critical limits can be found in annex II: Case 1 – non-exceedance and non-violation; case 2 –

non-exceedance and violation; case 3 – exceedance and non-violation; case 4 – exceedance and violation. Case 4 includes ecosystems that are subject to immediate risk of damage by N deposition. Case 1 implies full protection. Cases 2 and 3 include ecosystems for which recovery delay times (RDT) and damage delay times (DDT) could be identified respectively.

18. Investigation of combinations of the cases of (non-)exceedance of critical loads with (non-)violation of a critical limit value of 0.3 mg N l^{-1} was conducted using the CCE background database. This critical limit was not only associated with vegetation changes, but also with nutrient imbalances in deciduous forests.

19. Results indicated that for CLE in 2010 and 2050 about 56% and 55% of European ecosystems were in case 4 (critical load exceeded and critical limit violated). Case 1 (critical load not exceeded and critical limit not violated) was 35% in 2010 and increased to 37% in 2050. The latter percentage would be close to being attained already in 2020, confirming the fast response of N concentration to changes in N deposition.

20. For the MFR scenario, as compared to the CLE scenario, most of the ecosystems moved from case 4 to case 1. Case 1 (critical load not exceeded and critical limit not violated) applied to about 65% of the ecosystems, while case 4 (critical load exceeded and critical limit violated) covered 29% in 2050. Again, first time attainment of these area percentages occurred soon after 2020.

21. The computations for the violation of the critical limit (cases 2 and 4) confirmed the early attainment before 2030 of the area that would be safe for MFR in 2050. For example, violation was computed by the French NFC for an area of 96% in 2010, which diminished 91% for CLE and 57% for MFR in 2020, and 90% for CLE and 41% for MFR in 2030. For the German NFC these percentages were 54% in 2010, 43% (CLE) and 26% (for MFR) in 2020 and 43% (CLE) and 23% (MFR) in 2050. Hardly any additional area would became protected after 2030.

22. This type of analysis could be performed for any reasonable deposition scenario which the Task Force on Integrated Assessment Modelling might wish to explore for the revision of the Gothenburg Protocol.

23. Complete documentation for the results of the 2007/2008 call for data and CCE applications with the 2008 critical load database is being published (CCE 2008).

IV. UNCERTAINTY ANALYSIS

24. The uncertainty of exceedance of critical loads is driven by uncertainties in modelling methods and the input data relating to emissions, depositions and critical loads. These are the three main components of integrated assessment of environmental impacts. Because these components are not scenario-dependent, the uncertainty of exceedance is relatively invariant between emission scenarios. This allows for a robust comparison of scenario outcomes in the context of integrated assessment.

25. Uncertainties in modelling methods and data of critical loads are difficult to establish, because critical loads cannot be measured. Moreover, biological endpoints are lacking to validate impacts of computed critical load exceedance of natural ecosystem areas at the European scale. Validation requires that site specific impacts, which are established with relatively small (spatial and temporal) scale in situ or in vitro experiments, be extrapolated to the spatial and temporal scales in Europe used in integrated assessment modelling.

26. ICP Modelling and Mapping addressed the robustness of critical loads and dynamic modelling rather than its uncertainty. CCE has developed a methodology (CCE 2007) "Ensemble assessment of impacts" (EAI), to identify the likelihood of exceedance of critical loads of nutrient N in European ecosystems. EAI uses both empirical and computed critical loads of nutrient N. An application of EAI on deposition patterns for CLE in 2020 revealed that ecosystem areas which were "very likely" or "virtually certain" to be at risk were dominant in western and central Europe. Similar conclusions emerged for nutrient N when the analysis was limited to Natura 2000 areas.

27. The analysis of uncertainties in the context of integrated assessment modelling was expected to benefit from the use of EAI. The method could be combined with other elements that affected the variability of ecosystem at risk, i.e. where the critical load was exceeded or the critical limit violated in an EMEP grid cell, such as deposition, (sub-)selections of land-cover classes (see CCE 2007) and the status of critical limits.

V. PROPOSED METHODOLOGY FOR THE PROTOCOL REVISION WORK

28. The following presents a proposed methodology for collaboration with CIAM to support the work on the revision of the Gothenburg Protocol. As of 2008, CCE is able deliver the following knowledge to CIAM, the Task Force on Integrated Assessment Modelling and the Working Group on Strategies and Review (within the constraints of available regional data at European scale):

(a) Modelled critical loads and information on delay times of damage and recovery using dynamic modelling for any given emission scenario;

(b) Empirical critical loads and information on biological impacts to vegetation for any given emission scenario;

(c) Improved robustness of the identification of areas at risk, using the EAI approach described above.

29. The Task Force of ICP Modelling and Mapping acknowledged that CIAM and CCE needed to collaborate closely for the use of effects-oriented information to support the revision of the Gothenburg Protocol and further work in support of the thematic strategy on air pollution of the European Commission. The Task Force recommended that:

(a) Modelled critical loads and dynamic modelling results be used:

(i) For assessing the location, the magnitude (average accumulated exceedance (AAE)) and area exceeded (by CCE and CIAM);

(ii) For optimization of emission reduction strategies under the Task Force on Integrated Assessment Modelling (by CIAM);

(iii) For obtaining a tentative indication of RDT and DDT caused by changing exceedance (by CCE);

(iv) In conjunction with the CCE background database of modelled critical loads and exceedance as well as the dynamic modelling outcomes in the framework of EAI (by CCE);

(v) For tentative regional application of dynamic models to assess impacts on soil chemistry and biology and related time horizons, in response to changes in exceedance (ICP Modelling and Mapping and others), subject to the availability of regionalized input data;

(b) Empirical critical loads and dose-response relationships be used:

(i) For assessing the robustness (EAI) of the location, magnitude (AAE) and area of exceedance (by CCE);

(ii) For obtaining tentative indications of possible biological effects caused by exceedance of empirical critical loads (by CCE);

(iii) In conjunction with the CCE background database of empirical critical loads and exceedance in the framework of EAI (by CCE);

(c) In its work, CCE would use emission scenarios developed by CIAM and the Task Force on Integrated Assessment Modelling.

VI. OTHER BUSINESS

30. CCE had established first tentative maps of critical loads of acidity, nutrient N, cadmium, lead and mercury for the countries in Eastern Europe, Caucasus and Central Asia (EECCA) in collaboration with Alterra research institute in the Netherlands (www.alterra.wur.nl).

35 CCE had collaborated with EMEP Meteorological Synthesizing Centres-West and East to produce tentative exceedance maps of acidification, eutrophication and heavy metals in EECCA countries. Results would be published by CCE (2008) and in the reports of both EMEP centres.

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CCE (2007) Critical loads of nitrogen and dynamic modelling, *CCE Progress Report 2007*. www.mnp.nl/cce.

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[1] The references have been reproduced as received by the secretariat.

Annex I

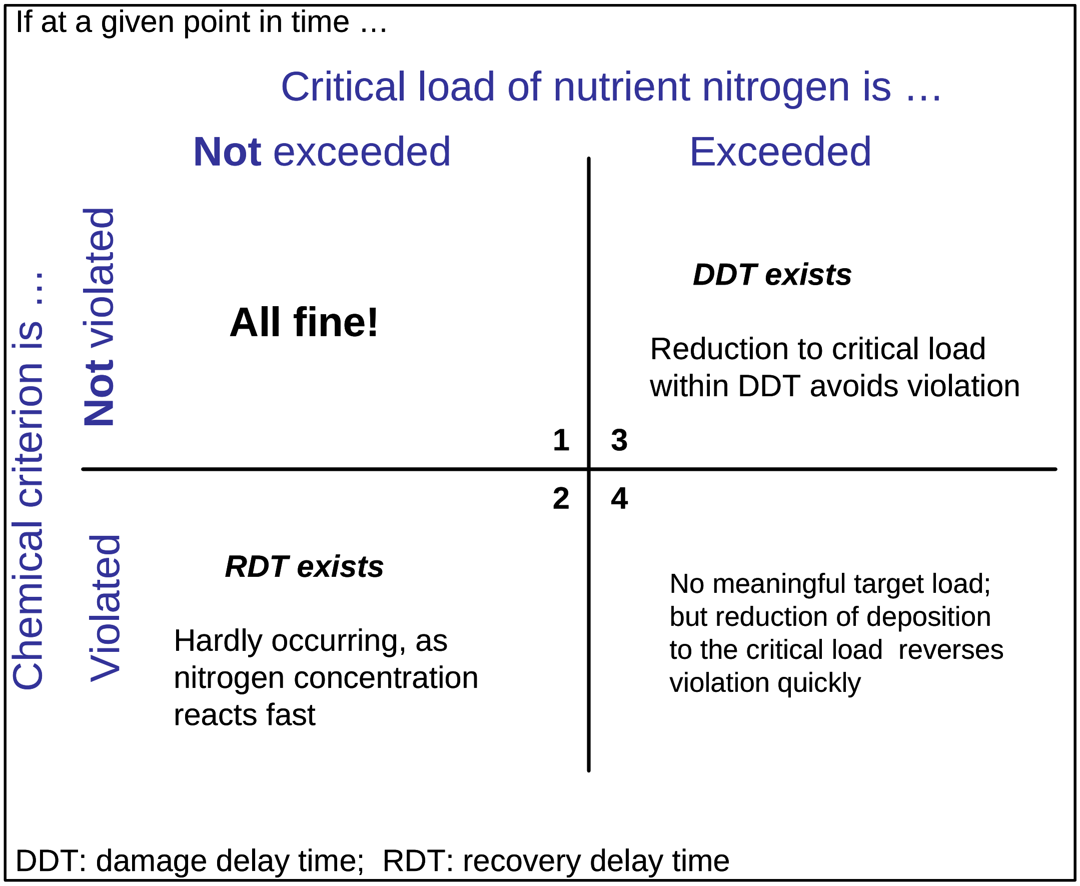
Natural ecosystem area at risk

Table. Percentage of the natural ecosystem area at risk of acidification (left) and of eutrophication for Parties to the Convention within the EMEP modelling domain for two emission scenarios: current legislation (CLE) in 2000, 2010 and 2020, and maximum feasible reductions (MFR) in 2020 (CCE 2008).

	Acidification					Eutrophication				
Country	Area (km^2)	CLE in 2000 (% at risk)	CLE in 2010 (% at risk)	CLE in 2020 (% at risk)	MFR in 2020 (% at risk)	Area (km^2)	CLE-2000 (% at risk)	CLE in 2010 (% at risk)	CLE in 2020 (% at risk)	MFR in 2020 (% at risk)
AL	16,954	0	0	0	0	16,954	100	99	99	43
AT	35,746	2	1	0	0	40,255	100	94	78	5
BA	31,892	17	15	10	0	31,892	89	81	77	40
BE	6,250	29	21	19	4	6,250	100	99	94	37
BG	48,330	0	0	0	0	48,330	94	91	80	18
BY	64,023	18	17	16	0	64,023	99	99	99	56
CH	9,805	9	5	3	1	9,625	99	96	91	21
CY	2,461	0	0	0	0	2,461	68	68	68	17
CZ	27,626	28	22	20	5	27,626	100	100	100	99
DE	102,891	58	32	24	5	102,891	84	67	58	36
DK	3,584	50	42	37	2	3,584	100	100	100	99
EE	24,728	0	0	0	0	24,728	67	57	47	5
ES	187,115	3	0	0	0	187,115	95	93	90	48
FI	273,634	3	2	2	0	240,403	47	41	36	2
FR	177,359	12	8	6	1	180,099	98	95	91	41
GB	81,815	39	19	15	7	92,244	26	19	17	9
GR	53,671	3	1	1	0	53,671	98	97	97	60
HR	31,698	5	3	3	0	31,698	100	100	99	81
HU	20,805	26	8	7	0	20,805	100	100	100	56
IE	8,935	23	8	6	2	2,449	88	81	77	73
IT	124,788	0	0	0	0	124,788	69	61	55	14
LT	19,018	34	32	32	4	19,018	100	100	100	92
LU	1,015	15	13	13	0	1,015	100	100	99	98
LV	35,823	20	14	12	0	35,823	99	99	96	44
MD	3,483	1	0	0	0	3,483	100	100	100	72
MK	13,945	12	1	0	0	13,945	100	100	100	53
NL	6,968	76	71	71	60	4,447	94	88	88	76
NO	179,158	16	11	10	3	137,701	22	14	11	0
PL	90,330	77	61	50	3	90,330	100	100	99	68
PT	31,121	8	3	3	0	31,121	97	83	69	6
RO	97,964	46	22	12	0	97,964	19	20	15	0
RU	1,821,560	1	1	2	0	1,821,560	21	24	28	2
SE	443,660	17	10	9	2	150,865	56	47	43	13
SI	10,996	7	0	0	0	10,996	98	92	82	0
SK	20,532	18	9	8	0	20,532	100	100	100	83
UA	72,200	5	3	4	0	72,200	100	100	100	92
YU	41,108	18	9	3	0	41,108	97	95	92	34
EU-27	1,937,164	19	11	9	2	1,619,811	74	69	64	28
EMEP domain	4,222,991	11	7	6	1	3,864,000	49	48	47	17

Annex II

Four cases of combinations of critical load (non-)exceedance and (non-)violation of chemical criterion



Note: From CCE (2007).
