wge **Working Group on Effects of the Convention on Long-range Transboundary Air Pollution**

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Critical Loads and Dynamic Modelling Results

CCE Progress Report 2004

J-P Hettelingh, J Slootweg, M Posch

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ICP M&M Coordination Center for Effects

This investigation has been performed by order and for the account of the Directorate for Climate Change and Industry of the Dutch Ministry of Housing, Spatial Planning and the Environment within the framework of RIVM project M259101, 'UNECE-LRTAP'; and for the account of (the Working Group on Effects within) the trust fund for the partial funding of effect-oriented activities under the LRTAP Convention.

RIVM, P.O. Box 1, 3720 BA Bilthoven, telephone: 31 - 30 - 274 91 11; telefax: 31 - 30 - 274 29 71

Abstract

This report describes the results of the call for critical load and dynamic modelling data that the Coordination Center for Effects issued on 18 November 2003, with the deadline of 31 March 2004. Critical loads are thresholds of air polluting compounds which should not be exceeded to protect ecosystems from risk of damage, e.g. from acidification and eutrophication. Dynamic modelling data provide information on the future time required to have an ecosystem recover from such a risk, whenever critical loads are no longer exceeded. For dynamic modelling countries were requested to submit so-called *target loads*, i.e. a deposition (path) which ensures recovery in a given year and maintained thereafter.

Sixteen countries submitted updated data on critical loads of acidity and of nutrient nitrogen. Eleven countries also submitted the requested target loads. Several countries noted the need for a follow-up call to complete their contributions.

The submitted critical load data were compared to depositions computed with preliminary results of the new model of EMEP. The latter model enables the computation of ecosystem specific deposition (e.g. forests), contrary to the old model which computed an average deposition in each 150x150 km^2 grid cell. The comparison of ecosystem specific deposition to the 2004 critical loads leads to a larger area of unprotected ecosystems than that computed in the past. It is shown that ecosystems which are unprotected against acidification and eutrophication in 2000 cover 11% and 35% of the European ecosystem area respectively. According to the emissions ceilings prescribed in the Gothenburg Protocol and NEC Directive for 2010, these percentages are computed to be about 8% and 34%, respectively.

Preface

You have before you a Progress Report of the Coordination Center for Effects (CCE) of the International Cooperative Programme on the Modelling and Mapping of Critical Levels and Loads and Air Pollution Effects, Risks and Trends (ICP M&M). This ICP is part of the Working Group on Effects of the 1979 Convention on Long-range Transboundary Air Pollution.

This Report focuses on the results of the decision taken by the Working Group on Effects at its 22st session, inviting the CCE to issue, in the autumn of 2003, a call for updated critical loads and dynamic modelling data. The report includes national documents justifying the methods and data used by National Focal Centres (NFCs). It does not, as is the case with CCE Status Report, extend on methodological issues. The reader is referred to the CCE Status Report 2003 for the latest overview of methods regarding critical loads and dynamic modelling.

The call for data yielded an update of the critical loads database that can be used in integrated assessment. However, regarding dynamic modelling the 20th Task Force Meeting of the ICP M&M decided that results (target loads) should not be used for policy support. Therefore, the dynamic modelling results presented in this report are to be considered preliminary.

This report consists of two parts:

Part I contains three chapters. Chapter 1 provides a comprehensive summary of European maps of critical loads, resulting from the 2003 call for data, and exceedances. Exceedances are mapped using EMEP depositions computed both with the Lagrangian and the Eulerian model.
Chapter 2 includes a detailed overview of the NFC results of the call for data on critical loads, while Chapter 3 focuses on the analysis of NFC submissions regarding dynamic modelling.

Part II consists of reports by the National Focal Centres (NFCs). The emphasis has been on the documentation of national critical loads and dynamic modelling and the input data used to calculate them. These reports have not been reviewed and thus reflect the NFCs' intentions of what to report.

Finally, if you want to learn more about the CCE, visit the CCE www.rivm.nl/cce from which you can also download other CCE reports including the dynamic modelling manual.

July 2004,
Coordination Center for Effects
Netherlands Environmental Assessment Agency (MNP)
National Institute for Public Health and the Environment (RIVM)

Acknowledgements

The calculation methods and resulting maps contained in this report are the product of collaboration within the Effects Programme of the UNECE Convention on Long-range Transboundary Air Pollution, involving many individuals and institutions throughout Europe. The various National Focal Centres whose reports on their respective mapping activities appear in Part II are gratefully acknowledged for their contributions to this work.

In addition, the Coordination Center for Effects thanks the following:

- The Directorate for Climate Change and Industry of the Dutch Ministry of Housing, Spatial Planning and the Environment for its continued support.

- The EMEP Meteorological Synthesizing Centre-West for providing European sulphur and nitrogen deposition data.

- The Working Group on Effects and the Task Force of the ICP on Modelling and Mapping for their collaboration and assistance.

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PART I. Status of Maps and Methods

Samenvatting

De Working Group on Effects (WGE), onder de Conventie voor Grensoverschrijdende Luchtverontreiniging, nodigde tijdens zijn 22e sessie (Geneve 3-5 september 2003), het Coordination Center for Effects (CCE) van het Milieu Natuur Planbureau aan het RIVM uit om vernieuwde gegevens te verzamelen over kritische waarden en dynamische modellering data van het netwerk van 25 Partijen onder de Conventie .

Kritische waarden zijn drempels voor atmosferische depositie waarboven een ecosysteem (bijvoorbeeld bos) bloot staat aan een schaderisico, bijvoorbeeld door verzuring of vermesting. Dynamische modellering geeft informatie over de tijdsduur die nodig is voor herstel van een ecosysteem nadat de kritische drempel niet meer is overschreden. De deelnemende landen werden verzocht om zogenaamde *target loads* te berekenen, i.e. een depositiewaarde (ontwikkeling) die herstel in een gegeven jaar mogelijk maakt. Teneinde de deelnemende landen te ondersteunen zijn in de afgelopen jaren door het CCE regionaal toepasbare methoden ontwikkeld en trainingsbijeenkomsten georganiseerd.

Dit rapport beschrijft het resultaat van het verzoek tot dataverzameling die door het CCE op 18 november 2003 werd uitgevaardigd met een deadline van 31 maart 2004. Resultaten zijn gepresenteerd en besproken op de 14e CCE workshop en 20e Task Force bijeenkomst van de International Cooperative Programme on Modelling and Mapping (ICP M&M). Deze bijeenkomsten werden van 24 tot 28 mei 2004 gehouden aan het International Institute of Applied Systems Analysis (IIASA/CIAM) in Laxenburg op uitnodiging van het Oostenrijkse Federale Ministerie van Milieu.

Het doel van de dataverzameling is om een vernieuwde Europese databank van kritische drempels samen te stellen en voor het eerst een Europese target load databank te ontwikkelen. Deze gegevens worden gebruikt bij de ondersteuning van Europees luchtbeleid door middel van geïntegreerde modellen.

Zestien landen leverden kritische drempels voor verzuring en vermesting. Elf landen stuurden ook target loads. Verschillende landen gaven aan dat er een herhaald verzoek om data (herfst 2004) nodig is om hun bijdragen te kunnen vervolmaken. Een beschrijving van de bijdragen en werkwijzen van de verschillende landen is ook in dit rapport opgenomen.

De kritische waarden van 2004 werden vergeleken met atmosferische deposities die zijn berekend met het nieuwe EMEP model. Laatstgenoemd model kan ecosysteem-specifieke deposities berekenen, in tegenstelling tot het oude model dat een gemiddelde depositie berekent in elke 150x150 km^2 roostervierkant. De vergelijking van 2004 kritische waarden met ecosysteem-specifieke deposities leidt tot een vergroting van het ecosysteemgebied in Europa dat aan risico's van verzuring en vermesting blootstaat. Dit in vergelijking tot in het verleden gemaakte berekeningen. Ecosystemen waarvan de verzuringsdrempel of vermestingsdrempel is overschreden beslaan respectievelijk 11% en 35% van het Europese ecosysteemareaal in 2000. Gegeven de emissieplafonds die in het Gotenburg-protocol (onder de Conventie) en Nationale Emissie Richtlijn (Europese Commissie) zijn vastgesteld, bedragen deze percentages in 2010 respectievelijk 8% en 34%.

Summary

The Working Group on Effects (WGE), under the Convention on Long-range Transboundary Air Pollution, at its 22nd session invited the Coordination Center for Effects (CCE) of the Netherlands Environmental Assessment Agency at RIVM to issue a call for data on critical loads and dynamic modelling data in the autumn of 2003.

Critical loads are thresholds of air polluting compounds which should not be exceeded to protect ecosystems from risk of damage, e.g., from acidification and eutrophication. Dynamic modelling data provide information on the future time required to have an ecosystem recover from such a risk, whenever critical loads are no longer exceeded. For dynamic modelling countries were requested to submit so-called *target loads*, i.e. a deposition (path) which ensures recovery in a given year and maintained thereafter.

This report describes the results of the call for data which the Coordination Center for Effects issued on 18 November 2003, with a deadline of 31 March 2004. Results were presented and discussed at the 14th CCE workshop and 20th Task Force Meeting of the International Cooperative Programme on Modelling and Mapping (ICP M&M). These meetings were held from 24 to 28 May 2004 at the International Institute of Applied Systems Analysis (IIASA/CIAM) in Laxenburg upon invitation by the Federal Ministry of the Environment of Austria.

The objective of the call for data was to produce an updated (2004) European database on critical loads and a novel European database on target loads. These databases are prepared for use in integrated assessment modelling exercises in support of European air pollution abatement policies. It was the first time that Parties to the Convention embarked on the use of dynamic models to generate target loads.

Sixteen countries submitted updated data on critical loads of acidity and of nutrient nitrogen. Eleven countries also submitted the requested dynamic modelling results. Several countries noted the need for a follow-up call to complete their contributions.

The submitted critical load data were compared to depositions computed with preliminary results of the new model of EMEP. The latter model enables the computation of ecosystem specific deposition (e.g. forests), contrary to the old model which computed an average deposition in each 150x150 km^2 grid cell. The comparison of ecosystem specific deposition to the 2004 critical loads leads to a larger area of unprotected ecosystems than that computed in the past. It is shown that ecosystems which are unprotected against acidification and eutrophication in 2000 cover 11% and 35% of the European ecosystem area, respectively. According to the emissions ceilings prescribed in the Gothenburg Protocol and NEC Directive for 2010, these percentages are computed to be about 8% and 34%, respectively.

National reports which justify the work conducted by parties in response to the call for data are included in this report as well.

1 Status of European Critical Loads and Dynamic Modelling

Jean-Paul Hettelingh, Maximilian Posch and Jaap Slootweg

1.1 Introduction

The Working Group on Effects (WGE), at its 22nd session, 'invited the CCE to issue a call for data on critical loads and dynamic modelling data in autumn 2003, stressed the importance of active participation of all Parties in the modelling and mapping activities, and urged Parties to continue their efforts to respond to calls for data' (EB.AIR/WG.1/2003/2 para. 37f). It also decided to inform the Executive Body of its need for guidance in selecting target years for dynamic modelling. The CCE organised two training sessions (Tartu, 19 May 2003; Prague, 13-15 October 2003) to familiarise National Focal Centres (NFCs) of the International Co-operative Programme on Modelling and Mapping of Critical Levels and Loads and their Air Pollution Effects, Risks and Trends (ICP M&M) further with the use of dynamic models to respond to the call for data. At these training sessions, concepts described in the Dynamic Modelling Manual (Posch et al., 2003) were demonstrated to the National Focal Centres using the Very Simple Dynamic (VSD) model, the Model of Acidification of Groundwater In Catchments (MAGIC) and the Soil Acidification in Forest Ecosystems (SAFE) model.

The CCE issued the call on 18 November 2003, setting the deadline to 31 March 2004, after consultation with the Joint Expert Group on Dynamic Modelling (JEG) at its meeting in Sitges (5-7 November 2003). In addition to information provided in the Dynamic Modelling manual, also a detailed instruction document had been compiled by the CCE and distributed to the National Focal Centres. It was also made available on the CCE website (www.rivm.nl/cce) and can be found in Annex I.

The objective of the call, in accordance to the medium-term work plan of the WGE (EB.Air/WG.1/2003/2 page 18), is to produce an updated database on critical loads and dynamic modelling results which could be submitted to Task Force on Integrated Assessment Modelling (TFIAM).

This chapter provides a summary of the results of the call for data on critical and target loads, including exceedance maps. A more detailed overview and analysis of national data submissions regarding critical loads and dynamic modelling variables is presented in Chapters 2 and 3, respectively.

1.2 Summary of the purpose of dynamic modelling and terminology

Important dynamic modelling results for possible use by the TFIAM are so-called target loads. A target load is the deposition (path) which ensures recovery by having the prescribed chemical (or, ideally, biological) criterion (e.g., the Al:Bc ratio) be met in a given year and maintained thereafter. The variety of deposition paths to reach a target load is numerous. We restrict to deposition pathways that are characterised by three numbers (years): (i) the protocol year, (ii) the implementation year, and (iii) the target year (see Figure 1-1). The protocol year for dynamic modelling is the year up to which the deposition path is assumed to be known and cannot be changed any more. This can be the present year or a year in the (near) future, for which emission reductions are already agreed. As protocol year countries were requested to use 2010, the year for which the Gothenburg Protocol and the EU NEC Directive are expected to be in place. The implementation year for dynamic modelling is the year in which all reduction measures to reach the final deposition (the target load) are assumed to be implemented. Between the protocol year and the implementation year deposition are assumed to change linearly. After consultation with the chairmen of the ICP M&M, the WGE, the Working

Group on Strategies and Review (WGSR) and other Convention representatives, 2015 was chosen as a preliminary implementation year. The target year for dynamic modelling is the year in which the chemical criterion (e.g., the Al:Bc ratio) is met (for the first time). Countries were requested to submit target loads for the years 2030, 2050 and 2100.

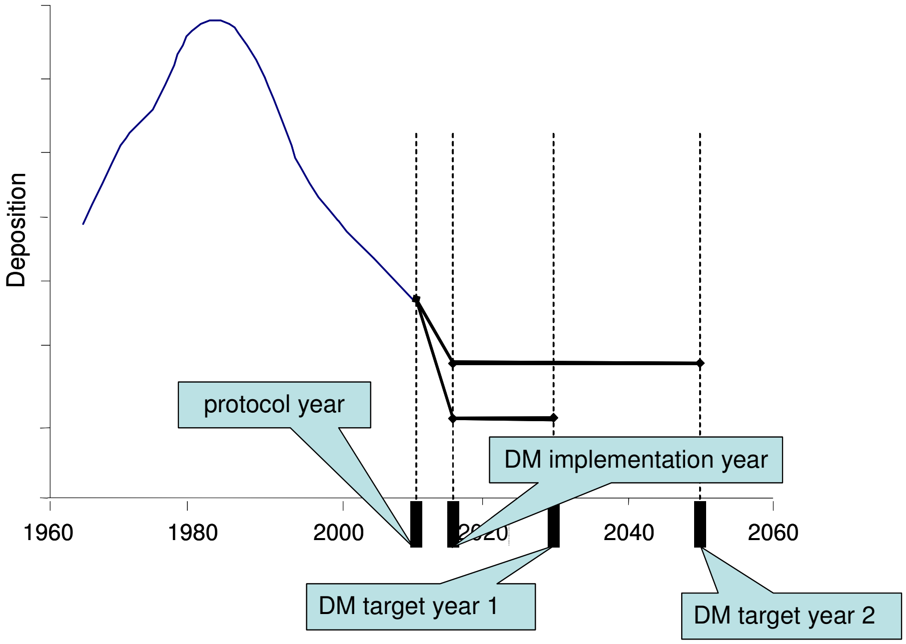

Figure 1-1. Schematic representation of deposition paths leading to target loads by dynamic modelling (DM), characterised by three key years. (i) The year up to which the (historic) deposition is fixed (protocol year); (ii) the year in which the emission reductions leading to a target load are implemented (DM implementation year); and (iii) the years in which the chemical criterion is to be achieved (DM target years)

In addition to information on target loads and target years, NFCs were also requested to ensure consistency between critical loads and dynamic modelling. This implies that each record in the critical load database should contain data that can be used to compute critical loads and to run the dynamic model. However, to maintain important statistical information on the (distribution of) sensitivity of ecosystems within an EMEP grid cell, NFCs were requested not to leave out records where only critical loads data were available. Information on the deposition history was available from EMEP Lagrangian modelling results (Schöpp et al., 2003; EMEP, 1998). Results of the call for data were presented at the 14th CCE workshop and 20th Task Force Meeting of the ICP M&M. These meetings were held from 24 to 29 May 2004 at the International Institute of Applied Systems Analysis (IIASA/CIAM) in Laxenburg upon invitation by the Federal Ministry of the Environment of Austria.

1.3 Results of the call for data

Sixteen countries submitted updated data on critical loads of acidity and of nutrient N. As approved under the Convention, the European background database is used to compute and map critical loads for ecosystems in countries that never submitted data. For countries who submitted data in one of the earlier calls for data, the latest available submission of critical loads was used.

The critical loads consist of four basic variables which were asked to be submitted and which were used to support the Gothenburg Protocol. These variables are the basis for the maps used in the effect modules of the European integrated assessment modelling effort: (a) the maximum allowable deposition of S, $CL_{max}(S)$, i.e. the highest deposition of S which does not lead to 'harmful effects' in the case of zero nitrogen deposition, (b) the minimum critical load of nitrogen, $CL_{min}(N)$ to ensure sufficient nitrogen for plant uptake including nitrogen immobilisation (c) the maximum 'harmless' acidifying deposition of N, $CL_{max}(N)$, in the case of zero sulphur deposition, and (d) the critical load of nutrient N, $CL_{nut}(N)$, preventing eutrophication of ecosystems.

Eleven countries also submitted the requested dynamic modelling results. Switzerland reported that it needed more time to prepare a representative set of dynamic modelling data. Belgium, the Czech Republic, Denmark, and Slovakia indicated that they could not finalise their response to the call for data in time. Norway and Sweden noted the preliminary nature of their submission. Many countries indicated at the 14th CCE workshop and 20th Task Force of the ICP Modelling and Mapping that their submission of dynamic modelling data should be used in integrated assessment for testing purposes only, while emphasising that a follow-up call for data at the end of 2004 should be considered. Dynamic modelling results submitted in this call are likely to change when depositions of acidifying compounds computed with the Unified Model on a 50x50 km^2 can become available for dynamic modelling instead of depositions computed with the EMEP Lagrangian model on 150x150 km^2 grid cells which were used in this round.

Table 1-1. Overview of the response to the call for, and status of, European critical loads on acidification and eutrophication including preliminary dynamic modelling results[#]

colnr.	1 CLaci Km^2	2 TLFs %	3 2030 TL=PL	4 2030 TL<CL	5 2030 n.f.	6 2050 TL=PL	7 2050 TL<CL	8 2050 n.f.	9 CLnut km^2
AT*	37572	99.9	96.4	3.4	0.0	96.6	3.3	0.0	37572
BE	7282	-	-	-	-	-	-	-	7282
BG*	48345	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48345
BY*	103366	-	-	-	-	-	-	-	103366
CH*	11238	-	-	-	-	-	-	-	21866
CY*	4534	-	-	-	-	-	-	-	4534
CZ	18272	-	-	-	-	-	-	-	18272
DE*	105745	61.8	48.1	12.2	1.5	48.3	12.3	1.2	105745
DK*	3149	-	-	-	-	-	-	-	3149
EE	21450	-	-	-	-	-	-	-	22411
ES	85225	-	-	-	-	-	-	-	85225
FI*	266830	-	-	-	-	-	-	-	240403
FR*	180102	100.0	97.4	2.6	0.0	97.5	2.5	0.0	180102
GB*	77674	0.8	0.7	0.1	0.0	0.5	0.2	0.0	74206
HR	6931	-	-	-	-	-	-	-	7009
HU*	10448	100.0	100.0	0.0	0.0	100.0	0.0	0.0	10448
IE	8936	-	-	-	-	-	-	-	8936
IT*	119854	100.0	100.0	0.0	0.0	100.0	0.0	0.0	119854
MD	11985	-	-	-	-	-	-	-	11985
NL*	7583	100.0	64.5	13.5	22.0	64.5	13.6	21.9	4623
NO*	453087	19.9	11.2	8.4	0.3	11.2	8.4	0.3	226631
PL*	88383	100.0	88.1	11.9	0.0	88.2	11.8	0.0	88383
RU	3517136	-	-	-	-	-	-	-	3517136
SE*	395101	63.8	52.7	8.7	2.4	53.1	8.8	1.9	182223
SK	19227	-	-	-	-	-	-	-	19227

[*] Revised data submitted in 2004;

[#] TLFs = Target load functions; TL = Target load; PL = Present load; CL = Claci km^2= The ecosystem area for which critical loads of acidification are available; n.f. = Not feasible; Clnut km^2 = The ecosystem area for which critical loads of nutrient N are available; critical load calculation and mapping methods are summarised in Hettelingh et al. (2003).

Results are summarised in Table 1-1, which gives an overview of the ecosystem area for each country (column 1) for which critical loads of acidity (column 2) and critical loads of nutrient nitrogen (last column) are available. The latest available submission of critical loads was used for countries who did not submit data in 2004. Information is also provided (column 3) on the percentage of a country's ecosystem area for which dynamic modelling results (target loads) have been submitted. Eight out of eleven countries were able to compute target loads for 100% of the ecosystem area. For other countries a subset of the ecosystem area was used for dynamic modelling. Next, Table 1-1 shows the percentage of the ecosystem area for which the chemical criterion is no longer violated when the emissions of the protocol year are kept constant between 2010 and 2030 (column 4) and 2050 (column 7). In principle this percentage should be larger in 2050 than in 2030. A relatively low percentage of the ecosystem area could recover with target loads lower than critical loads in 2030 (column 5) or 2050 (column 8). The percentage of the ecosystem area where submitted target loads for 2030 and 2050 are infeasible are provided in columns 6 and 9, respectively. The percentage of ecosystems for which target loads are infeasible is high in the Netherlands in comparison to other countries because tentative use was made of an indicator on nitrogen availability and soil pH to describe the change (recovery) of plant species composition (biodiversity). Other countries do not (yet) include biodiversity in their assessments. When applications are restricted to criteria described in the Mapping Manual, such as the calcium-aluminium ratio, percentages similar to other countries are obtained for the share of infeasible areas.

Figure 1-2 shows the EMEP grid cells for which target loads were submitted. Target loads turn out to be available in most of the European EMEP grid cells which are exceeded (see Figure 1-6). For countries that never submitted critical loads, the background database could also be used to compute target load values which are compatible with the critical loads.

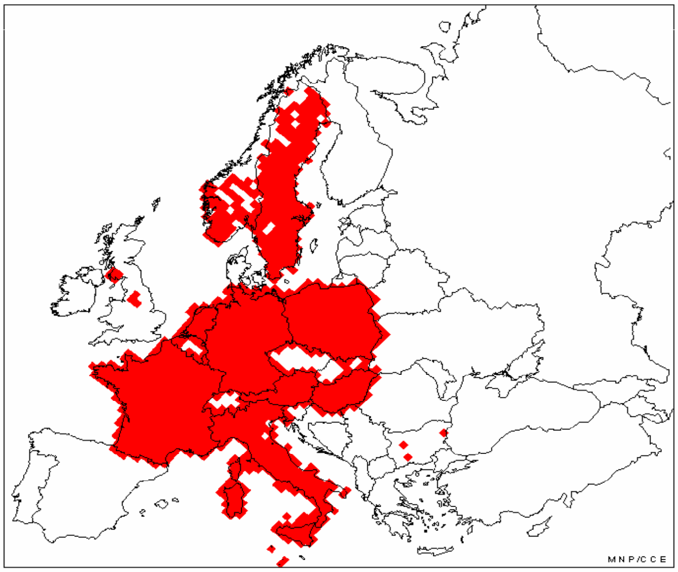

Figure 1-2. EMEP grid cells (red shaded) for which target load values have been submitted by the National Focal Centres of Austria, Bulgaria, France, Germany, Hungary, Italy, the Netherlands, Norway, Poland, Sweden and the United Kingdom.

1.4 Maps of critical loads

This section contains maps of critical loads for ecosystems within 50×50 km^2 EMEP (EMEP50) grid cells. The maps are based on updated national contributions from 16 countries. For other countries the latest data submission was used. For countries that never submitted critical loads data the European background database (Posch et al., 2003) has been used.

Figure 1-3 shows 5th and 50th percentile maps of $CL_{max}(S)$ and $CL_{nut}(N)$, reflecting deposition values in grid cells at which 95% and 50% of the ecosystems are protected respectively. In these maps the critical loads of all ecosystems have been combined. The analysis of critical loads required to protect 95% of the ecosystems from acidification reveals that most sensitive areas ($CL_{max}(S)$ lower than 200 eq ha^{-1}a^{-1}) occur in northern Europe, the east of the United Kingdom, the south west of France and in Belarus. To protect 50% of the areas, low critical loads prevail in northern Europe. The difference between the 5th an 50th percentile maps of $CL_{nut}(N)$ is illustrated for example in Germany, Moldova, Poland, Sweden and Russia where the areas in the lowest critical load range (red shaded) are clearly reduced. This is obvious because higher percentiles correspond to higher critical loads that protect a smaller area of ecosystems.

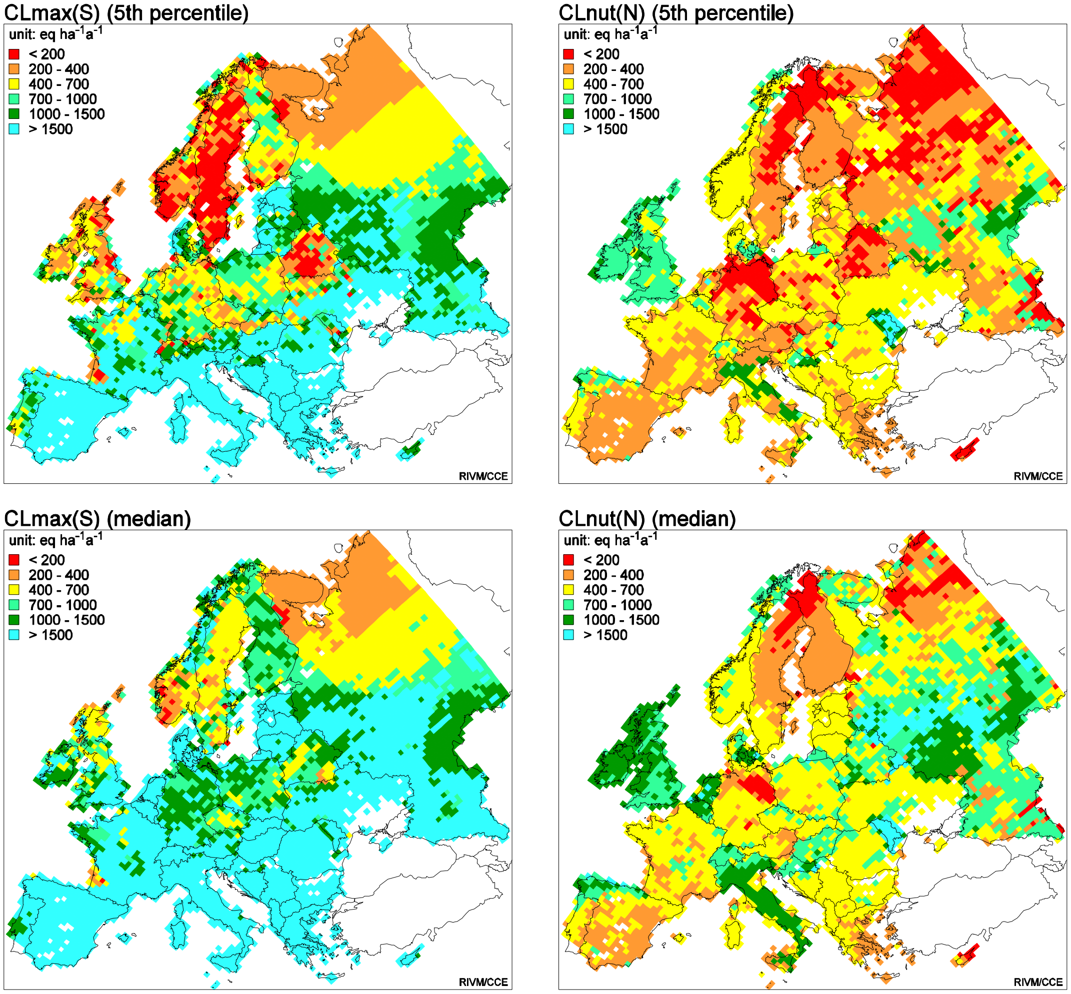

Figure 1-3. The 5th percentiles of the maximum critical loads of sulphur (top left), and of the critical loads of nutrient nitrogen (top right). The 50th percentiles are shown at the bottom left and right, respectively. The maps present these quantities on the EMEP50 grid.

Figure 1-4 shows analogous maps for $CL_{max}(N)$ and $CL_{min}(N)$. Relatively low values of the 5th percentile $CL_{max}(N)$, indicating the maximum critical load for nitrogen acidity at zero deposition of sulphur, occur mostly in the northern regions of Europe (see top left map). Values of the 5th percentile $CL_{min}(N)$ reflecting the lowest acceptable thresholds of nitrogen uptake and immobilisation, tend to be low in most parts of Europe (top right map).

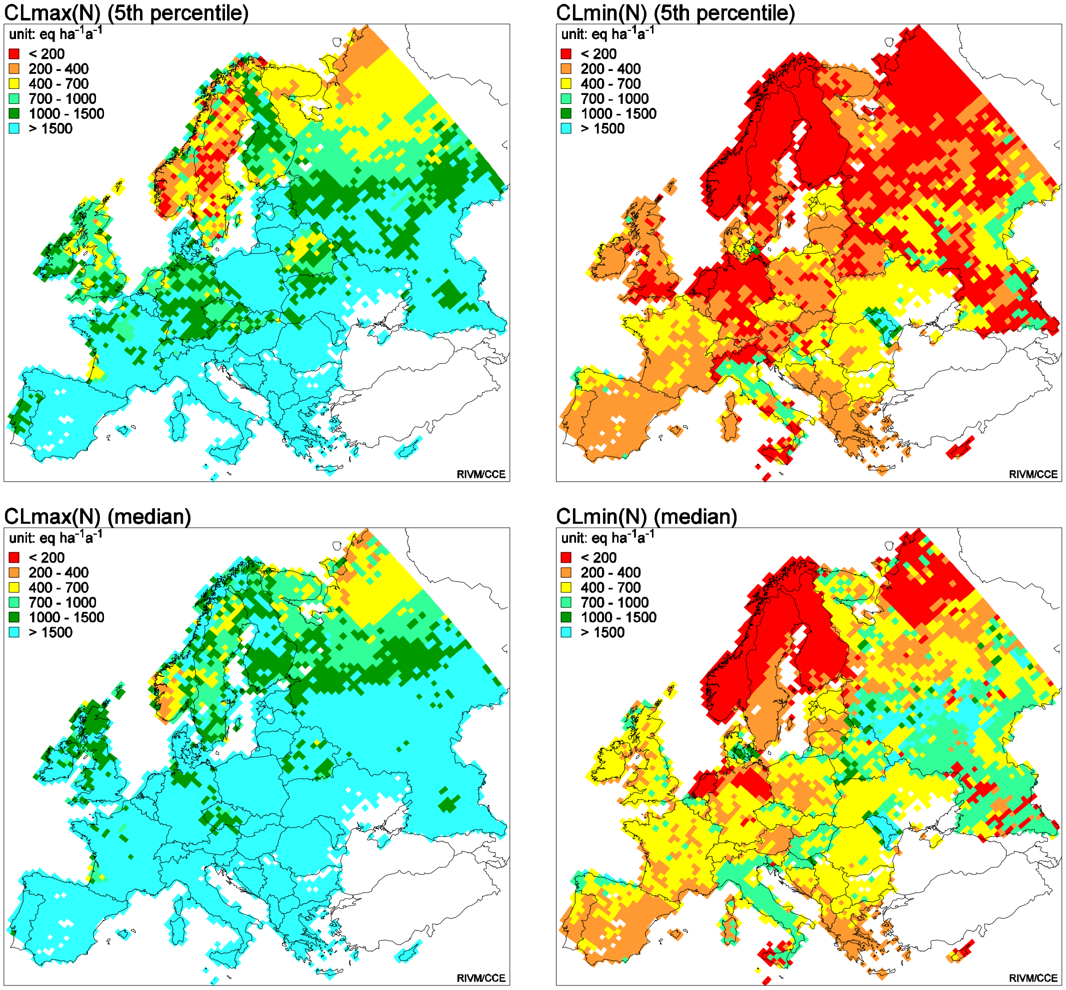

Figure 1-4. The 5th percentiles of the maximum critical loads of nitrogen (top left), and of the minimum critical loads of nitrogen (top right), on the EMEP50 grid resolution. The 50th percentiles are shown at the bottom left and right, respectively.

1.5 Comparison of 2003 and 2004 critical loads

Figure 1-5 provides a comparison of the statistics of the 2003 and 2004 critical load data. The minimum, 5th, 25th, 50th, 75th, 95th percentiles and the maximum of the critical loads of each country that submitted data in 2004 are shown in a 'diamond plot'. Statistics of $CL_{max}(S)$ are on the left ranging over an interval of 0 to 4000 eq ha^{-1} a^{-1}, whereas $CL_{nut}(N)$ (right) ranges from 0 to 2000 eq ha^{-1} a^{-1}. The dark blue and turquoise diamonds reflect 2004 and 2003 statistics respectively. A comparison between 2003 and 1998 (critical loads used to support the Gothenburg Protocol) can be found in Hettelingh et al. (2003). This year the recently appointed NFC of Cyprus (CY) made a first submission of critical loads, therefore a comparison with 2003 data is lacking. Compared to 2003 the median values (shown as vertical line dividing a 'diamond') of $CL_{max}(S)$ increased in Austria (AT), Germany (DE), and the Netherlands (NL) while decreasing in Belarus (BY), France (FR), United

Kingdom (GB), Norway (NO) and Poland (PL). For $CL_{nut}(N)$ the median value has increased in Belarus and decreased in Austria, Germany, France, the Netherlands and Poland. The 5th percentile of $CL_{nut}(N)$ of 2004 is lower in Austria, Germany, France, The Netherlands and Poland. Changes in the statistics are a result of updates of national critical load databases, details of which are provided in the NFC reports (see Part II).

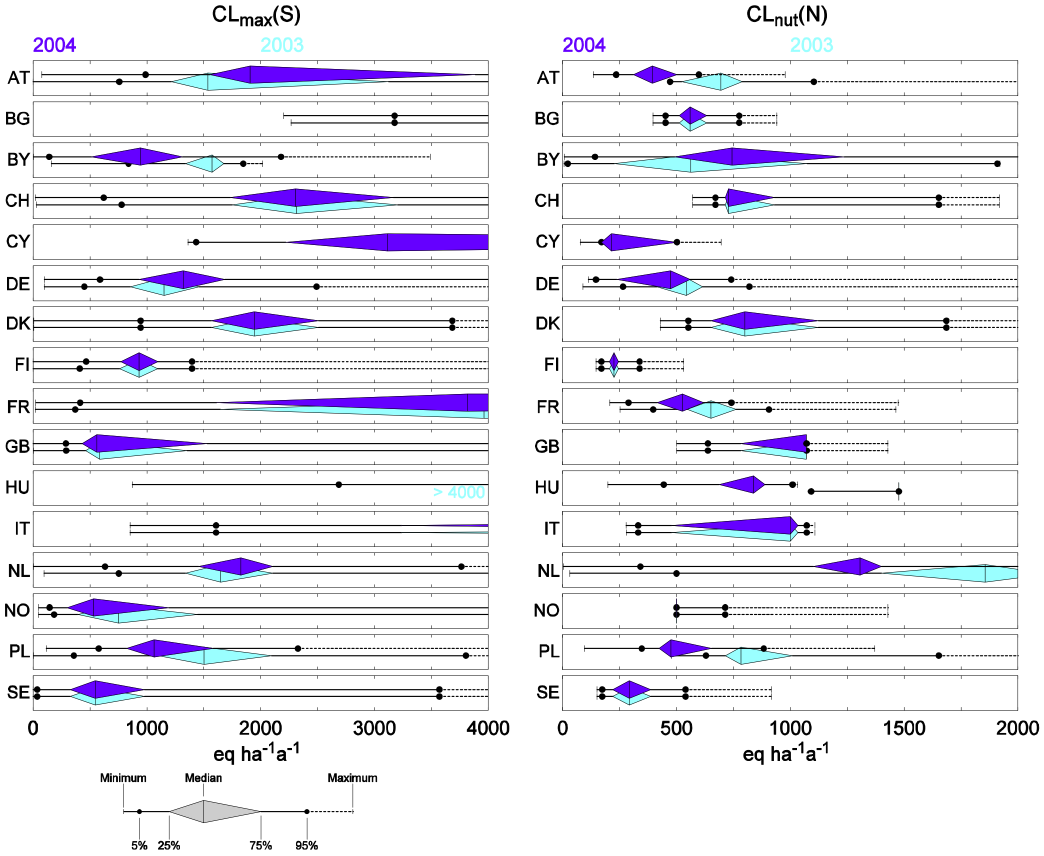

Figure 1-5. Diamond plot of the minimum, 5th, 25th, 50th, 75th, 95th percentiles and maximum critical loads of $CL_{max}(S)$ (left) and $CL_{nut}(N)$ (right) for the national data of 2004 (dark-blue) and 2003 (turquoise), respectively. The legend shows that 5th percentile is indicated by the dot to the left of the diamond and the 95th percentile by the dot on the right, while the median is indicated by the vertical line in the diamond.

1.6 Maps of critical load exceedances

Exceedances in this section refer to the 'average accumulated exceedance' (AAE). The AAE is the area-weighted average of exceedances (accumulated over all ecosystem points) in a grid cell, and not only the exceedance of the most sensitive ecosystem. An AAE may be computed for all ecosystem categories within a grid cell, but also for one single ecosystem category (such as a forest) in a grid cell for which data points are submitted by an NFC. The European critical load database contains about 1.4 million critical load data points. Maps of AAE provide information about the *magnitude* of the exceedances (see Posch et al., 2001 for further details). The AAE, for all ecosystems, was used in integrated assessment modelling to support the analysis of emission reduction alternatives.

The analysis in this section focuses on the difference in magnitudes of the AAE for acidity (a) when using acid deposition values computed with two different EMEP models, i.e. the well-known

Lagrangian model (EMEP, 1998) and the more recent Unified Model (Tarrasón et al., 2003), (b) when computed in EMEP50 and 150x150 km^2 (EMEP150) grid cells, and (c) when using acid deposition values computed on forest ecosystems or as average. Combinations of (a), (b) and (c) are explored as well. The AAE has been computed using critical loads of acidity.

Figure 1-6 shows a sequence of 6 maps of average accumulated exceedance as follows:

1. The top-left AAE map is based on average acid deposition in EMEP150 grid cells with the Lagrangian model and critical loads of 1998. This AAE map was used in support of the Gothenburg Protocol. The result shows two grid cells on the border of the Netherlands and Germany, where the AAE exceeds 800 eq ha^{-1}a^{-1} (red shading).
2. The top-right AAE map is similar to (1), except that the latest critical load database (2004) is used. The AAE turns out to decrease on the border of Germany and The Netherlands (and in the Etna region) and increase in eastern Germany and Poland.
3. The left-middle AAE map is similar to the map described in (2), i.e. based on Lagrangian average deposition and 2004 critical loads, on 50x50 km^2 EMEP grid cells. The Lagrangian deposition computed as average in a 150x150 km^2 grid cell is applied to the 50x50 km^2 grid cells inside.
4. The right-middle map shows the AAE when the Lagrangian deposition used in (3) is replaced by the grid average acid deposition computed with the Unified Model, (using an average of the 1999 and 2003 meteorology). The 2004 critical load database is used to compute AAE. The use of the Unified Model to compute grid-average depositions turns out to reveal lower AAE magnitudes on the German-Dutch and German-Czech border than when the Lagrangian model is used. However, overall the differences are not striking.
5. The bottom-left map shows the AAE computed with 2004 critical loads using forest–specific deposition for forests while using the average deposition for non-forest ecosystems. The deposition values are all computed with the Unified Model. Compared to map 4, much higher exceedances occur due to the fact that deposition onto a forest is higher than the average of depositions over various ecosystems within a grid cell. The reason why the deposition to forests is higher than average deposition is due to the ‘roughness’ of forests which ‘catches’ more pollutants. Therefore, an ecosystem specific AAE is more accurate than the grid average computed in the past, using the Lagrangian EMEP model. Ideally, depositions would be required for each of the 1.4 million critical load data points submitted by NFCs to further improve the accuracy of AAE.
6. Finally, the bottom-right map is analogous to (5), but now using only the critical loads of forest ecosystems and forest specific deposition. The difference with map (5) is not significant with respect to the magnitude and regional distribution of the AAE. The reason is that most of the critical loads are computed for forest soils.

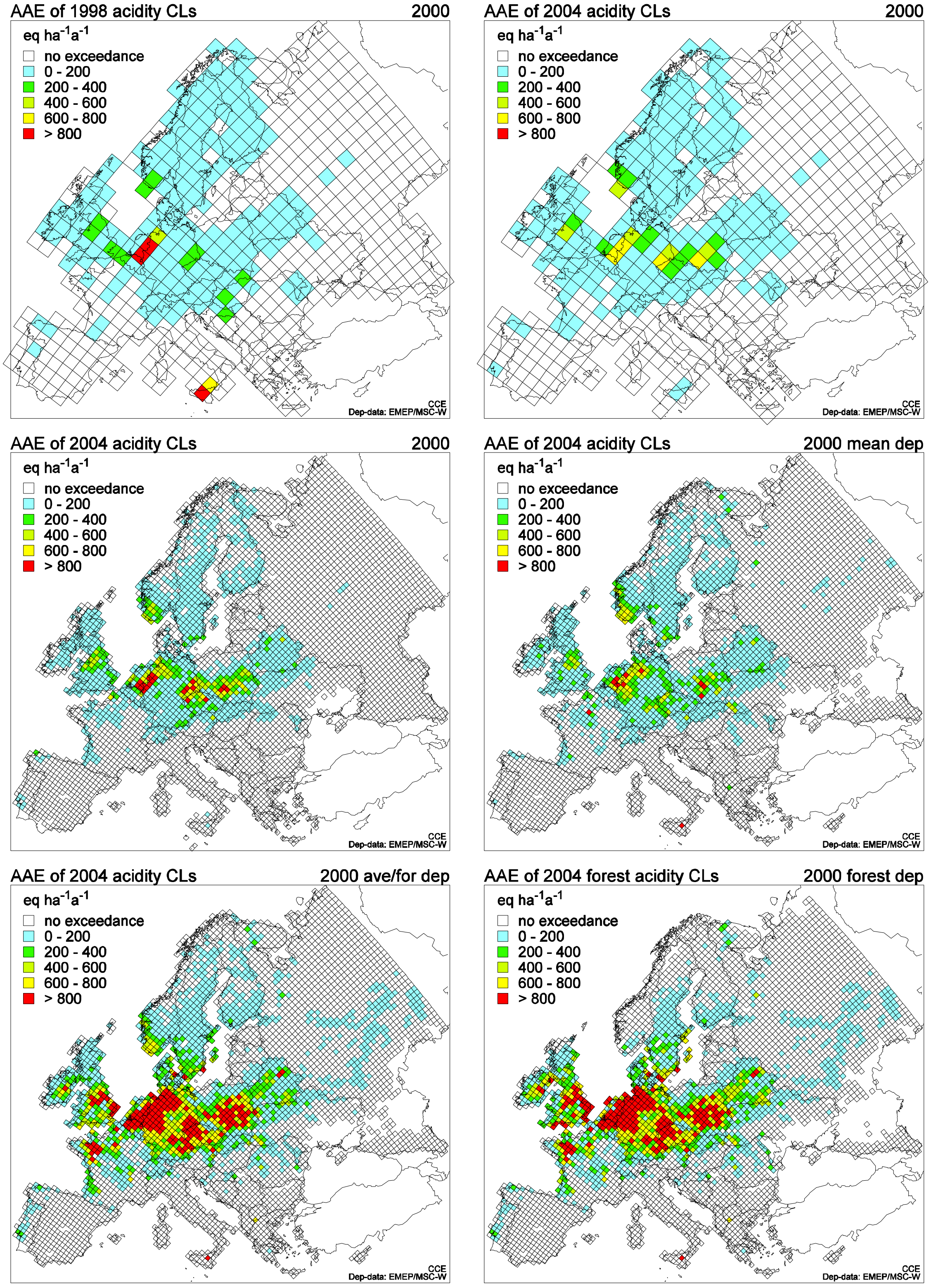

Figure 1-6. Average accumulated Exceedance (AAE) in 2000 using EMEP Lagrangian model average deposition with 1998 critical loads on 150x150km^2 (top left), idem with 2004 critical loads (top right), idem on 50x50 km^2 (middle-left), using EMEP-Unified-model average deposition with 2004 critical loads (middle-right), idem using EMEP-Unified-model forest-specific deposition and the average deposition for other ecosystems (bottom-left), and finally focussing on forests only (bottom right).

Table 1-2 lists the results mapped in Figure 1-6 in terms of the percentage of the ecosystem area which is unprotected from acidification. The Table includes also results for 2010 and reflects two European regional breakdowns, i.e. one region covering most of the 49 European Parties to the Convention (‘Europe’) for which deposition and critical loads data are available, and the other mapping the European Union of 25 member states (‘EU25’). Table1-3 is analogous to Table 1-2 showing the percentage of the ecosystem that is unprotected for the risk of excessive nutrient nitrogen deposition.

Table 1-2. Percentage of the ecosystem area for which acidity critical loads are exceeded in 2000 and 2010 according to the emissions ceilings prescribed in the Gothenburg Protocol and NEC directive[*]

	2000		2010	
	Europe	EU25	Europe	EU25
Lagrangian model				
(1) 1998 critical loads	3.9	8.5	2.3	4.2
(2) 2004 critical loads	6.4	12.2	4.7	8.3
Unified Model & 2004 Crit.loads				
(4) grid average deposition	8.2	15.4	5.4	8.7
(5) ecosystem specific deposition	11.0	22.4	8.2	16.0
(6) forests only[a]	13.3	23.7	10.0	17.0

[*] Numbers in brackets refer to the explanations of the consecutive maps of Figure 1-6.
[a] numbers refer to % of forest area.

Compared to the use of the 1998 critical loads database, Table 1-2 shows that the update of the critical loads database in 2004 yields an increase in Europe of ecosystems at risk of acid deposition, as computed with the Lagrangian model both in 2000 (+1.5 percent point) and 2010 (+2.4 percent point). The use of the Unified Model to compute a grid average deposition leads to a further increase of the unprotected ecosystem area in Europe to 8.2% and 5.4% in 2000 and 2010 respectively. When distinguishing between forest specific deposition and other ecosystems (average deposition) then the percentage of unprotected ecosystems in Europe increases further by about 3.0 percent point. Finally it can be seen that 13.3% and 10% of the forest ecosystems is unprotected in Europe in 2000 and 2010 respectively when forest specific deposition (Unified Model) is compared to forest critical loads of acidity. Thus, compared to the area of all ecosystems at risk of *average acidification* computed in 1998-1999 (3.9% in 2000 and 2.3% in 2010), computations of *ecosystem specific acidification* now reveals that 11% is unprotected in 2000 which is reduced to 8.2% in 2010.

Table 1-3. Percentage of the ecosystem area for which nutrient nitrogen critical loads are exceeded in 2000 and 2010 according to the emissions ceilings prescribed in the Gothenburg Protocol and NEC Directive.[*]

	2000		2010	
	Europe	EU25	Europe	EU25
Lagrangian model				
1998 critical loads	26.0	60.7	24.6	54.4
2004 critical loads	24.5	56.0	23.1	49.0
Unified Model & 2004 Crit.loads				
grid average deposition	29.2	64.9	28.5	59.2
ecosystem specific deposition	35.1	77.7	34.7	73.0
forests only[a]	53.2	80.9	52.3	76.3

[*] Explanations are analogous to Table 1-2.
[a] numbers refer to % of forest area.

Table 1-3 shows that the area of all ecosystems at risk of *average eutrophication* computed for 1998 critical loads (26% in 2000 and 24.6% in 2010), increases to 35.1% in 2000 and 34.7% in 2010 when computing *ecosystem-specific eutrophication.* The use of the critical loads database of 2004 to compute exceedances with Lagrangian-modelled depositions leads to a decreasing percentage of ecosystems at risk, i.e. from 26% to 24.5% in 2000 and from 24.6% to 23.1% in 2010. The use of nitrogen deposition computed with the Unified Model shows that the percentage of unprotected ecosystems increases significantly to 53.2% in 2000 (52.3% in 2010) when focussing on forest soils.

Note that the area of ecosystems that are unprotected from eutrophication (see Table 1-3) is significantly larger than area which is unprotected from acidification (Table 1-2), both in 2000 and 2010. Finally, also note in Tables 1-2 and 1-3, that the percentage of the unprotected ecosystems in the EU25 is generally higher than in Europe. The reason is that Russia contains a relatively large area of protected ecosystems.

In summary, the increase of the computed risk of acidification can be attributed both to the updated critical loads database as to EMEP computed depositions using the Unified Model. However, the increase of the computed risk of eutrophication is largely due to deposition results generated with the Unified Model. The ability of the Unified EMEP model to compute ecosystem specific depositions improves the quality of the assessment of risks based on critical loads within a single EMEP grid cell. Where in the past only one single average deposition value could be compared to a range of critical loads (for different ecosystem categories) to yield an *average* risk, now *specific* risk assessments are possible focussing on an individual ecosystem within an EMEP grid cell. This increases the similarity with findings in the field, where measured deposition has been shown to be higher in forest ecosystems than outside.

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2 Summary of National Critical Loads Data

Jaap Slootweg, Maximilian Posch and Jean-Paul Hettelingh

2.1 Introduction

The 1998 European critical loads database was used to support the negotiations of the effects-based Gothenburg Protocol of the 1979 Convention on Long-range Transboundary Air Pollution. Since then progress has been made in the work of the scientific community supporting the effects-related work in relation to critical loads and dynamic modelling. Members of the Working Group on Effects (WGE) welcomed the progress achieved in the application of dynamic modelling and the steps taken to link dynamic modelling to integrated assessment. Consequently, the WGE in its 22th session invited the CCE 'to issue a call for data on critical loads and dynamic modelling data in autumn 2003.'

To apply dynamic modelling data to integrated assessment, the CCE also requested target loads in addition to critical loads. A target load is the deposition for which a pre-defined chemical (or biological) status is reached in the target year, and maintained (or improved) thereafter. To ensure the robustness of integrated assessment updated critical loads, consistent with target loads, are necessary. To demonstrate the pathways of recovery of ecosystems with decreasing acidifying depositions the CCE also requested in this call the value of the applied criterion in the target years 2030, 2050 and 2100.

This chapter reports on the steady state results (critical loads and parameters) of the call for data issued in December 2003 with the deadline of 31 March 2004. The results and parameters related to dynamic modelling are described in Chapter 3.

2.2 Requested variables

A complete submission for this call consisted of

1. Updated critical loads
2. Target load functions for the target years 2030, 2050 and 2100
3. Value of the applied criterion in the target years when running the dynamic model with the 2010 (Gothenburg) depositions kept constant afterwards.
4. Input variables to allow consistency checks and inter-country comparisons

Previous calls demanded a single table of ecosystems with its properties, but the extended scope of this year's call brought about the use of related tables which contained respectively:

- input variables and critical loads 'Table 1'
- target load functions 'Table 2'
- values of the applied criterion in target years 'Table 3'

To simplify the inclusion of dynamic modelling results for aquatic ecosystems, a specific format was adopted with relevant input variables 'Table 4'. A list of all four Tables, with their variable names, units and a description as send to all National Focal Centres can be found in Annex I.

2.3 National responses

Cyprus submitted critical loads for the first time, bringing the number of National Focal Centres (NFCs) to 25. The CCE had communications (nearly 500 e-mails) with 23 countries, of which 16 submitted data. From these 11 countries also submitted results of dynamic modelling. Switzerland indicated to have calculated target loads, but needed further investigation. Belgium, the Czech Rebublic, Denmark, Slovakia and Switzerland have indicated to be working on dynamic modelling, but need more time. Sweden submitted target loads, but stated that the critical load data of 2003 is still valid, and dynamic modelling results are not to be used for policy purposes. An overview of the national submissions is given in Table 2-1.

Table 2-1. National responses to the call for critical loads and dynamic modelling results.

Country	**Code**	**Critical loads data**	**Dynamic modelling results**	**Remarks** (DM = Dynamic Modelling.)
Austria	AT	X	X	
Belarus	BY	X	-	
Bulgaria	BG	X	All sites safe	
Cyprus	CY	X	-	
Denmark	DK	X	-	
Finland	FI	X	-	
France	FR	X	X	
Germany	DE	X	X	
Hungary	HU	X	All sites safe	
Italy	IT	X	All sites safe	
Netherlands	NL	X	X	
Norway	NO	X	X	
Poland	PL	X	X	
Sweden	SE	X	X	DM not for policy purposes
Switzerland	CH	X	-	'More time needed'
United Kingdom	GB	X	X	
Total NFCs		16	11	

2.4 Types, numbers and areas of the national submissions

All 16 submissions adopted the EUropean Nature Information System (EUNIS) to classify the ecosystem types, and some used a very detailed level. These levels are truncated to a maximum of 2 characters. The figures in this chapter show aggregated categories of the submitted ecosystem types to EUNIS level 1, or grouped further into the main categories listed in the first column of Table 2-2.

Table 2-2. Types of ecosystems for different levels, as used in this report.

Main categories	**EUNIS Level 1**	**EUNIS code**	**EUNIS description**
Forest	Forest	G	Woodland and forest habitats and other wooded land
		G1	Broadleaved deciduous woodland
		G2	Broadleaved evergreen woodland
		G3	Coniferous woodland
		G4	Mixed deciduous and coniferous woodland
Vegetation	Grassland	E	Grassland and tall forb habitats
		E1	Dry grasslands
		E2	Mesic grasslands
		E3	Seasonally wet and wet grasslands
		E4	Alpine and sub alpine grasslands
	Shrubs	F	Heath land, scrub and tundra habitats
		F1	Tundra
		F2	Arctic, alpine and sub alpine scrub habitats
		F4	Temperate shrub heath land
		F5	Maquis, matorral and thermo-Mediterranean brushes
		F7	Spiny Mediterranean heaths
		F9	Riverine and fen scrubs
	Wetlands	D	Mire, bog and fen habitats
		D1	Raised and blanket bogs
		D2	Valley mires, poor fens and transition mires
		D4	Base-rich fens
		D5	Sedge and reed beds, normally without free-standing water
		D6	Inland saline and brackish marshes and reed beds
	Other	A2	Littoral sediments
		B1	Coastal dune and sand habitats
		B2	Coastal shingle habitats
		C3	Littoral zone of inland surface water bodies
		Y	Undefined
Water	Water	C	Inland surface water habitats
		C1	Surface standing waters
		C2	Surface running waters

Table 2-3 lists the areas (in km^2) and the number of submitted ecosystems, indicating the resolution each country uses for its calculations.

Figure 2-1 shows the percentage of the total country area for which critical loads have been submitted, separately for acidification, eutrophication, and ecosystems for which dynamic modelling has been performed. Most countries that submitted dynamic modelling results were able to do so for a part of the total data set. Norway and the United Kingdom submitted target loads for aquatic ecosystems.

Forest is the dominant ecosystem considered in most of Europe, but also waters (mainly in the Northern part of Europe), grassland, shrubs and wetlands are considered. The United Kingdom, Norway and Sweden have a separate dataset for aquatic ecosystems for which DM results have been submitted. (Swedish DM data are not shown in Figure 2-1). The forested area of Norway can be part of the catchment area of the submitted rivers and lakes, counting areas twice (resulting in a coverage of 119% of the total country area).

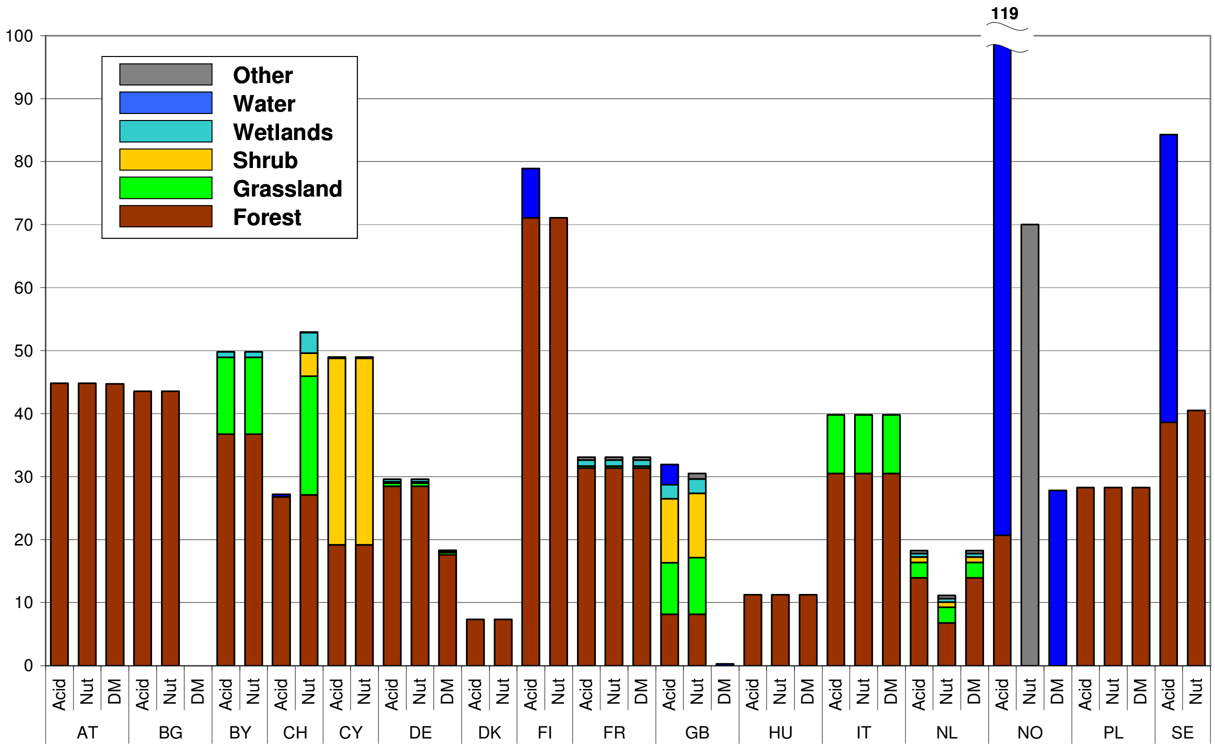

Figure 2-1. National distribution of ecosystem types (% of total country area) for critical loads for acidification (Acid) eutriphication (Nut) and results of dynamic modelling (DM).

Table 2-3. Number of ecosystems and areas per national contribution.

Country	Total Country Area	EUNIS lev.1	Acid CLs		Nutrient CLs		Dyn.mod. results	
			# ecosyst	Area (km^2)	# ecosyst	Area (km^2)	# ecosyst	Area (km^2)
Austria	83858	Forest	489	37,572	489	37,572	487	37,521
Belarus	207595	Forest	6,917	76,316	6,917	76,316		
		Grassland	1,542	25,302	1,542	25,302		
		Wetlands	145	1,746	145	1,746		
		total	8,604	103,364	8,604	103,364		
Bulgaria	110994	Forest	88	48,345	88	48,345	4	0
Cyprus	9251	Forest	7,099	1,775	7,099	1,775		
		Shrub	10,951	2,738	10,951	2,738		
		Other	87	22	87	22		
		total	18,137	4,535	18,137	4,535		
Denmark	43094	Forest	9,758	3,149	9,758	3,149		
Finland	338144	Forest	3,079	240,379	3,083	240,403		
		Water	1,450	26,426				
		total	4,529	266,805	3,083	240,403		
France	543965	Forest	3,840	170,657	3,840	170,657	3,840	170,657
		Grassland	81	1,580	81	1,580	81	1,580
		Wetlands	67	5,123	67	5,123	67	5,123
		Other	156	2,741	156	2,741	156	2,741
		total	4,144	180,101	4,144	180,101	4,144	180,101

Germany	357022	Forest	406,750	101,688	406,750	101,688	251,163	62,791
		Grassland	7,170	1,793	7,170	1,793	5,532	1,383
		Shrub	2,703	676	2,703	676	382	96
		Wetlands	5,579	1,395	5,579	1,395	4,046	1,012
		Other	779	195	779	195	200	50
		total	422,981	105,747	422,981	105,747	261,323	65,332
Hungary	93030	Forest	6,615	10,460	6,615	10,460	6,615	10,460
Italy	301336	Forest	338	91,910	338	91,910	338	91,910
		Grassland	164	27,943	164	27,943	164	27,943
		total	502	119,853	502	119,853	502	119,853
Netherlands	41526	Forest	35,375	5,786	17,060	2,827	35,375	5,786
		Grassland	8,055	1,027	8,055	1,027	8,055	1,027
		Shrub	1,717	343	1,717	343	1,717	343
		Wetlands	1,540	230	1,540	230	1,539	230
		Other	649	197	649	197	649	197
		total	47,336	7,583	29,021	4,624	47,335	7,583
Norway	323759	Forest	662	67,011				
		Water	2,435	386,077			121	90,115
		Other			1,610	226,631		
		total	3,097	453,088	1,610	226,631	121	90,115
Poland	312685	Forest	88,382	88,382	88,382	88,382	88,382	88,382
		Water	1	1	1	1		
		total	88,383	88,383	88,383	88,383	88,382	88,382
United Kingdom	243307	Forest	150,208	19,748	151,815	19,896		
		Grassland	99,451	20,010	119,062	21,897		
		Shrub	78,550	24,669	78,985	24,785		
		Wetlands	18,682	5,455	19,079	5,506		
		Water	1,717	7,790			109	599
		Other			10,299	2,119		
		total	348,608	77,672	379,240	74,203	109	599
Switzerland	41285	Forest	691	11,056	1,456	11,191		
		Grassland			7,777	7,777		
		Shrub			1,512	1,512		
		Wetlands			1,348	1,348		
		Water	101	182	38	38		
		total	792	11,238	12,131	21,866		
Sweden	449964	Forest	1,764	173,759	1,863	182,223		
		Water	2,887	205,502				
		total	4,651	379,261	1,863	182,223		

2.5 National critical loads and input variables

This section shows the critical loads and most important related variables of the national contributions. The characteristics can often be explained by studying the national reports, in Part II of this report.

Figure 2-5 show the 5th percentile and median values for the critical loads for sulphur and nutrient nitrogen on EMEP50 grid for the countries that submitted data this year. Compared to last years results the updates in critical loads show only minor changes for $CL_{max}(S)$ (see Posch et al., 2003.) Belarus has extended the area for which they made their calculations to the whole of the country. Germany and Poland appear a little less sensitive.

In comparison with 2003 the updated $CL_{nut}(N)$ for the Netherlands is more in line with its neighbouring countries. Germany is more sensitive than earlier. (See Posch et al., 2003).

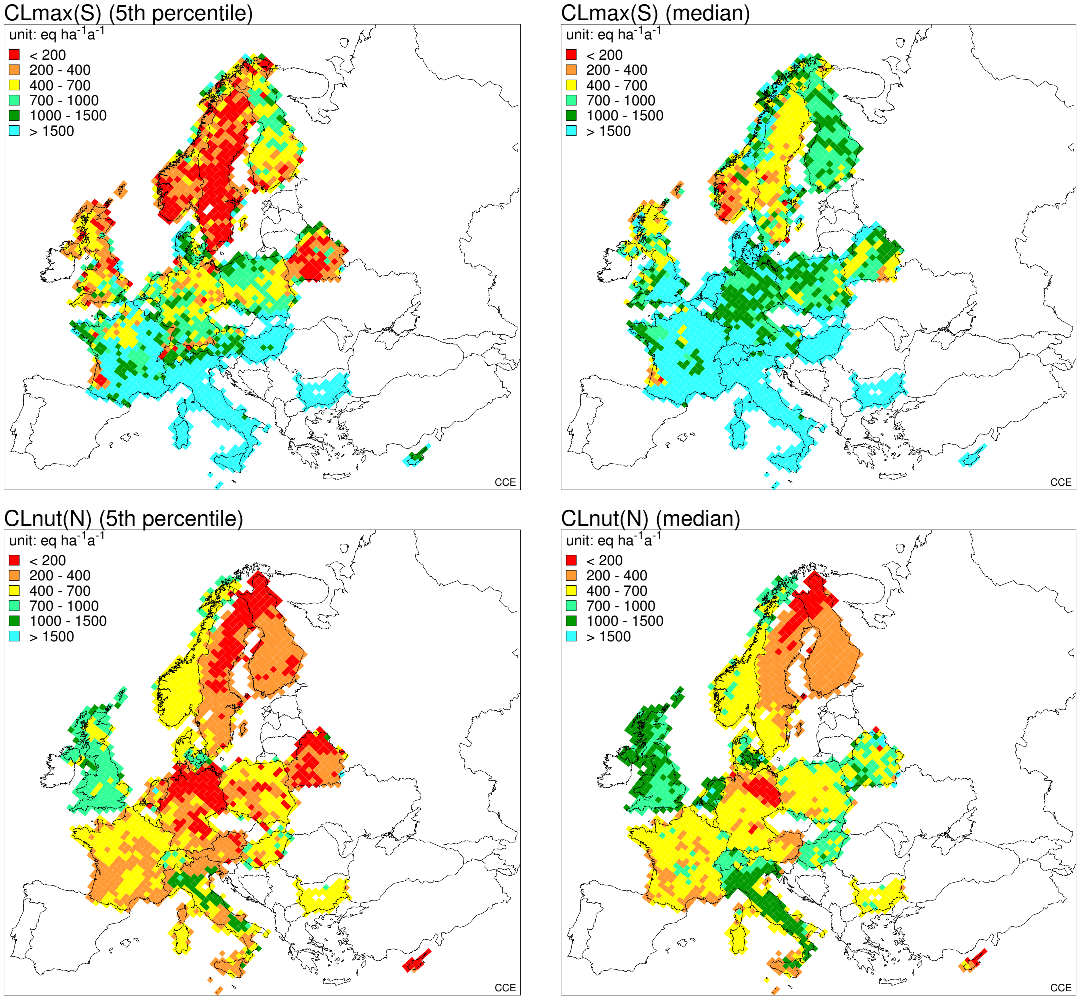

Figure 2-2. The 5th percentile (left) and median (right) EMEP50 grid values of the maximum critical loads of sulphur (top) and the critical loads of nutrient nitrogen (bottom).

The complete distributions of the national critical loads, $CL_{max}(S)$, $CL_{min}(N)$, $CL_{max}(N)$ and $CL_{nut}(N)$ are plotted in Figure 2-3 and Figure 2-4 in a cumulative distribution function (cdf) for all countries that submitted data for this or previous calls. The cdfs show the cumulated area of ecosystems as a function of the variable, normalised to 100% (no vertical scale is plotted in the cdf-graphs). The thin black dotted line ('EU-DB') represents the cdf of the respective variable from the European background database, which contains data for forest soils only (see Chapter 3). The ecosystem types are the aggregated classes from the first column of Table 2-2. The number of ecosystems is also given for every cdf, except for the cdfs of background database.

For the majority of the countries the median $CL_{nut}(N)$ is lower than the median for $CL_{max}(S)$.

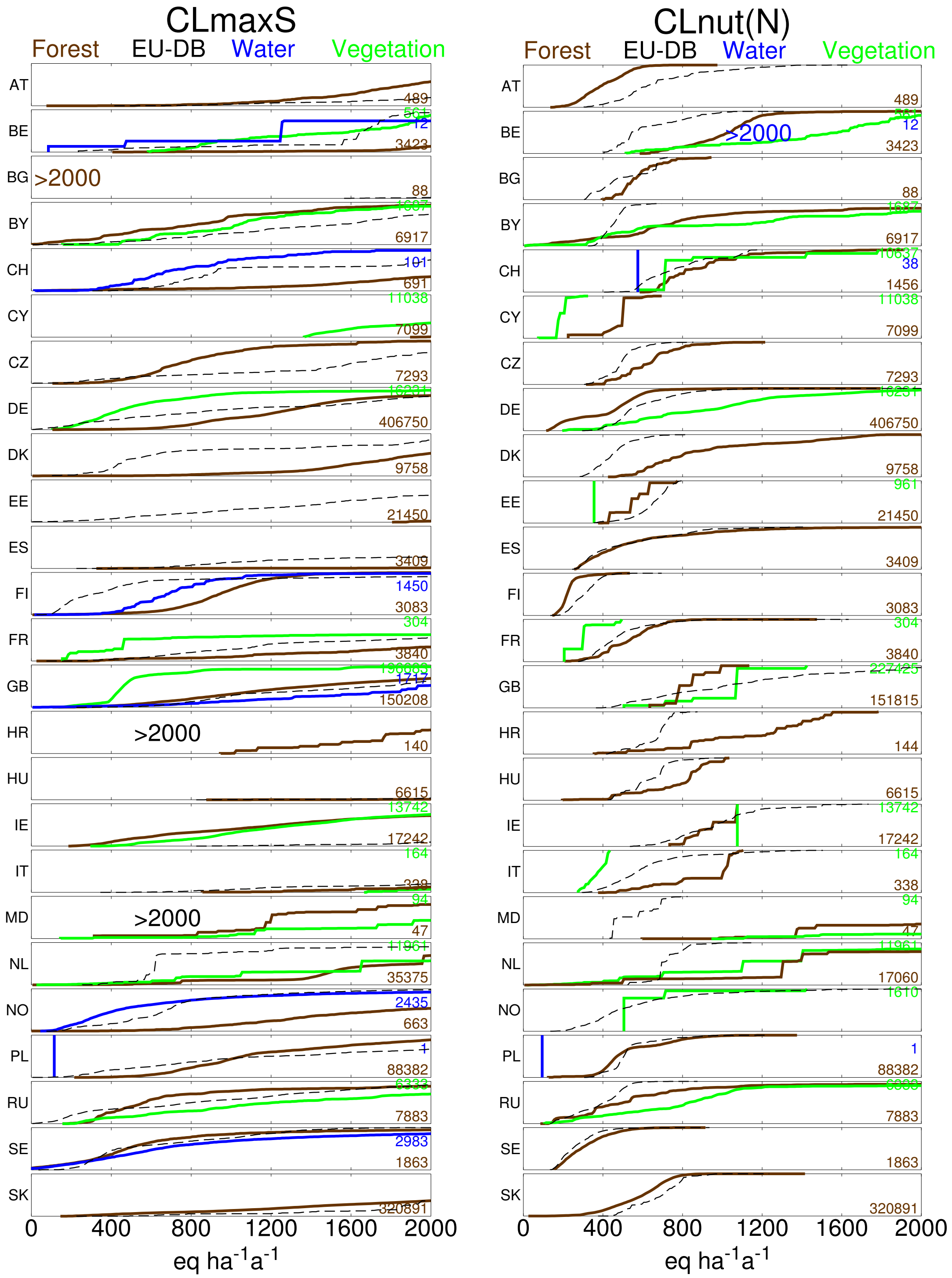

Figure 2-3. The cumulative distribution functions (cdfs) of maximum critical load of sulphur (left) and the critical load of nutrient nitrogen (right) for forest water and vegetation, and for the European background database ('EU-DB')

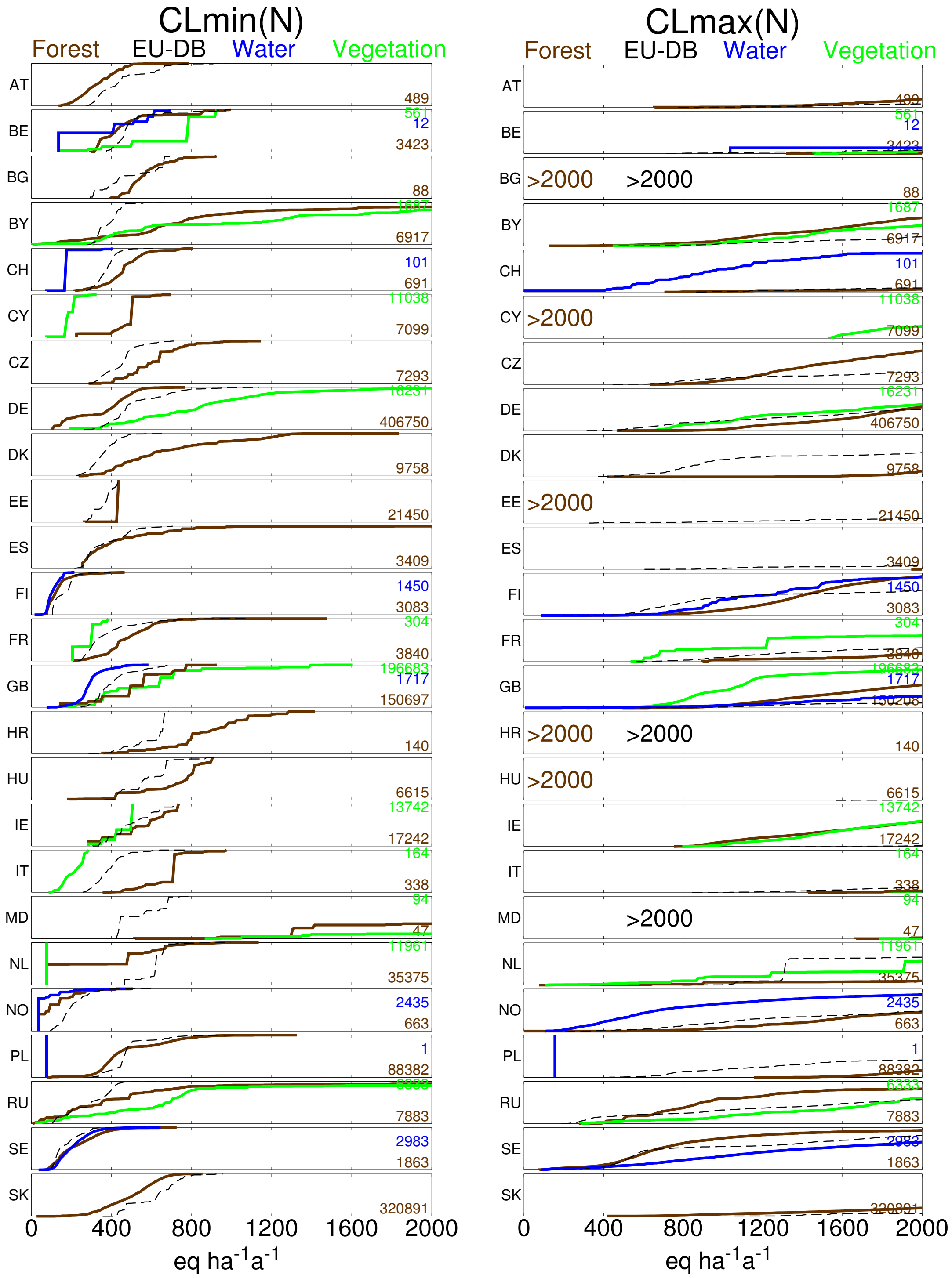

Figure 2-4. The cdfs of minimum (left) and maximum (right) critical load of nitrogen forest, water and vegetation, and for the European background database.

For most of Europe $CL_{max}(N)$ is much larger then $CL_{nut}(N)$. This means that with relatively low depositions of sulphur eutrophication will occur more likely than acidification.

The CCE requested most of the variables that are needed to compute the critical loads. A selection (combination) of the distributions of these variables is plotted in the next graphs, to demonstrate characteristics of the national submissions. The graphs will only show the 16 countries that submitted data for this call.

Figure 2-5 shows the amount of water percolating through the root zone (Q_{le}) and the denitrification fraction (f_{de}). Countries can either assume a fraction to be denitrified (f_{de}) or a fixed amount (N_{de}). The choice they made can be derived from the presence of the relevant cdf in the graph for f_{de}. N_{de} is not shown in this report, but values are below 250 eq ha^{-1} a^{-1} for most ecosystems. Well-aerated soils will have lower denitrification. Ecosystems with a high flow of water are not necessarily wet, and therefore can have low denitrification, as indicated by the differences in distributions of Q_{le} and f_{de} for several countries.

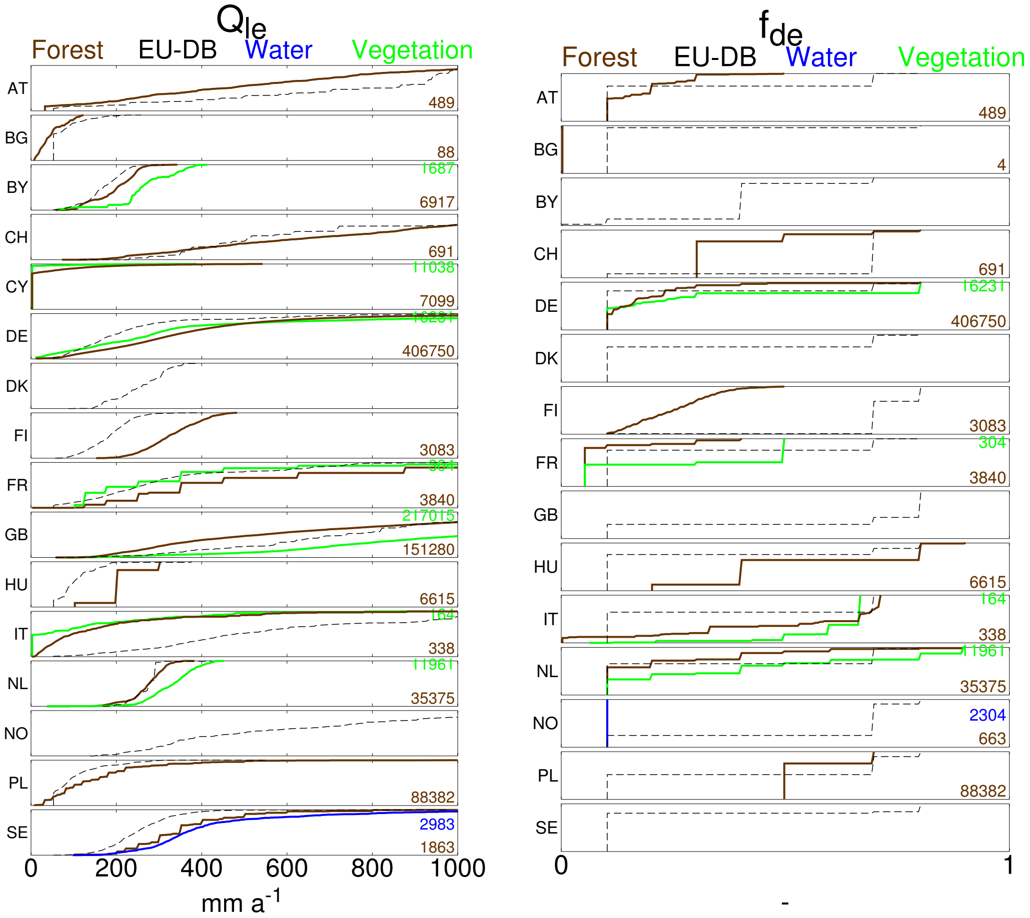

Figure 2-5. The cdfs of the amount of water percolating through the root zone (Q_{le}, left) and the fraction of nitrogen denitrified in the soil (f_{de}, right)

In the Simple Mass Balance (SMB) model nitrogen leaves the system by denitrification, immobilisation in the soil, net uptake by harvesting and leaching. The long-term acceptable immobilisation and the acceptable leaching of nitrogen are shown in Figure 2-6. The background database uses the constant value of 1 kgN ha^{-1} a^{-1} for immobilisation, as recommended in the Mapping Manual (UBA, 2004).

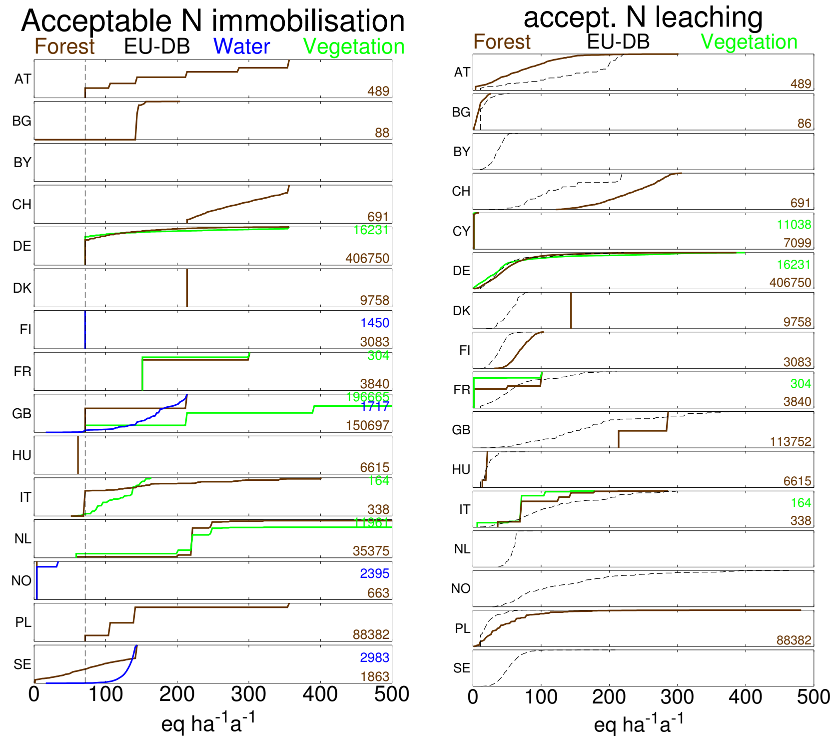

Figure 2-6. The cdfs of the acceptable amount of nitrogen immobilised in the soil (left) and the acceptable amount of leaching nitrogen.

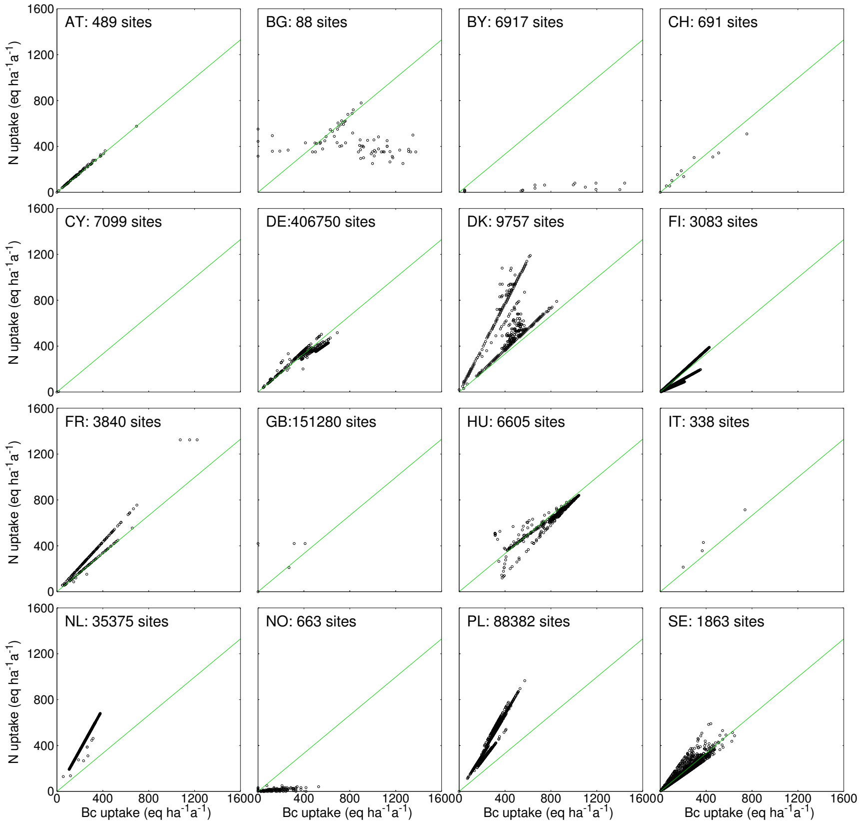

Figure 2-7. Net base cation uptake versus nitrogen uptake for forest ecosystems.

Figure 2-7 shows the correlation between nitrogen and base cation uptake for forests. The green line gives the ratio for spruce when only stems are harvested. The calculation of this ratio is based on the mean values of element content in stems according to Jacobsen et al. (2002) also listed in Table 5.8 of the Mapping Manual (UBA, 2004).

In previous calls for data the CCE requested base cation weathering and sea salt corrected base cation deposition, but this call asked for the individual ions. The reason is to improve the understanding of the manner in which countries compile the base cation deposition. Figure 2-8 show total base cation weathering and the sea salt corrected base cation deposition. For countries with missing values for the individual ions, it was assumed calcium was used for the total base cation amount, and sea salt correction already applied for the deposition.

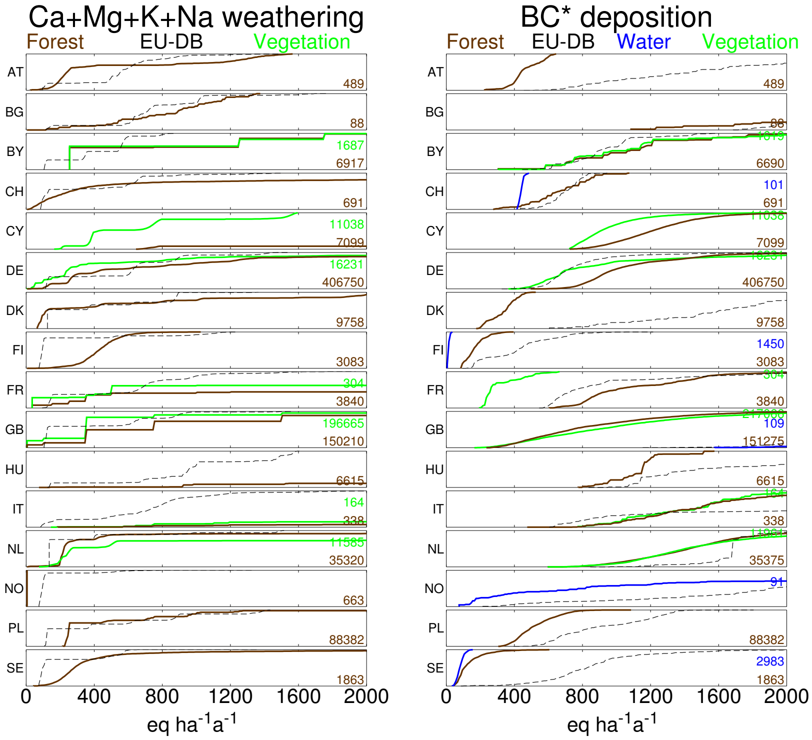

Figure 2-8. The cdfs of base cation weathering (left) and sea salt corrected base cation deposition(right).

In the simplest case, the equilibrium between Al and H in the soil solution can be described by the gibbsite equilibrium. However, in the latest version of the Mapping Manual a more general (empirical) relationship has been proposed, i.e. $[Al] = K_{Alox} \cdot [H]^{expAl}$, which for $expAl$=3, includes the gibbsite equilibrium. In Figure 2-9 the relationship between the logarithm of K_{Alox} and the exponent $expAl$ is depicted for the NFC data as black dots; and the crosses are from measurements at about 120 European Forest Intensive Monitoring sites (De Vries et al., 2003). Figure 2-9 shows that there is a strong correlation between $\log_{10}K_{Alox}$ and $expAl$, and that the data used by the NFCs are fairly much in line with the European observational data. Actually, the majority of the countries (AT, DE, FR, GB, IT) use the gibbsite equilibrium ($expAl$=3) with $\log_{10}K_{Alox}$=8, here highlighted as the intersection point of the axes.

The latest additions to the Simple Mass Balance (SMB) method, as described in the Mapping Manual, are bicarbonate leaching and the inclusion of the dissociation of organic acids. The partial CO_2 pressure in the soil (pCO_2) is in equilibrium with the concentration of bicarbonate in the soil solution according to Henry's law. The unit used for pCO_2 is multiples of the partial pressure in air, which is about $3.7 \cdot 10^{-4}$ atm.

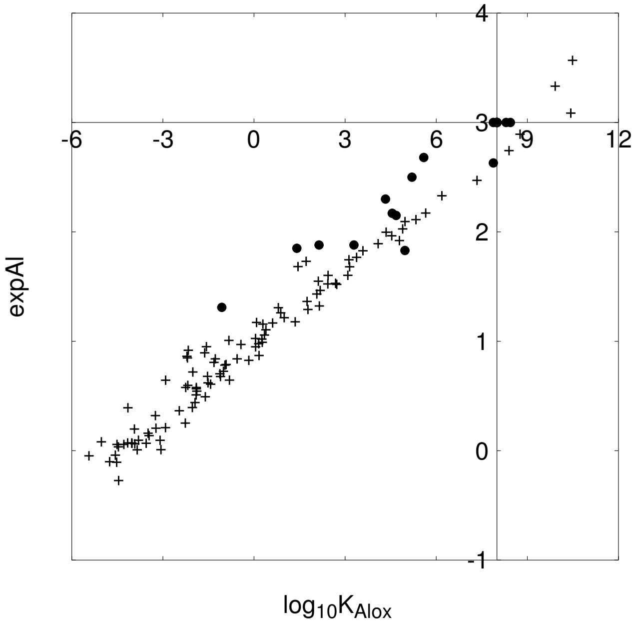

Figure 2-9. The logarithm of K_{Alox} versus the exponent expAl describing the Al-H equilibrium. The black dots are the data from the NFCs, whereas the crosses are derived from measurements at about 120 Forest Intensive Monitoring sites (De Vries et al., 2003). Data lying on the horizontal axis indicate the use of a gibbsite equilibrium (expAl=3).

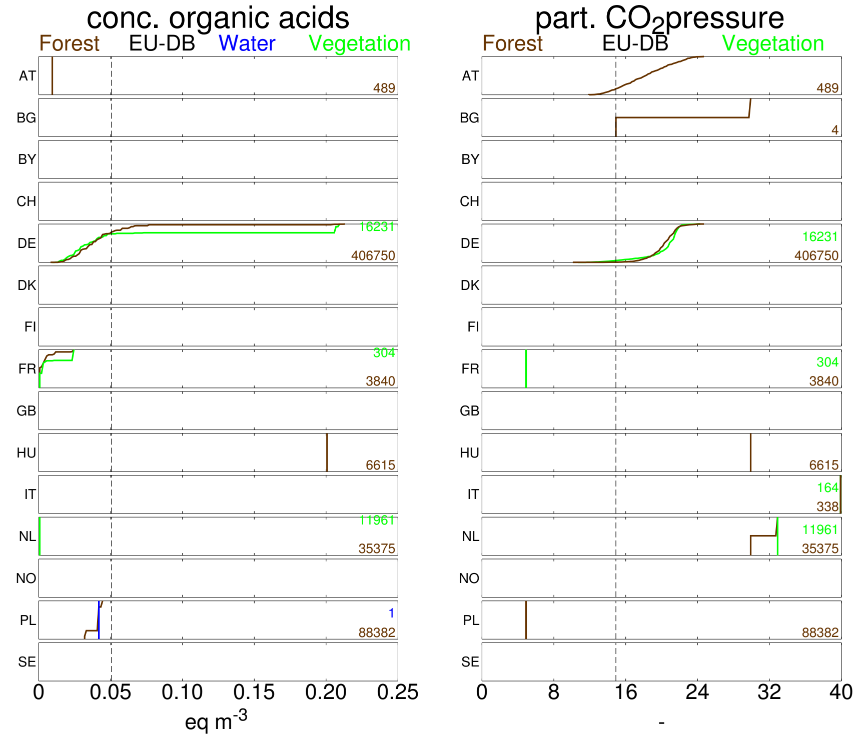

Figure 2-10. The cdfs of the concentration of the organic acids (left) and the multiples of partial CO_2 pressure expressed as multiples of the partial pressure of CO_2 in the air (right).

Organic acids, if present, could be considered part of the charge balance of the ions in the soil leaching flux. The dissociated anion $HCOO^-$ relates to the concentration of the organic acids

(*cOrgacids*). More details on these extensions of the SMB-method can be found in the Mapping Manual. A few countries adapted to these enhancements, as can be seen in Fig. 2-10.
The background database uses fixed values (*cOrgacids* = 0.05 eq m^{-3}, factor pCO_2 = 15).

Different chemical criteria are used as limits to protect ecosystems, and for some different critical values apply. Several countries use for certain types of ecosystems combination of criteria, e.g. Bulgaria uses pH and Bc:Al, Germany uses pH and base saturation and the Netherlands use combinations of Bc:Al, nitrogen availability, base saturation and pH, because it includes biodiversity as endpoint. The criterion used by the countries is listed in Table 2-4 together with ranges for their critical values used.

Table 2-4. Criteria used by the NFCs for ecosystem types as percentages of the total ecosystem numbers.

		Al:Bc*)	[Al]	bsat	pH	Bc:H	ANC	other	unknown
(range of critical value)		0.5 – 1.7	0.2 eq/m^3	56-83%	3.8 – 6.2	0.2 – 1.2	0 – 18 eq/m^3		
Country code	Ecosystem type								
AT	Forest	100							
BG	Forest							100	
BY	Forest								100
	Vegetation								100
CH	Forest								100
	Vegetation								100
	Water						83		17
CY	Forest	26		74					
	Vegetation	6		94					
DE	Forest	18			44	2		37	
	Vegetation	8			39	23		30	
DK	Forest								100
FI	Forest	100							
	Water						100		
FR	Forest	83			17				
	Vegetation	43			57				
GB	Forest				6			76	18
	Vegetation						92		8
	Water						100		
HU	Forest	100							
IT	Forest	100							
	Vegetation	100							
NL	Forest							49	51
	Vegetation							100	
NO	Forest								100
	Vegetation								100
	Water						25		75
PL	Forest		100						
	Water								100
SE	Forest								100
	Water								100

*The criterion Bc:Al has been converted to Al:Bc.

It is important that conclusions of integrated assessment based on dynamic modelling are in line with the conclusions based the mapping of critical loads, i.e. that steady state mass balance results are consistent with result of dynamic modelling. The overall distribution of critical loads (by conventional methods and data sets) should therefore be similar to the distribution of critical loads that can be achieved by the methods and data set used in dynamic modelling. In Figure 2-11 the distributions of the maximum critical loads for sulphur and the critical load for nutrient nitrogen are plotted for the whole of the national data sets and the subsets used for dynamic modelling for both terrestrial and aquatic ecosystems. Most deviations are in countries which did dynamic modelling for a specific subset (mostly aquatic ecosystems) of which sufficient data were available.

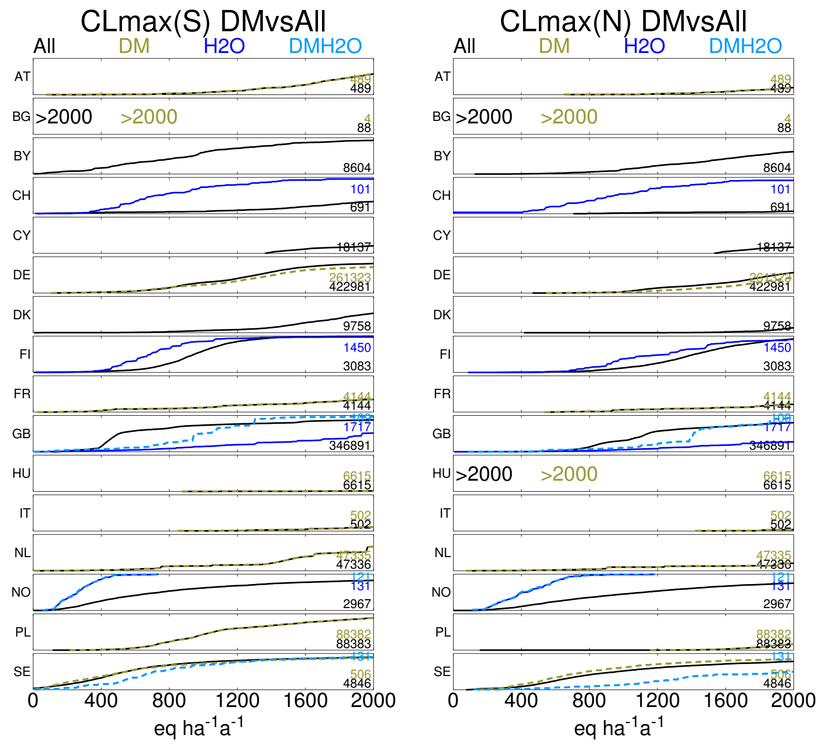

Figure 2-11. The maximum critical loads of sulphur (right) and nitrogen (left) for all terrestrial ecosystems (black line), all aquatic ecosystems (dark blue line), and for ecosystems for which dynamic modelling was applied, also split into terrestrial (brownish dashed line) and aquatic (light blue dashed line).

2.6 Conclusions and recommendations

Of the now 25 National Focal Centres, 16 submitted updated critical loads. Critical loads have been updated slightly, the main updates related to the critical load for nutrient nitrogen. Although in many cases the critical loads for forest are higher then for other ecosystem types, especially for low critical loads, forest is still the dominant ecosystem type considered. Regarding aquatic ecosystems an increasing number of ecosystems is considered for dynamic modelling.

With relatively low depositions of sulphur, damage due to eutrophication will be more likely than by acidification. Considering the current trends in sulphur and nitrogen emissions, increasing attention is needed for dynamic modelling of (nutrient) nitrogen.

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3 Summary and Analysis of Target Load Data

Maximilian Posch, Jaap Slootweg and Jean-Paul Hettelingh

3.1 Introduction

The purpose of this Chapter is: (a) to summarise the definition of a target load and related technical terms; (b) to analyse the target load information provided by National Focal Centres (NFCs), and (c) to give a short overview of the target load calculations carried out with the European background data base. According to a decision at the 2004 Task Force meeting of the ICP on Modelling and Mapping, the target load information received in response to the call for data issued in November 2003 will not be used in integrated assessment modelling. Thus the main purpose of the analysis presented here is to compare results from different countries and thereby to encourage NFCs to re-visit their input data sets and calculation methods.

3.2 Definitions

The most straightforward use of a dynamic model is so-called scenario analysis. Scenario analysis (in the context of dynamic modelling) is the computation of a future value of a chemical parameter for a chosen/given deposition trend as driving force, i.e., the future deposition is determined first, and then the (chemical) consequences for the soil or surface water are evaluated. These steps can be repeated until an acceptable deposition reduction is achieved, which can be a lengthy trial and error process. To speed up the process, another approach is to back-calculate the required deposition path from a *prescribed* future value of a chemical variable. Such a deposition, called a ***target load***, is the deposition (path) which ensures that the prescribed chemical criterion (e.g., Al/Bc=1) is met in a given year. If it exists at all, there exists an infinite variety of deposition paths, i.e. target loads. To bring order into this multitude and to make results comparable, a target load is a deposition path characterised by three values (years): (i) the protocol year, (ii) the implementation year, and (iii) the target year, which are connected by straight lines (see also Figure 1-1 in Chapter 1):

(i) The ***protocol year*** is the year up to which the deposition path is assumed to be known and cannot be changed any more. This can be the present year or a year in the (near) future, for which emission reductions are already agreed upon. An example is the year 2010, for which the Gothenburg Protocol, the EU NEC Directive and other (national) legislation is (soon expected to be) in force.

(ii) The ***implementation year*** for dynamic modelling is the year in which all reduction measures to reach the final deposition (the target load) are assumed to be implemented. Between the protocol year and the implementation year the deposition is assumed to change linearly. To avoid confusion with the term ‘implementation year’ as used by integrated assessment modellers, we (occasionally) prefix it with ‘DM’ for ‘dynamic modelling’.

(iii) Finally, the ***target year*** for dynamic modelling is the year in which the chemical criterion (e.g., the Al:Bc ratio) is met (for the first time). Again, ‘DM’ is prefixed to emphasise the use of the term in dynamic modelling.

To avoid cases where a target load is (formally) calculated which leads to a violation of the criterion *after* the target year (see examples in Posch et al., 2003a), we define that ***a target load is the deposition for which a pre-defined chemical or biological status is reached in the target year and maintained (or improved) thereafter.***

So far, only a single pollutant has been considered. In the case of acidification, however, the deposition of both N and S contribute to the problem. Thus, pairs of N and S deposition have to be determined which result in the desired chemical status in the target year. And all pairs define the so-called *target load function* (TLF) in the (N_{dep},S_{dep}) plane, in the same way as critical loads define the critical load function (CLF). Of course, different TLFs are obtained for different target years, approaching the critical load function when the target year approaches infinity. Examples of TLFs are shown in Figure 3-1.

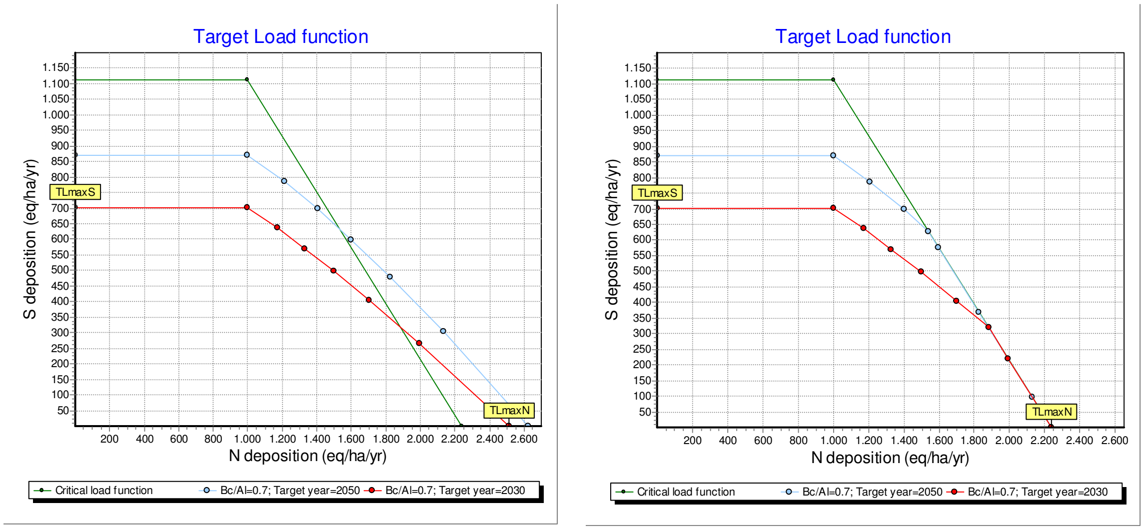

Figure 3-1. Examples of target load functions for different target years (left). Also shown is the corresponding critical load function (green line). On the right the minimum with this CLF is displayed.

Due to the finite buffers in the soil, such as time-dependent N immobilisation, a TLF can intersect with the CLF for certain values of the depositions (see Figure 3-1). To ensure that the chemical criterion is also met *after* the target year, the minimum of the TLF and the CLF has to be determined; and this is also illustrated in Figure 3-1.

For more information on target loads and related topics see the Dynamic Modelling Manual (Posch et al., 2003a) and its update as Chapter 6 of the Mapping Manual (www.icpmapping.org).

3.3 Analysis of national dynamic modelling and target load data

In addition to data on critical loads and input data needed to compute them, the call for data issued in November 2003 also requested data which are only needed for carrying out dynamic modelling. The most important are data characterising the finite pools, such as base saturation and CEC, which are irrelevant for critical loads, but determine the temporal behaviour (damage delay and recovery) of an ecosystem.

In Figure 3-2 the cumulative distribution functions (cdfs) of the base saturation and the cation exchange capacity (CEC) of soils in forests (brown), semi-natural vegetation (green) and catchments (blue) for the 11 countries which submitted dynamic modelling data are displayed.
For comparison, the respective cdfs from the European background database maintained at the CCE are shown as thin black dashed lines. While in most countries base saturation covers a wide range, they are rather small in the Netherlands. The CEC has fairly small values in Italy, Poland and for forests in the Netherlands, where more than 90% of the forest area has a CEC smaller than 70 meq kg^{-1}.

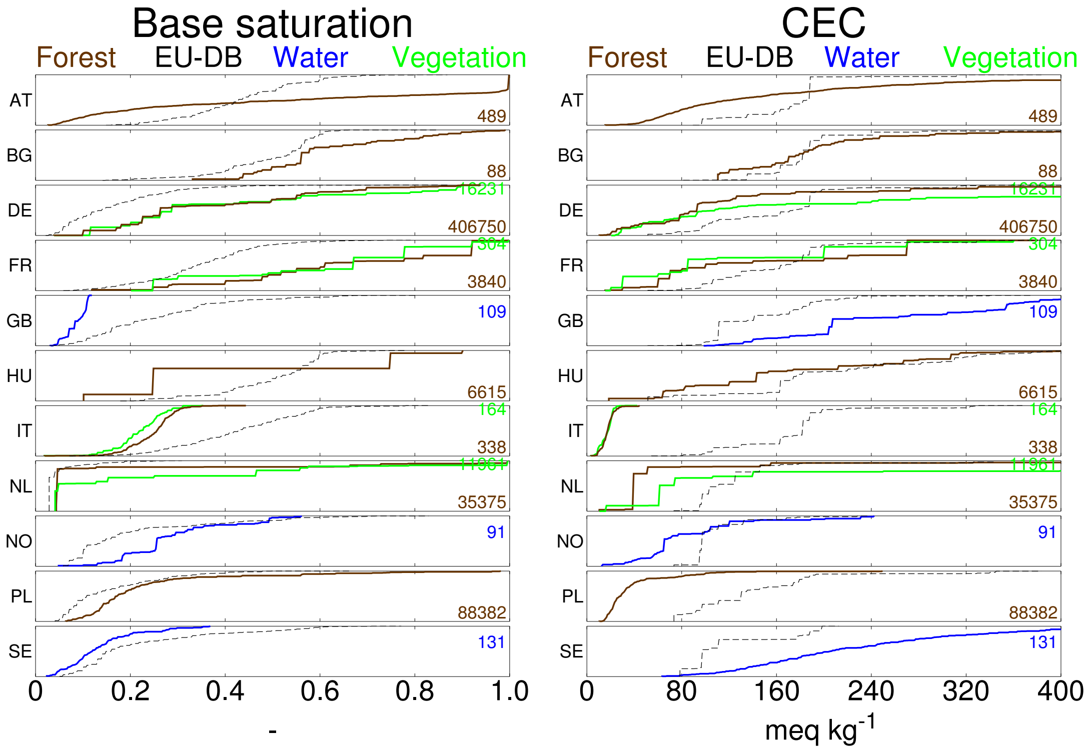

Figure 3-2. Cumulative distribution functions of the base saturation (right) and the cation exchange capacity (left) of soils in forests (brown), semi-natural vegetation (green) and catchments (blue) for the 11 countries which submitted dynamic modelling data. The number of ecosystems in the respective category is given on the right-hand side. The thin black dashed line shows the data from the European background database for the respective country.

In Figure 3-3 the cumulative distribution functions of the carbon-to-nitrogen ratio and the carbon pool of (top) soils in forests (brown), semi-natural vegetation (green) and catchments (blue) are shown for the 11 countries, with the respective cdfs from the European background database shown as thin black dashed lines. With few exceptions, for almost all countries these variables lie in the same reasonable range. This range not only indicates the variation between countries, but probably also the different choices of the depth for which those quantities have been determined.

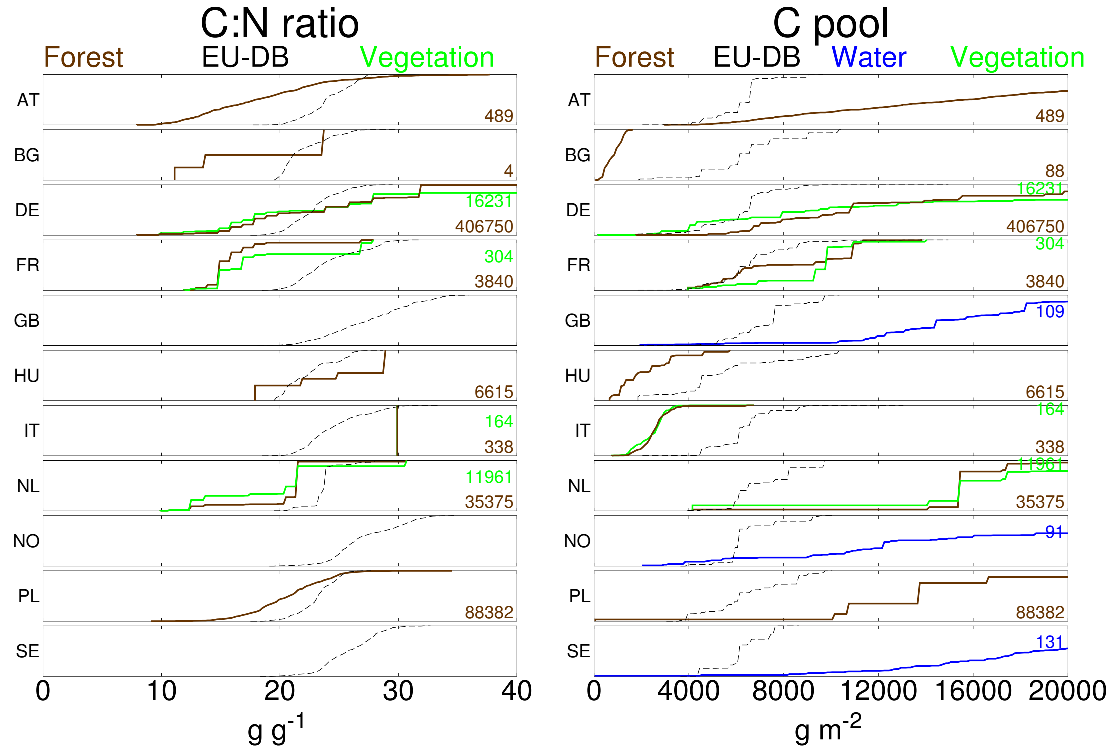

Figure 3-3. Cumulative distribution functions of the C:N ratio (right) and the C pool (left) of soils in forests (brown), semi-natural vegetation (green) and catchments (blue) for the 11 countries which submitted dynamic modelling data. The number of ecosystems in the respective category is given on the right-hand side. The thin black dashed line shows the data from the European background database for the respective country.

The equilibrium between the soil solution and the exchange complex is described in all dynamic models by so-called exchange constants or selectivity coefficients, here K_{AlBc} and K_{HBc}. The logarithms of the pairs of exchange constants used by the countries are shown in Figure 3-4. As can be seen, most of the values lie in the range 0–2 for $\log_{10}K_{AlBc}$ and 2.5–4.5 for $\log_{10}K_{HBc}$, and they do not show any significant correlation. Exchange constants are hardly ever measured (determined) at sites, but they are used as calibration parameters to fit model performance to observations (e.g., measured base saturation). Such calibrations can be inferred from the Austrian data (shown as crosses in Figure 3-4), which lie on a straight line; the reason being that when using Gapon exchange and gibbsite equilibrium, it is only the *ratio* of the exchange constants that counts. From the data of the other countries it is not possible to infer any calibration. Since exchange constants are in general poorly known, it is recommended that they are calibrated to observed parameters, such as base saturation.

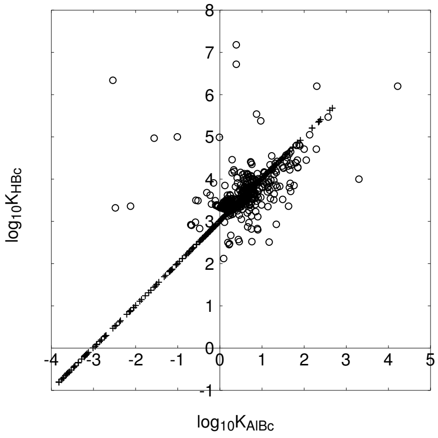

Figure 3-4. Logarithms of the pairs of exchange constants (K_{AlBc}, K_{HBc}) used in the calculation of target loads. The crosses show the data from Austria, the circles those from the other countries (see text for explanations).

The latest call for data was the first call in which, in addition to *input* data for dynamic modelling, also *results* of dynamic modelling, in particular the computation of target load functions for acidity, were requested. The year 2010 was prescribed as the obvious 'protocol year' (referring to the Gothenburg Protocol), the year 2015 was chosen as 'implementation year', and 'target years' were 2030, 2050 and 2100.

Target load information has been provided by 11 NFCs, which are listed in Table 3-1. The Table also gives the percentage of the ecosystem area, for which target loads have been calculated (i.e. for which the variable 'TLstatus' was ≥ 0; see Annex I). This ranges from a (very) small fraction in Bulgaria and the United Kingdom to (almost) all ecosystems in six countries.

Table 3-1. Percentage of ecosystem area in the 11 countries for which target load information has been provided (see Table 3-2 for country codes and Chapter 2 for total ecosystem areas).

AT	BG	DE	FR	GB	HU	IT	NL	NO	PL	SE
99.9	0.0	61.8	100	0.8	100	100	100	19.9	100	63.8

When calculating a target load (function), four cases are distinguished according to the instructions given with the call for data (see Annex I):

- There is non-exceedance in 2010 and the chosen chemical criterion, e.g. Al/Bc is not violated (the ecosystem is 'safe'); TLstatus=0 in Table 1 in Annex I. No further target load (TL) calculations have to be carried out, and there is no entry in Table 2 of Annex I.
- The ecosystem is 'safe' in the respective target year (Tyr), i.e. the chemical criterion is not (or no longer) violated when the deposition is not changed after 2010; Status4Year=3 in Table 2 of Annex I.
- There exists a genuine target load function (TLF), which has to be smaller (or equal) to the corresponding critical load function (see section 3.2); Status4Year=1 in Table 2 of Annex I.
- A TLF is not feasible, i.e. the chemical criterion cannot be met, even when the deposition is reduced to zero in the implementation year; Status4Year=2 in Table 2 of Annex I.

Table 3-2 gives the percentages for each of those four cases for the 11 countries which carried out target load calculations. The numbers in column 3-6 are percentages, and the add up to 100% (except for rounding errors).

Table 3-2. Characterisation of target load calculations in the 11 countries (in percent): (a) safe in 2010 (column 3); (b) safe in the respective target year (col.4); (c) a target load function has been calculated (col.5); and (d) a target load function does not exist (col.6).

Country	*target year*	**safe in 2010**	**safe in Tyr**	***TLF exists***	**not feasible**
Austria	2030:	96.6	0.0	3.4	0.0
(AT)	2050:	96.6	0.2	3.3	0.0
	2100:	96.6	0.2	3.3	0.0
Bulgaria	2030:	100	0	0	0
(BG)	2050:	100	0	0	0
	2100:	100	0	0	0
Germany	2030:	0.0	77.9	19.7	2.5
(DE)	2050:	0.0	78.2	19.9	2.0
	2100:	0.0	78.2	20.3	1.5
France	2030:	28.3	69.1	2.6	0.0
(FR)	2050:	28.3	69.2	2.5	0.0
	2100:	28.3	69.8	2.0	0.0
United Kingdom	2030:	0.0	89.4	10.5	0.1
(GB)	2050:	0.0	71.2	28.6	0.3
	2100:	0.0	64.0	32.2	3.8
Hungary	2030:	100	0	0	0
(HU)	2050:	100	0	0	0
	2100:	100	0	0	0
Italy	2030:	100	0	0	0
(IT)	2050:	100	0	0	0
	2100:	100	0	0	0
Netherlands	2030:	31.2	33.3	13.5	22.0
(NL)	2050:	31.2	33.3	13.6	21.9
	2100:	31.2	33.3	14.3	21.2
Norway	2030:	56.3	0.0	42.0	1.7
(NO)	2050:	56.3	0.0	42.0	1.7
	2100:	56.3	0.0	42.8	0.9
Poland	2030:	77.3	10.9	11.9	0.0
(PL)	2050:	77.3	10.9	11.8	0.0
	2100:	77.3	11.0	11.7	0.0
Sweden	2030:	61.3	21.3	13.6	3.8
(SE)	2050:	61.3	21.9	13.8	3.0
	2100:	61.3	21.9	15.2	1.6

As can be seen from Table 3-2, in three countries (Bulgaria, Hungary and Italy) all sites (for which TL calculations have been done) are ‘safe’ in 2010, i.e. no deposition reductions beyond the Gothenburg Protocol are necessary. Thus these countries are not further considered in the following. The percentages in column 3 (‘safe in 2010’), which are obviously independent of the target year, vary between zero and 100 percent. Common sense would suggest that the percentages in column 6 decrease (or stay the same) with increasing target year, since the longer a system experiences zero deposition of S and N, the more likely it is to recover, i.e. to find a (non-zero) target load.

The percentage of sites, which are not yet safe in 2010, but do become so in the target year (column 4), varies between zero (BG, HU, IT) and almost 90 percent (United Kingdom). The cases for which no TLF could be found varies between zero and less than 4% in all countries, except for the Netherlands, where no TLFs could be found for about 22% of the cases, where recovery computations included indicators for biodiversity (see Chapter 1).

From the definition of a target load (see above) it follows that for a target year closer to the present the target load is smaller than (or at most equal to) that for a target year further in the future, i.e.

shorter recovery times require lower target loads. Whether this is the case for the data delivered by the 8 countries which have calculated TLFs, can be seen in Figure 3-5.

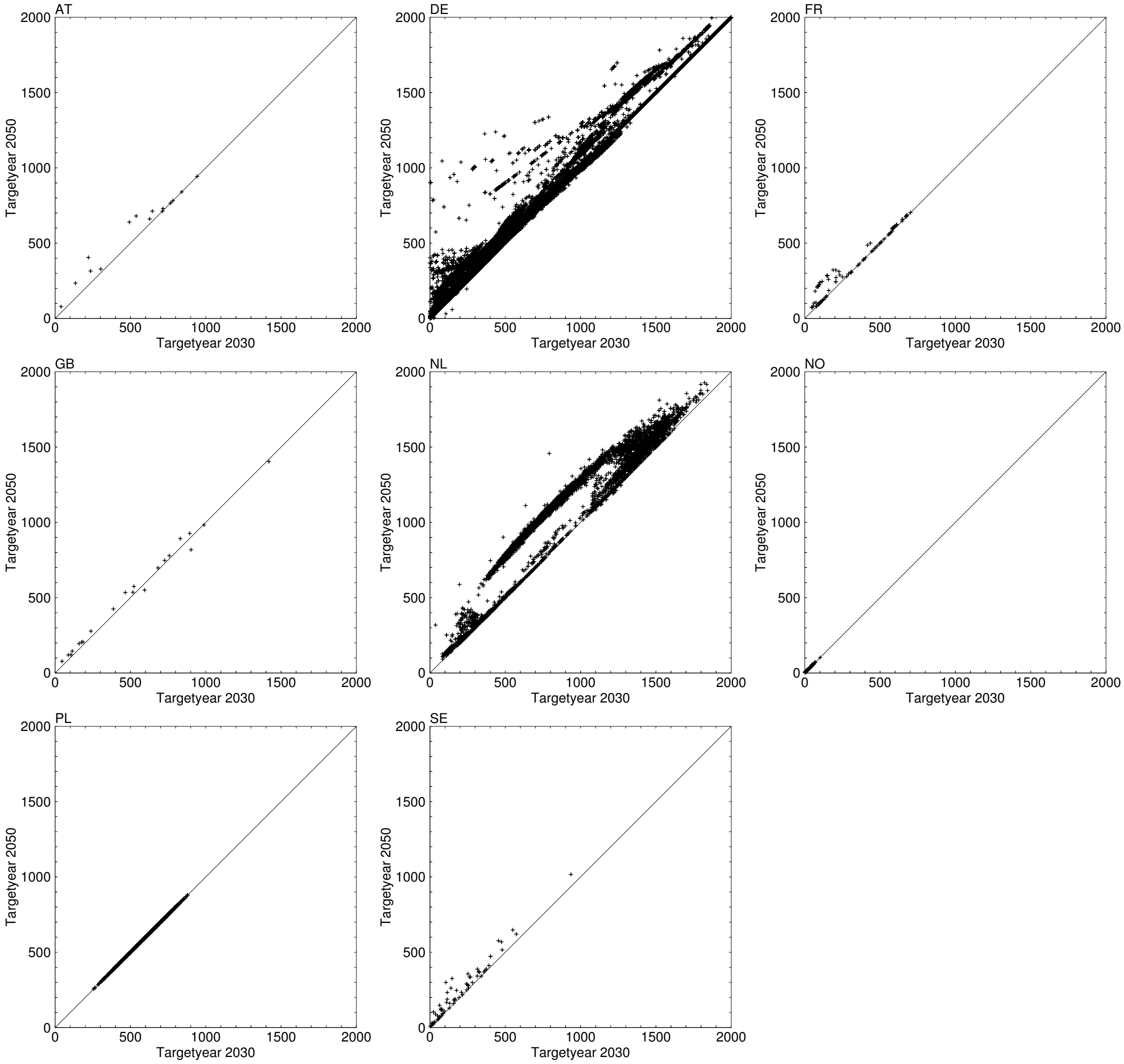

Figure 3-5. Correlation between the maximum S target load, $TL_{max}(S)$, for the target years 2030 (horizontal axes) and 2050 (vertical axes). Ideally (and for meaningful policy applications) all data points should be located above (or on) the 1:1 line.

Selecting the maximum S target load, $TL_{max}(S)$, i.e. the target load for S in the case of zero N deposition, the correlation between those values for the target years 2030 and 2050 are shown in Figure 3-5 for the sites for which target loads have been calculated (and are smaller than 2000 eq/ha/a). As can bee seen, in most cases the target loads for 2030 are lying above the 1:1 line, i.e. they are smaller than those calculated for the year 2050. In cases in which they are just below the 1:1 line, this can be due to imprecision (rounding errors), since target loads are calculated iteratively. Another reason why in some cases the 2050 target load is smaller than the 2030 TLs is a few countries have applied non-constant (forest) uptake scenarios. This makes the magnitude of a target load dependent on whether the target year coincides with a period of high forest growth or not. In such a case the target load for 2050 could be lower than that for 2030. Also the way in which (time-dependent) N immobilisation is modelled (N saturation and subsequent higher leaching) could result in lower target loads for later years. However, by definition, a target load cannot exceed the critical load for the ecosystem. Considering that the use of target loads is on a large regional scale, NFCs should consider moving from site-specific uptake scenarios to averages over larger areas, which are less varying and thus avoid the problems mentioned above.

Not only do target loads have to have the same order relation as target years, i.e. $Tyr_1 < Tyr_2 \Rightarrow TL_1 \leq TL_2$, but all target loads have also to be smaller than the corresponding critical load. Consequently, the ratio TL/CL has to be smaller than or equal to one. For the case of $TL_{max}(S)$ this is displayed for four countries in Figure 3-6.

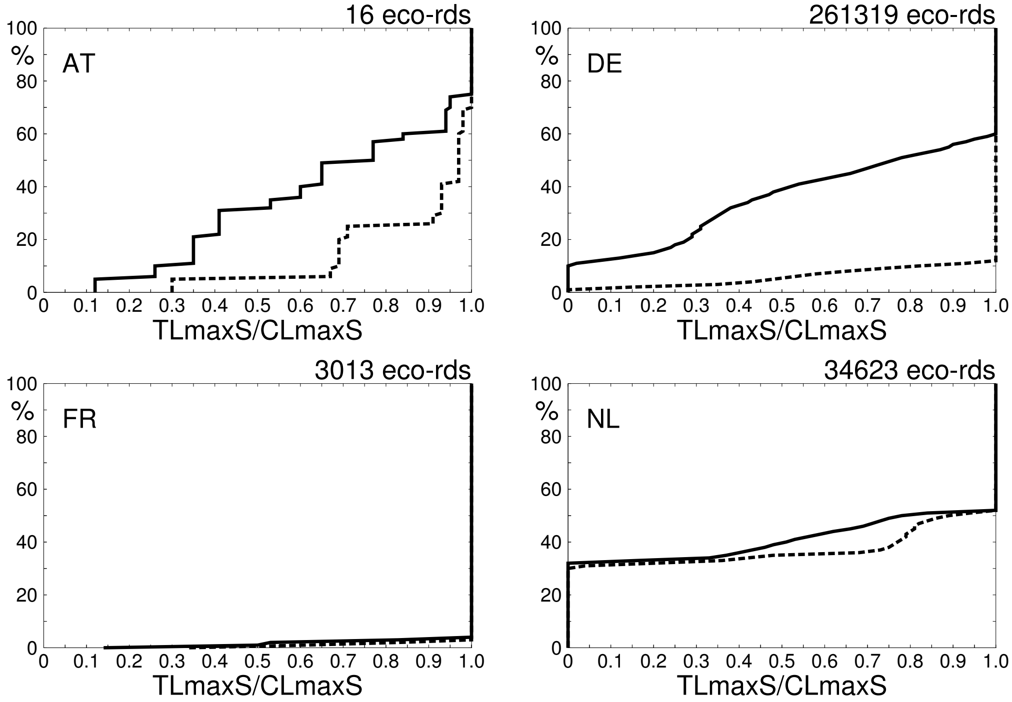

Figure 3-6. Comparison between the target loads $TL_{max}(S)$ and the maximum critical loads of S, $CL_{max}(S)$, in the form of cumulative distribution functions of the ratios $TL_{max}(S)/CL_{max}(S)$ for Austria, Germany, France and the Netherlands for the target years 2030 (solid line) and 2100 (dashed line).

Figure 3-6 displays only those cumulative distribution functions of ecosystem records ('eco-rds') for which a target load function has actually been calculated, i.e. the ecosystems for which there is an entry in one of the last three columns of Table 3-2 (TLstatus≥1). Furthermore, in Figure 3-6 the ecosystems are weighted with their area and thus cannot be directly compared. From the cdfs one can easily see the ecosystems which are infeasible, $TL_{max}(S)/CL_{max}(S)=0$, and those for which the target load equals the critical load, $TL_{max}(S)/CL_{max}(S)=1$, and the proportions vary strongly between the countries shown. For the reasons mentioned above, the cdf for the target year 2100 (dashed line) should lie below the one for Tyr=2030 (solid line).

The application of dynamic models, and especially the computation of target loads, is much more involved and data demanding than the computation of critical loads. This was also reflected in the results from the latest call for data. Consequently, at the 2004 meeting of the Task Force on Modelling and Mapping it was agreed that a new call for dynamic modelling outputs should be issued, which would allow to take into account improvements made over the course of the last year and to increase participation of NFCs.

3.4 Target loads derived from the European background data base

The European background data base is maintained by the CCE and used to fill in critical loads for countries which never submitted national data. This data base ('EU-DB'), which includes forest soils only, is described in Chapter 4 in Posch et al. (2003b). Since then only a few changes have been made, notably the inclusion of bicarbonates and organic acids into the mass balance. Cumulative distributions (cdfs) of most of the variables, including critical loads, are shown as thin dashed black lines in Chapter 2 in comparison with the respective national data.

The European background data base has also been used by the CCE to calculate target load functions (TLFs), using the Very Simple Dynamic (VSD) model (Posch et al., 2003a). TLFs have been calculated for 66,483 sites (each >1 km^2), covering about 2.5 million km^2. Table 3-3 shows that 78.7 percent of them are safe in 2010, i.e. there is non-exceedance of critical loads and $Al/Bc \leq 1$ mol/mol. Between 8.6% (in 2030) and 9.2% (in 2100) of the sites become safe in or before the respective target year, when continuing with the 2010 deposition. Furthermore, between 6.6% (in 2030) and 4.2% (in 2100) of the sites are infeasible (i.e. $Al/Bc=1$ cannot be reached in the target year even with zero deposition), leaving 6.1% (2030), 6.8% (2050) and 7.9% (2100), respectively, for which target load functions were calculated.

Table 3-3. Characterisation of target load calculations for the European background data base (in percent): (a) safe in 2010 (column 2); (b) safe in the respective target year (col.3); (c) a target load function has been calculated (col.4); and (d) a target load function does not exist (col.5).

Target year	**safe in 2010**	**safe in Tyr**	***TLF exists***	**not feasible**
2030:	78.7	8.6	6.1	6.6
2050:	78.7	8.8	6.8	5.7
2100:	78.7	9.2	7.9	4.2

In Figure 3-7 the correlation between the values of $TL_{max}(S)$, i.e. the target load for S in case of zero N deposition, are shown for the combination of target years 2030/2050 and 2050/2100 (top row) as well as the correlation between $TL_{max}(S)$ for 2100 and 2030 with $CL_{max}(S)$ (bottom row). As should be, all points lie above the 1:1 line since a target load is the smaller the closer the target year is to the present, and all target loads are smaller than the corresponding critical load (=target load for infinite time).

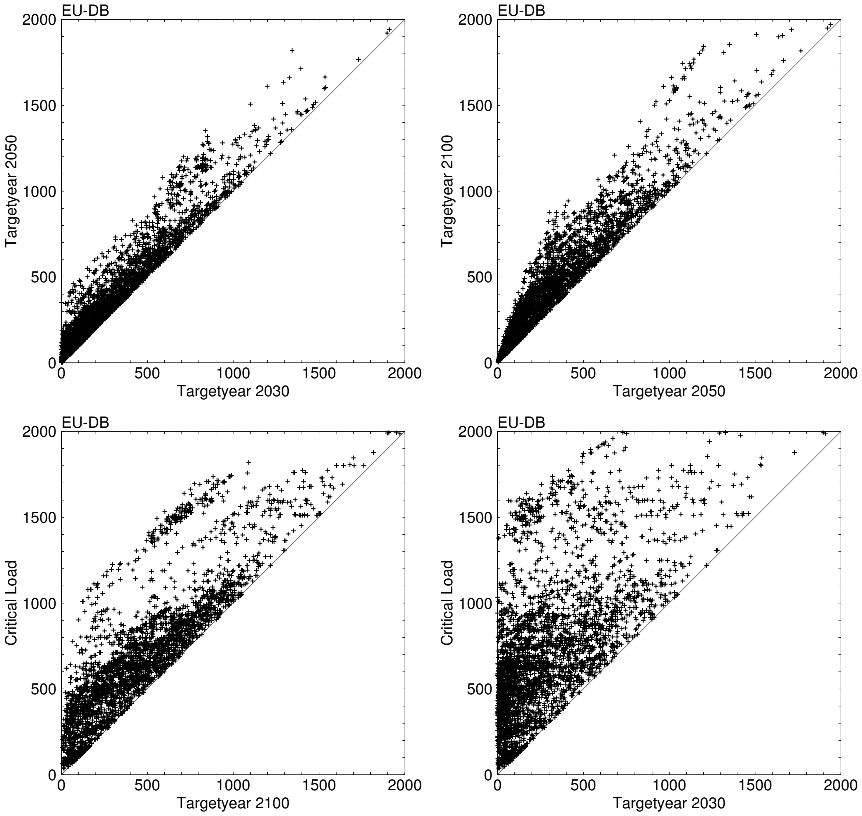

Figure 3-7. Correlation between the maximum S target load, $TL_{max}(S)$, (a) between target years 2030 and 2050, (b) 2050 and 2100, (c) Tyr=2100 and $CL_{max}(S)$, and (d) Tyr=2030 and $CL_{max}(S)$ for the European background data base. As should be, all data points are lying above (or on) the 1:1 line.

Figure 3-8 displays the cumulative distribution functions (cdfs) of ecosystem records ('eco-rds') for which a target load function has been calculated (about 29% of the overall number) for the target years 2030 (solid line) and 2100 (dashed line). In constructing these cdfs the ecosystems have been weighted with their respective area. From the cdfs one can easily see the fraction of the ecosystem area where target loads are infeasible, $TL_{max}(S)/CL_{max}(S)=0$, and that for which the target load equals the critical load, $TL_{max}(S)/CL_{max}(S)=1$, leaving between 18.6% (=4.6% of the total ecosystem area for 2030) and 25% (=6.2% of total area for 2100) with target loads smaller than critical loads. The cdf for the target year 2050 (not shown) lies between the two cdfs shown.

As an illustration, Figure 3-9 compares the 5-th percentile of the maximum critical load of acidity, $CL_{max}(S)$, with the 5-th percentile target load $TL_{max}(S)$ for the year 2030, using the European background data base for both maps. It shows that the largest difference between critical loads and target loads occurs in the central belt stretching from the United Kingdom via Germany and southern Sweden to the east. This is not surprising, since this largely coincides with the area which has experienced the highest excess depositions over the past decades and thus needs the longest recovery times or – if the recovery has to happen by 2030 – the lowest target depositions.

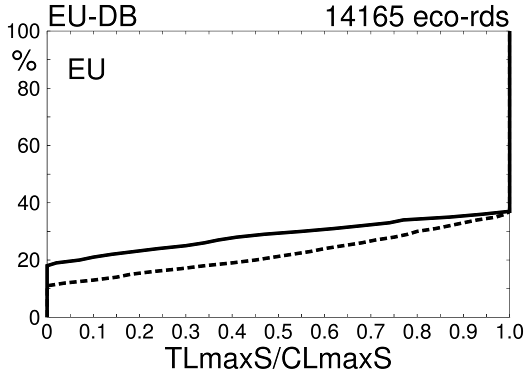

Figure 3-8. Comparison between the target loads $TL_{max}(S)$ and the maximum critical loads of S, $CL_{max}(S)$, in the form of cumulative distribution functions of the ratios $TL_{max}(S)/CL_{max}(S)$ for the target years 2030 (solid line) and 2100 (dashed line) for the European background data base. Note that 100% corresponds to the ecosystem area which is not (yet) safe in 2010.

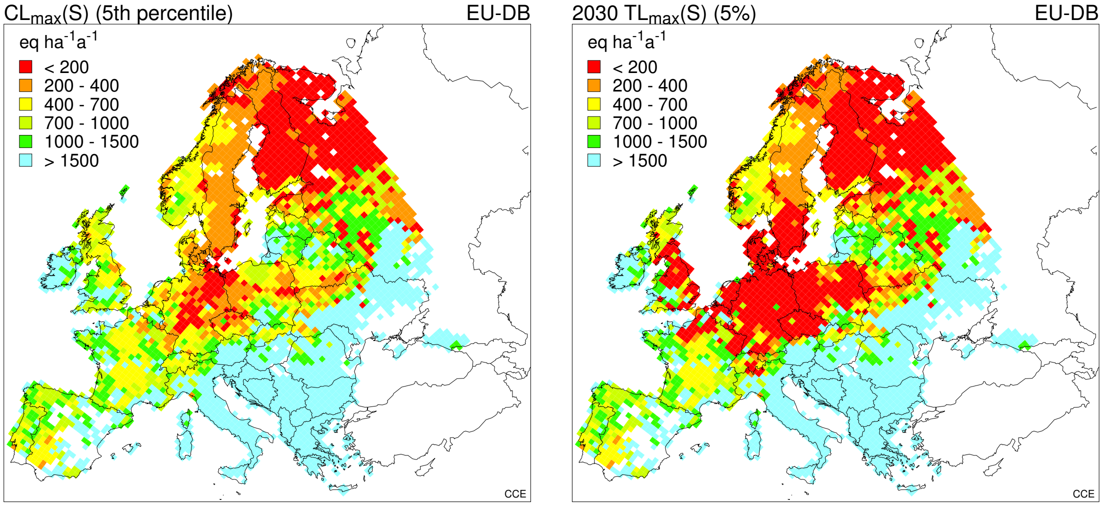

Figure 3-9. The 5-th percentile of $CL_{max}(S)$ (left) and $TL_{max}(S)$ for 2030 (right), using the European background data base in both maps.

As in the case of critical loads, the European background data base could be used to fill in data gaps for countries which do not provide national dynamic modelling results. This, however, requires the consensus of all parties involved.

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PART II. National Focal Centre Reports

This part consists of reports on national input data on critical load and dynamic modelling calculations submitted to the Coordination Center for Effects (CCE) by National Focal Centres (NFCs).

A total of 25 countries collaborate with the ICP on Modelling and Mapping by submitting critical loads data and related information to the CCE. Following the call for data made at the end of 2003 (with the deadline of 31 March 2004), 16 countries (Austria, Belarus, Bulgaria, Cyprus, Denmark, Finland, France, Germany, Hungary, Italy, the Netherlands, Norway, Poland, Sweden, Switzerland and United Kingdom) submitted updates of their critical load databases. An analysis of the data submissions is provided in Chapter 2 of Part I. Belgium, Croatia, the Czech Republic, Estonia, Ireland, the Republic of Moldova, the Russian Federation, Slovakia and Spain did not submit updated data. Their previously submitted databases were retained unchanged.

NFCs were asked to focus in their national contributions on describing their critical load and dynamic modelling database and documenting the methods used, and especially include a justification if data or models are applied which are not given in the Mapping Manual or the Dynamic Modelling Manual.

The NFC reports received were formatted, but were neither reviewed nor editted.

AUSTRIA

National Focal Centre

Christian Nagl
Umweltbundesamt GmbH
Department of Air Quality Control
Spittelauer Lände 5
1090 Vienna
tel: +43-1-313 04 5866
fax: +43-1-313 04 5400
christian.nagl@umweltbundesamt.at
www.umweltbundesamt.at

Collaborating institutions

Lead collaborating institution:

Erik Obersteiner
Umweltbundesamt Gmbh
Department of Terrestrial Ecology
Spittelauer Lände 5
1090 Vienna
tel: +43-1-31 304-3690
fax: +43-1-31 304-3700
erik.obersteiner@umweltbundesamt.at
www.umweltbundesamt.at

Data submitting institution:

Austrian Federal Office and Research Centre for Forests
Franz Mutsch
Department of Forest Ecology
Klemens Schadauer
Department of Forest Inventory
Seckendorff-Gudent-Weg 8
1131 Vienna
tel: +43-1-87 838-0
http://bfw.ac.at

Status

In response to the call for data of November 2003 a new dataset of critical loads and dynamic modelling is provided. Some changes to the methods and the input data compared to the up to 2001 datasets have been made:

- Most calculations are now based on the measured soil parameters of the Austrian Forest Soil Inventory. Therefore the number of records in the dataset was reduced to 489, reflecting the number of suitable sample plots.
- Only forest ecosystems are included (G1, G3, G4 according to EUNIS classification).
- Runoff calculation is based on the Hydrological Atlas of Austria.

Data sources

Soils: Soil information is based on the Austrian Forest Soil Inventory from Austrian Federal Office and Research Centre for Forests (Forstliche Bundesversuchsanstalt, 1992). About 500 sample plots were collected in a 8.7 x 8.7 km grid between 1987 and 1990. Most of the soil input parameters to critical loads and target loads calculation were taken from this dataset. The data are part of the BORIS soil information system run by the Federal Environment Agency.
Nutrient uptake: Information on biomass uptake comes from the Austrian Forest Inventory, sampled by the Austrian Federal Office and Research Centre for Forests - BFW (Schieler et al., 2001). Mean harvesting rates for the years from 1992 to 1996 were aggregated on EMEP grid cell basis. Grid cells

with too few sample points were combined with neighbouring cells. Base cation and nitrogen content were taken from Jacobsen et al. (2002).

Ecosystem: Three forest ecosystem types have been investigated according to EUNIS classification: G1 (Fagus sylvatica, Quercus robur), G3 (Picea abies, Pinus sylvestris, Larix decidua), G4. Ecosystem area was identified by dividing the known ecosystem area per grid cell (from forest inventory) by the number of soil inventory points falling in this ecosystem type.

Runoff: Runoff was calculated as the difference between precipitation and evapotranspiration with 5% of the precipitation assumed to be surface runoff. Both datasets are published in the Hydrological Atlas of Austria (BMLFUW, 2003)

Depositions:

The following data sources have been used:

Sulfur and Nitrogen deposition time series provided by CCE (Schöpp et al., 2003)

Base cation minus chloride deposition used in the 2001 critical loads calculation (Kovar et al., 1991)

Calculation Methods

The calculations and assumptions are generally in accordance with the Mapping Manuals (Posch et al., 2003, UBA revision process 2003/2004) and the CCE Status Reports. A detailed description of the parameters and the data and methods used for their derivation is given in Table AT-1.

The Access version of VSD was used for critical loads calculation and dynamic modelling. For the cation exchange the Gapon model was used, the exchange constants were calibrated. Theta was set to be 0.3, CNmin and CNmax were set to be 15 resp. 40. Oliver constants for the organic acid dissociation model were set to be 4.5, 0, 0.

Base cations were included lumped in the Ca column for weathering, deposition and uptake. Due to the lack of spatial distributed information on organic acids, default values for all records were used. Calcareous soils occur at 30% of the sample points representing about 40% of the ecosystem area.

Table AT-1: Data description, methods and sources.

Variable	Explanation and Unit	Description
EcoArea	Area of the ecosystem within the EMEP grid cell (km^2)	calculated from from Austrian forest inventory data
CLmaxS	Maximum critical load of sulphur (eq ha^{-1} a^{-1})	calculated by VSD
CLminN	Minimum critical load of nitrogen (eq ha^{-1} a^{-1})	calculated by VSD
CLmaxN	Maximum critical load of nitrogen (eq ha^{-1} a^{-1})	calculated by VSD
CLnutN	Critical load of nutrient nitrogen (eq ha^{-1} a^{-1})	Mapping Manual 5.3, Eq. 5.5
nANCcrit	The quantity –ANCle(crit) (eq ha^{-1} a^{-1})	calculated by VSD
Nleacc	Acceptable nitrogen leaching (eq ha^{-1} a^{-1})	Mapping Manual 5.3, Eq. 5.6; Nacc = 0.0143 eq m^{-3}
crittype	Chemical criterion used	used: molar Al/Bc
critvalue	Critical value for the chemical criterion	used: 1
thick	Thickness of the soil (m)	mostly 0.5 m, sometimes less, depending on soil inventory data
bulkdens	Average bulk density of the soil (g cm^{-3})	Manual for Dynamic Modelling 5.1.3 Eq. 5.1
Bcdep	Total deposition of base cations (eq ha^{-1} a^{-1})	Austrian survey data (Kovar et al., 1991)
Cldep	Total deposition of chloride (eq ha^{-1} a^{-1})	used: 0, already excluded from BC depositions
Bcwe	Weathering of base cations (eq ha^{-1} a^{-1})	Mapping Manual 5.3, Eq. 5.39; Table 5-8 (WRc = 20 for calcarous soils)
Bcupt	Net growth uptake of base cations (eq ha^{-1} a^{-1})	[average yearly yield rate * base cation content], data from Austrian forest inventory, base cation contents from Jacobsen et al., 2002
Qle	Amount of water percolating through the root zone (mm a^{-1})	[Precipitation * 0.95 (for surface runoff) - Evapotranspiration], data from Hydrological Atlas from Austria
lgKAlox	Equilibrium constant for the Al-H relationship (log10)	used: 8 (gibbsite equilibrium)
expAl	Exponent for the Al-H relationship	used: 3 (gibbsite equilibrium)
pCO2fac	Partial CO_2-pressure in soil solution as multiple of the atmospheric CO_2 pressure (-)	[log10pco$_2$ = -2.38 + 0.031 * Temp (°C)], atmospheric CO_2 pressure = 0.00037 atm; equation recommended by CCE
cOrgacids	Total concentration of organic acids (m*DOC) (eq m^{-3})	used: 0,01 (recommended by Max Posch)
Nimacc	Acceptable amount of nitrogen immobilised in the soil (eq ha^{-1} a^{-1})	see German NFC Report in Posch et al., 2001, p.142, Table DE-7

Nupt	Net growth uptake of nitrogen (eq ha^{-1} a^{-1})	[average yearly yield rate * N content], data from Austrian forest inventory, N contents from Jacobsen et al., 2002
fde	Denitrification fraction (0<=fde<1) (-)	see German NFC Report in Posch et al., 2001, p.142, Table DE-8
CEC	Cation exchange capacity (meq kg^{-1})	soil inventory; calibratet to pH 6.5 (Manual for Dynamic Modelling 5.1.3 Eq. 5.3)
bsat	Base saturation (-)	soil inventory
yearbsat	Year in which the base saturation was determined	year of soil inventory (1987-1990)
lgKAlBc	Exchange constant for Al vs Bc (log10)	calibrated by VSD; starting value 0
lgKHBc	Exchange constant for H vs Bc (log10)	calibrated by VSD; starting value 3
Cpool	Initial amount of carbon in the topsoil (g m^{-2})	[thick * bulkdens * Corg(%) * 10 000]; summed over all layers
CNrat	C/N ratio in the topsoil	Cpool / Npool
yearCN	Year in which the CNratio and Cpool were determined	year of soil inventory (1987-1990)
Sdep2010	Deposition of S in 2010 (eq ha^{-1} a^{-1})	data from CCE (Schöpp et al., 2003)
NOxdep2010	Deposition of NOx in 2010 (eq ha^{-1} a^{-1})	data from CCE (Schöpp et al., 2003)
NH3dep2010	Deposition of NH3 in 2010 (eq ha^{-1} a^{-1})	data from CCE (Schöpp et al., 2003)

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BELARUS

National Focal Center

Oleg Bely, Natallia Lysukha
Belarussian Research Centre ‘Ecology’
31A Horuzhaya St.
220002 Minsk
tel: +375-17-234 7065
fax: +375-17-234 8072
belnic@tut.by, promeco@tut.by

Calculation methods

The steady-state mass balance (SSMB) method was used, along with an additional algorithm developed by Prof. Bashkin of the National Focal Centre of Russia.

BULGARIA

National Focal Center

Yavor Yordanov
Executive Environment Agency
Tzar Boris III Str. 136
BG-1618 Sofia
BULGARIA
Tel: 359 2 9406473
Fax: 359 2 9559015
landmont@nfp-bg.eionet.eu.int

Collaborating Institutions

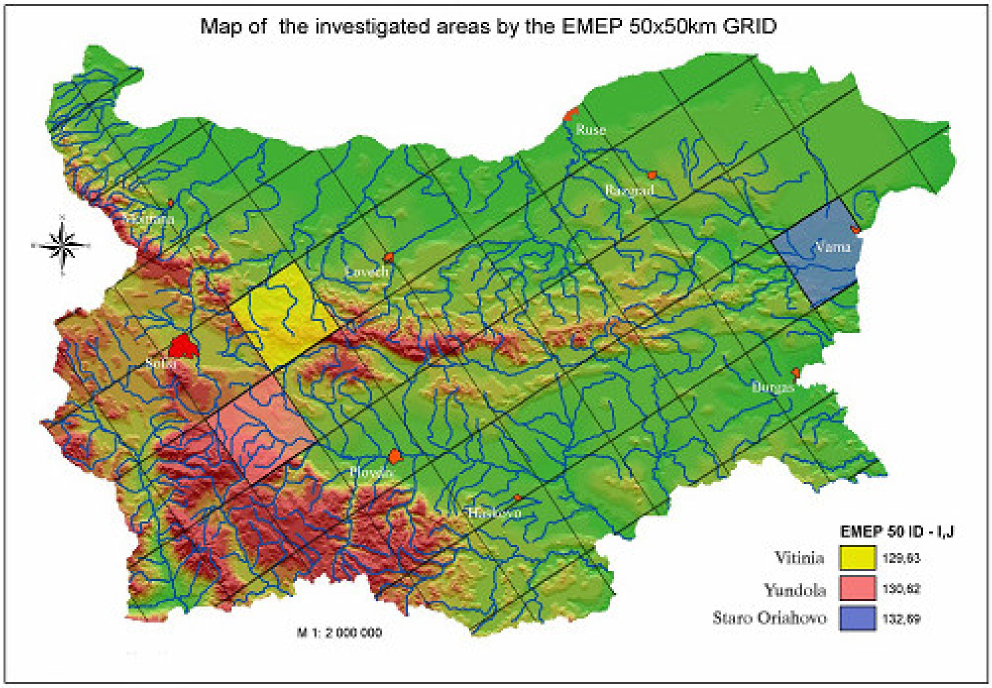
Prof. Dr. Nadka Ignatova- scientific responsible of the project
Department of Chemistry and Biochemistry
Prof. Dr. Kitka Jorova
Department of Soil Science
Ass. Prof. Ivan Myashkov
Department of Ecology
University of Forestry
Kliment Ochridsky Street 10
1756 SOFIA
tel: +359 2 91907 (351) (N I)
+359 2 91907 (360) (K J)
+359 2 91907 (357) (I M)
fax: +359 2 62 28 30
e-mail: nadia_ignatova@hotmail.com

Assoc. Prof. Dr. Maria Groseva
Department of Soil Science
Forest Research Institute
Kliment Ochridsky Street 136
1756 SOFIA
tel: +359 2 62 29 61
fax: +359 2 62 29 65

Ass. Prof. Radka Fikova
Central Laboratory of Total Ecology
Bulgarian Academy of Sciences
Gagarin Street 2
1300 SOFIA
tel: +359 2 7191

Receptors: Coniferous and deciduous forests in 3 EMEP 50 km network stations.

Station mane	Lon [degrees]	Lat [degrees]	I50	J50
Staro Oriahovo	27.82	43.06	132	69
Vitinia	23.92	42.92	129	63
Yundola	23.89	41.92	131	62



Calculation methods

Critical loads of nitrogen as a nutrient, maximum values for the critical loads of sulfur and acidifying nitrogen, and minimum critical load of nitrogen have been calculated according to the 1996 Manual (UBA, 1996) using the Steady state mass balance method as follow:

1. ***Critical loads of acidity for forest siols*****:**

C L (A) = B C w + Q [H] crit + R Al/Ca (B C dep + B C w - B C u) =
= 2.5 B C w + 0.09 Q + 1.5 B C dep - 1.5 B C u

where:

C L (A) = critical load of acidity
B C w = weathering of base cations
Q = annual runoff of water under root zone, m^3 ha^{-1} yr^{-1}
[H^+] crit = critical concentration of protons (= 0.09 eq m^{-3} which corresponds to pH 4.0) (Hettelingh and de Vries, 1992)
R Al/Ca = critical Al/Ca ratio (= 1.5 eq eq^{-1})
B C dep = atmospheric deposition of basic cations (BCdep - Cldep), eq ha^{-1} yr^{-1}
B C u = net growth uptake of basic cations, eq ha^{-1} yr^{-1}

2. ***Maximum and minimum critical loads of sulfur and nitrogen***:

C L max (S) = C L (A) + B C dep - B C u
C L min (N) = N u + N i
C L max (N) = C L min (N) + C L max (S)

where:

N u = net growth uptake of nitrogen, eq ha^{-1} yr^{-1}
N i = nitrogen immobilization

For podsols and hystosols, Ni = 3 kg ha^{-1} yr^{-1} (214 eq ha^{-1} yr^{-1}) and 2 kg ha^{-1} yr^{-1} (143 eq. ha^{-1}.yr^{-1}) for other soils (UBA, 1996)

3. ***Critical load of nutrient nitrogen***

C L nut (N) = N u + N i + N le (crit)
N le (crit) = Q [N] crit

where:

N le (crit) = leaching of nitrogen at critical load, eq ha^{-1} yr^{-1}
[N] crit = concentration of nitrogen in the soil solution at critical load (for coniferous = 0.0143 eq m^{-3}; for deciduous = 0.0215 eq m^{-3}) (Posch et al., 1995)

4. ***Critical leaching of alkalinity***

A N C le (crit) = Al le (crit) + H le (crit);
Al le (crit) = R Al/BC (B C dep + B C w - B C u);
H le (crit) = Q [H] crit

where:

A N C le (crit) = critical leaching of alkalinity, eq ha^{-1} yr^{-1}
Al le (crit) = Al^{3+} critical leaching, eq ha^{-1} yr^{-1}
[Al] crit = critical concentration of Al^{3+} equal to 0.2 eq m^{-3} (de Vries, 1988);
H le (crit) = H^{+} critical leaching, eq ha^{-1} yr^{-1}

Dynamic Modelling of Critical loads

Very Simple Dynamic (VSD) model has been used for dynamic modeling procedure. This model consists of a set of mass balance equations, describing the soil input and output relationships and fluxes, and soil properties. The input data needed to run the VSD model have been also needed in the steady state masse balance model for calculating critical loads described in details in the previous status reports on calculating and mapping critical loads of acidity, sulfur and nitrogen (Ignatova et al., 1999; 2001). The most important additional soil data, concerning soil parameters, have been the carbon content in the soil, carbon / nitrogen ratio, soil bulk density, clay and sand content, as well as the soil pH.

Also, the environmental conditions have been presented by mean annual temperature, annual bulk precipitation and the average altitude above see level for each grid cell.

Data for volumetric water content at field capacity are not available for all EMEP grids.

Data sources

National monitoring data

♦Critical loads have been calculated for all major tree species using soil data base of the content of the organic mater (%), the clay content for the fraction 0,01 mm in the soil (%), soil bulk density, cation exchange capacity CEC, Base saturation, C/N ratio and the pH of the soil. in grid cells of 16 km / 16 km..

♦ Runoff of water under root zone has been measured in grid cells of 10 x 10 km^2 for the entire country (Kehayov, 1986).

♦ 3 automatic measurement stations of atmospheric deposition by precipitation have been used for base cations deposition.

♦ Nitrogen and base cations net uptake rates are obtained by multiplying the element contents of the stems (N, Ca, K, Mg and Na) with annual harvesting rates (Ignatova et al., 1997). - Data on biomass removal for forests have been derived from the National Forests Survey Agency. The content of base cations and nitrogen in the biomass has been taken from the literature for different harvested parts of the plants (stem and bark of forest trees) (Jorova, 1992; Ignatova, 2001; De Vries and Bakker, 1998; De Vries et al., 2001)

National synthetic maps

♦ Soil type information on the FAO soil map of Bulgaria;
♦ Geological map of Bulgaria 1 : 500 000
♦ Vegetation map of Bulgaria 1 : 500 000
♦ Mean annual temperature map 1: 500 000
♦ Mean annual precipitation map 1: 500 000

Calculation data

In the absence of more specific data on the production of basic cations through mineral weathering for most of study regions, weathering rates have been calculated according to the dominant parent material obtained from the lithology map of Bulgaria and the texture class taken from the FAO soil map for Europe, according to the clay contents of the Bulgarian forest soils (UBA, 1996).
Gibbsite equilibrium constant Kgibb for the Al - H relationship (m^6 / eq^2) has been estimated in accordance with the soil organic mater in % and type of soils using the manual (UBA, 1996).

Results and comments

All data necessary to run the VSD model and to evaluate critical loads of acidity, sulfur and nitrogen (33 parameters as a total) have been prepared in Excel database files version 2000 and mapped for 3 EMEP 50 x 50 km2 grid cells using Arc-view software.

The CL's and TL's functions were produced for each of observed grid cells. All CL and TL values displayed that '*NO DEPOSITION REDUCTION NEEDED'*. In spite of this, the TL function was calculated. Results regarding to VSD model calculating of CL function and expected TL's of sulfur and nitrogen at 2030, 2050 and 2100 shown:

Values for each parameter and the resulting critical loads are stored for each forest type (coniferous and deciduous forests) in separate records for each EMEP 50 x 50 km2 grid cell when the forest is a mixture of both tree types, in accordance with the area fractions of the tree species.

If the dynamic of actual depositions stay on the 2003 year level, there is no expected exceedance of CL at Undola disrtict. All foresights of TL's for 2030, 2050 and 2100 are below CL. For Vitinia and Staro Oriahovo districts the expected depositions are greater than CL [Table 1].

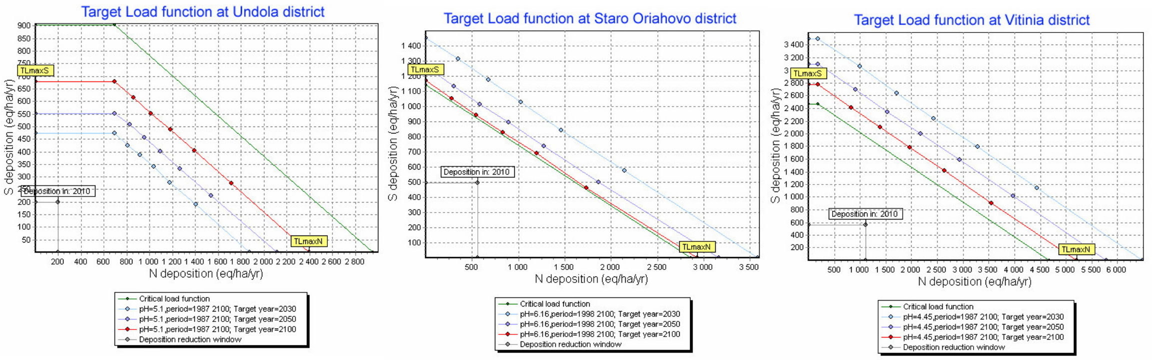
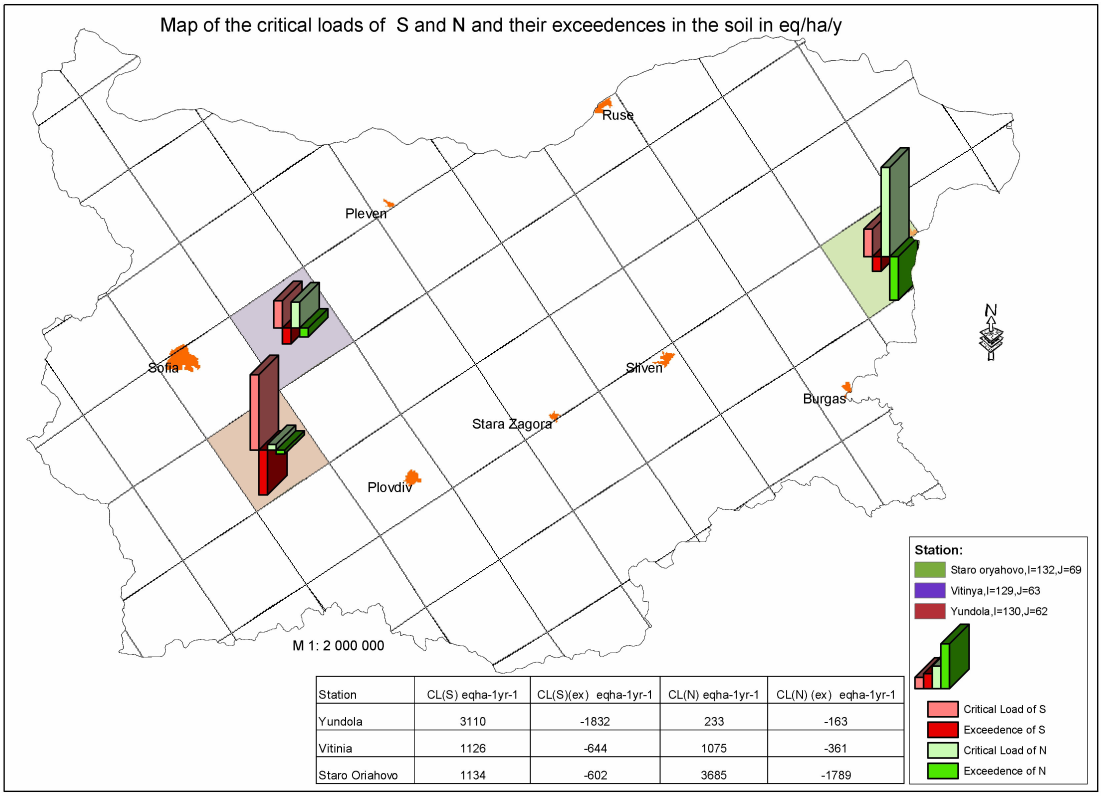


Table 1. TL function for 3 observed districts – Undola, Staro Oriahovo and Vitinia

The frequency distribution of the values for both deciduous and coniferous is shown in Table 2.



Station	CL(S) eqha-1yr-1	CL(S)(ex) eqha-1yr-1	CL(N) eqha-1yr-1	CL(N) (ex) eqha-1yr-1
Yundola	3110	-1832	233	-163
Vitinia	1126	-644	1075	-361
Staro Oriahovo	1134	-602	3685	-1789

Table 2. Critical loads of sulfur (red) and nitrogen (green) and their exceedences at 3 EMEP stations – Undola, Vitinia and Staro Oriahovo for 2003 [eq/ha/yr].

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CYPRUS

National Focal Center

Christos Malikkides
Department of Labour Inspection
Section of Industrial Pollution Control and Air Quality
12 Apellis Str.
1480 Nicosia
CYPRUS
Tel. +(357) 22405630
Fax +(357) 22663788
e-mail: cmalikkides@dli.mlsi.gov.cy

Calculation methods for critical loads of acidity and nutrient nitrogen

Cyprus has submitted for the first time national critical load data using the steady-state mass balance approach. About 40 % of the area of Cyprus is covered by forests and other (semi-)natural vegetation for which critical loads of acidity and nutrient nitrogen are computed (see table CY-1).

The critical loads are calculated in accordance to the methods described in the Mapping Manual1 (updated version 2004). The Cyprus critical load database consists of 18 137 records, a detailed description of the data and the methods for derivation is given in table CY-2.

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[1] UBA (1996/2004) Manual on Methodologies and Criteria for Mapping Critical Levels/Loads and Geographical Areas where they are exceeded. UNECE Convention on Long-range Transboundary Air Pollution, Federal Environmental Agency, Berlin, updated version 2004 (see: www.icpmapping.org)

Table CY -1: Ecosystem types used as receptors for the critical loads approach

Vegetation type	**Latitude (UTM/WGS84)**	**Altitude**	**Geological zone**	**Prefered soil groups/ parent materials**	**Dominant species**	**Charakter species**	**Percentage of the total area of Cyprus**	**Percentage of total receptor area**	**EUNIS-Code**	
Heath	below 3895000	>1950	Troodos Terrane	Eutric Cambisols from tectonized Harzburgites	Juniperus foetidissima	Alyssum troodii	0.08	0.19	F7.4G	Cyprian hedgehog-heaths
High forest	below 3895000	1500-1950	Troodos Terrane	Eutric Cambisols from Serpentinites	Pinus nigra	Juniperus foetidissima	0.22	0.63	G3.5	[Pinus nigra] woodland
High forest	below 3895000	1200-1500	Troodos Terrane	Eutric lithic Leptosols from Gabbro	Pinus brutia	Pinus nigra	0.61	1.44	G3.75	[Pinus brutia] forests
High forest	below 3895000	800-1200	Troodos Terrane	Eutric lithic Leptosols from sheeted dykes (diabase)	Pinus brutia	Cedrus brevifolia	349	8.24	G3.9C	[Cedrus] woodland
High forest	below 3895000	400-800	Troodos and Mamonia Terranes	Eutric lithic Leptosols from diabase dykes	Pinus brutia	Quercus alnifolia	10.7	25.28	G2.136	Cyprian [Quercus alnifolia] forests
High forest	above 3895000	400-1200	Kyrenia Terrane	Calcaric lithic Leptosols from Dolomitic limestone	Cupressus sempervirens	Pinus brutia	1.35	3.19	G3.91	Western Palaearctic [Cupressus] forests
Macchie	above 3895000	0-400	Kyrenia Terrane	Calcaric leptic Regosols from greywacke	Juniperus phoenicea	Calicotome villosa	4.41	10.43	F5.132	[Juniperus phoenicea] arborescent matorral
Macchie	below 3895000	0-400	Circum Troodos sedimentary succession and Mamonia Terrane	Skeletic calcaric Regosols from Chalks, marls	Genista fasselata	Cistus spec.	10.40	24.56	F5.24	Low [Cistus] maquis
Garique	everywhere	0-400	Circum Troodos sedimentary succession and Mamonia Terrane	Calcic Luvisols from alluvial sands, silts, gravels and clays	Thymus capitatus	Sarcopoterium spinosum	10.74	25.38	F7.341	Cyprian phrygana
Riparian	everywhere	0-1500	Azonal	Calcaric fluvic Cambisols from alluvial sands, silts, gravels and clays	Platanus orientalis	Alnus orientalis	0.11	0.26	G1.38	Mediterranean [Platanus orientalis] woods
Salt lakes	everywhere	-3-3	Azonal	Gleyic Solonchalks	Salicornia europaea	Halopeplis amplexicaulis	0.20	0.48	A2.652	Mediterranean coastal halo-nitrophilous pioneer communities
							42.32	100.00		

Table CY-2 : National critical load database and calculation methods / approaches

Parameter	**Term**	**Unit**	**Description1)**
Critical load of acidity	CLmaxS	eq ha^{-1} a^{-1}	Manual, equation 5.22 (5.31, 5.34, 5.36);
	CLminN	eq ha^{-1} a^{-1}	Manual, equation 5.23
	CLmaxN	eq ha^{-1} a^{-1}	Manual, equation 5.24
Critical load of nutrient nitrogen	CLnutN	eq ha^{-1} a^{-1}	Manual, equation 5.3 including nitrogen loss by fire (Nfire)
Uptake of base cations by vegetation	Bcupt	eq ha^{-1} a^{-1}	Manual, equation 5.7, 5.8
Weathering of base cations	BCwe	eq ha^{-1} a^{-1}	Manual, equation 5.39, weighted mean for actual rooting zone
Gibbsite equilibrium constant	Kgibb	m^6 eq^{-2}	300
Acid neutralisation capacity leaching	nANC(crit)	Eq ha^{-1} a^{-1}	the minimum value using equation 5.31, 5.34, 5.36 and 5.37 (adapted, see table CY-3) was taken for the calculation
Nitrogen immobilisation	Nimm	eq ha^{-1} a^{-1}	temperature dependent, see CCE-Status Report 2001, page 142, table DE-7
Nitrogen uptake by vegetation	Nupt	eq ha^{-1} a^{-1}	Manual, equation 5.7, 5.8
Denitrification	Nde	eq ha^{-1} a^{-1}	depending on pH, temperature and soil moisture
Acceptable nitrogen leaching	Nle(acc)	eq ha^{-1} a^{-1}	$N\ le(acc) = Q \cdot 10 \cdot [N]crit$; $[N]crit$ = 0,0143 eq m^{-3}
Nitrogen loss by fire	Nfire	eq ha^{-1} a^{-1}	explanation is given in the text

Table CY-3: Minimum acceptable pH and base saturation of Cyprian soil groups.

No	Code	Parent material	Buffer system	Minimum accapta-ble pH	Minimum accaptable BS
1	LP.li.eu-RG.le.eu	Sheeted dykes (diabase)	Silikate minerals	5	56
2	CM.eu-RG.ah.eu	Gabbro (Olivine-, uralite-)	Manganese minerals	4.5	43
3	LP.li-CL.ptp	Pleistozene gravels, sand, silts	Carbonate minerals (CaCO3)	6.2	83
4	LP.li.ca-RG.le.ca	Biocalcarenites, sandstones, limestones	Carbonate minerals (CaCO3)	6.2	83
5	CL.ptp-LV.cr.ca	Biocalcarenites, sandstones, sandy marls	Carbonate minerals (CaCO3)	6.2	83
6	LV.cc-LV.vr.cr	Alluvial sands, silts, gravels and clays	Clay-minerals	4.2	34
7	RG.ca.sk-LP.li.ca	Calks, marls with cherts	Carbonate minerals (CaCO3)	6.2	83
8	LP.rz.ca-CM.le.ca	Calks, marls, calcarenites	Carbonate minerals (CaCO3)	6.2	83
9	RG.le.ca-LP.li	Greywacke, marls, sandstones, siltstones	Carbonate minerals (CaCO3)	6.2	83
10	CM.vr-RG.ca	Calcarenites, sands and gravels	Carbonate minerals (CaCO3)	6.2	83
11	CM.fv.ca-CM.vr	Alluvial sands, silts, gravels and clays	Carbonate minerals (CaCO3)	6.2	83
12	CM.ca-RG.ca	Biocalcarenites, sandstones, limestones	Carbonate minerals (CaCO3)	6.2	83
13	CM.vr-RG.ca	Alluvial sands, silts, gravels and clays	Carbonate minerals (CaCO3)	6.2	83
14	VR.cr.eu	Calcarenites, sands and gravels	Carbonate minerals (CaCO3)	6.2	83
15	LP.li.ca-LP.rz.mo	Dolomitic limestone, recrystallized limestone	Carbonate minerals (CaCO3)	6.2	83
16	SC.gl	Alluvial sands, silts, gravels and clays	Clay-minerals	4.2	34
17	RG.le.sk	Siltstones, calcilutites, radiolarian mudstone, quartzitic sandstone	Carbonate minerals (CaCO3)	6.2	83
18	CA.le.vr-VR.cr	Lava breccias, volcaniclastic breccias, porphyr, calcilutites	Carbonate minerals (CaCO3)	6.2	83
19	RG.gp-GY.le	Gypsum with chalky marls	Carbonate minerals (CaCO3)	6.2	83

The term 'Nitrogen loss by fire' was calculated using the equation

$$N_{\text{fire}} = \left\{ k_{gr} \cdot \frac{1}{f_{st:li}} p_{li} \cdot ctN_{li} + k_{gr} \cdot \left(1 - \frac{1}{f_{st:li}}\right) p_{st} \cdot ctN_{st} \right\} \cdot t \cdot l_N - N_{uharv}$$

with:

k_{gr} = average annual growth rate ($m^3\,ha^{-1}a^{-1}$),

ρ_{st} = density of stem wood/branch (t/m3),

ρ_{li} = density of litter (t/m3),

ctN = N content in stems/branches (subscript st) and litter (subscript li) (g/kg)

f st:li = stem/branch-to-litter-ratio (m^3/m^3),

t = return time period of fire events (a) (in Cyprus: vegetation loss due to fire at each site is once in a period of 33 years).

l_N = part of the total N-stock of the vegetation, which will be removed from the ecosystem due to fires (in Cyprus: In assumption of 80 % N losses in Cyprus about 2,4 % of the total N-stock of the vegetation will be removed from the ecosystem due to fires)

For computation of the denitrification term an equation was used proposed by Sverdrup and Ineson (1993)[2] based on the Michaelis-Menten reaction mechanism and includes a dependence on soil moisture, pH and temperature (Mapping Manual, chapter 5.3.1.1).

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[2] Sverdrup and Ineson (1993) Kinetics of denitrification in forest soils. Compuscript, 18 pp.

Critical loads of acidity, CLmax(S):

The highest critical loads of acidity with values up to 15 keq ha^{-1} a^{-1} are observed in the Troodos mountains. Less sensitive soils (eutric leptosols from diabase) are combined with medium high weathering rates of base cations and relatively high precipitation surplus. Medium high critical loads (about 2.5 – 7.5 keq ha^{-1} a^{-1}) are located in the Pentadactylos mountains, including the Karpasia region. Here calcareous soils from limestone cause a high critical limit for Bc/Al-ratio. The lowest critical loads (1.3 – 2.5 keq ha^{-1} a^{-1}) have to be allocated to the lowlands between Pentadactylos and Troodos from Morfou to Ammochostos (including the Mesaoria region), the lowlands around Larnaca Bay and from Lemosos to Pafos (including the Akamas region). Pliocene biocalcarenites and alluvial sands, silts and gravels have a medium potential weathering rate of base cations. But garique vegetation does not take advantage of cycling this supply in the soil because of the small rooting zone. Simultaneously the annual precipitation surplus is near zero, therefore the leaching of ANC is very low. The regional distribution of critical loads of acidity is shown in Figure CY-1, a statistical classification of sensitivity is given by table CY-4.

Table CY-4 : Statistical classification of receptor sensitivity for critical loads of acidity, CLmax(S)

CLmax(S) sensitivity classes (eq ha^{-1} a^{-1})	Percentage of the sensitivity classes to total receptor area (%)	Percentage of the sensitivity classes to the total area of Cyprus (%)
< 2500	34.52	14.61
2500-5000	28.75	12.17
5000-7500	0.85	0.36
7500-10 000	31.13	13.17
10 000-12 000	4.74	2.01
>12 000	0.02	0.01
	100.00	42.32

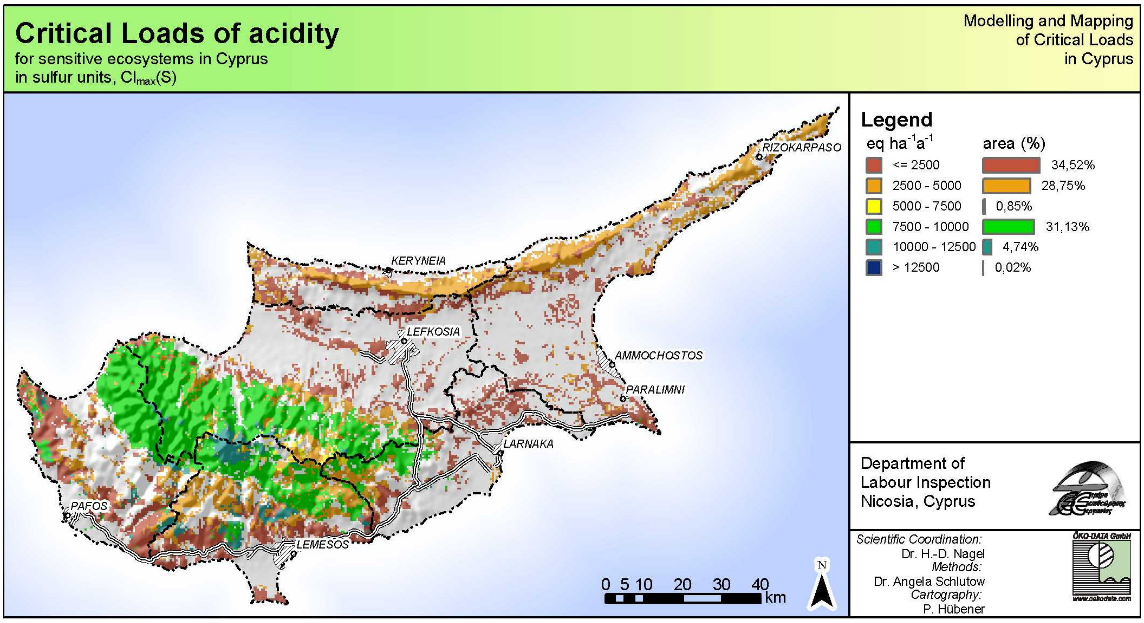

Figure CY-1 : Regional distribution of critical loads of acidity, CLmax(S), in Cyprus

Critical loads of nutrient nitrogen, CLnut(N):

In contrast to the insensitivity concerning acid inputs the critical loads of nutrient nitrogen underline the necessity to protect ecosystems in Cyprus from anthropogenic nitrogen inputs. Similar to the critical loads of acidity the Troodos mountains have also high critical loads of nutrient nitrogen (about 5-10 kg N ha^{-1} a^{-1}). A significant uptake by harvesting of the Calabrian pine is accompanied of relatively high precipitation surplus. Medium high critical loads (2,5 - 5 kg ha^{-1} a^{-1}) are located in the Pentadactylos mountains, including the Karpasia region. Calcareous soils from limestone could cause a high growth rate, but trees are not harvested in this region. The lowest critical loads values (1,5 - 2,5 kg ha^{-1} a^{-1}) are observed in the Kommandaria region, in the lowlands between Pentadactylos and Troodos from Morfou to Ammochostos (including the Mesaoria and Solea region), in the lowlands around Lanarca Bay and from Lemosos to Pafos (including Akamas region). Pliocene biocalcarenites and alluvial sands, silts and gravels have a medium high nutrient supply, but maquis and garique vegetation are not able to use this because missing precipitation in the lowlands. The regional distribution of critical loads of nutrient nitrogen is shown in Figure CY-2, a statistical classification of sensitivity is given by table CY-5.

Table CY-5 : Statistical classification of sensitivity for critical loads of nutrient nitrogen, CLnut(N)

CLnut(N) sensitivity classes (kg ha-1 a-1)	Percentage of the sensitivity classes to total receptor area (%)	Percentage of the sensitivity classes to the total area of Cyprus (%)
< 2	0,48	0,20
2-2,5	25,15	10,65
2,5-3	32,62	13,80
3-4	5,19	2,19
4-5	0,63	0,27
5-6	3,50	1,49
6-7	30,32	12,83
7-8	0,42	0,18
8-9	1,44	0,61
>9	0,26	0,11
	100,00	42,32

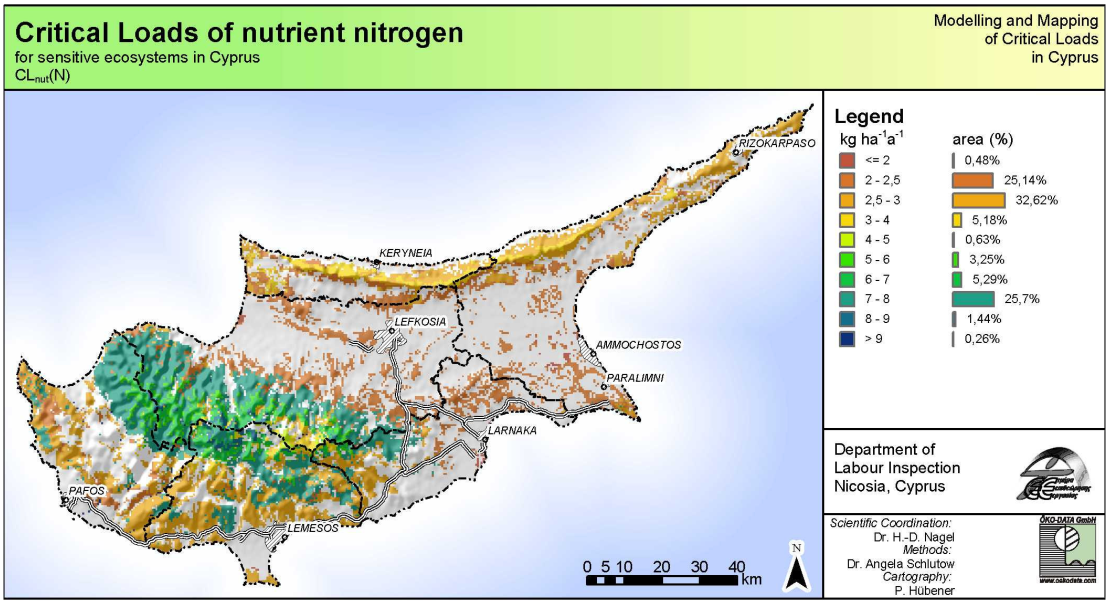

Figure CY-2 : Regional distribution of critical loads of nutrient nitrogen, CLnut(N), in Cyprus

DENMARK

National Focal Centre

Jesper Bak, Hans Løkke
National Environmental Research Institute
Dept. of Terrestrial Ecology
25 Vejlsøvej
DK-8600 Silkeborg
tel: +45 89201400
fax: +45 89201414
email: jlb@dmu.dk

National maps produced

- Critical load, and exceedance of the critical load of acidity for forest soils and extensively managed, permanent grasslands calculated with PROFILE, and for grasslands with the SSMB model.
- Critical load and exceedance of the critical load of nutrient nitrogen for production forests calculated with PROFILE.
- Critical load and exceedance of the critical load of nutrient nitrogen for inland- and coastal heathland, raised bogs, pastures, sensitive meadows, and sensitive (lobelia) lakes
- National deposition maps of NHX on a 30x30 km grid.
- National deposition map of NOX on a 30x30 km grid.
- National deposition map of SOX on a 30x30 km grid.

Calculation method

Critical loads of acidity and N eutrophication: The PROFILE model has been used to calculate the critical load for acidity and for nitrogen eutrophication, and the values of BCu, Nu, BCw, and ANCle,crit. From this calculation, the values of CLmin(S), CLmax(S), CLmin(N), and CLmax(N) have been derived. In calculating the critical load for grasslands, the weathering rate for 11 classes of mineralogy were calculated at 1000 points with the PROFILE model (1). The calculation of critical loads for grasslands were performed with the SMB model (2). The total number of calculations and the calculated critical loads for the different vegetation types are illustrated in Table 1.

A BC/Al ratio of 1 was used as the chemical criteria for both forest soils and grasslands. For the calculation of critical loads for nutrient nitrogen, a critical N leaching, Nlea, crit, of 2 kg N ha^{-1} yr^{-1} and an immobilisation, Nimm,crit, of 3 kg N ha^{-1} yr^{-1} were applied. For the model calculations, the root zone has been stratified in a 5 cm thick A/E horizon, and a soil dependant B and C horizon. A total root depth of 50 cm was applied for spruce and pine, 70 cm for beech, 90 cm for oak, and 25 cm for grasslands, respectively.

Table DK-1. Calculated critical loads for acidification and for N-eutrophication for different ecosystems. All values are given in keq ha^{-1} yr^{-1} as the range between the 5 and the 95 percentile.

	beech	oak	spruce	pine	grass
Calculations	2825	448	5480	1035	18178
CL(A)	0.9 - 2.7	0.8 - 2.2	1.4 - 4.1	1.4 – 2.4	0.9 - 2.4
CLnut(N)	1.2 - 1.9	1.2 - 2.0	0.6 - 1.1	0.5 - 0.7	-

Empirically based critical loads for N eutrophication:

Critical loads of nutrient nitrogen for inland and coastal heathland, raised bogs, pastures, sensitive meadows and sensitive (lobelia) lakes have been derived on a 5x5 km national grid. The basis of the assessment has been the registration of nature areas according to section 3 of the Danish Nature Protection Act and the revision of the empirical based critical loads following the Bern workshop. The quality and quantity of the available data does not allow critical loads to be assessed on a plot scale, and a distribution function of critical loads has therefore been assessed for each nature type and applied on a 5x5 km grid. The variation in critical loads for each nature type is caused by differences in biotic conditions, management history, conservation status, and administratively set quality targets for the areas.

Data for dynamic modelling*:*

As a response to the call for data for dynamic modelling, 2003, a Danish dataset has been prepared. A full set of parameters for dynamic modelling only exist for a very limited number of research sites which is too limited to represent the whole country. It has therefore been decided to extend the existing critical load database with a set of extra parameters needed for dynamic modelling of soil acidification. Some of the data already existed because PROFILE has been used for the critical load calculations. The extension has been made for all the points in the Danish critical load database, i.e. 27966 data points. Before the data should be used for policy development under the Convention, it wil be necessary to perform a national validation exercise comparing VSD results based on the generalised input data with results obtained with the SAFE model on locations where better input data is available. Table 3 summarises the transfer functions used in deriving the data.

Table DK-2. Derivation of additional data for dynamic modelling

Thick	soil dependent, national data
Bulk density, rho	1/(0.065 + 0.05 x Corg%), Corg% < 15; 0.759, Corg% > 15
Theta	0.04 x 0.0077 x clay%
CEC	transfer function from mapping manual
BS	transfer function from mapping manual
Cpool	Thick [m] x Corg% x 200000
C/N	transfer function from mapping manual

National deposition maps:

As part of the Danish Nation-wide Background Monitoring Programme, deposition calculations of both NH_Y, NO_X and NH_X to Danish sea and land area are performed on a 30x30 km national grid on a yearly basis. The latest reporting of data from this programme has been in 2002.

Data sources

The main sources of data have not been changed since the 1997 status report. In addition to the existing data sources, a dataset of 1000 points from the Danish grid net for soil data has been included as a basis for deriving and checking transfer functions. The sources and resolution of data are shown in table 3:

Table DK-3: Sources of data

Parameter	Resolution	source
soil mineralogy	60 points	DLD, literature
additional soil data	1000 points	DSG
soil texture	1:500,000	DLD
geological origin	1:500,000	DLD
crop yields	County	DSO
forest production	1:500,000	DLD, DSO
ecosystem cover	25 ha	NERI
deposition (S, N)	30x30 km	NERI
meteorology	1:1,000,000	DMI

DLD: National Institute of Soil Science, dep. of land data
DSG: Danish grid net for soil data.
DSO: Danish Statistical Office
NERI: National Environmental Research Institute
DMI: Danish Meteorological Institute

Comments and conclusions

The main focus of the Danish NFC in the past two years has been

- Further work on methods and data for the calculation of critical loads for nutrient nitrogen for sensitive, natural or seminatural terrestrial ecosystems, primarily raised bogs and heathlands.
- A case study on the accumulation of nitrogen and calculation of a site-specific critical load for a Danish heath.
- Preparation of a new monitoring programme for terrestrial nature in Denmark.
- Estimation of the uncertainties in calculated critical load exceedances with special emphasis on the influence of local scale variation in NH_X deposition.

As indicated, only minor progress has been made in the availability of data for calculating steady state critical loads. The now yearly updated national deposition maps are believed to provide a better basis for calculation of critical load exceedances. In the exceedance calculations, the 30x30 km2 deposition fields are downscaled to 1x1 km resolution for each ecosystem type. The NH_Y deposition values are further modified on the basis of the emission density of NH3 in a circular neighbourhood with a radius of 2,5 km. Furthermore, local variation in deposition within the 1x1 km grid is taken into account in the exceedance calculations. The data needed for dynamic modelling has primarily been derived from the existing datasets through the use of transfer functions, both from the draft mapping manual and derived from national data. The usefulness of the dataset has not yet been sufficiently validated.

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FINLAND

National Focal Center

Maria Holmberg
Martin Forsius
Finnish Environment Institute
P.O.Box 140
FIN-00251 Helsinki, Finland
tel: +358-9-403000
fax: +358-9-4030 0390
email: maria.holmberg@ymparisto.fi

Critical loads

Finland assigns critical loads to forests (240 384 km^2) and lakes (33 231 km^2). The calculation of critical loads for Finnish forest soils follows the methodology of the UNECE Mapping Manual (UBA 1996) and was described in detail by Johansson (1999) and Johansson et al. (2001). For lakes, the methodology was described by Kämäri et al. (1993) and Posch et al. (1993, 1997). Neither the methods nor the input data for the calculation of Finnish critical loads of sulphur and nitrogen have been updated since 2001 and the Finnish data used in the 2004 Status Report corresponds to those reported in 2001. The soils and lakes in Fennoscandia are sensitive to acidification, partly because the minerals weather slowly and have low contents of base cations (Henriksen et al., 1998). Therefore the calculated critical loads are low, compared with values for areas with carbonaceous minerals. Critical loads of acidity are still exceeded in Finland, although the deposition load is lower than in central Europe. Critical loads of nutrient N are exceeded only in the south of the country.

Table FI-1 Summary of Finnish critical loads

Critical loads parameter (units)	EUNIS code	Min. value	Max. value	Data/ Method	Reference	Uncertainty
$CL_{max}(S)$ (eq ha^{-1} a^{-1})	G1 G3 G1 & G3	31 2 0	1887 2561 2561	$= BC^*_{dep} - Cl^*_{dep} + BC_w - BC_u - ANC_{le}(crit)$	Mapping Manual (UBA, 1996)	CV ±30% (Johansson, 1999)
	C1	11	5096		Posch et al. (1993)	
$CL_{min}(N)$ (eq ha^{-1} a^{-1})	G1 G3 G1 & G3	77 74 74	461 267 461	$=N_i + N_u$	Mapping Manual (UBA, 1996)	
	C1	15	211		Posch et al. (1993)	
$CL_{max}(N)$ (eq ha^{-1} a^{-1})	G1 G3 G1 & G3	272 254 254	461 3648 3648	$= CL_{min}(N) + CL_{max}(S) /(1-f_{de})$	Mapping Manual (UBA, 1996)	
	C1	87	19450		Posch et al. (1993)	
$CL_{nut}(N)$ (eq ha^{-1} a^{-1})	G1 G3 G1 & G3	158 147 147	531 337 531	$= N_i + N_u + N_{de} + N_{le}(acc)$	Mapping Manual (UBA, 1996)	
	C1	-	-	not calculated	-	-

$BC^*_{dep} - Cl^*_{dep}$ (eq ha^{-1} a^{-1})	G1	31	263	interpolated from observations in 39 stations 1993-1995	Johansson (1999)	CV ±30% Johansson and Janssen (1994)
	G3	31	263			
	G1 & G3	31	263			
	C1	21	202			
BC^*_u (eq ha^{-1} a^{-1})	G1	6	428	Proportional to tree growth and BC conc. in stem and bark	Johansson (1999)	CV ±37 % (birch) CV ±48 % (spruce) CV ±40 % (pine) Johansson and Janssen (1994)
	G3	4	300			
	G1 & G3	4	428			
	C1	-	-	not calculated	-	
BC_w (eq ha^{-1} a^{-1})	G1	0	859	Zirconium method applied to coarse till fraction	Johansson and Tarvainen (1997)	CV ±24 % Johansson and Janssen (1994)
	G3	0	859			
	G1 & G3	0	859			
	C1	10	4951	pre-acidification estimate		
$ANC_{le}(crit)$ (eq ha^{-1} a^{-1})	G1	30	1247		Mapping Manual (UBA, 1996)	not determined
	G3	50	1662			
	G1 & G3	30	1662			
	C1			criterion set $ANCcrit$= 20μeql-1	Lien et al. (1996)	
N_u (eq ha^{-1} a^{-1})	G1	5	390	proportional to tree growth and N conc. in stem and bark	Johansson (1999)	37 % (birch) 55 % (spruce) 44 % (pine) Johansson and Janssen (1994)
	G3	3	196			
	G1 & G3	3	390			
			186			
	C1	12	186			
N_i (eq ha^{-1} a^{-1})	G1	71	71			
	G3	71	71			
	G1 & G3	71	71			
	C1	71	71			
$N_{le}(acc)$ (eq ha^{-1} a^{-1})	G1	32	103			
	G3	32	103			
	G1 & G3	32	103			
	C1	-	-	not calculated	-	-
N_{de} (eq ha^{-1} a^{-1})	G1	0	21	$= f_{de}(N_{dep} - N_i - N_u)$ $f_{de}=0.1+0.7 fpeat$	Posch et al. (1997)	
	G3	0	79			
	G1 & G3	0	79			
	C1			$fpeat$= 0.02472COD + 0.05105	Henriksen et al. (1993)	

Precipitation surplus Q (mm)	G1 G3 G1 & G3	150 150 150	481 481 481	Digitized runoff map 1961-1975	Leppäjärvi (1987)	CV ±5 % Johansson and Janssen (1994)
	C1	153	518			
KAlox (mol/L)	G1 G3 G1 & G3	108.3 108.3 108.3	108.3 108.3 108.3		Mapping Manual (UBA, 1996)	
	C1	-	-	Not used	-	-

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FRANCE

National Focal Centre

Dr. Anne Probst,
Mr. David Moncoulon,
Laboratoire des Mécanismes de Transferts en Géologie

LMTG/OMP
UMR 5563 CNRS/UPS/IRD
14, avenue Edouard Belin
F-31400 Toulouse
Email : aprobst@lmtg.obs-mip.fr
Email : dmoncou@lmtg.obs-mip.fr

Dr. Jean-Paul Party
Sol-Conseil
251 rte La Wantzenau - Robertsau
F-67000 Strasbourg

Collaborating Institutions

Dr. Laurence Galsomiès,
Dr. Christian Elichegaray
ADEME
Centre de Paris - Vanves
Département Air
27, rue Louis Vicat
F-75737 Paris-Cedex 15

Dr. Erwin Ulrich,
Dr. Luc Croisé
Office National des Forêts
Direction Technique
Département Recherche et Développement
Réseau Renecofor
Boulevard de Constance
F-77300 Fontainebleau

Dr. Louis-Michel Nageleisen
Ministère de l'Agriculture, de l'Alimentation, de la Pêche et des Affaires Rurales (DGFAR)
Département de la Santé des Forêts Antenne Spécialisée
Cenre INRA de Nancy
F-54280 Chamenoux

Dr. Philippe Cambier
Science du Sol
INRA
F-78026 Versailles Cedex

Dr. Anne-Christine Le Gall
Direction des Risques Chroniques
Unité MECO
INERIS BP N°2
F-60550 Verneuil en Halatte

Mr. Marc Rico
Mme Monique Allaux
Ministère de l'Ecologie et du Développement Durable
Bureau de la pollution atmosphérique, des équipements énergétiques et des transports
Direction de la Pollution et de la Prévention des Risques
20, avenue de Ségur
F-75007 Paris

The French ecosystem classification was updated in 2003 for calculation and mapping the critical loads of acidity and nutrient nitrogen (Moncoulon et al., sub.; Probst et al., 2003). In 2004, the French NFC has provided updated calculations of critical loads and input data required for dynamic modelling. Preliminary results on target loads calculation were also sent to the Coordination Center for Effects.

Nevertheless, due to remaining uncertainties on dynamic model simulations, target load data will be improved by the French NFC for the next call for data.

To answer to the 2004 call for data, the French ecosystem database has been updated with new data describing:

- soil parameters from the soil European database (Badeau and Peiffer, 2001) on a 16 km x 16 km grid ;
- past acid deposition data with outputs from (1) the Chimere model (developped by (Vautard et al., 2000) in collaboration with ADEME. Data provided by INERIS) and (2) the EMEP model;
- mineralogy and lithology data on 155 sites (Moncoulon et al., 2003)

The studied area, representing French forest and natural vegetation ecosystems, consists of 180,101 km², i.e. 32% of France total area.

Critical load calculation method

The Steady State Mass Balance (SSMB) model was applied on the soil toplayer (0-20 cm) as described in Posch et al. (1995). The critical loads for sulphur *(Eq. 1),* acid nitrogen *(Eq. 2, 3)* and nutrient nitrogen *(Eq. 4*) were calculated as follows :

$$CL_{max}(S) = BC_{dep} + BC_w – BC_u + ANC_{le}(crit) \qquad (Eq.\ 1)$$

$$CL_{min}(N) = N_i + N_u \qquad (Eq.\ 2)$$

$$CL_{max}(N) = CL_{min}(N) + CL_{max}(S)/(1-F_{de}) \qquad (Eq.\ 3)$$

$$CL_{nut}(N) = N_i + N_u + N_{le}/(1-F_{de}) \qquad (Eq.\ 4)$$

BC_{dep}, BC_w and BC_u are respectively the atmospheric deposition, the weathering rate and the vegetation uptake for base cations. ANC_{le}(crit) is the critical leaching of acid neutralising capacity. N_i, N_u, N_{le} are respectively the immobilisation, uptake and leaching rate of nitrogen. F_{de} is the denitrification factor.

Target Loads calculation method

The objective of the 2004 call for data is the application of dynamic modelling to determine the ecosystem reaction to variation in acid atmospheric deposition.

Among the available dynamic models, VSD model (Posch et al., 2003) has been compared with WITCH model (Godderis et al. in prep) and SAFE model (Sverdrup et al., 1995) on French ecosystems (Probst et al., 2003 ; Moncoulon et al., 2003).

On acid ecosystems (eolian sandy soil, sandstones, schists of Britanny), only acceptable differences appeared between the 2 model outputs. On soils with higher buffering capacity, significant differences appeared between the models.

In order to derive target loads on French ecosystems, VSD model has been calibrated with the SAFE and WITCH model outputs. Initial base saturation has been used for calibration. Since target loads are only calculated on the most sensitive ecosystems, VSD outputs are reasonably consistent with the other models.

Nevertheless, advances in target load calculations will occur in the coming months as improvements of input parameters will be combined with an enhanced calibration of dynamic models with recent field data. The use of a more complete dynamic model (SAFE, WITCH, etc.) that takes into account variations in base cation deposition and in weathering rates during the simulation period would also improve the results.

Denitrification factor

$CL_{max}(N)$ and $CL_{nut}(N)$ equations (eqs. 3 and 4) have been in some way modified since 2003. Initially, the denitrification factor (F_{de}) had not been taken into account in France since this factor was not well known. In the present study, critical load calculation had to be consistent with dynamic model outputs, and for that reason, F_{de} has been integrated in the calculation of the 2004 critical loads (table FR-1). To check the influence of this modification, critical loads calculated in 2003 and 2004 were compared. No significant differences appeared between the 2 sets of data : similar sensitive sites were emphasized and the same range of values were calculated and mapped.

Table FR-1 : Denitrification factor values (adapted from UBA, 2003)

Soil type	**F_{de}**
Non hydromorphic soil	0.05 to 0.2
Hydromorphic silt or sandy soil	0.3
Hydromorphic clay	0.4
Peat soil and marshes	0.5

Base cation uptake

Detailed data are needed for each nutrient cation uptake rate (Ca, Mg and K). Base cation uptake is calculated according to the Mapping Manual (UBA, 1996). Productivity data are calculated from the IFN network database (Inventaire Forestier National, 2002).

Critical acid neutralising capacity leached methodology

In order to improve consistency between critical loads and target loads, critical leached acid neutralising capacity has also been updated. Critical load values using 2003 and 2004 acid neutralising calculation method have been compared. Here also, no significant differences appeared.

Table FR-2 : Critical limit value

Soil and bedrock type	***ANC criteria***	**Critical limit value**
Soft calcareous sediments	Al/BC	1,2
Hard calcareous sediments	Al/BC	1,2
Soft acid sediments		
Sands	pH	4,6
Sandy silex formations	pH	4,6
Others	Al/BC	1,2
Hard acid sediments		
Schists	pH	4,6
Sandstones	pH	4,6
Others	Al/BC	1,2
Metamorphic rocks		
Acid granit	pH	4,6
Others	Al/BC	1,2
Volcanic rocks	Al/BC	1,2

Deposition data

Cation and chloride deposition

BCdep (base cation deposition) and Cldep (chloride deposition) were determined using French National Forest Office data on a 10 km x 10 km grid (CROISE et al., 2002). Deposition data were sea-salt corrected assuming that 100% of Na deposition was originating from sea-salts. To mitigate the lack of throughfall data at the national scale (ULRICH et al., 1998), a coefficient was applied to open field data to derive total deposition to forest soils.

No past deposition data for base cation are available from EMEP model. Since base cation deposition increases with acid deposition, this bufferring capacity should be taken into account. In the VSD model, base cation deposition is considered constant during the simulation. Since base cation deposition increases with acid deposition, this buffering capacity should be taken into account. Results would be improved if historical base cation deposition data were available. Such data will hopefully be made available by EMEP in the future.

Sulphur and nitrogen deposition

Past depositions

The past open field deposition for sulphur and nitrogen have been provided by the EMEP model outputs between 1880 and 2010 at a 5 years time step. Nevertheless, for exeedance calculations and consistency with critical loads, it would be necessary to take into account throughfall deposition data.

2010 Gothenburg protocol depositions

The Gothenburg protocol imposes 2010 as the year from which emissions ceilings must be respected. The sulphur and nitrogen deposition values for that year have been calculated with the CHIMERE model by INERIS, according to two emission scenarii:

- the Current Legislation (CLE);
- the Maximum Feasible Reduction (MFR)

Other deposition data for 2010 (also corresponding to the Gothenburg protocol) were provided by the RIVM. They originate the EMEP model outputs on 50 km x 50 km EMEP grid. These values differ from both CLE and MFR CHIMERE model outputs. Finally, the EMEP model outputs were used as a reference since this allowed for a greater consistency with the past deposition data.

Ecosystem input data for dynamic modelling

Data for soil parameters are needed to build the input data file for dynamic models application. Therefore, the European Database and the Renecofor Network data are used to describe the following parameters (table FR-3) for each of the 31 soil types of the ecosystem database :

- soil bulk density;
- cation exchange capacity;
- base saturation on soil complex;
- amount of carbon in the top soil;
- carbon / nitrogen ratio.

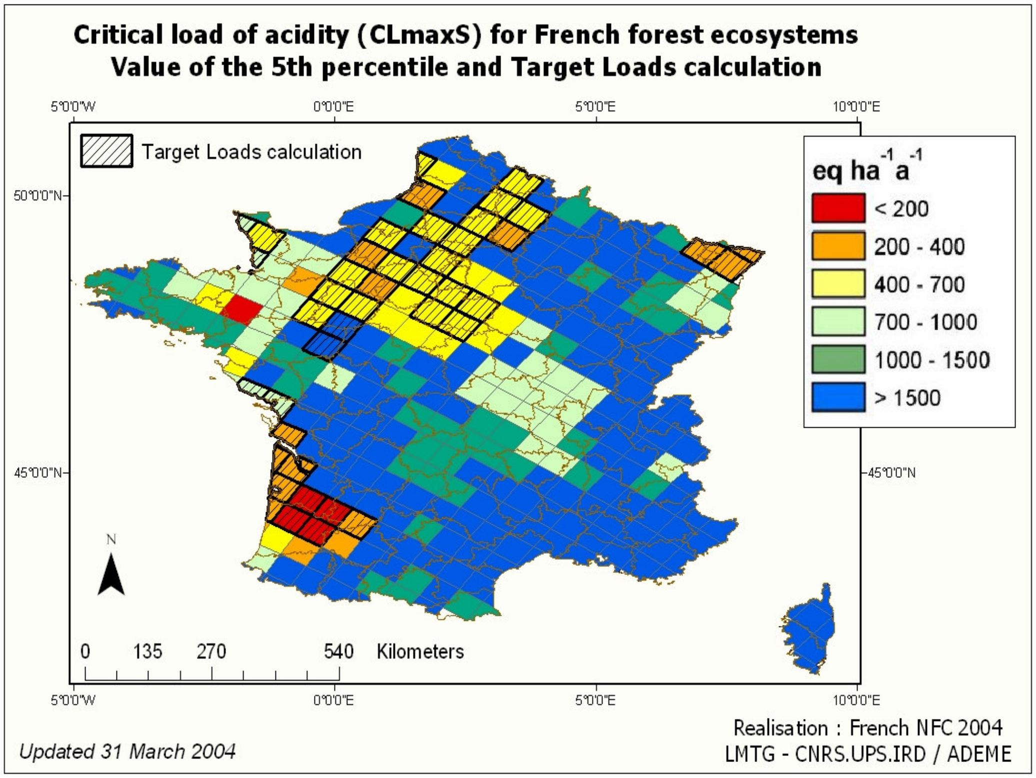
Table FR-3 : Soil parameters

	Units	Min	Max	Median
Bulk density	$g.cm^{-3}$	0.732	1.4	0.915
Conc. Org. Acids	$eq.m^{-3}$	0	0.02436	3.5×10^{-5}
CEC	$meq.kg^{-1}$	1	38	20
Base saturation	-	0.12	1	0.78
Carbon	$g.m^{-2}$	3920	14000	9878
C/N		12	28	15

The total concentration of organic acids in soil solution is calculated from DOC (Dissolved Organic Carbon) which is estimated from pH and clay content in soil layer. To be consistent with critical load calculations, only one soil layer (the toplayer) must be taken into account to compute target loads. Therefore all French soils were assumed to consist of a single soil layer. For French forest soils, the first 20 centimeters were considered as the receptor for Target Loads (which is consistent with Critical Loads methodology). Due to the lack of knowledge on pCO2 factor, only one value (5 atm.) was considered for pCO2 in the topsoil (first 20 cm).

Exceedance area determination

To determine the exceedance areas, S and N deposition data (1880 to 2010) were compared to critical loads for nitrogen and sulphur. The first step was to determine areas where critical loads were exceeded in the past (i.e. at any time between 1880 and 2010). All sensitive ecosystems have been exeeded during this period. Only calcareous ecosystems have always been safe. At the national scale, the areas where exeedance will still occur in 2010 or where ANC will still exceed critical limit in the target year are presented in the following map (fig.FR-1). On these sites, target loads have been thus calculated. These sites are the eolian sands of the Landes, schists of Normandy, acid sands in the center part of France and sandstones in the Vosges mountains.


Critical load of acidity (CLmaxS) for French forest ecosystems
Value of the 5th percentile and Target Loads calculation

Updated 31 March 2004

Realisation : French NFC 2004
LMTG - CNRS.UPS.IRD / ADEME

Figure.FR-1 : critical load of acidity (ClmaxS) for French forest ecosystems. Value of the 5th percentile and Target Loads calculation

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GERMANY

National Focal Centre

OEKO-DATA
Hans-Dieter Nagel
Hegermuehlenstr. 58
D-15344 Strausberg
tel.: +49-3341-3901921
fax: +49-3341-3901926
email: hans.dieter.nagel@oekodata.com

Calculation methods for critical loads of acidity and nutrient nitrogen an for dynamic modelling

The German NFC provides an update of the national critical load data (steady-state mass balance approach) as well as all basis data for the applications of the dynamic model VSD for Europe. Critical loads are calculated in accordance to the methods described in the Mapping Manual (UBA, 1996; updated version 2004). The German critical load database consists of 423 526 records, a detailed description of the data and the methods for derivation is given in table DE-1.
About 30 % of the area of Germany are covered by forests and other (semi-)natural vegetation for which critical loads of acidity and nutrient nitrogen are computed (table DE-2).

Table DE-1: National critical load database and calculation methods / approaches

Parameter	Term	Unit	Description
Critical load of acidity	CLmaxS	eq ha^{-1} a^{-1}	Manual, equation 5.22
	CLminN	eq ha^{-1} a^{-1}	Manual, equation 5.25
	CLmaxN	eq ha^{-1} a^{-1}	Manual, equation 5.26
Critical load of nutrient nitrogen	CLnutN	eq ha^{-1} a^{-1}	Manual, equation 5.5
Acid neutralisation capacity leaching	nANC(crit)	eq ha^{-1} a^{-1}	Manual, the minimum value of the following approaches using different chemical criteria was taken for the calculation (see crittype in the call for data): -1 equation 5.34 3 equation 5.31, base saturation limited in connection to equation 5.37 (adapted, see Table DE-3) 5 equation 5.36 7 equation 5.31
Acceptable nitrogen leaching	Nle(acc)	eq ha^{-1} a^{-1}	Manual, equation 5.6*; [N]crit* = 0,0143 eq m^{-3}
Thickness of the soil layer	thick	m	Actually rooted zone, depending on vegetation and soil type
Bulk density of the soil	bulkdens	g cm^{-3}	German general soil map (BUEK 1000), Hartwich et al. (1995)
Bc and Cl deposition	Cadep, Mgdep, Kdep, Nadep, Cldep	eq ha^{-1} a^{-1}	National deposition data, Gauger et al. (2003)
Weathering of base cations	Cawe; Mgwe and Kwe = 0	eq ha^{-1} a^{-1}	Manual, equation 5.39
Weathering of Na	Nawe	eq ha^{-1} a^{-1}	Manual, table 5.12-5.14, adapted
Uptake of base cations by vegetation	Caupt; Mgupt and Kupt	eq ha^{-1} a^{-1}	Manual, equation 5.8 (without branches) Manual, table 5.8 for element contents
Amount of water percolating through the root zone	Qle	mm a^{-1}	German climate atlas (2002)

Parameter	**Term**	**Unit**	**Description**
Gibbsite equilibrium constant	lgKAlox (Kgibb)	(m^6 eq^{-2})	8 (300)
Partial CO2-pressure in soil solution in relation to the atmospheric CO2 pressure	pCO2fac		Manual, equation 5.44
Total concentration of organic acids	cOrgacids	eq m^{-3}	DOC: de Vries & Bakker (1998), page 99, equation 87
Nitrogen immobilisation	Nimm	eq ha^{-1} a^{-1}	Temperature dependent, see CCE-Status Report 2001, page 142, table DE-7
Nitrogen uptake by vegetation	Nupt	eq ha^{-1} a^{-1}	Manual, equation 5.8 (without branch) Manual, table 5.8 for element contents
Denitrification factor	fde	-	Depending on clay content and soil type, see CCE-Status Report 2001, page 142, table DE-8
Cation exchange capacitiy	CEC	meq kg^{-1}	Bodenkundliche Kartieranleitung (1994)
Base saturation	bsat		Based on Level I forest soil inventory in Germany
Exchange constant for Al vs. Bc	lgKAlBc		Gaines-Thomas, based on Manual
Exchange constant for Al vs. H	lgKAlH		Gaines-Thomas, based on Manual
Initial amount of carbon in the topsoil	Cpool	g m^{-2}	Based on Level I forest soil inventory in Germany
C/N ratio in the topsoil	CNrat		Based on Level I forest soil inventory
Deposition of S in 2010	Sdep2010	eq ha^{-1} a^{-1}	Schöpp et al. (2003)
Deposition of NOx in 2010	NOxdep2010	eq ha^{-1} a^{-1}	Schöpp et al. (2003)
Deposition of NH3 in 2010	NH3dep2010	eq ha^{-1} a^{-1}	Schöpp et al. (2003)
EUNIS code	EUNIScode		Schlutow (2004)

Most of the data are based on soil properties described for the reference profiles of the units of the General Soil Map of Germany (BUEK 1000).

Climate data were provided by German Weather Services. Both the annual precipitation and temperature are 30 year means (1971 – 2000).

Table DE-2: Ecosystem types (EUNIS Code) used as receptors for the calculation of critical loads

EUNIS Code	Area km²	Percentage of area Germany	Percentage of receptor area
A2.561	13,50	0,004	0,013
A2.63B	23,25	0,007	0,022
B1.71	129,00	0,036	0,122
B1.72	10,00	0,003	0,009
B2.51	0,25	0,000	0,000
C3.25	31,50	0,009	0,030
C3.26	6,00	0,002	0,006
D2.22	14,75	0,004	0,014
D2.31	6,75	0,002	0,006
D2.32	281,00	0,079	0,265
D2.3D	9,25	0,003	0,009
D4.1G	35,00	0,010	0,033
D4.1H	125,00	0,035	0,118
D5.11	20,75	0,006	0,020
D5.21	272,25	0,076	0,257
D5.3	640,00	0,179	0,604
D6.16	6,75	0,002	0,006
E1.23	2,00	0,001	0,002
E1.26	97,00	0,027	0,092
E1.27	86,75	0,024	0,082
E1.28	23,75	0,007	0,022
E1.72	504,50	0,141	0,476
E1.93	21,75	0,006	0,021
E2.22	208,00	0,058	0,196
E2.23	259,25	0,073	0,245
E2.25	6,25	0,002	0,006
E3.41	159,25	0,045	0,150
E3.43	61,50	0,017	0,058
E3.44	22,00	0,006	0,021
E3.51	9,50	0,003	0,009
E3.52	79,75	0,022	0,075
E4.41	97,25	0,027	0,092
E4.43	63,75	0,018	0,060
E4.51	121,00	0,034	0,114
F2.41	3,75	0,001	0,004
F4.11	33,00	0,009	0,031
F4.21	94,50	0,026	0,089
F4.22	202,50	0,057	0,191
F4.261	12,50	0,004	0,012
F4.262	337,50	0,095	0,319
F9.2	6,25	0,002	0,006
G1.221	1.080,00	0,302	1,020
G1.41	2.341,50	0,656	2,211
G1.43	24,75	0,007	0,023
G1.51	327,50	0,092	0,309
G1.61	8.832,50	2,474	8,341
G1.63	10.643,25	2,981	10,051
G1.65	1.400,00	0,392	1,322
G1.66	5.456,00	1,528	5,153
G1.87	5.618,00	1,574	5,306
G1.91	10.665,75	2,987	10,073
G1A.16	10.018,25	2,806	9,461
G3.1B	26,25	0,007	0,025
G3.1C	10.398,75	2,913	9,821
G3.1D	3.119,25	0,874	2,946
G3.1F	787,00	0,220	0,743
G3.42	7.896,75	2,212	7,458
G3.E2	447,50	0,125	0,423
G4.1	358,00	0,100	0,338
G4.4	1.056,75	0,296	0,998
G4.5	46,50	0,013	0,044
G4.6	15.234,50	4,267	14,387
G4.71	2.100,25	0,588	1,983
G4.8	3.864,25	1,082	3,649
total	**105.881,50**	**29,66**	**100,00**

Table DE-3: Buffer substance systems and their lowest acceptable base saturation

Buffer substance system	**lowest acceptable pH**	**lowest acceptable base saturation (BS)**	**BUEK-unit Legend-No.**
Carbonat-Buffer (CaCO3)	6,2	83	2, 3, 4, 5, 54, 68, 69
Silicate-Buffer (primary silicates)	5,0	56	8, 9, 11, 12, 13, 14, 15, 21, 22, 29, 35, 36, 37, 38, 39, 40, 41, 44, 47, 48, 49
Exchange-Buffer (Clayminerales)	4,5	43	18, 24, 42, 45, 46, 50, 51, 52, 53
Mangan-Oxides/ Clayminerales	4,2	34	10, 19, 23, 26, 28, 43
Aluminium-Buffer (n [Al(OH)x(3-x)+], Aluminium-Hydroxosulfates)	4,0	30	65, 66, 67, 70
Aluminium-Iron-Buffer (like Aluminium-Buffer, „soil-Fe(OH)3“)	3,8	20	1, 6, 7, 16, 17, 20, 25, 27, 30, 31, 32, 55, 56, 58, 64
Iron-Buffer (Ironhydrit)	3,2	5	33, 34, 57, 59, 60, 61, 62, 63, 71

(Ulrich 1985, adapted)

The pH in soil solution in the regarded soil should not reach values below the lowest acceptable value of the range of the recent buffer system in a long time perspective. The pH can be directly transformed into base saturation (BS) values (AG Bodenkunde, 1994).

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HUNGARY

National Focal Centre

Miklós Dombos, Zsófia Bakacsi, László Pásztor
Research Institute for Soil Science and Agricultural Chemistry of Hungarian Academy of Sciences
Herman Ottó utca 15.
1022 Budapest
tel:+36-1-3564682
fax:+36-1-3564682
email: dombos@rissac.hu

Collaborating Institutes

Miklós Manninger
Hungarian Research Institute for Forestry

Introduction

Critical load data have been updated for the Hungarian forest ecosystems in 2003. Critical loads of acidity for forests ecosystems were calculated using dynamic modeling and SMB approach, implemented in the VSD and MAKEDEP models. Critical load functions and dynamic modeling parameters were calculated according to the Mapping Manual revised in 2003, Dynamic Modeling Manual and further literature sources.

Mapping Forest Habitats

The provided database has been derived from the AGROTOPO soil database and the CORINE Land Cover database linked to additional information on the spatial distribution of Hungarian forests. The AGROTOPO database was split into 2740 polygons including all types of forests and providing the spatial distribution of the dominant and subdominant tree species.

Data Sources

The AGROTOPO soil database has been used to derive most of the soil physical and chemical parameters for each polygon. Most of the dynamic modeling input parameters derived from AGROTOPO database have categorical values thus these values had to recalculate by using mean values or to fit to other databases, such as the Hungarian Soil Monitoring Database (TIM) or soil data on ICP Forest Sites. Data about biomass, growth, nutrient content and base cation deposition have been collected from the ICP Hungarian Forest Sites database (Table HU–1.)

Derivation of input parameters

Base cation deposition: Wet and dry deposition data from 14 ICP Forest Sites have been interpolated according to the spatial distribution models of other air pollutant elements.
Weathering of base cations: Base cation weathering rates were calculated according to the method used in Mapping Manual (p.16. Eq 5.39). However, the amount of the weathering of the individual elements has not been calculated.

$$BC_w = z \cdot 500 \cdot (WRc - 0.5) \cdot \exp\left(\frac{A}{281} - \frac{A}{273+T}\right)$$

Wrc value for calcareous soils has been set to 20 that affected strongly the crtical load values of acidity increasing the values ca. one order of magnitude.

Base cations and nitrogen uptake: The method used in the Mapping Manual has been used, but also dynamic modeling of uptake values have been estimated by using MAKEDEP on data of ICP Forest Sites.Nu : Mapping Manual – p.5. eq. 5.7.

$$N_u = \frac{N : removed \cdot in \cdot harvested \cdot biomass(eq/ha)}{rotation \cdot period(year)}$$

Nutrient content, growth rate values have been collected from ICP Forests Sites. Spatial distribution has been derived according to the dominant tree species (AGROTOPO Forests database).
Bulk density: Measured data in TIM database, spatial distribution according to the Hungarian soil classification categories in AGROTOPO Soil Database.
Thickness: Direct data in AGROTOPO Soil Database.
Equilibrium constant for the Al-H relationship and its exponent: According to Van der Salm and De Vries (2001).

$$[Al] = K_{Alox} \cdot [H]^a$$

Soil type	**Depth (cm)**	log10 *KAlox*a)	*a*	*N*
All	humus layer	-1.03	1.17	275
Sandy soils	0–10	3.54	2.26	274
	10–30	5.59	2.68	377
	30–100	7.88	3.13	271
Loess soils	0–10	-0.38	1.04	45
	10–30	3.14	1.83	46
	30–100	4.97	2.21	40
Clay	all depths	4.68	2.15	152
Peat	all depths	1.41	1.85	163

Cation exchange capacity: CEC 30 measured data on TIM sites in each soil type. Spatial derivation according to soil types in AGROTOPO Soil Database. CEC has also been estimated according to Modeling Manual p. 41. eq.5.2., however correlation between derived and measured CEC values was weak.
Base saturation: According to the Modelling Manual p.4.1 Table 5. This is a simple derivation to the soil texture classes.
Exchange constants: According to the Dynamic Modelling Manual p. 45 Table 9. and p.44. Table8. Estimation of these parameters on the basis of measurements in Hungarian soils has been started.
C to N ratio: Dynamic Modelling Manual - version 0.95 p. 47. eq.5.6.

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Table HU-1. Summary of the Hungarian Critical Load values and the parameters used in dynamic modelling in 2003.

Parameters	Minimum	Lower Quartile	Median	Upper Quartile	Maximum	Data Sources Methods
Maximum critical load of sulphur CLmaxS (eq ha^{-1} a^{-1})	872	4819	8826	35506	41827	
Minimum critical load of nitrogen CLminN (eq ha^{-1} a^{-1})	180	599	776	810	900	
Maximum critical load of nitrogen CLmaxN (eq ha^{-1} a^{-1})	1929	8923	42891	59953	258550	
Critical load of nutrient nitrogen CLnutN (eq ha^{-1} a^{-1})	198	656	827	847	1120	
nANCcrit (eq ha^{-1} a^{-1})	309	2635	5287	21278	25261	
Acceptable nitrogen leaching Nleacc (eq ha^{-1} a^{-1})	14.3	22	22	22	22	Mapping Manual - 5. 5.3.1.2. p.4. Table 5-1.
Thickness of the soil thick (m)	0.1	0.5	0.5	0.5	0.5	AGROTOPO Soil Database
Average bulk density of the soil bulkdens (g cm^{-3})	0.49	1.372	1.4435	1.462	1.535	AGROTOPO Soil Database
Total deposition of Base Cations Cadep (eq ha^{-1} a^{-1})	290	355	402	432	640	Values from 14 Hungarian ICP Forest Sites, spatial derivation according to other elements (EMEP)
Mgdep (eq ha^{-1} a^{-1})	115	140	159	171	253	
Kdep (eq ha^{-1} a^{-1})	68	83	94	101	150	
Nadep (eq ha^{-1} a^{-1})	306	374	423	455	675	
Cldep (eq ha^{-1} a^{-1})	114	139	157	169	250	
Weathering of Base Cations Bcwe (eq ha^{-1} a^{-1})	77	2148	3376	14425	15652	Mapping Manual - 5. p.16. Eq 5.39
Net growth uptake of calcium Caupt (eq ha^{-1} a^{-1})	190	550	830	900	1000	Mapping Manual - 5. 5.3.2. and MAKEDEP Nutrient content, growth rate values from ICP Forests Sites, Spatial derivation according to the dominant tree species (AGROTOPO Forests database)
Net growth uptake of magnesium Mgupt (eq ha^{-1} a^{-1})	13.4	16.4	18.5	26.7	37.4	

Net growth uptake of potassium Kupt (eq ha^{-1} a^{-1})	30.2	36.9	41.6	60.2	84.2	
Qle Percolation	100	200	200	200	300	
Equilibrium constant for the Al-H relationship lgKAlox	1.41	4.68	4.97	4.97	5.59	Van der Salm and De Vries (2001)
Exponent for the Al-H relationship expAl	1.83	1.83	1.83	2.15	2.68	
Partial CO_2-pressure in soil solution pCO2fac	30					
Total concentration of organic acids cOrgacids (eq m_{-3})	0.2					
Acceptable amount of nitrogen immobilised in the soil Nimacc	60					
Net growth uptake of nitrogen Nupt (eq ha^{-1} a^{-1})	120	539	716.5	750	840	Mapping Manual - 5. 5.3.1.3. and MAKEDEP Nutrient content, growth rate values from ICP Forests Sites, Spatial derivation according to the dominant tree species (AGROTOPO Forests database)
Denitrification fraction fde	0.2	0.4	0.4	0.8	0.9	Modelling Manual p. 39. Table 3.
Cation exchange capacity CEC (meq kg^{-1})	18	82	145.4	267	414.48	Measured Data on 30 Soil Monitoring Sites, spatial derivation from AGROTOPO database
Base saturation	0.1	0.25	0.25	0.75	0.9	. Modelling Manual p.4.1 Table 5.
Exchange constant for Al vs Bc (log10) lgKAlBc	0.39	0.876	0.876	0.876	2.306	Dynamic Modelling Manual p. 45 Table 9
Exchange constant for H vs Bc (log10) lgKHBc	5.39	5.541	5.541	6.204	7.185	Dynamic Modelling Manual p.44. Table8.
Initial amount of carbon in the topsoil Cpool (g m^{-2})	600	1200	1800	3080	5700	AGROTOPO
C/N ratio in the topsoil CNrat	18	18	25	29	29	Dynamic Modelling Manual - version 0.95 p. 47. eq.5.6.

ITALY

National Focal Centre

Mara Angeloni
Ministry for the Environment
Via Cristoforo Colombo
I- 00147 Rome
tel: + 39-6-5722 8113
angeloni.mara@minambiente.it

Collaborating institutions

Patrizia Bonanni, Valerio Silli
APAT (National Agency for the Environmental Protection and Technical Services)
Via Vitaliano Brancati, 48
I- 00144 Rome
Tel: +39-6-5007 2800 (Patrizia Bonanni)
+39-6-5007 2801 (Valerio Silli)
Fax: +39-6-5007 2986
bonanni@apat.it; silli@apat.it

Roberto Daffinà
APAT Consultant
Via Vitaliano Brancati, 48
I- 00144 Rome
Tel: +39-6-5007 2962
Fax: +39-6-5007 2986
daffina@apat.it

Armando Buffoni
APAT Consultant
Via Pergolesi 2
20124 Milano
Tel/fax 02 66713184
ab-mi@libero.it

Calculation Methods

The methodology adopted in calculating Critical Loads of acidity and nutrient nitrogen have been previously described in the 1999 Status Report, excepted for the critical load of acidity, CL(A), now calculated by SMB methodology as suggested by the Mapping Manual (UBA, 1996):

$$CL(A) = ANC_w + ANC_{l(crit)}$$

where

$$ANC_{l(crit)} = \left(\mathrm{(Al/BC)c} \cdot \frac{\mathrm{Xbc} \cdot ANC_w + BC_{dep} - BC_u - \mathrm{BCle(min)}}{K_{gibb}} \right)^{1/3} \cdot Q^{2/3}$$

$$+ \mathrm{(Al/BC)c} \cdot \left(\mathrm{Xbc} \cdot ANC_w + BC_{dep} - BC_u - \mathrm{BCle(min)} \right)$$

Table IT-1.

Critical loads parameters / units	Ecosystem	Min value	Med value	Max value	Data sources/Methods used	Justification
Cl_{max} (S) (eq $ha^{-1}yr^{-1}$)	E1	1668	21857	24641	$= CL(A)+BC_d-BC_u$	Mapping manual
	E4	1837	21589	25673		
	G2	2790	21652	24378		
	G3	850	5596	24337		
	G4	1205	20085	23414		
Cl_{min} (N) (eq $ha^{-1}yr^{-1}$)	E1	88	166	210	$= N_u+N_{icrit}$	Mapping manual
	E4	186	243	279		
	G2	419	636	979		
	G3	350	493	650		
	G4	714	715	715		
Cl_{max} (N) (eq $ha^{-1}yr^{-1}$)	E1	1800	21988	24817	$= CL_{min}(N)+CL_{max}(S)$	Mapping manual
	E4	2095	21825	25909		
	G2	3311	22239	25006		
	G3	1429	5975	24687		
	G4	1920	20800	24129		
Cl_{nut} (N) (eq $ha^{-1}yr^{-1}$)	E1	309	375	434	$= N_i+N_u+[N_{le} / (1\text{-}fde)]$	Mapping manual
	E4	279	296	393		
	G2	370	479	659		
	G3	568	786	843		
	G4	1000	1035	1108		
nANCcrit (eq $ha^{-1}yr^{-1}$)	E1	987	12091	13776	Mapping Manual	UBA (1996)
	E4	10941	11919	14440		
	G2	629	11936	13586		
	G3	511	3337	13688		
	G4	680	11004	12990		
Nleacc (eq $ha^{-1}yr^{-1}$)	E1	71	71	179	Based on Runoff values (see table1)	Bonanni et al. (2001)
	E4	7	7	107		
	G2	35	35	45		
	G3	71	143	286		
	G4	71	71	179		
Crittype	E1	1			According to the SMB methodology	
	E4					
	G2					
	G3					
	G4					
Critvalue	E1	1			According to the SMB methodology	
	E4					
	G2					
	G3					
	G4					
Thick (m)	E1	0.5			Default suggested value	
	E4					
	G2					
	G3					
	G4					
Bulkdens (g cm^{-3})	E1	0.81	0.82	0.84	0.825-0.037*log(2*Corg)	Manual for Dynamic modelling of soil response to atmospheric deposition
	E4					
	G2					
	G3					
	G4					
Ca_u (eq $ha^{-1}yr^{-1}$)	E1	42			Calculated by Italian experts	Hetteling et al. (1991) Based on average volume increment x basic wood density x concentration in wood (Bonanni et al., 2001
	E4	76				
	G2	100				
	G3	223				
	G4	417				
Mgu (eq $ha^{-1}yr-^{1}$)	E1	18			Calculated by Italian experts	Hetteling et al. (1991) Based on average volume increment x basic wood density x concentration in wood (Bonanni et al., 2001)
	E4	27				
	G2	53				
	G3	81				
	G4	173				
Ku (eq $ha^{-1}yr-^{1}$)	E1	15			Calculated by Italian experts	Hetteling et al. (1991) Based on average volume increment x basic wood density x concentration in wood (Bonanni et al., 2001)
	E4	26				
	G2	47				
	G3	72				
	G4	149				
Ca_{dep} (eq $ha^{-1}yr-^{1}$)	E1	384	705	1184	Calculated by the following expression:	-Italian Network for the assesment of atmospheric
	E4	523	718	1006		
	G2	274	717	1259		

	G3 G4	469 343	670 711	1259 1259	$BC_{dep} = \begin{cases} 2 * BC_{wet} & , se\ BC_{wet} < 250 \\ 250 + BC_{wet} & , se\ BC_{wet} \geq 250 \end{cases}$ Where BC_{dep} and BC_{wet} is the wet deposition	depositions. -UBA, 1996 -Downing et al., 1993. Annex II
Mg_{dep} (eq ha-1yr-1)	E1 E4 G2 G3 G4	140 151 80 146 124	305 261 350 263 333	482 410 494 494 494	Calculated by the following expression: $BC_{dep} = \begin{cases} 2 * BC_{wet} & , se\ BC_{wet} < 250 \\ 250 + BC_{wet} & , se\ BC_{wet} \geq 250 \end{cases}$ Where BC_{dep} is the total deposition (dry and wet) and BC_{wet} is the wet deposition	-Italian Network for the assesment of atmospheric depositions. -UBA, 1996 -Downing et al., 1993. Annex II
K_{dep} (eq ha^{-1}yr^{-1})	E1 E4 G2 G3 G4	40 50 20 38 30	83 79 90 76 89	214 158 228 228 228	Calculated by the following expression: $BC_{dep} = \begin{cases} 2 * BC_{wet} & , se\ BC_{wet} < 250 \\ 250 + BC_{wet} & , se\ BC_{wet} \geq 250 \end{cases}$ Where BC_{dep} is the total deposition (dry and wet) and BC_{wet} is the wet deposition	-Italian Network for the assesment of atmospheric depositions. -UBA, 1996 -Downing et al., 1993. Annex II
Cl_{dep} (eq ha-1yr-^{1})	E1 E4 G2 G3 G4	113 129 105 114 129	446 238 568 256 456	1405 1007 1498 1498 1498	Calculated by the following expression: $BC_{dep} = \begin{cases} 2 * BC_{wet} & , se\ BC_{wet} < 250 \\ 250 + BC_{wet} & , se\ BC_{wet} \geq 250 \end{cases}$ Where BC_{dep} and BC_{wet} is the wet deposition	-Italian Network for the assesment of atmospheric depositions. -UBA, 1996 -Downing et al., 1993. Annex II
Ca_{we} (eq ha^{-1}yr^{-1})	E1 E4 G2 G3 G4	67 239 477 87 296	2932 2126 3263 2533 3120	4584 3090 4641 5152 4838	By suggestions reported in the *Mapping Vademecum* is possible to create correspondences between basic cations leaching rate and soil type. **NB: in soils with very high BC weathering it is considered the default mean value 8896**	-Soil Map of the European Communities (ECE, 1985) -Chart of average temperature assessed in Italy - Van der Salm et al, 1998 -Hettelingh and de Vries W., 1990
K_{we} (eq ha^{-1}yr^{-1})	E1 E4 G2 G3 G4	9 108 64 12 185	1586 1267 1771 1292 1586	2454 2322 2322 2322 2322	By suggestions reported in the *Mapping Vademecum* is possible to create correspondences between basic cations leaching rate and soil type. **NB: in soils with very high BC weathering it is considered the default mean value 8896**	-Soil Map of the European Communities (ECE, 1985) -Chart of average temperature assessed in Italy - Van der Salm et al, 1998 -Hettelingh and de Vries W., 1990
Mg_{we} (eq ha^{-1}yr^{-1})	E1 E4 G2 G3 G4	47 92 216 59 92	688 498 801 635 769	2297 1189 2876 2200 2876	By suggestions reported in the *Mapping Vademecum* is possible to create correspondences between basic cations leaching rate and soil type. **NB: in soils with very high BC weathering it is considered the default mean value 8896**	-Soil Map of the European Communities (ECE, 1985) -Chart of average temperature assessed in Italy - Van der Salm et al, 1998 -Hettelingh and de Vries W., 1990
Na_{we} (eq ha^{-1}yr^{-1})	E1 E4 G2	21 129 155	2052 1598 2277	2999 2999 2999	By suggestions reported in the *Mapping Vademecum* is possible to create correspondences between basic cations leaching rate and soil type.	-Soil Map of the European Communities

	G3	28	1659	2999	**NB: in soils with very high BC weathering it is considered the default mean value 8896**	ECE (1985) -Chart of average temperature assessed in Italy - Van der Salm et al, 1998 -Hettelingh and de Vries W., 1990
	G4	177	2046	2999		
Qle (mm yr^{-1})	E1	0	4	934	**=P-E-R** P = precipitation E = evapotranspiration R= surface runoff	Bonanni et al., 2001
	E4	0	188	867		
	G2	5	22	344		
	G3	16	161	1255		
	G4	1	59	783		
lgKAlox	E1	300			Mean default value for soils with poor organic matter	Mapping Manual
	E4					
	G2					
	G3					
	G4					
expAl	E1	3			Default value suggested by CCE	Manual for Dynamic Modelling of Soil Response to Atmospheric Deposition
	E4					
	G2					
	G3					
	G4					
pCO2fac (x atm. press.)	E1	40			By Italian experts based on experimental data	Calculated as average in all ecosystems
	E4					
	G2					
	G3					
	G4					
cOrganics	E1				Not available at the moment	
	E4					
	G2					
	G3					
	G4					
***Nimacc* (eq ha^{-1}yr^{-1})**	E1	53	92	149	**=Ni+Nfire+Nvol-Nfix** where : Ni=N immobilised in soil organic matter with : Nfire= N losses in smoke Nvol= N losses via NH3 volatilisation Nfix= N fixed by biological fixation	Mapping Manual (UBA, 1996)
	E4	129	154	164		
	G2	120	229	400		
	G3	50	136	200		
	G4	71	72	72		
***Nupt* (eq ha^{-1}yr^{-1})**	E1	71	71	71	By Italian experts	Based on average volume increment x basic wood density x concentration in wood (Bonanni et al., 2001)
	E4	107	107	143		
	G2	214	214	214		
	G3	357	429	429		
	G4	714	714	714		
***Nde* (eq ha^{-1}yr^{-1})**	E1	107	143	143	Based on runoff values as table IT-2 shown below	Bonanni et al., 2001
	E4	7	14	14		
	G2	0	0	18		
	G3	35	71	71		
	G4	143	177	179		
Fde	E1	0.4	0.7	0.7	Based on soil type and soil texture	Mapping Manual
	E4	0.1	0.6	0.7		
	G2	0.0	0.0	0.3		
	G3	0.2	0.3	0.3		
	G4	0.4	0.7	0.7		
CEC (meq kg^{-1})	E1	3	17	43	CEC= (0.44* pH+3.0) clay +(5.1 pH –5.9) Corg (Eq. 5.2 M&M Manual)	Manual for Dynamic Modelling of Soil Response to Atmospheric Deposition
	E4	5	17	32		
	G2	3	18	43		
	G3	3	16	45		
	G4	3	18	33		
Bsat	E1	2	21	35	Average value weighted by ecosystem area (Tab.5 Mapping Manual)	Manual for Dynamic Modelling of Soil Response to Atmospheric Deposition
	E4	8	22	32		
	G2	2	25	39		
	G3	2	22	45		
	G4	2	25	44		
YearBsat	E1	1999			--------------	
	E4					
	G2					
	G3					
	G4					
lgKAlBc	E1	0	0.9	2.6	Average value weighted by ecosystem area (Tab. 9 M&M Manual)	Manual for Dynamic Modelling of Soil Response to
	E4	0.2	1.0	2.1		
	G2	0	0.7	2.6		

	G3	0	0.9	2.1		Atmospheric Deposition
	G4	0	0.7	2.0		
lgKHBc	E1	2.1	3.7	5.5	Average value weighted by ecosystem area	Manual for Dynamic Modelling of Soil Response to Atmospheric Deposition
	E4	2.7	3.9	5.1		
	G2	2.5	3.7	5.5		
	G3	2.5	3.8	5.0		
	G4	2.1	3.8	5.0		
Cpool (gm^{-2})	E1	708	2418	6766	10^6*bulkdens*thick (of soil)*Corg/100	Manual for Dynamic Modelling of Soil Response to Atmospheric Deposition
	E4	1266	2603	4021		
	G2	708	2643	6766		
	G3	708	2337	6451		
	G4	708	2530	4021		
CNrat	E1	30			As average value	VSD Help manual
	E4					
	G2					
	G3					
	G4					
YearCN	E1	1999			-----------	
	E4					
	G2					
	G3					
	G4					
S dep 2010	E1	149	247	3820	Provided by CCE (EMEP dep.)	
	E4	178	240	494		
	G2	129	244	3820		
	G3	178	247	3820		
	G4	154	253	3820		
NOx dep 2010	E1	0.1	0.2	0.4	Provided by CCE (EMEP dep.)	
	E4	0.2	0.3	0.4		
	G2	0.1	0.2	0.3		
	G3	0.2	0.3	0.4		
	G4	0.1	0.3	0.4		
NH3 dep 2010	E1	0.1	0.4	2.1	Provided by CCE (EMEP dep.)	
	E4	0.2	0.8	2.1		
	G2	0.1	0.3	0.9		
	G3	0.2	0.7	2.1		
	G4	0.1	0.5	2.1		
TLstatus	E1				Not available yet	
	E4					
	G2					
	G3					
	G4					
EUNIScode	E1				Reclassification of ecosystems carried out by Italian experts	See table.IT-3
	E4					
	G2					
	G3					
	G4					

Table IT-2- Ranges of runoff and Nle values (eq N ha^{-1} y^{-1})

Q (runoff) (mm)	**Ecosystems**					
	Tundra	**Boreal for.**	**Temper. Con.f.**	**Temper. Dec.f.**	**Medit. for.**	**Acid Grassland**
EUNIS	**E4**	**G3**	**G3**	**G4**	**G2**	**E1**
(0 - 300]	7	143	71	71	36	71
(300 - 600]	54	179	125	125	45	107
(600 - 900]	107	214	179	179		143
(900 - 1100]		250				179
(1100 - 1300]		286				

Table IT-3 - Preliminary reclassification in 1-level EUNIS codes

ECOSYSTEM TYPE	EUNIS CODE
MEDITERRANEAN FOREST	G2
ACID GRASSLAND	E1
TUNDRA	E4
BOREAL FOREST	G3
TEMPERATE CONIFEROUS	G3
TEMPERATE DECIDUE	G4

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NETHERLANDS

National Focal Centre

Arjen van Hinsberg
National Institute for Public Health and the Environment (RIVM)
P.O. Box 1
NL-3720 BA Bilthoven
Tel: +31-30-2743062
Fax: +31-30-2744419
E-mail: arjen.hinsberg@rivm.nl

Collaborating Institutions

Gert Jan Reinds, Hans Kros, Wim de Vries
Alterra Green World Research
P.O. Box 47
6700 AA Wageningen
Tel: +31-317 474697
Fax: + 31- 317 419000
E-mail: gertjan.reinds@wur.nl

Calculation Methods

Critical loads

Since 2001 , critical loads were submitted for protection of:

1. Ground water quality, protecting against contamination by nitrate (critical N load) and Al (critical acid load)
2. Forests (soils) against nutrient unbalance due to elevated foliar N contents (critical N load) and against root damage due to elevated Al/Bc ratios or soil quality deterioration by requiring no changes in pH (or base saturation) and/or readily available Al (critical acid load).
3. Plant species composition in terrestrial ecosystems against eutrophication (critical N load) and acidification (critical acid load).
4. Plant species composition in fens against eutrophication (critical N load).

These concepts were derived in the evaluation of the Dutch acid rain abatement strategies (Albers et al., 2001).

This year, critical acid loads were only submitted for protection of forests (using both the Al/Bc criterion and by requiring no changes in pH or base saturation), and plant species composition. Moreover, nutrient nitrogen critical loads were submitted only for plant species composition. Critical loads for groundwater protection were not submitted anymore as they were (almost) always much higher than all the other critical loads. For the same reason the critical nutrient N loads for forests related to nutrient unbalances were also left out of the critical load database. Calculation methods have been described in last years progress report (Van Hinsberg and de Vries, 2003).

Target loads

The target loads for protection of forest soils were computed with the VSD model using a critical Al/Bc criterion. Target loads for protection of plant species composition in terrestrial ecosystems were computed with the SMART2 model using a combined pH and N availability criterion that originates from the MOVE model (Van Hinsberg and Kros, 2001).

Both VSD and SMART2 were calibrated, starting simulations in 1880 and adjusting exchange parameters such that base saturation in 1995 was correctly simulated. Base saturation in 1995 was assigned to each gridcell using a transfer function with soil type, vegetation type and ground water regime. For VSD also the C/N ratio and the carbon pool were back-calculated whereas for SMART2 calibration on the amount of litter was performed by adjusting, within defined limits, litterfall rate and/or mineralization constant.

The target loads computed with VSD were compared to critical loads based on the Al/Bc criterion and to those based on the concept of requiring no changes in pH or base saturation (a criterion for which no meaningful target loads can be computed). The minimum of the three functions was submitted. This means that sometimes the target load for Al/Bc is submitted although the critical load for constant pH is lower than the critical load for Al/Bc: for such cells obtaining a certain Al/Bc ratio in a specific year simply requires more deposition reduction that aiming at no pH change on an infinite time scale.

Target loads for plant species composition were computed with SMART2 using critical limits for both pH and N availability (Van Hinsberg and Kros, 2001). These critical limits stem from the MOVE model and are defined for about 120 different nature targets in the Netherlands. Nature targets were assigned to combinations of soil/vegetation/groundwater-regime/geographical area. Computed target load functions were compared to critical loads derived with a statistical model based on SMART2/MOVE results (Van Hinsberg and Kros, 2001). The minimum of the two functions was submitted. For gridcells where the statistical model did not yield a meaningful critical load, empirical critical loads were used (Van Hinsberg and Kros, 2001), and no target load function was submitted.

The percentage of ecosystems for which target loads are infeasible is relatively high (22%). Most problems arise in some grasslandtypes and bogs. Here the models indicate that the current deposition levels result in both an increased nitrogen availability and decreased soil-pH, unsuitable for the disired plant species composition. Although field data shows that these nature types have indeed suffered much from air pollution and experiments have shown that regeneration of such acidified and/or eutrified ecosystems often needs additional measures, modelled data needs also futher checks.

Data derivation

Spatial resolution and distinguished vegetation types and soil types

All critical loads and target loads were calculated for 250×250m grid cells. The specification of the vegetation-soil combination in the 250×250m grid cells were derived from an overlay of the 1:50,000 soil map and a vegetation map based on both satellite observations and several detailed vegetation surveys. Five types of vegetation and sixteen major soil types were distinguished. Regarding vegetation types, we distinguished three groups of tree species (deciduous forests, pine forests and spruce forests), grassland and heathland. Table NL-1 describes the ecosystems for which data were derived.

Table NL- 1 Distinguished vegetation types for which calculations can be carried out

Ecosystem	Key species
Deciduous forest	e.g. *Quercus spec., Betula spec., Fagus spec.* and species from the ground vegetation
Pine forest	e.g. *Pinus sylvestris* and species from the ground vegetation
Spruce forest	e.g. *Pseudotsuga menziesii* and species from the ground vegetation
Grassland (semi-natural)	Several species depending on moisture status (wet – dry), soil acidity (acid – calcareous), and nutrient availability (nutrient poor – nutrient rich)
Heathland (dry, wet and bogs)	Wet Heathlands: e.g. *Erica tetralix*, Dry Heathlands: e.g. *Caluna vulgaris*

Soil types were differentiated in sixteen major groups including two non-calcareous sandy soils and one calcareous sandy soil, three loess soils, four non-calcareous clay soils, a calcareous clay soil and five peat soils (Van der Salm, 1999). All these soil types were further sub- divided in five hydrological classes depending on the seasonal fluctuations of the ground water table. Parameterisation of processes included in both VSD and SMART2 was kept similar.

Derivation of data needed for critical load calculations and target loads (dynamic modelling)

Data for all vegetation-soil combinations within each grid cell were mostly derived by using relationships with basic land characteristics such as tree species and soil type.

Base cation deposition: Bulk deposition data for base cations for a 1×1 km grid were interpolated from 14 monitoring stations for the year 1993. However, bulk deposition only includes wet deposition and a very small part of dry deposition. Dry deposition was calculated by multiplying base cation concentrations in the bulk (wet) deposition by a scavenging ratio to estimate air concentrations, which in turn were multiplied by a deposition velocity, depending on meteorology and land use, using the model DEADM (Erisman and Bleeker, 1995). An estimate of seasalt inputs of Cl and SO_4 was made by assuming an equivalent Cl/Na and SO_4/Na ratio in both bulk deposition and dry deposition equal to these ratios in sea-water: 1.165 for Cl and 0.116 for SO_4. Seasalt Cl and SO_4 were subtracted from the total base cation deposition values to obtain seasalt- corrected base cation inputs.

Weathering of base cations: Base cation weathering rates for non-calcareous sandy soils were taken from De Vries (1994a), who derived weathering rates on the basis of one-year batch experiments scaled to field observations. Weathering rates for calcareous soils were derived from De Vries et al. (1994b). For the loess, clay, and peat sub soil types, weathering rates were calculated from pedotransfer functions relating weathering rates to the silt and clay contents of the soils (Van der Salm, 1999). The pedotransfer functions for loess and clay soil were based on laboratory experiments. Weathering rates for peat soils were estimated using pedotransfer functions for clay soils and the clay content of peat soils.

Uptake: Uptake rates of nitrogen and base cations were calculated based on the concept of nutrient-limited uptake, which is defined as the uptake that can be balanced by a long-term supply of base cations. This amount, referred to as the critical base cation uptake, BC_{gu}(crit), is calculated from mass balances for each base cation (Ca, Mg and K) separately, as total deposition and weathering minus a minimum leaching of BC. We used a minimum leaching of 50 $mol_c.ha^{-1}.yr^{-1}$ for Ca and Mg and 0 $mol_c.ha^{-1}.yr^{-1}$ for K. From the critical base cation uptake, the corresponding critical N uptake (Ngu(crit)) is calculated from the ratio between each cation and nitrogen in the biomass (cf. Posch et al., 1993, Eqs. 4.7 and 4.8).

Nitrogen immobilisation: The long-term critical N immobilisation rate was calculated by accepting a change of 0.2% of nitrogen in organic matter pool in the upper soil layer (0–30 cm) during one rotation period (100 years). Immobilisation rates thus increase with higher organic matter contents, and generally range between 100 and 350 $mol_c.ha^{-1}.yr^{-1}$. These values correspond well with a range of between 2 and 5 $kg.ha^{-1}.yr^{-1}$ mentioned in the mapping manual. For the target load computations, N immobilisation was computed using the formulations in VSD and SMART2 that compute N immobilisation as a function of C/N ratio in the topsoil.

Denitrification: Denitrification fractions were derived for each soil type based on data for agricultural soils. These data were corrected for the more acidic forest soils. Values thus derived varied between 0.1 for well-drained sandy soils to 0.8 for peat soils (De Vries, 1996).
In SMART2 the denitrification- and nitrification fractions are computed as a function of pH and groundwater regime (e.g. Kros, 1998).

Runoff: Runoff was calculated as the difference between precipitation and evapotranspiration. Precipitation estimates have been derived from an overlay with 30-year average (1970-2000) results of 280 weather stations in the Netherlands. Interception fractions, relating interception to precipitation, have been derived form literature data for all tree species considered. Data for evaporation and transpiration have been calculated for all combinations of tree species and soil types with a separate hydrological model (De Vries, 1996).

Al release constants: Al release is described in VSD and SMART2 by a general formula relating Al to protons as described in the mapping manual (Posch et al., 2003). For both the SMB and VSD application an empirical relation between Al and H concentrations was constructed using data on soil solution concentrations, measured at four different depth in 200 forested sites on sandy soils, 38 on non-calcareous clay soils, 40 on loess soils and 30 peat soils have been used (Leeters et al., 1994; Klap et al., 1999). More information on the derivation is given in Van der Salm and De Vries (2001). An overview of the values of KAl_{ox} and α is given in Van Hinsberg and de Vries (2003).

Derivation of additional soil data needed for target loads (dynamic modelling)

Data sets that were used to derive the various soil data needed for dynamic modelling are described in the status report 2003 (Van Hinsberg and de Vries, 2003) and includes approximately 300 forest stands on sand-, loess-, clay-, and peat soils.

Depth of the rooting zone:
The depth of the rooting zone varied between 30 and 100 cm as a function of soil and vegetation type. These values were based on expert judgement by foresters. For the dynamic model SMART2, a fixed rooting depth of 0.4 m was used.

Bulk density of the soil:
In accordance with the modelling manual (Posch et al., 2003), values for the soil bulk density of sandy soils and clay soils ($C_{org} \leq 15\%$) were estimated from the measured organic carbon content and clay content in the various data sets, according to Hoekstra and Poelman (1982). For loess, bulk densities of 1420, 1428, 1486, 1542 and 1553 $kg.m^{-3}$ were assigned to A, E, AC, B, C horizons respectively, based on measurements. For peat soils ($C_{org} > 15\%$), the bulk density was estimated as a function C_{org} alone according to Van Wallenburg,(1988).

Volumetric water content at field capacity:
The volumetric soil moisture content (m^3 moist.m^{-3} soil) of sandy soils, loess soils and peat soils was based on measured soil moisture contents on a dry weight basis (m^3 moist.kg^{-1} soil) multiplied by the estimated bulk density of the soil ($kg.m^{-3}$) with the following maxima: 35% for sandy soils, 45% for loess soils and 90% for peat soils. For clay soils, no data were available. Following to the modelling manual (Posch et al., 2003), an approximation of the annual average soil moisture content was made as a function of the clay for soils with less than 30 % of clay. For soils with more than 30% clay, a constant value of 0.27 was assumed.

Cation exchange capacity and base saturation:
The CEC value was measured at the actual (unbuffered) pH in the above mentioned soil data sets. Especially acid soils (non-calcareous sandy soils, most loess and peat soils) this implies that the cation exchange constants are only applicable in the limited pH range of the soils considered (mainly between pH 3 and 5). The CEC at pH 6.5 was estimated by calculating the CEC as a function of the clay and organic carbon content, accounting for the impact of pH according to (Helling et al., 1964) and adjusting using the ratio between measured and estimated CEC at the actual soil pH (cf. Van Hinsberg and de Vries, 2003). Base saturation was calculated as the ratio of the amount of bases divided by the CEC at pH 6.5 as derived above.

Carbon pool and C/N ratio in the topsoil:
C/N ratio in the topsoil were related to the topsoil and based on measured values the in the above mentioned soil data sets. The C pool was calculated for the same depth by multiplication of the measured C content with the estimated bulk density and a soil depth of 20 cm.

For SMART2 many more data were required that describe e.g. the nutrient cycling in forests. An overview of the SMART2 model is provided in Kros (1998) together with the parametrisation of the model for the Netherlands that was also used for the current target load calculations.

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NORWAY

National Focal Center

Thorjørn Larssen
Norwegian Institute for Water Research
P.O. Box 173 Kjelsås
0411 Oslo
tel: +47 22185194
fax: +47 22185200
email: thorjorn.larssen@niva.no

Collaborating Institutions

Norwegian Institute for Air Research
P.O. Box 100
2007 Kjeller
Norway

Norwegian Institute for Nature Research
Tungasletta 2
7485 Trondheim
Norway

Norwegian Institute for Land Inventory
P.O. Box 115
1431 Aas
Norway

Calculation of Target Load Functions (TLFs)

We have calculated target load functions according to the specifications in the call. The calculations are based on a population of 131 lakes in southern Norway. These are lakes included in SFT's monitoring programme and are those for which we have sufficient data to calculate target load functions with our dynamic model MAGIC. Due to resource limitations we have confined our work at this time to lakes south of 62.5 degrees N latitude. Target loads were not calculated for lakes having measured ANC values in 1995-1997 (average) higher than ANClimit. The variable ANClimit was calculated in accordance with the Mapping Manual. 81 of the lakes had ANC below ANClimit and TLFs was calculated.

Even though data for only 131 lakes are reported at this time, the data submitted for the critical loads update in the call with deadline in 2003 are still valid for Norway.

Ranges of model inputs and parameters and comments on their sources and justifications are listed in the table.

Table NO-1

Var	Unit	Min	Max	Assumptions, data sources and justifications
EcoArea	%	100%	100%	We consider 100% of the land area to contain watersheds for lakes and rivers. We have not calculated the area of the EMEP grid cells, which should be given here (minus the part of the cell covering ocean).
CLmaxS	eq ha^{-1} a^{-1}	5.36	73.24	Calculated with FAB model (according to Mapping Manual)
CLminN	eq ha^{-1} a^{-1}	3.20	42.32	
CLmaxN	eq ha^{-1} a^{-1}	11.78	118.42	
CLnutN				Not applicable
crittype		6	6	ANC is used as criterion for all lakes
critvalue	μeq L^{-1}	1.27	18.15	Variable ANClimit calculated according to Mapping Manual
SoilYear		1995	1995	Same year (1995) used for all soil analyses
ExCa	%	2.17	40.41	Taken from nearest relevant soil sampling locations or as a combination of nearest forested and non-forested soil sampling location. Data from forested catchments from the National Forest Inventory; data from non-forested catchments from different research and monitoring projects.
ExMg	%	0.69	24.47	
ExNa	%	0.75	6.75	
ExK	%	0.26	7.43	

thick	m	0.03	0.89	
BulkDens	kg m^{-3}	192.30	906.98	
CEC	meq kg^{-1}	12.31	242.52	
Cpool	g m^{-2}	2080	85371	
Npool	g m^{-2}	99	4914	
Porosity	%	50	50	Assumption. Constant value used for all sites.
Nimacc	eq ha^{-1} a^{-1}	34	34	Default values for FAB model from Mapping Manual
UptCa	meq m^{-2} a^{-1}	0.00	29.74	Based National Forest Inventory.
UptMg	meq m^{-2} a^{-1}	0.00	5.61	
UptK	meq m^{-2} a^{-1}	0.00	6.44	
UptNa	meq m^{-2} a^{-1}	0.00	1.06	
UptSO4	meq m^{-2} a^{-1}	0.00	0.00	
UptNH4	meq m^{-2} a^{-1}	0.00	0.00	
HlfSat	µeq L^{-1}	100	100	Assumption. Constant value used for all sites.
Emx	meq kg^{-1}	1.00	1.00	Assumption. Constant value used for all sites.
Nitrif	%	100	100	Assumption based on the fact that ammonium concentrations are very low.
Denitrf	%	0.00	0.00	
CNRange		11.00	11.00	Constant range based on empirical data from Gundersen et al. (1998)
CNUpper		10	73.4	Calibrated
DepYear		1995	1995	
Cldep	eq ha^{-1} a^{-1}	66.78	5366	Deposition flux of Cl sat equal to catchment output flux
Cadep	eq ha^{-1} a^{-1}	2.47	198.6	Calculated from Cl using standard sea salt ratios and assuming no non-sea salt deposition
Mgdep	eq ha^{-1} a^{-1}	13.09	1039.8	
Nadep	eq ha^{-1} a^{-1}	57.30	4363	
Kdep	eq ha^{-1} a^{-1}	1.20	96.60	
NH4dep	eq ha^{-1} a^{-1}	74.04	811.0	Calculated from observed ratios in deposition to SO4. SO4 deposition was calculated from runoff flux assuming geological contribution and background deposition as described in mapping manual.
NO3dep	eq ha^{-1} a^{-1}	74.77	695.5	
LakeYear		1995	1995	Lake chemistry taken from the National Lake Monitoring Program (SFT, 2003). Average for 1995-1997 was used.
Calake	µmol L^{-1}	2.99	39.25	
Mglake	µmol L^{-1}	1.78	37.43	
Nalake	µmol L^{-1}	7.39	247.94	
Klake	µmol L^{-1}	1.02	16.37	
NH4lake	µmol L^{-1}	0.00	0.00	
SO4lake	µmol L^{-1}	4.51	68.36	
Cllake	µmol L^{-1}	8.46	302.75	
NO3lake	µmol L^{-1}	1.38	34.76	
DOC	µmol L^{-1}	0.73	31.96	Organic acid fraction of DOC assuming tri-protic acid and charge density of 10.2 µeq/mg C
RelArea	%	0.41	36.36	Data for each catchment taken from maps
RelForArea				
RetTime	yr	0.50	0.50	Assumption. Constant value used for all sites.
Qs	m	0.41	4.49	Runoff taken from 30-year normal runoff maps.
expAllake		3.00	3.00	Assumption. Constant value used for all sites.
pCO2	%	0.05	0.05	Assumption. Constant value used for all sites.
Nitrifilake	%	100	100	Assumption. Constant value used for all sites.

Cased	m a^{-1}	0.00	0.00	Assumption. Constant value used for all sites.
Mgsed	m a^{-1}	0.00	0.00	
Nased	m a^{-1}	0.00	0.00	
Ksed	m a^{-1}	0.00	0.00	
SO4sed	m a^{-1}	0.00	0.00	
Clsed	m a^{-1}	0.00	0.00	
NH4sed	m a^{-1}	5.00	5.00	Assumption, based on generalisation described in Mapping Manual
NO3sed	m a^{-1}	5.00	5.00	
UptNH4lake	%	0.00	0.00	Assumption. Constant value used for all sites.
UptNO3lake	%	0.00	0.00	Assumption. Constant value used for all sites.
Sdep2010	eq ha^{-1} a^{-1}	80.43	621.5	Calculated from estimate of total input in 1995 and Current Legislation forecast scenarios taken from Posch et al. (2003)
NOxdep2010	eq ha^{-1} a^{-1}	49.35	459.0	
NH3dep2010	eq ha^{-1} a^{-1}	71.08	778.6	

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POLAND

National Focal Centre

Wojciech A. Mill, Adrian Schlama
Institute of Environmental Protection
Section of Integrated Modelling
Grunwaldzka Str. 7B/2
PL-41-106 Siemianowice Śl.
tel/fax: +48 32 2281482
mill@silesia.top.pl

Collaborating Institutions

Dorota Rzychoń, Adam Worsztynowicz
Institute for Ecology of Industrial Areas
Kossutha 6
PL-40-881 Katowice
Tel: +48 32 2546031
rzychon@ietu.katowice.pl
worsztynowicz@ietu.katowice.pl

State Inspectorate of Environmental Protection,
Department of Monitoring
Contractor:
Ryszard Twarowski, Jan Błachuta
Institute of Meteorology
and Water Management
the Wrocław Branch
Parkowa Str. 30
PL-51-616 Wrocław
tel: +48 71 3281446

Krzysztof Okła, Jolanta Starzycka
General Directorate of the State Forests
Spatial Information System
Wawelska 52/54
PL-00-922 Warszawa

Revisions made to critical loads data

Basically critical loads were calculated in accordance with the methodology presented in the latest draft version of Mapping Manual. All changes made to the input data sets are listed below.

Receptors mapped: Broadleaved (EUNIS class G1) and coniferous (EUNIS class G3) woodlands have been supplemented with surface waters (EUNUS class C1) of the Polish part of Tatra Mountains.

National deposition data: Base cation deposition data sets provided by the State Monitoring of Environment have been updated to the measured values for 2002.
Nitrogen and base cation uptake: New electronic maps of Polish forests have been produced by the Spatial Information System of the General Directorate of State Forests. Based on them the default yields of harvestable parts of considered tree species used until now has been replaced with site specific values. Furthermore, in addition to stems also the removal of branches is considered in nutrient uptake calculations.
A summary of changes in the mean values of $CL_{max}(S)$, $CL_{min}(N)$, $CL_{max}(N)$ and $CL_{nut}(N)$ since 1998 is given in Table PL-1.

Maps submitted

Based on the results of critical load calculations updated maps of $CL_{max}(S)$, $CL_{min}(N)$, $CL_{max}(N)$ and $CL_{nut}(N)$ for Polish forest ecosystems and Tatra Mountains lakes were produced. They are presented in Figures PL 1-2.

Input data for VSD model

To perform calculations of target load functions input data set required by the VSD model was delivered. Table PL-2 summarizes selected site-specific parameters.

Target load functions for 2030, 2050 and 2100

Target load functions for the years 2030, 2050 and 2100 with the implementation year 2015 have been calculated for all ecosystems considered. For all target years the $[Al]_{crit} = 0.2$ eq m^{-3} critical chemical value was applied while running the dynamic model with the 2010 (Gothenburg Protocol) deposition kept constant afterwards. The results are submitted in the attached ACCESS database files.

Table PL-1. Summary of changes in the mean values of critical loads for Polish forest ecosystems

Critical loads parameter	EUNIS code	1998	2001	2003	2004
$CL_{max}(S)$	G1	1964	1361	1879	2057
[eq $ha^{-1}yr^{-1}$]	G3	2080	1179	1732	1628
$CL_{min}(N)$	G1	946	1179	1179	709
[eq $ha^{-1}yr^{-1}$]	G3	571	711	711	413
$CL_{max}(N)$	G1	6450	4526	5712	5740
[eq $ha^{-1}yr^{-1}$]	G3	5647	3479	4742	4226
$CL_{nut}(N)$	G1	1041	1266	1266	769
[eq $ha^{-1}yr^{-1}$]	G3	650	837	837	471

Table PL-2. Summary of selected input data to the VSD model

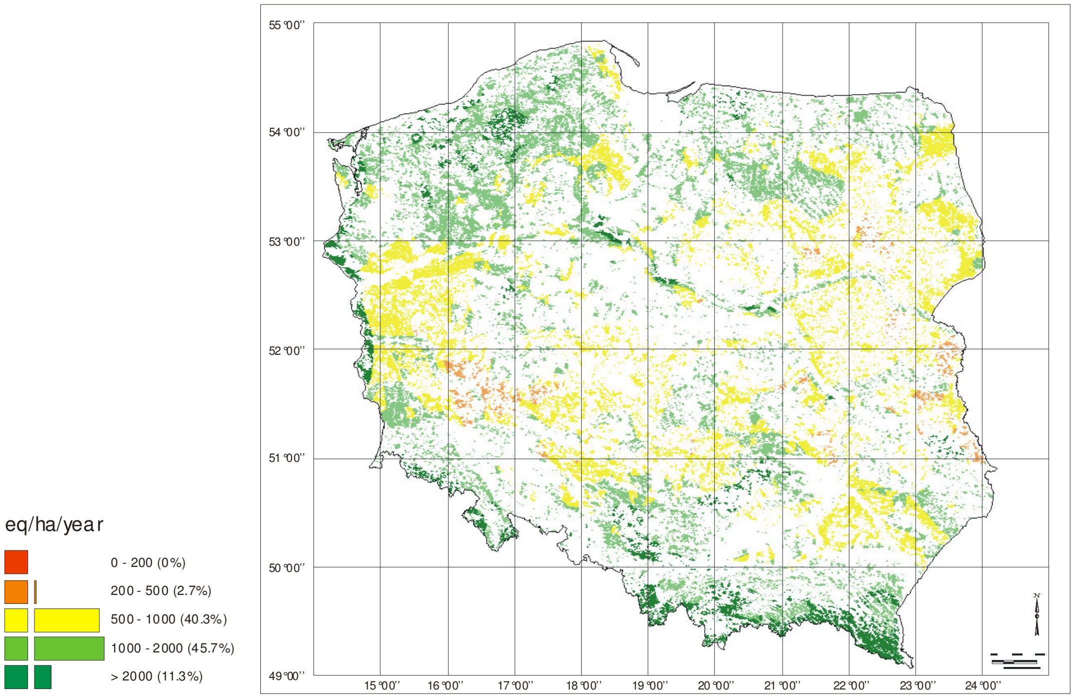
Parameter	Symbol	Unit	Source/ Method
Depth of rooting zone	*thick*	m	Soil layers are assigned to the O, A/E, B and C "gross-horizons" of 0.05, 0.10, 030 and 0.40 m thickness respectively
Average bulk density	*bulkdens*	g cm^{-3}	Królikowski L., (1986), Album Gleb Polski, PWN, Warszawa
Base cation deposition	*Cadep, Mgdep, Kdep and Nadep*	eq $ha^{-1}a^{-1}$	State Monitoring of Environment - Institute of Meteorology and Water Management the Wroclaw Branch
Cation exchange capacity	*CEC*	meq kg^{-1}	II-level forest monitoring by the Forest Research Institute under a contract of State Inspectorate of Environmental Protection
Base saturation	*bsat*		II-level forest monitoring by the Forest Research Institute under a contract of the State Inspectorate of Environmental Protection
Initial amount of carbon in the topsoil	*Cpool*	g m^{-2}	II-level forest monitoring by the Forest Research Institute under a contract of the State Inspectorate of Environmental Protection
C/N ratio in the topsoil	*CNrat*		II-level forest monitoring by the Forest Research Institute under a contract of the State Inspectorate of Environmental Protection

Figure PL-1. Critical loads.

Institute of Environmental Protection
Department of Environmental Policy - Section of Integrated Modelling
Grunwaldzka Str. 7b/2, 41-106 Siemianowice Sl., Poland

Maximum critical loads of sulphur

2004



Maximum critical loads of nitrogen

2004

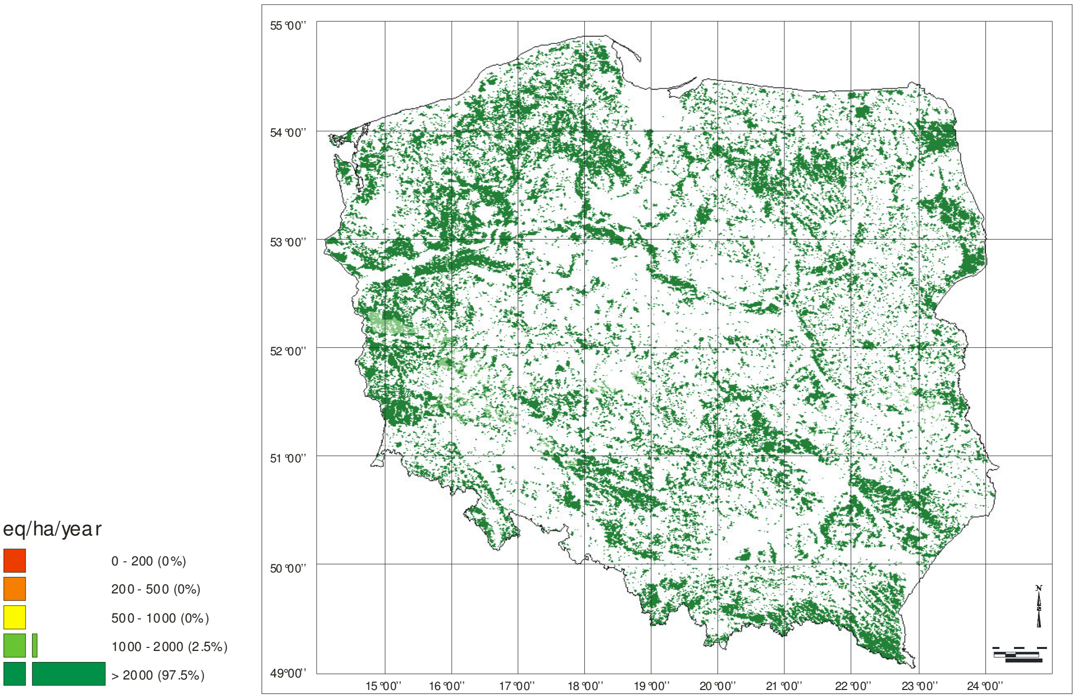
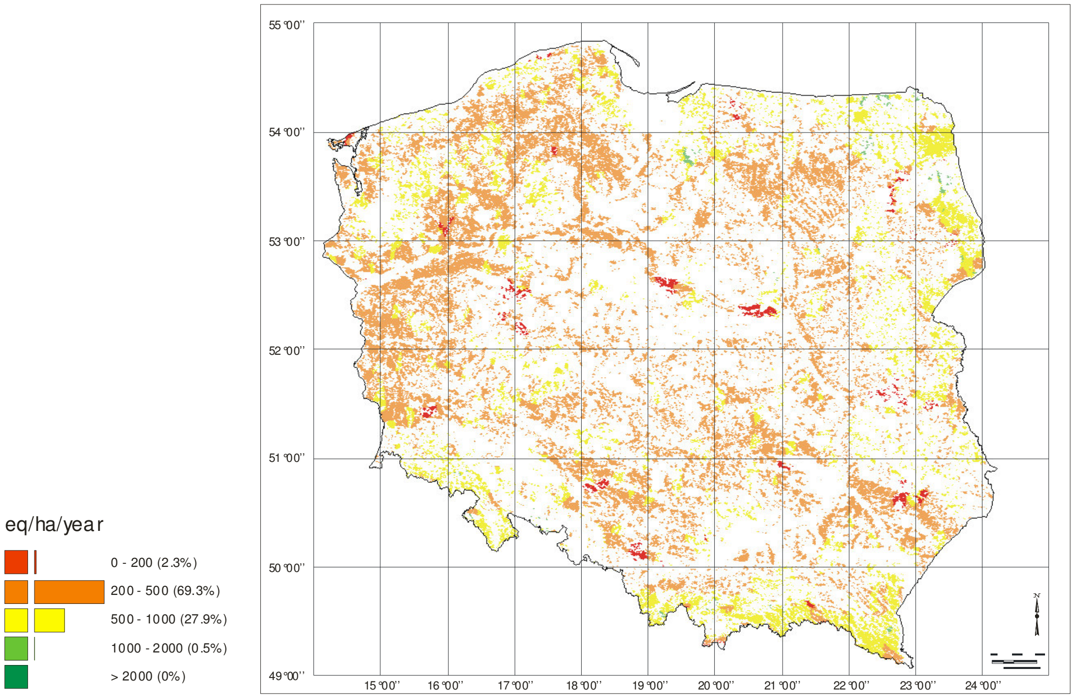


Figure PL-2. Critical loads.

Institute of Environmental Protection
Department of Environmental Policy - Section of Integrated Modelling
Grunwaldzka Str. 7b/2, 41-106 Siemianowice Sl., Poland

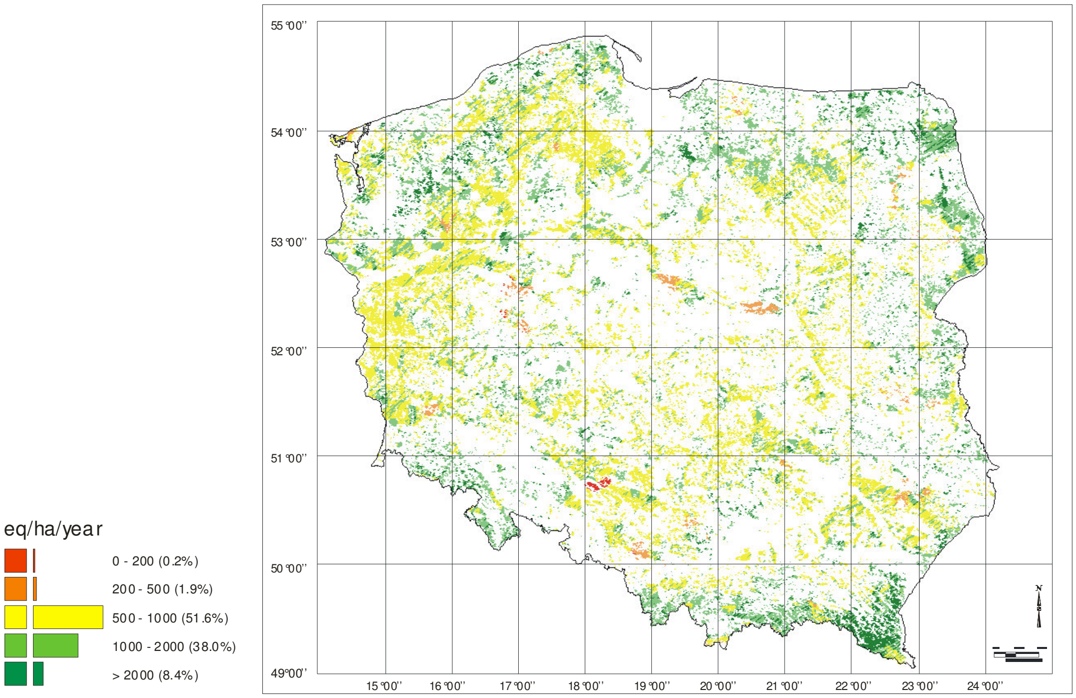
Minimum critical loads of nitrogen

2004



Critical loads of nutrient nitrogen

2004



SLOVAKIA *

National Focal Center

Dusan Zavodsky
Slovak Hydrometeorological Institute
Jeseniova 17
SK-833 15 Bratislava, Slovakia
tel: +421 2 59415 377
fax: +421 2 54775 670
zavodsky@shmu.sk

Collaborating Institutions

Jozef Mindas, Pavel Pavlenda
Forest Research Institute
T.G.Masaryka 22
SK-960 92 Zvolen, Slovakia
tel: +421 45 5314 206
fax: +421 45 5321 883
mindas@fris.sk, pavlenda@fris.sk

Jaroslav Skvarenina, Vladimir Kunca
Technical University Zvolen
T.G.Masaryka 24
SK-960 53 Zvolen, Slovakia
jarosk@vsld.tuzvo.sk

Calculation methods

Critical loads of acidity and nutrient nitrogen for forest soils

The critical loads of sulfur and nitrogen for forest soils were calculated by using the steady-state mass balance method according to the Mapping Manual (UBA 1996).

Dynamic modelling of soil response to atmospheric deposition

The first stage of the dynamic modelling activities has been started in Slovakia according to the Dynamic Modelling Manual (Posch et al., 2003). We used the VSD model as the simplest extension of the SMB model for critical loads.

Calculation of the target loads

The first stage of the target loads calculations has been started in Slovakia according to CCE instructions and the latest version of the VSD model (VSD studio, and VSD excel file).

Critical loads for sulfur and nitrogen

Based on the new field data from ICP Forest monitoring plots (level II) and application of the ‘canopy budget model‘, the update of base cation deposition has been started and site specific data of base cation deposition for forest sites will be available at the end of 2004.

Dynamic modelling and target loads

The dynamic modelling and target loads calculations for the forest monitoring plots in Slovakia are under the progress. There are 111 forest monitoring plots in Slovakia (Fig.1), that represent the variability of site conditions and tree species composition of Slovak forests.

*** No updated data submitted**

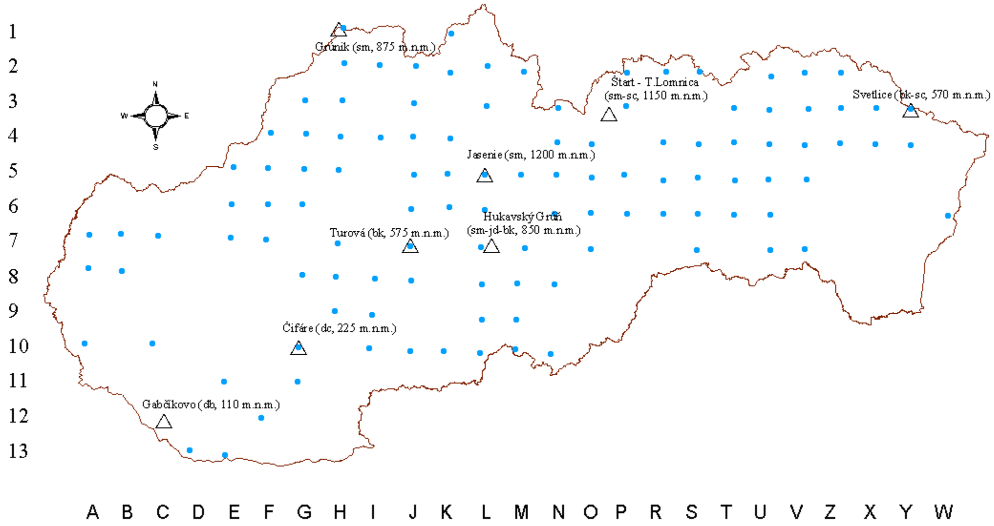


Figure SK-1. Spatial distribution of forest monitoring plots (level I and level II) in Slovakia.

Many parameters were measured and/or estimated for these plots including all parameters for steady-state mass balance method of CL calculations. Special parameters needed for VSD model application are described as follows:

<u>Soil input data:</u>

- measured: soil survey 1998 (forest soil monitoring database): CEC, EBC, C, N (data for 10-20 cm soil layer as „medium“ layer of the soil compartment used for calculation)
- calculated - using pedotransfer function: BD, theta
- derived from data in VSD manual according to soil texture/soil type: exchange constants, Al exponent
- estimated – combination of measured data at some of plots and estimated data at some of plots: clay content.

The input data are in some cases (CEC, Base saturation) not fully comparable due to some differencies in methodology (BaCl2 extract instead of NH4OAc extract).

<u>Deposition data:</u>

The analysis of historical measurements of S, N compounds concentrations has been carried out based on the data from EMEP stations in Slovakia, data from the various research plots, ICP Forest monitoring sites, IGP measurements in Slovakia (1956-57) and emissions data. In near future, the new deposition data for dynamic modelling and target loads calculations will be prepared.

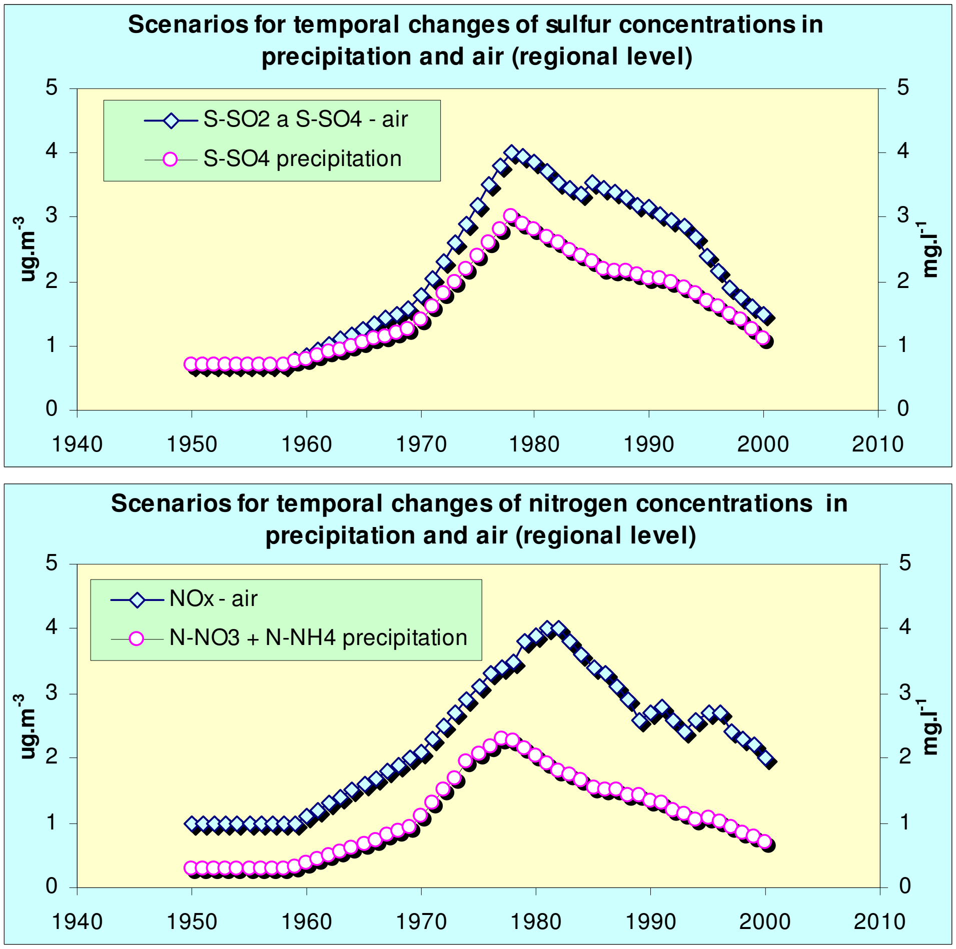


Figure SK-2. Preliminary results for temporal changes analysis of sulfur and nitrogen compounds concentrations in air and precipitation as a basis for preparation of deposition scenarios.

SWEDEN

National Focal Center

Ulla Bertills
Swedish Environmental Protection Agency
SE-106 48 Stockholm
Phone. +46 8 698 1502
Fax: + 46 8 698 1584
email: ulla.bertills@naturvardsverket.se

Håkan Staaf
Swedish Environmental Protection Agency
SE-106 48 Stockholm
Phone. +46 8 698 1442
Fax: + 46 8 698 1402
email: hakan.staaf@naturvardsverket.se

Collaborating Institutions

Mattias Alveteg
Department of Chemical Engineering
University of Lund
P.O. Box 124
S-221 01 Lund
Phone: + 46 46 222 3627
Fax: + 46 46 149156
Email: mattias.alveteg@chemeng.lth.se

Daniel Kurz
EKG Geo-Science
Ralligweg 10
CH-3012 Bern
Phone: + 41 31 302 6867
Fax: + 41 31 302 6825
Email: geoscience@swissonline.ch

Filip Moldan
Swedish Environmental Research Institute
P.O. Box 47 086
SE-402 58 Göteborg
Phone: +46 31 725 6231
Fax: + 46 31 48 2180
Email: filip.moldan@ivl.se

Lars Rapp
Swedish University of Agricultural Sciences
Department of Environmental Assessment
P.O. Box 7050
S-750 07 Uppsala
Phone: + 46 18 673826
Fax: + 46 18 67 3594
Email: lars.rapp@md.slu.se

Harald Sverdrup
Department of Chemical Engineering
University of Lund
P.O. Box 124
S-221 01 Lund
Phone: + 46 46 222 8274
Fax: + 46 46 149156
Email: harald.sverdrup@chemeng.lth.se

Introduction

This report provides a brief overview of the methods and data sources used for the first Swedish delivery on results from dynamic modelling of both soils and surface waters. It should be noted that these data do not replace the current database on static critical loads. The results should be considered preliminary, and we feel that there are still some methodological issues that have to be resolved before the database could be used as a basis for negotiating emission reductions on a European scale.

Calculation methods

Forest ecosystems:

Calculations were first carried out using the SAFE model setup. In the SAFE model setup MAKEDEP (Alveteg et al., 2002) was used to derive site specific time series of deposition, nutrient uptake and nutrient cycling for the simulation period, 1800-2100. The SAFE model includes chemical weathering, nitrification, Gapon type cation exchange, empirical aluminium concentration control and soil solution equilibria. The model is calibrated against present base saturation only by varying the initial base saturation. As the model is initialized at 1800 assuming steady-state, varying the initial base saturation is equivalent to varying the Gapon selectivity coefficient.

In the present exercise SAFE was applied to 665 forest sites selected from the Swedish data base of 1883 forest sites for static critical loads (Posch et al., 2001; Sverdrup et al., 2002). SAFE was run with sulphate adsorption and rate-controlled nitrogen immobilisation turned off. The soil was divided into 3-5 soil layers based on available data and using adaptive uptake distribution. Climate parameters were kept constant throughout the modelling period. . After target load functions and critical load functions had been calculated using SAFE, calculations were carried out using MULTITL (Posch et al., 2003) by letting SAFE2VSD (as sub-module of MULTITL) extract the input to VSD from the PRESAFE/SAFE run results (Kurz & Posch 2002). The molar $Bc/Al^{3+} = 1$ was used as critical parameter value.

Deposition of other elements than S and N were averaged for the time period 2010 to the end of the modeling period (2100) and were kept constant in the TL runs after 2010. An average value was approached from the value in 2000 by linear interpolation. In VSD flux data other than deposition of S and N was averaged for the rotation period of the forest, and the averaged values were applied after 2010. This average future value is approached linearly from the value in 2000. In the current version of SAFE the average future values are instead based on projected data from 2010 onwards and CL and TL functions are reported as N and S deposition pairs starting with the minimum N deposition.

Freshwaters:

Target load functions were calculated on a selection of 131 Swedish lakes using MAGIC model (Cosby et al., 1985). Existing MAGIC calibration on these lakes (Moldan et al., in press) had to be modified to make the dynamic model (MAGIC) calculations consistent with calculations of critical loads by a static model (FAB) with respect to nitrogen dynamics (Cosby et al., 2001). The TLFs were calculated with MAGIC assuming that N deposition above a long-term N immobilisation of 2 kg/ha/yr will eventually lead to elevated N leaching.

The critical load function (CLmax(S), CLmin(N), CLmax(N)) was calculated using the first-order acidity balance (FAB) model as described in Henriksen et al. (1993), Posch (1995) and Rapp et al. (2002). In order to make the critical load consistent with the MAGIC model, the weathering rate, calculated by MAGIC, was used in FAB. The chemical threshold, ANClimit, was set to 20 μeq/l in cases where [BC*o] > 25 μeq/l. In other cases, ANClimit was set to 0.75[BC*o] to allow for naturally low ANC concentrations. The N-immobilisation was set to a maximum of 2 kg N/ha/yr (terrestrial) and then weighted to land use types within the catchment. The average denitrification fraction for each catchment was related linearly to the fraction of peatlands in the catchment area (*fde=0.1+0.7fpeat*) as suggested in Posch et al. (1997). By contrast with the literature and the manual, the net uptake of base cations was taken into account when calculating CLmax(S).

Data sources

Deposition:

Historical deposition data were derived from updated EMEP150 grid specific deposition histories 1880- 2030 over Europe according to Schöpp et al. (2003). The deposition curves were scaled to fit the present deposition (1998) of the 50x 50 km of the investigated forests and lakes. The deposition histories were supplemented with an estimated deposition pattern between 1800 – 1880, scaled to fit the individual sites.

Present day deposition (1998 for SAFE and 1997 for MAGIC) was estimated by the MATCH model in a 20 x 20 km square grid over Sweden (Robertson et al., 1999, www.smhi.se). The data were provided by the SMHI (Swedish Meterorological and Hydrological Institute). For the lakes, the deposition was adjusted using the observed lake water chemistry to account for the local variation within the 20x20 km squares (Moldan et al., 1997). The total deposition of Cl^-, SO_4^{2-} and base cations was adjusted at each site using lake water chemistry. It was assumed that, as a result of the declining SO_4^{2-} deposition in preceding years, an estimated 35 % of the SO_4^{2-} in the output flux of the lakes in the calibration year 1997 had been desorbed from catchment soils or, in lakes with large retention time, it originated from the lake water itself. The modelled deposition of N species was adjusted to account for variations in dry deposition of by assuming that the ratio between the adjusted deposition and the deposition given by SMHI was the same for the N species and SO_4^{2-} at each lake.

Forest ecosystems:

The forest sites has been selected from sample plots of The Swedish National Inventory of Forests, RIS (www-ris.slu.se) which provided data on general soil and stand characteristics. Soils samples were taken during 1983-87 and 1993- 2003. Biomass and litter fall data have been derived from Marklund (1988) and element concentrations in different components from various inventories and experimental sites. Soil mineralogy was derived according to Warfvinge and Sverdrup (1995) and data on root depth were used according to Rosengren and Stjernquist (2004).

Freshwaters:

Water chemistry data originate from the Swedish national monitoring program. In total, 131 lakes were included in the calculation and measurements from 1997 were used. Long-term averages (1961-1990) of runoff volumes provided by the Swedish Meteorological Institute (SMHI) were used. Land use data were taken from the Swedish National Land Survey. Long-term averages of nutrient uptake were derived from the Swedish Forest Inventory 1983-92.

Soil data for the lake catchments were derived from The National Survey of Forest Soils and Vegetation, a subprogramme within RIS (www-ris.slu.se). Soil depth, amount of exchangeable Ca^{2+}, Mg^{2+}, Na^+ and K^+ per mass of soil, CEC, soil pH and amount of C and N were vertically aggregated for the profiles of each soil sample included for a lake. Soil bulk densities were estimated by Karltun (1995) and averaged over the profiles. Soil water DOC was assumed to be 8 mg/l for all catchments (based on data from permanent forest monitoring plots in Sweden, ICP Forests, level II).

Comments and conclusions

Forest ecosystems:

1. Nutrient uptake is a model output while it was a model input in the CL calculations delivered earlier using PROFILE. The differences in used nutrient uptakes and resulting CL is yet to be investigated.

2. There are differences between SAFE and VSD results. This may partly be due to slight differences in assumption used in the simulations, e.g. in the averaging procedure discussed above, but also due to differences in model design, e.g. in soil stratification.

3. TL functions may not be present even for sites which recover between the target years: For some sites the Bc/Al ratio changes rapidly near the critical limit. Thus, even if the level to which a site recovers is highly dependent on deposition levels, the year at which the chemical criteria is passed may be insensitive to changes in deposition levels, within reasonable limits.

Freshwaters:
1. In response to the call, the TLFs were calculated with MAGIC model on population of 131 lakes in Sweden. Provided that there are about 85 000 lakes in Sweden, the submitted TLFs are rather a test of methodology than results representing the whole country.

2. Several unexpected results appeared during the model application. An issue of substantial importance is what will happen with deposited nitrogen in future. Contrary to our expectation for several lakes the target load decreases with time, i.e. smaller reductions in deposition are required if the chemistry target is to be achieved sooner (2030) than later (2050 or 2100). This is because of modelled progressing nitrogen saturation (in response to continued N deposition) causing an increasing NO_3 leaching with time. A similar effect could be expected when soil acidification in the catchment slowly progress after the implementation year. An increase in lake ANC in such catchments due to decreased SO_4 deposition might be enough to bring the water quality over the chosen threshold (ANC=20μeq/l in this case) at a certain target year. However, provided infinite time, the slowly progressing soil acidification might eventually cause ANC to drop back below the threshold. In both cases the steady state critical load (FAB model), which assumes infinite time will be lower or equal to target load for any specific target year.

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SWITZERLAND

National Focal Centre

Swiss Agency for the Environment,
Forests and Landscape (SAEFL)
Air Pollution Control Division
Beat Achermann
CH - 3003 Bern
tel: 41-31-322.99.78
fax: 41-31-324.01.37
beat.achermann@buwal.admin.ch

Collaborating Institutions

METEOTEST
Beat Rihm
Fabrikstrasse 14
CH - 3012 Bern
tel: 41-31-307.26.26
fax: 41-31-307.26.10
office@meteotest.ch
EKG Geo-Science
Daniel Kurz
Ralligweg 10
CH – 3012 Bern
tel: 41-31-302.68.67
fax: 41-31-302.68.25
geoscience@swissonline.ch

What is unchanged?

In March 2003, two files with Swiss critical load data and related information were supplied that are still valid and should be used by the CCE:
ch_f_200303.dbf:
data for forest (CL for acidity and nutN, VSD-Input)
ch_n_200303.dbf:
data for various natural and semi-natural ecosystems (CL for nutN, only empirical method)

What is new?

There is a new file containing CL of acidity for lakes: **ch_l_200403.dbf**:
It contains data from FAB-model calculations, which were carried out for 101 lakes in Southern Switzerland. These alpine lakes are at altitudes between 1650 and 2700 meter (average 2200 m).
<u>Methods:</u>
The underlying First-order Acidity Balance (FAB) model was described by Henriksen and Posch (2001). For the implementation of the model, Max Posch from the CCE provided very helpful support and Fortran-Programmes (Posch, 2004).
In the present application, the base cations are not estimated from the lake water chemistry but from fluxes in individual parts of the catchment (forest, grassland, bare land). The flux in each part is calculated as deposition plus weathering, minus net uptake.
<u>Input data:</u>
The deposition of BC, N and S was calculated with a generalised combined approach (FOEFL, 1994 and 1996; Rihm & Kurz, 2001), for the reference year 2000.
Input values for uptake, immobilization and denitrification are shown in Table 1. The net uptake of BC and N for forests is consistent with the amounts used for the critical load calculations for forests. For grassland, relatively low uptakes are used which correspond to a the poor management in form of goat and sheep grazing.

Table 1: Values for uptake, immobilization and denitrification used in the FAB-model application for alpine lakes.

parameter	land use categories			units
	FOREST	GRASSLAND	BARE LAND	
N uptake	56	36	0	eq ha^{-1} a^{-1}
BC uptake	54	0	0	eq ha^{-1} a^{-1}
N immobilisation	357	143	0	eq ha^{-1} a^{-1}
Denitrification factor	0.3	0.2	0	fraction

The in-soil weathering rates are very low in those catchments because of very thin soils, low temperature and in many cases slow weathering minerals. Therefore, the weathering rates (WR) of BC for each catchment was estimated by quantifying rock-water interaction processes and a simplified hydrological model.

The catchments were digitized using regional geological maps and were classified into 5 lithological units: quaternary cover, leucocratic granite/gneis, melanocratic granite/gneis, amphibolite, and carbonate bearing rocks (example in Figure 1). Digital elevation maps were used to estimate surface runoff, average linear velocities and the resulting travelling time of the infiltrating water for each individual lithological area in a catchment. Dissolved BC's of the infiltrating water were estimated using a reactive transport model, where transfer functions for the dependence of 'travelling-time' and „mineral dissolution" were calculated for each lithology. Travelling time is essential, since longer reaction time of the water with the bedrock lithology contributes significantly to the overall catchment WR. The contribution from bedrock to the "Field Weathering Rate" WR is restricted to saturated groundwater and infiltrates into the lake mainly at deeper levels. At low porosity, e.g. 2%, a recharge of 400 mm a-1 has been estimated. The remaining surface runoff is the dominant H+ source, which infiltrates the lake directly, or after relatively short travelling time when the surface is covered by quaternary deposits.

In the used approach the lithologies were treated as porous homogeneous media, neglecting preferential flow paths. The averaged water composition was then calculated from the contribution of each lithology and expressed as field weathering rate WR for each of the 101 catchments.

This estimation approach was verified on individual catchments, where the water budgets and the lake chemistry is known. Despite the simplifications of the used approach, it was shown that the estimated water composition is in general agreement with the solution composition measured by the MOLAR project.

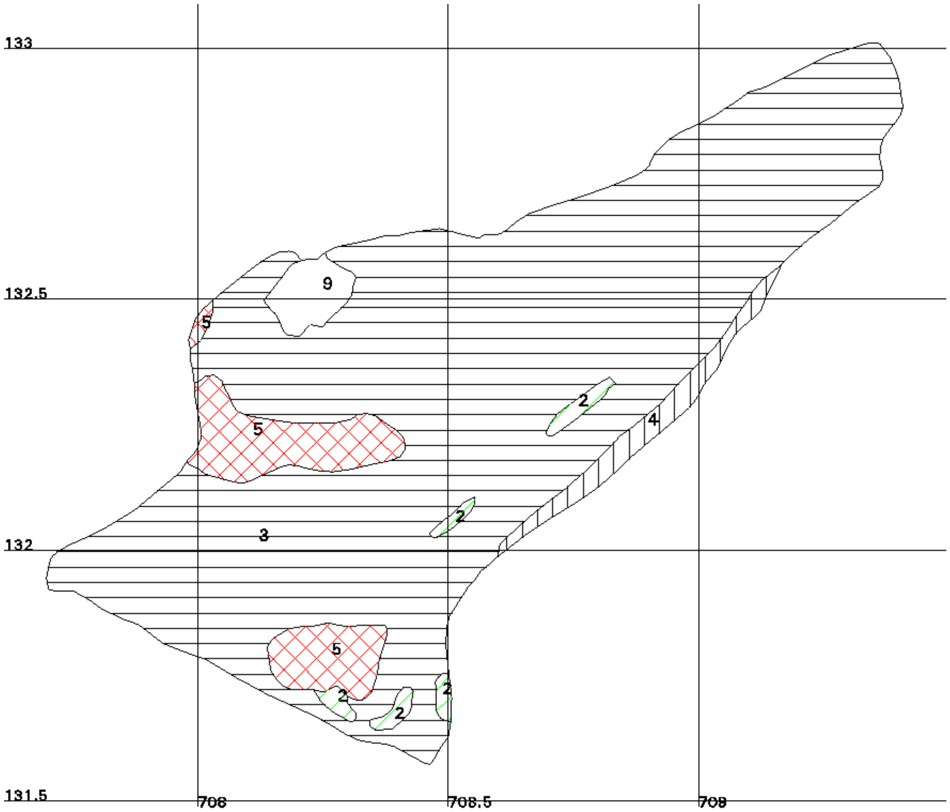

Figure 1: Digitized lithological units in the catchment of lake No 99: quaternary cover (5), leucocratic granite/gneiss (4), melanocratic granite/gneiss (3), amphibolite (2), and carbonate bearing rocks (1), surface water (9).

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UNITED KINGDOM

National Focal Centre

Jane Hall
Jackie Ullyett, Liz Heywood,
Rich Broughton, Joseph Fawehinmi
Centre for Ecology and Hydrology
Monks Wood, Abbots Ripton
Huntingdon PE28 2LS
Tel: + 44 (0)1487 772429
Fax: +44 (0)1487 773467
Email: jrha@ceh.ac.uk
Web: http://critloads.ceh.ac.uk

Collaborating Institutions

Terrestrial Effects
Bridget Emmett
Centre for Ecology and Hydrology
Orton Building, Deiniol Road
Bangor LL57 2UP
Tel: +44 (0)1248 370045
Fax: +44 (0)1248 355365
Email: bae@ceh.ac.uk

Freshwater Effects
Chris Curtis
Environmental Change Research
Centre, Department of Geography
University College London
26 Bedford Way
London WC1H 0AP
Tel: +44 (0)20 7679 7553
Fax: +44 (0)20 7679 7565
Email: ccurtis@geog.ucl.ac.uk

Dynamic Modelling
Alan Jenkins
Centre for Ecology and Hydrology
Maclean Building
Crowmarsh Gifford
Wallingford OX10 8BB
Tel: +44 (0)1491 838800
Fax: +44 (0)1491 692424
Email: jinx@ceh.ac.uk

Deposition data
David Fowler
Centre for Ecology and Hydrology
Bush Estate
Penicuik EH26 0QB
Tel: +44 (0)31 445 4343
Fax: +44 (0)31 445 3943
Email: dfo@ceh.ac.uk

Introduction

This update to the critical loads of acidity and nutrient nitrogen for sensitive UK habitats has been made in light of new research findings and revisions to (i) the woodland habitat maps, (ii) the mapping of critical loads for peat soils, (iii) the critical chemical criterion used in the calculation of acidity critical loads for woodlands occurring on organo-mineral soils, (iv) the number of freshwater sites for which acidity critical loads are calculated, (v) the critical chemical threshold of acid neutralising capacity used in the calculation of acidity critical loads for freshwaters. No changes have been made to the UK critical loads for nutrient nitrogen. This report provides an overview of the revisions made. A summary of the critical loads data submitted is provided in Tables UK-1 (terrestrial habitats) and UK-2 (freshwater habitats) and a comparison of the previous and updated mean critical load values in Table UK-3. In addition, for the first time the UK has submitted dynamic modelling outputs for 109 freshwater sites (Table UK-4). A detailed report (Hall et al., 2004) and maps are available on the UK NFC web site (http://critloads.ceh.ac.uk).

Woodland habitat maps

The UK calculates acidity and nutrient nitrogen critical loads for both managed and unmanaged woodlands (Hall et al., 2003), where the unmanaged woodland consists of ancient and semi-natural woodland, yew and Scots Pine that is ‘managed’ for biodiversity or amenity, but not timber production. The managed woodland is primarily productive forest where harvesting and removal of trees takes place.

This year, whilst revisiting the acidity critical load methods to be applied to woodlands on different soil types, it became apparent that there were areas of managed broadleaved woodland mapped in grid squares dominated by peat soils. The UK’s Forest Research (FR) considered this was unlikely, and suggested it was more likely they were young coniferous trees. This discrepancy has arisen because in the 2002-03 mapping exercise, the decision was made to map young trees (undefined in the source data from the National Inventory of Woodland and Trees: FC, 2003) as managed broadleaved woodland. FR therefore recommended that these woodland areas be removed from the managed broadleaved woodland map and added to the managed coniferous woodland map.

The original data sets from the FR were duly modified and the habitats re-mapped using the methods described in Hall et al. (2003). This has resulted in a 6% increase in the area of managed coniferous woodland (EUNIS class G3) and a 0.5% decrease in the area of managed broadleaved woodland (EUNIS class G1).

The mapping of acidity critical loads for peat soils

The following equation, based on setting the critical load to the amount of acid deposition that would give rise to an effective rain pH of 4.4, is used to calculate acidity critical load for UK peat soils:

$CLA = Q * [H^+]$

Where:
Q = runoff in metres
$[H^+]$ = critical hydrogen ion concentration equivalent to pH 4.4

This method is supported by UK data published by Calver (2003), Skiba and Cresser (1989) and Calver et al. (2004 in press).

UK soil critical load experts discussed and agreed that the corresponding soil solution pH to an effective rain pH of 4.4, would also be pH 4.4. Therefore the method used for peat soils can be expressed as a simple mass balance (SMB) equation with a criterion of critical soil solution pH 4.4. The equation used remains the same as that above, as the leaching of aluminium and base cation weathering can both be set to zero for peat soils.

This method is applicable to upland and lowland acid peat soils, but not to the lowland/arable fen peats which are not as sensitive to acidification and therefore require a higher critical load. The critical loads for lowland/arable fen areas were re-set to 4.0 keq ha^{-1} yr^{-1}; this high value is at the top of the empirical range of critical load values for soils (Hornung et al., 1995a). Previously the lowland/arable fen areas were defined by selecting any 1km square dominated by peat soil that also contained any arable land, according to the CEH Land Cover Map 2000 (LCM2000; Fuller et al., 2002). When this method was reviewed in December 2003, it was agreed that the critical load of 4.0 keq ha^{-1} yr^{-1} had been set for some areas that would not in fact be considered to be lowland/arable fen. To refine this, a map was created identifying this habitat as those squares that are dominated by peat soil and where arable is the dominant land cover according to LCM2000. This reduced the number of 1km squares requiring the critical load to be re-set to 4.0 keq ha^{-1} yr^{-1} from 2829 to 514; subsequently the mean acidity critical load for the peat-dominated squares across the UK was reduced from 1.1 keq ha^{-1} year^{-1} to 0.8 keq ha^{-1} yr^{-1}. This has reduced the acidity critical loads where terrestrial habitats occur on peat soils.

Calculating critical loads for woodlands on organo-mineral soils

There have been three main changes to the critical load calculations for woodlands on organo-mineral soils:

(i) For the 2003 data submission different methods were applied to the calculation of acidity critical loads for woodlands on mineral, organic and peat soils (Hall et al., 2003). The acidity critical loads for woodlands on organic soils were based on a critical soil solution of pH 4.0. In December 2003 UK experts reviewed the methods applied to UK woodlands and agreed that the soil types previously classified as “organic” were really “organo-mineral”, ie, mineral soils with a peaty top. Therefore soil water aluminium must be accounted for when considering acidification processes in these soils and must be included in the criterion used in the SMB equation. It was therefore agreed that it is more justifiable to maintain consistency of approaches for both mineral and organo-mineral soils and to use the molar soil solution ratio of Ca:Al=1 criteria for both soil types.

(ii) The gibbsite coefficient (Kgibb) in the SMB equation is set to 950 m^6 eq^{-2} for mineral soils. For the organo-mineral soils expert judgement recommended using a gibbsite coefficient of 100 m^6 eq^{-2} on the basis that the tree roots are largely limited to the upper soil horizons because sub-soil conditions such as frequent waterlogging in heavy textured soils can often inhibit root development below the surface organic layer.

(iii) The application of phosphate and potassium fertilisers (primarily rock phosphate and muriate of potash) as a contribution to the base cation budget to managed woodlands has been taken into account in the calculation of acidity critical loads for the managed woodlands on organo-mineral and peat soils. Critical loads are required to protect these managed habitats and to protect the land under managed conifer forest for future non-forest use and possible reversion to semi-natural land uses.

Critical loads of acidity for freshwaters

The number of freshwater sites in acidified regions for which acidity critical loads are calculated and mapped has been increased using new survey information. This updated mapping data set includes sites where the MAGIC dynamic model has been applied, providing consistency between the sites where both static and dynamic models are applied. FAB critical loads are now supplied for a total of 1722 sites across the UK. Additionally outputs from MAGIC are provided for 109 of these sites (see section below).

A stakeholder workshop, hosted by Defra (Hall et al., 2004), was held prior to this data submission to discuss and agree the most appropriate value(s) of the critical chemical threshold of acid neutralising capacity (ANCcrit) used in the calculation of acidity critical loads. The workshop considered the supporting scientific evidence and concluded that an

ANCcrit value of 20 μeql^{-1} should be applied to all sites, except for naturally acidic sites where data suggest that the pre-industrial value was lower, in which case ANCcrit 0 μeql^{-1} should be retained. As a result ANCcrit 20μeql^{-1} has been applied to 1679 sites and ANCcrit 0 μeql^{-1} to the remaining 43 sites.

The data submitted are based on the reformulated FAB model of Henriksen & Posch (2001). This version of FAB takes account of direct deposition to the lake surface, whereas the previous version (Posch et al., 1997) assumed that all deposited N had first to pass through the terrestrial catchment before reaching surface waters.

Dynamic modelling results

The dynamic model MAGIC (Model of Acidification of Groundwater In Catchments) has been used to generate Target Load Functions (TLFs) for 109 sites as part of this data submission. All 109 sites are surface standing waters (EUNIS class C1). MAGIC is a lumped-parameter model of intermediate complexity, developed to predict the long-term effects of acidic deposition on soils and surface water chemistry (Cosby et al., 1985a,b,c, 1986, 2001).

TLFs have been calculated using MAGIC model applications for 52 sites in Galloway (south-west Scotland) and 57 sites in the south Pennines (northern England). The models are calibrated with best available soils, surface water and deposition chemistry data. Present day sulphur deposition is estimated from observed surface water flux and scaled to the predicted reduction for 2010 reported in the EMEP GP-NEC (Gothenburg Protocol and National Emissions Ceiling Directive) database. Present day nitrogen deposition is taken directly from the UK 5 km deposition database for 1998-2000 (Pennines sites) or 1995-97 (Galloway sites) and scaled to 2010 using the reductions reported in the EMEP GP-NEC database. Target load functions are submitted for the target years 2030, 2050 and 2100. A summary of the results is presented is Table UK-4.

The UK plans to apply dynamic models to (a) c.800 freshwater sites across the country, (b) all 1 km squares in the terrestrial critical loads dataset where there is potential for current damage (i.e. chemical conditions below the critical threshold for that soil and habitat class), since these are the sites at which recovery may be expected, and target loads can be calculated. Dynamic modelling outputs for terrestrial habitats are not included in this data submission. The UK is currently working on terrestrial dynamic modelling and collating the additional data required; and subject to data availability, will make results available for the next call for data.

Table UK-1. Summary of UK critical load values for terrestrial habitats and justification for their use.

Critical loads parameter (units)	EUNIS code	UK Habitat	Minimum Value	Maximum Value	Data sources/ Methods used	Justification
CLmax(S) (eq ha^{-1} yr^{-1})	G1	Managed broadleaved woodland	100	12069	= CL(A) + (BC*dep – Cl*dep) – BCu	Mapping Manual (UBA, 1996, 2003)
	G3	Managed coniferous woodland	100	13437		
	G1&G3	Unmanaged woodland	213	12905		
	F4.11	Wet dwarf shrub heath	130	4460		
	F4.2	Dry dwarf shrub heath	140	4590		
	E1.26	Calcareous grassland	4000	4368		
	E1.7	Dry acid grassland	130	4490		
	E3.5	Wet acid grassland	130	4470		
	E4.2	Montane	140	4130		
	D1	Bogs	130	4220		
CLmin(N) (eq ha^{-1} yr^{-1})	G1	Managed broadleaved woodland	562	920	= Nu + Ni + Nde	Mapping Manual (UBA, 1996, 2003)
	G3	Managed coniferous woodland	352	710		
	G1&G3	Unmanaged woodland	142	500		
	F4.11	Wet dwarf shrub heath	499	857		
	F4.2	Dry dwarf shrub heath	1249	1607		
	E1.26	Calcareous grassland	856	1214		
	E1.7	Dry acid grassland	223	581		
	E3.5	Wet acid grassland	223	581		
	E4.2	Montane	178	536		
	D1	Bogs	178	536		
CLmax(N) (eq ha^{-1} yr^{-1})	G1	Managed broadleaved woodland	662	12920	= CLmax(S) + CLmin(N)	Mapping Manual (UBA, 1996, 2003)
	G3	Managed coniferous woodland	514	13932		
	G1&G3	Unmanaged woodland	498	13047		
	F4.11	Wet dwarf shrub heath	629	5046		
	F4.2	Dry dwarf shrub heath	1389	5839		
	E1.26	Calcareous grassland	4856	5224		
	E1.7	Dry acid grassland	363	4713		
	E3.5	Wet acid grassland	363	4770		
	E4.2	Montane	318	4421		
	D1	Bogs	318	4725		

CLnut(N) (eq ha^{-1} yr^{-1})	G1	Managed broadleaved woodland	776	1134	N mass balance = Nu + Ni + Nde + Nle(acc)	Mapping Manual (UBA, 1996, 2003)
	G1-LA	Broadleaved woodland – effects on epiphytic lichens	714	714	Empirical 10 kg N ha^{-1} yr^{-1}	Achermann & Bobbink, 2003; Hall et al. (2003); Mapping Manual (UBA, 2003)
	G3	Managed coniferous woodland	638	996	N mass balance = Nu + Ni + Nde + Nle(acc)	Mapping Manual (UBA, 1996, 2003)
	G1&G3-GF	Unmanaged woodland – effects on ground flora	857	857	Empirical 12 kg N ha^{-1} yr^{-1}	Achermann & Bobbink, 2003; Hall et al. (2003); Mapping Manual (UBA, 2003)
	F4.11	Wet dwarf shrub heath	1071	1071	Empirical 15 kg N ha^{-1} yr^{-1}	
	F4.2	Dry dwarf shrub heath	857	857	Empirical 12 kg N ha^{-1} yr^{-1}	
	E1.26	Calcareous grassland	1429	1429	Empirical 20 kg N ha^{-1} yr^{-1}	
	E1.7	Dry acid grassland	1071	1071	Empirical 15 kg N ha^{-1} yr^{-1}	
	E3.5	Wet acid grassland	1071	1071	Empirical 15 kg N ha^{-1} yr^{-1}	
	E4.2	Montane	500	500	Empirical 7 kg N ha^{-1} yr^{-1}	
	D1	Bogs	714	714	Empirical 10 kg N ha^{-1} yr^{-1}	
	B1.3/B1.4	Supralittoral sediment (dune grasslands)	1071	1071	Empirical 15 kg N ha^{-1} yr^{-1}	
BC*dep – Cl*dep (eq ha^{-1} yr^{-1})	G1	Managed broadleaved woodland	0	800	Updated from measured mean data for 2000 to mean data for 1998-2000 for woodland habitats	Mapping Manual (UBA, 1996, 2003), Hall et al. (2003, 2004). Non-marine deposition values used in the calculation of CLmaxS. Total BCdep and Cldep submitted to CCE.
	G3	Managed coniferous woodland	0	800		
	G1&G3	Unmanaged woodland	0	800		
	F4.11	Wet dwarf shrub heath	0	590	Updated from measured mean data for 2000 to mean data for 1998-2000 for low-growing vegetation	
	F4.2	Dry dwarf shrub heath	0	590		
	E1.26	Calcareous grassland	0	590		
	E1.7	Dry acid grassland	0	590		
	E3.5	Wet acid grassland	0	590		
	E4.2	Montane	0	590		
	D1	Bogs	0	590		
Total Ca dep (eq ha^{-1} yr^{-1})	G1	Managed broadleaved woodland	80	930	Updated from measured mean data for 2000 to mean data for 1998-2000 for woodland habitats	Mapping Manual (UBA, 1996, 2003), Hall et al. (2003, 2004). Total (marine plus non-marine) deposition values used in the SMB equation to calculate acidity critical loads for UK woodland habitats.
	G3	Managed coniferous woodland	80	860		
	G1&G3	Unmanaged woodland	80	930		
	F4.11	Wet dwarf shrub heath	-	-	SMB not used, so Ca deposition not required, but data submitted.	
	F4.2	Dry dwarf shrub heath	-	-		
	E1.26	Calcareous grassland	-	-		
	E1.7	Dry acid grassland	-	-		

	E3.5	Wet acid grassland	-	-		
	E4.2	Montane	-	-		
	D1	Bogs	-	-		
BCu (eq ha^{-1} yr^{-1})	G1	Managed broadleaved woodland	315	410	Values based on soil/woodland type	Values from Forest Research, based on site-specific measurements from ten ICP Forests Intensive Forest Health monitoring sites (Level II) in the UK. (Hall et al., 2003, 2004) Values used in CLmaxS only, estimates of calcium uptake used in SMB for mineral soils.
	G3	Managed coniferous woodland	270	270		
	G1&G3	Unmanaged woodland	0	0	Unmanaged woodland, uptake set to zero assuming no harvesting	
	F4.11	Wet dwarf shrub heath	0	0	Set to zero; uptake negligible	Rawes & Heal (1978); Reynolds et al. (1987)
	F4.2	Dry dwarf shrub heath	0	0		
	E1.26	Calcareous grassland	222	222	Includes removal by sheep grazing	Published data
	E1.7	Dry acid grassland	0	0	Set to zero; uptake negligible	Rawes & Heal (1978); Reynolds et al. (1987)
	E3.5	Wet acid grassland	0	0		
	E4.2	Montane	0	0		
	D1	Bogs	0	0		
Ca uptake	G1	Managed broadleaved woodland	195	290	Values based on soil/woodland type and used in SMB equation	Values from Forest Research, based on site-specific measurements from ten ICP Forests Intensive Forest Health monitoring sites (Level II) in the UK. (Hall et al., 2003, 2004)
	G3	Managed coniferous woodland	160	160		
	G1&G3	Unmanaged woodland	0	0	Unmanaged woodland, uptake set to zero assuming no harvesting	
	F4.11	Wet dwarf shrub heath	-	-	SMB not used, so Ca uptake values not required.	
	F4.2	Dry dwarf shrub heath	-	-		
	E1.26	Calcareous grassland	-	-		
	E1.7	Dry acid grassland	-	-		
	E3.5	Wet acid grassland	-	-		
	E4.2	Montane	-	-		
	D1	Bogs	-	-		
ANCw (eq ha^{-1} yr^{-1})	G1	Managed broadleaved woodland	100	4000	Based on mid-range empirical acidity critical loads for soils.	Methods agreed by UK experts. Hall et al. (2003), Mapping Manual
	G3	Managed coniferous woodland	0	4000		

	G1&G3	Unmanaged woodland	0	4000	ANCw set to zero for peat soils. Note: calcium weathering only used in calculation of ANCle(crit).	(2004).
	F4.11	Wet dwarf shrub heath	0	4000	Empirical critical loads of acidity for soils, based on base cation weathering rates, applied to non-woodland terrestrial habitats.	Hornung et al. (1995a), Hall et al. (2003), Mapping Manual (2004).
	F4.2	Dry dwarf shrub heath	0	4000		
	E1.26	Calcareous grassland	4000	4000		
	E1.7	Dry acid grassland	0	4000		
	E3.5	Wet acid grassland	0	4000		
	E4.2	Montane	0	4000		
	D1	Bogs	0	4000		
Cawe (eq ha^{-1} yr^{-1})	G1	Managed broadleaved woodland	5	4000	Derived from ANCw and used in the calculation of ANCle(crit).	Methods agreed by UK experts. Hall et al. (2003).
	G3	Managed coniferous woodland	0	4000		
	G1&G3	Unmanaged woodland	0	4000		
	F4.11	Wet dwarf shrub heath	-	-	Empirical critical loads of acidity for soils, based on base cation weathering rates, applied to non-woodland terrestrial habitats. Cawe alone not required, but data submitted.	Hornung et al. (1995a), Hall et al. (2003).
	F4.2	Dry dwarf shrub heath	-	-		
	E1.26	Calcareous grassland	-	-		
	E1.7	Dry acid grassland	-	-		
	E3.5	Wet acid grassland	-	-		
	E4.2	Montane	-	-		
	D1	Bogs	-	-		
ANCle(crit) (eq ha^{-1} yr^{-1})	G1	Managed broadleaved woodland	0	8000	Calculated via SMB equation: mineral and organo-mineral soils: critical molar ratio Ca:Al = 1 in soil solution; peat soils: critical soil solution pH 4.4.	Mapping Manual (UBA, 1996, 2003), Hall et al. (2003, 2004).
	G3	Managed coniferous woodland	0	9437		
	G1&G3	Unmanaged woodland	70	8530		
	F4.11	Wet dwarf shrub heath	0	0	Empirical critical loads of acidity for soils, based on base cation weathering rates, applied to non-woodland terrestrial habitats. ANCle(crit) set to zero.	Hornung et al. (1995a), Hall et al. (2003).
	F4.2	Dry dwarf shrub heath	0	0		
	E1.26	Calcareous grassland	0	0		
	E1.7	Dry acid grassland	0	0		
	E3.5	Wet acid grassland	0	0		
	E4.2	Montane	0	0		
	D1	Bogs	0	0		
Nu (eq ha^{-1} yr^{-1})	G1	Managed broadleaved woodland	420	420	Value equivalent to 5.88 kg N ha^{-1} year^{-1}	Values from Forest Research, based on site-specific

	G3	Managed coniferous woodland	210	210	Value equivalent to 2.94 kg N ha^{-1} year^{-1}	measurements from ten ICP Forests Intensive Forest Health monitoring sites (Level II) in the UK. (Hall et al. 2003)
	G1&G3	Unmanaged woodland	0	0	Uptake set to zero assuming no harvesting	
	F4.11	Wet dwarf shrub heath	36	36	Value, equivalent to 0.5 kg N ha^{-1} yr^{-1}.	Perkins (1978), Rawes & Heal (1978), Reynolds et al. (1987), Batey (1982), Gordon et al. (2001)
	F4.2	Dry dwarf shrub heath	36	36		
	E1.26	Calcareous grassland	714	714	Value equivalent to 10 kg N ha^{-1} yr^{-1}	
	E1.7	Dry acid grassland	81	81	Value, equivalent to 1.14 kg N ha^{-1} yr^{-1}	Frissel (1978)
	E3.5	Wet acid grassland	81	81		
	E4.2	Montane	36	36	Value equivalent to 0.5 kg N ha^{-1} yr^{-1}	UK experts agreed to apply the same value as used for F4.11 & F4.2 (Hall et al., 2003)
	D1	Bogs	36	36		
Ni (eq ha^{-1} yr^{-1})	G1	Managed broadleaved woodland	71	214	Ni values assigned according to soil type	Mapping Manual (UBA, 1996, 2003), Hornung et al. (1995b), Curtis (2002).
	G3	Managed coniferous woodland	71	214		
	G1&G3	Unmanaged woodland	71	214		
	F4.11	Wet dwarf shrub heath	71	214	= Ni + Nfire, (Nfire = 4.5 kg N ha-1 yr-1)	Inclusion of Nfire: UBA (1996, 2003). Nfire values: Chapman (1967), Allen (1964).
	F4.2	Dry dwarf shrub heath	71	214	= Ni + Nfire (Nfire = 15 kg N ha^{-1} yr^{-1})	
	E1.26	Calcareous grassland	71	214	Ni values assigned according to soil type	Mapping Manual (UBA, 1996, 2003), Hornung et al. (1995b).
	E1.7	Dry acid grassland	71	214		
	E3.5	Wet acid grassland	71	214		
	E4.2	Montane	71	214		
	D1	Bogs	71	214		
Nle(acc) (eq ha^{-1} yr^{-1})	G1	Managed broadleaved woodland	214	214	Value equivalent to 3 kg N ha^{-1} yr^{-1}	Williams et al. (2000)
	G3	Managed coniferous woodland	286	286	Value equivalent to 4 kg N ha^{-1} yr^{-1}	Emmett et al. (1993), Emmett & Reynolds (1996)
	G1&G3	Unmanaged woodland	-	-	Empirical nutrient nitrogen critical loads used, therefore Nle(acc) not assigned.	
	F4.11	Wet dwarf shrub heath	-	-		
	F4.2	Dry dwarf shrub heath	-	-		
	E1.26	Calcareous grassland	-	-		
	E1.7	Dry acid grassland	-	-		
	E3.5	Wet acid grassland	-	-		
	E4.2	Montane	-	-		

	D1	Bogs	-	-		
Nde (eq ha^{-1} yr^{-1})	G1	Managed broadleaved woodland	71	286	Nde values assigned according to soil type	Mapping Manual (UBA, 1996, 2003), Hornung et al. (1995b).
	G3	Managed coniferous woodland	71	286		
	G1&G3	Unmanaged woodland	71	286	Nde values assigned according to soil type. Only used in CLmin(N) as empirical nutrient nitrogen critical loads applied.	
	F4.11	Wet dwarf shrub heath	71	286		
	F4.2	Dry dwarf shrub heath	71	286		
	E1.26	Calcareous grassland	71	286		
	E1.7	Dry acid grassland	71	286		
	E3.5	Wet acid grassland	71	286		
	E4.2	Montane	71	286		
	D1	Bogs	71	286		
Precipitation surplus Q (mm)	G1	Managed broadleaved woodland	571	3130	1km runoff data based on 30-year (1941-1970) mean rainfall data.	Used in SMB equation for acidity critical loads for woodland habitats
	G3	Managed coniferous woodland	100	3393		
	G1&G3	Unmanaged woodland	83	3631		
	F4.11	Wet dwarf shrub heath	-	-	Empirical critical loads of acidity for soils, based on base cation weathering rates, applied to non-woodland terrestrial habitats. Therefore Q not required but data submitted.	
	F4.2	Dry dwarf shrub heath	-	-		
	E1.26	Calcareous grassland	-	-		
	E1.7	Dry acid grassland	-	-		
	E3.5	Wet acid grassland	-	-		
	E4.2	Montane	-	-		
	D1	Bogs	-	-		
Log KAlox	G1	Managed broadleaved woodland	7.6	8.5	Minimum value applied to organic soils, maximum value applied to mineral soils. Not used for peat soils.	Mapping Manual (UBA, 1996, 2003), Hall et al. (2003, 2004)
	G3	Managed coniferous woodland	7.6	8.5		
	G1&G3	Unmanaged woodland	7.6	8.5		
	F4.11	Wet dwarf shrub heath	-	-	Empirical critical loads of acidity for soils, based on base cation weathering rates, applied to non-woodland terrestrial habitats. Therefore log KAlox not assigned.	
	F4.2	Dry dwarf shrub heath	-	-		
	E1.26	Calcareous grassland	-	-		
	E1.7	Dry acid grassland	-	-		
	E3.5	Wet acid grassland	-	-		
	E4.2	Montane	-	-		
	D1	Bogs	-	-		

Table UK-2. Summary of UK critical load values for freshwater habitats and justification for their use.

Critical loads parameter (units)	EUNIS code	UK Habitat	Minimum Value	Maximum Value	Data sources/ Methods used	Justification
CLmaxS	C1	Surface standing water	0.1	27934	= Lcrit / (1 – ρS)	Mapping Manual (UBA, 1996, 2003)
	C2	Rivers and streams	5.4	37899		
CLminN	C1	Surface standing water	76	582	= *f*Nu + (1-r)(Ni + Nde)	Mapping Manual (UBA, 1996, 2003)
	C2	Rivers and streams	146	565		
CLmax(N) (eq ha^{-1} yr^{-1})	C1	Surface standing water	1	186387		
	C2	Rivers and streams	317	38198		
CLnut(N) (eq ha^{-1} yr^{-1})	C1	Surface standing water	-	-	CLnut(N) not assigned to freshwaters sampled in UK	Freshwaters sampled tend to be P-limited, not N-limited.
	C2	Rivers and streams	-	-		
Nimacc (eq ha^{-1} yr^{-1})	C1	Surface standing water	17	214	Ni values catchment weighted by soil type	Curtis (2002).
	C2	Rivers and streams	71	214		
Nde (eq ha^{-1} yr^{-1})	C1	Surface standing water	16	286	Uses catchment weighted Nde values (based on soil type) instead of *f*de	Use of *f*de as in UBA (1996, 2003) gives Nde values too high for UK (Curtis et al. 1998)
	C2	Rivers and streams	71	286		
Annual runoff Q (m)	C1	Surface standing water	0.1	3.85	1km catchment-weighted runoff based on mean rainfall data for 1941-70 for GB and 1961-90 for NI	Mapping Manual (UBA, 1996, 2003)
	C2	Rivers and streams	0.2	3.17		

Table UK-3. Summary of changes in the mean values of CLmax(S), CLmin(N) and CLmax(N)

Critical load	Broad habitat[1] (EUNIS class)	Previous (Feb 2003) mean value (eq ha^{-1} year^{-1})	Updated (Feb 2004) mean value (eq ha^{-1} year^{-1})	Difference between previous and updated means[2]
$CL_{max}(S)$	Acid grassland (E1.7 & E3.5)	824	729	11.5% decrease
	Calcareous grassland (E1.26)	3920	4005	2.2% increase
	Dwarf shrub heath (F4.11 & F4.2)	843	750	11% decrease
	Coniferous woodland (managed) (G3)	1965	1944	1.1% decrease
	Broadleaved woodland (managed) (G1)	2660	2788	4.8% increase
	Unmanaged woodland (G1&G3)	3243	3187	1.7% decrease
	Bogs (D1)	901	626	30.5% decrease
	Montane (E4.2)	557	483	13.3% decrease
	Standing open waters, rivers & streams (C1 & C2)[3]	3636	3255	10.5% decrease
$CL_{min}(N)$	Acid grassland (E1.7 & E3.5)	367	367	No change
	Calcareous grassland (E1.26)	889	889	No change
	Dwarf shrub heath (F4.11 & F4.2)	851	851	No change
	Coniferous woodland (managed) (G3)	478	478	No change
	Broadleaved woodland (managed) (G1)	663	662	0.2% decrease
	Unmanaged woodland (G1&G3)	245	245	No change
	Bogs (D1)	343	343	No change
	Montane (E4.2)	318	318	No change
	Standing open waters, rivers & streams (C1 & C2)[3]	307	294	4.2% decrease
$CL_{max}(N)$	Acid grassland (E1.7 & E3.5)	1192	1096	8.1% decrease
	Calcareous grassland (E1.26)	4809	4894	1.8% increase
	Dwarf shrub heath (F4.11 & F4.2)	1695	1602	5.5% decrease
	Coniferous woodland (managed) (G3)	2443	2422	0.9% decrease
	Broadleaved woodland (managed) (G1)	3323	3450	3.8% increase
	Unmanaged woodland (G1&G3)	3488	3432	1.6% decrease
	Bogs (D1)	1244	969	22.1% decrease
	Montane (E4.2)	874	801	8.4% decrease
	Standing open waters, rivers & streams (C1 & C2)[3]	5308	4653	12.3% decrease

[1] The “broadleaved, mixed and yew woodland” broad habitat is separated into “broadleaved woodland (managed)” and “unmanaged (ancient & semi-natural) coniferous and broadleaved woodland” abbreviated to “Unmanaged woodland” above; the latter includes Atlantic oak woods and unmanaged coniferous woodland.

[2] An increase or decrease in the mean critical load values does not necessarily mean that all values for that habitat have increased or decreased, some may have increased in value and others decreased in value.

[3] The number of sites in the freshwater data set has increased from 1163 to 1722.

TableUK- 4. Summary of results of dynamic model applications for 109 sites in EUNIS class C1.

Target Year	UK area	Number of sites by target load status:		
		TLF present	TL not feasible	Not exceeded*
2030	Pennines	15	0	42
	Galloway	6	2	44
2050	Pennines	18	0	39
	Galloway	9	3	40
2100	Pennines	21	0	36
	Galloway	12	5	35

* Site not exceeded in 2010 and no reduction required in target year.

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ANNEX 1

Instructions for Submitting Critical Loads and Dynamic Modelling Data

This annex is a reprint of the instructions as it was send to all National Focal Centres with the call for data.

Introduction

This document is a guide for the submission of data to the CCE on critical loads of acidity and eutrophication and dynamic modelling output (target load functions). The data submission should be accompanied by a document describing the sources and the methods used to produce the data.

Your submission should contain the following key outputs:
(1) **Updated critical loads** (see Table 1)
(2) **Target load functions for target years 2030, 2050 and 2100** (see Table 2)
(3) **Value of the critical chemical variable (e.g., Bc/Al ratio) in the target years when running the dynamic model with the 2010 (Gothenburg) depositions kept constant afterwards** (Table 3)
In addition, a number of input variables are asked to allow consistency checks and inter-country comparisons (see Table 1).

Please note:

- The deadline for the submissions is **<u>31 March 2004</u>**

- The data is preferably submitted in an Access database (mdb-file), but is also accepted as Excel or ASCII comma-delimited files. MS Access is capable of importing many formats, where so called ‘wizards’ (logical sequence of forms) help you in this process. If you download a template Access-database available from our website, you are sure to use the correct names for every columns. There are two such templates available. Template Access-database ‘callTL.mdb’ can be used if you submit results generated with an external dynamic model, while ‘callVSD.mdb’ is the template Access-database in which VSD has been embedded. If you prefer to use Excel, the CCE website includes a file ‘callVSD.xls’. All downloads are available as zipped files.
- Please email your submission to jaap.slootweg@rivm.nl, or inform him when uploading it to our ftp-server. The easiest way to assemble and submit data is to use the template Access database (callTL.mdb or callVSD.mdb). This database and the (information about) latest releases of software for dynamic modelling is made available on our website under ***News***: www.rivm.nl/cce
- Note that the latest version of the Mapping Manual is available on the website of the ICP M&M (www.icpmapping.org) with recent updates for chapter 5 (Critical Loads) and 7 (Dynamic Modelling). See also the various Help-files of the software provided by the CCE.
- Target load functions are asked for the **<u>target years 2030, 2050 and 2100</u>**, all with the **<u>implementation year 2015</u>**, in which deposition reductions after the **<u>protocol year 2010</u>** are fully implemented (see last section for details).

Most important changes since the last call for data:

- The *outputs* of dynamic modelling (target load functions) are to be put in Table 2. Table 2 is linked to *inputs* in Table 1 (critical loads and model parameters) by a new column, ‘SiteID’, uniquely identifying the site.
- Instead of lumping all base cations for deposition, weathering and uptake, they are now asked separately.
- To enable the use of a more general Al–H equilibrium, now lgKAlox and expAl are asked for (instead of Kgibb; see Dynamic Modelling Manual eq 3.8).
- The (calibrated) logarithms of the exchange constants, lgAlBc and lgAlH, are now asked.
- ‘Nde’ and ‘fde, which exclude each other, are now in two columns.
- For aquatic ecosystems a dedicated format (see Table 4) is used.
- Observed values for base saturation, C:N ratio and C pool are asked instead of the initial quantities (which should be calibrated from these observations).
- A few names of variables and their positions in Table 1 have changed.
- The depositions for NOx, NH_3 and S in 2010 (=protocol year) used for target load calculations for the site are asked.
- The EUNIS code should be provided, preferably with a maximum length of 4 characters.
- An **empty** (**null**) value should be used to indicate missing data (0 or –1 etc. are interpreted as data!)

Data structure

Every ecosystem within an EMEP50-grid cell for which critical loads are provided is represented in the file by one line (record), and every record has 50 entries (see Table 1), holding site information critical loads, and input data for CLs and dynamic modelling. Records for which no target loads are calculated should contain the value ‘–1’ in the column ‘TLstatus’. The target load functions themselves are to be submitted according to the structure given in Table 2. Finally, Table 3 contains the value of the critical chemical variable (e.g., Bc/Al ratio) in the target years when running the dynamic model with the 2010 (Gothenburg) depositions kept constant afterwards. Entries to Tables 1–3 are described in more detail below.

The easiest way to assemble and submit data is to use the template **Access database** (‘callVSD.mdb’) that is made available on our website www.rivm.nl/cce, under ‘News’. This template database contains 3 Tables, ‘inputs’, ‘targetloads’ and ‘critvalues’, resp., with the attributes listed in Tables 1-3. It also includes the Access implementation of the VSD model. You can download it from our website, import the data and use the form “calctargets” to do the calculations. A more detailed description on how to do this is included in the download (see ‘callVSD.doc’). Also available on the CCE website is a template Access database (‘callTL.mdb’) which can be used if you submit results generated with an external dynamic model or if you do not apply dynamic modelling.

Table 1. Attributes of the table 'inputs' (for surface waters see Table 4).

Variable	**Explanation**	**Note**
SiteID	Identifier for the site	1)
Lon	Longitude (decimal degrees)	2)
Lat	Latitude (decimal degrees)	2)
I50	EMEP50 horizontal coordinate	3)
J50	EMEP50 vertical coordinate	3)
EcoArea	Area of the ecosystem within the EMEP grid cell (km^2)	4)
CLmaxS	Maximum critical load of sulphur ($eq\ ha^{-1}\ a^{-1}$)	
CLminN	Minimum critical load of nitrogen ($eq\ ha^{-1}\ a^{-1}$)	
CLmaxN	Maximum critical load of nitrogen ($eq\ ha^{-1}\ a^{-1}$)	
CLnutN	Critical load of nutrient nitrogen ($eq\ ha^{-1}\ a^{-1}$)	
nANCcrit	The quantity $-ANC_{le(crit)}$ ($eq\ ha^{-1}\ a^{-1}$)	5)
Nleacc	Acceptable nitrogen leaching ($eq\ ha^{-1}\ a^{-1}$)	
crittype	Chemical criterion used: 7: molar [Bc]:[Al]; 1: molar [Al]:[Bc]; 2: [Al](eq/m^3); 3: base sat.(-); 4: pH; 5: molar[Bc]:[H]; 6: [ANC](eq/m^3); 0: empirical; –1: other	
critvalue	Critical value for the chemical criterion (given in *crittype*)	
thick	Thickness of the soil (m)	
bulkdens	Average bulk density of the soil ($g\ cm^{-3}$)	6)
Cadep	Total deposition of calcium ($eq\ ha^{-1}\ a^{-1}$)	7)
Mgdep	Total deposition of magnesium ($eq\ ha^{-1}\ a^{-1}$)	7)
Kdep	Total deposition of potassium ($eq\ ha^{-1}\ a^{-1}$)	7)
Nadep	Total deposition of sodium ($eq\ ha^{-1}\ a^{-1}$)	7)
Cldep	Total deposition of chloride ($eq\ ha^{-1}\ a^{-1}$)	7)
Cawe	Weathering of calcium ($eq\ ha^{-1}\ a^{-1}$)	7)
Mgwe	Weathering of magnesium ($eq\ ha^{-1}\ a^{-1}$)	7)
Kwe	Weathering of potassium ($eq\ ha^{-1}\ a^{-1}$)	7)
Nawe	Weathering of sodium ($eq\ ha^{-1}\ a^{-1}$)	7)
Caupt	Net growth uptake of calcium ($eq\ ha^{-1}\ a^{-1}$)	7) 8)
Mgupt	Net growth uptake of magnesium ($eq\ ha^{-1}\ a^{-1}$)	7) 8)
Kupt	Net growth uptake of potassium ($eq\ ha^{-1}\ a^{-1}$)	7) 8)
Qle	Amount of water percolating through the root zone ($mm\ a^{-1}$)	
lgKAlox	Equilibrium constant for the Al-H relationship (log_{10}) (The variable formerly known as Kgibb)	9)
expAl	Exponent for the Al-H relationship (=3 for gibbsite equilibrium)	9)
pCO2fac	Partial CO2-pressure in soil solution as multiple of the atmospheric CO2 pressure (-)	
cOrgacids	Total concentration of organic acids (m*DOC) ($eq\ m^{-3}$)	
Nimacc	Acceptable amount of nitrogen immobilised in the soil ($eq\ ha^{-1}\ a^{-1}$)	10)
Nupt	Net growth uptake of nitrogen ($eq\ ha^{-1}\ a^{-1}$)	8)
fde	Denitrification fraction (0<=fde<1) (-)	11)
Nde	Amount of nitrogen denitrified ($eq\ ha^{-1}\ a^{-1}$)	11)
CEC	Cation exchange capacity ($meq\ kg^{-1}$)	
bsat	Base saturation (-)	
yearbsat	Year in which the base saturation was determined	
lgKAlBc	Exchange constant for Al vs Bc (log_{10})	
lgKHBc	Exchange constant for H vs Bc (log_{10})	

Cpool	Initial amount of carbon in the topsoil (g m^{-2})	
CNrat	C/N ratio in the topsoil	
yearCN	Year in which the CNratio and Cpool were determined	
Sdep2010	Deposition of S in 2010 (Gothenburg Protocol) (eq ha^{-1} a^{-1})	
NOxdep2010	Deposition of NO_x in 2010 (Gothenburg Protocol) (eq ha^{-1} a^{-1})	
NH3dep2010	Deposition of NH_3 in 2010 (Gothenburg Protocol) (eq ha^{-1} a^{-1})	
TLstatus	–1: no TL is calculated 0: safe & non-exceedance in 2010 >= 1: Target load information is given in Table 2	
EUNIScode	EUNIS code, max. 4 characters	12)

<u>Notes on Table 1 (see last column):</u>

1) Use integer values only (4-bytes)!
2) The geographical coordinates of the site or a reference point of the polygon (sub-grid) of the receptor under consideration (in decimal degrees, i.e. 48.5 for 48°30', etc.)
3) Indices (2-byte integers) of the 50km x 50km EMEP-grid cell in which the receptor is located. It is the grid with North Pole at (8,110) as described in the 2003 CCE Status Report, Appendix A, p.127.
4) Please remove spurious records with an ecosystem area smaller than 0.01 km^2.
5) The **negative** Acidity Neutralising Capacity, equal to $Al_{le(crit)} + H_{le(crit)} – HCO3_{le(crit)}$ [–OrgAcids$_{le(crit)}$].
6) Asked earlier under the heading ‘rho’.
7) Values used in the critical load calculations.
8) These are net uptakes, the annual average amount taken from the site by harvesting.
9) From the equation $[Al]=KAl_{ox}\cdot[H]^{ExpAl}$. Note that we ask the decadic logarithm of the KAl_{ox}! For help with unit conversions see App.C of the 2003 CCE Status Report.
10) In previous calls referred to as Nimm. In general this will *not* be the amount immobilised at present! If data permit calculate Nimacc as $N_i+N_{fire}+N_{eros}+N_{vol}–N_{fix}$ (see Mapping Manual).
11) These to are mutually exclusive, i.e. one of them has to be blank!
12) You can find all the information on EUNIS codes on the web, follow the link http://eunis.eea.eu.int/eunis/index.jsp

Table 2. Attributes of the table ‘targetloads’.

Variable	**Explanation**	**Note**
SiteID	Identifier for the site (same as in Table 1)	
TargetYear	either 2030, 2050 or 2100	a)
Status4Year	1: TL function present 2: Target load not feasible 3: non-exceedance in 2010 & no reduction required in TargetYear;	a)
NrOfNodes	if Status4Year not equal to 1, this should be set to 0	a)
depN1	N-value of first node of TLF (should be 0!)	a)
depS1	S-value of first node of TLF	a)
depN2	N-value of second node	a)
depS2	S-value of second node	a)
…		a)
depN9	...	a)
depS9	...	a)

Notes on Table 2 (see last column):
a) For every site (SiteID) these records have to be repeated for every target year (2030, 2050 and 2100). The number of nodes (pairs of N- and S-deposition) describing a target load function (TLF) in the above Table should not exceed 9.

Table 3. Attributes of the table 'critvalue'.

Variable	Explanation	Note
SiteID	Identifier for the site (same as in Table 1)	
TargetYear	Target year	a)
Critvalue	Value of the critical chemical variable in the target year, with no changes in the depositions from 2010 onwards	a)

Notes on Table 2 (see last column):
a) For every site (SiteID) these records have to be repeated for every target year (2030, 2050 and 2100).

Aquatic ecosystems

For aquatic ecosystems Table 1 should be replaced by Table 4 below; Tables 2 and 3 are the same.

Table 4. Attributes of the table 'h2oinputs'

Variable	**Explanation**
SiteID	Identifier for the site
Lon	Longitude (decimal degrees)
Lat	Latitude (decimal degrees)
I50	EMEP50 horizontal coordinate
J50	EMEP50 vertical coordinate
EcoArea	Area of the ecosystem(whole catchment) within the EMEPgrid (km^2)
CLmaxS	Maximum critical load of sulphur (eq ha^{-1} a^{-1})
CLminN	Minimum critical load of nitrogen (eq ha^{-1} a^{-1})
CLmaxN	Maximum critical load of nitrogen (eq ha^{-1} a^{-1})
CLnutN	Critical load of nutrient nitrogen (eq ha^{-1} a^{-1})
crittype	Criterion used: 6: [ANC](eq/m^3); 0: other
critvalue	Value of the criterion used
SoilYear	Year for soil measurements
ExCa	Exchangeable pool of calcium in given year (%)
ExMg	Exchangeable pool of magnesium in given year (%)
ExNa	Exchangeable pool of sodium in given year (%)
ExK	Exchangeable pool of potassium in given year (%)
thick	Thickness of the soil (m)
Porosity	Soil pore fraction (%)
bulkdens	Bulk density of the soil (g cm^{-3})
Nimacc	Acceptable amount of nitrogen immobilised in the soil (eq ha^{-1} a^{-1})
CEC	Cation exchange capacity (meq kg^{-1})
HlfSat	Half saturation of SO4 ads isotherm (ueq L^{-1})
Emx	Maximum SO4 ads capacity (meq kg^{-1})
Nitrif	Nitrification in the catchment (meq m^{-2} a^{-1})
Denitrf	Denitrification rate in catchment (meq m^{-2} a^{-1})
Cpool	Amount of carbon in the topsoil in the given yearCN(g m^{-2})
Npool	Amount of nitrogen in the topsoil in the given yearCN(g m^{-2})
CNRange	The C/N ratio range where N accumulation occurs
CNUpper	The upper limit of C/N ratio where N accumulation occurs

CaUpt	Net growth uptake of calcium (meq m^{-2} a^{-1})
MgUpt	Net growth uptake of magnesium (meq m^{-2} a^{-1})
KUpt	Net growth uptake of potassium (meq m^{-2} a^{-1})
NaUpt	Net growth uptake of sodium (meq m^{-2} a^{-1})
SO4Upt	Net growth uptake of sulphate (meq m^{-2} a^{-1})
NH4Upt	Net growth uptake of ammonia (meq m^{-2} a^{-1})
DepYear	Year for deposition measurements
Cadep	Total deposition of calcium (eq ha^{-1} a^{-1})
Mgdep	Total deposition of magnesium (eq ha^{-1} a^{-1})
Kdep	Total deposition of potassium (eq ha^{-1} a^{-1})
Nadep	Total deposition of sodium (eq ha^{-1} a^{-1})
Cldep	Total deposition of chloride (eq ha^{-1} a^{-1})
NH4dep	Total deposition of ammonia (eq ha^{-1} a^{-1})
NO3dep	Total deposition of nitrate (eq ha^{-1} a^{-1})
LakeYear	Year for lake measurements
Calake	Measured concentration of calcium in lake(umol L^{-1})
Mglake	Measured concentration of magnesium in lake(umol L^{-1})
Nalake	Measured concentration of sodium in lake(umol L^{-1})
Klake	Measured concentration of potassium in lake(umol L^{-1})
NH4lake	Measured concentration of ammonia in lake(umol L^{-1})
SO4lake	Measured concentration of sulphate in lake(umol L^{-1})
Cllake	Measured concentration of chloride in lake(umol L^{-1})
NO3lake	Measured concentration of nitrate in lake(umol L^{-1})
RelArea	The area of the lake relative to the catchment (%)
RelForArea	The area of the forest relative to the catchment (%)
RetTime	Retention time in the lake (a)
Qs	Annual runoff flux (m a^{-1})
expAl	Exponent for the Al-H relationship ()
pCO2	Partial CO2-pressure in the lake in relation to the atmospheric CO2 pressure (%atm)
DOC	DOC concentration in the lake (umol L^{-1})
Nitriflake	Nitrification in the lake (%)
Cased	Sedimentation velocity of calcium in the lake (m a^{-1})
Mgsed	Sedimentation velocity of magnesium in the lake (m a^{-1})
Nased	Sedimentation velocity of sodium in the lake (m a^{-1})
Ksed	Sedimentation velocity of potassium in the lake (m a^{-1})
NH4sed	Sedimentation velocity of ammonia in the lake (m a^{-1})
SO4sed	Sedimentation velocity of sulphate in the lake (m a^{-1})
Clsed	Sedimentation velocity of chloride in the lake (m a^{-1})
NO3sed	Sedimentation velocity of nitrate in the lake (m a^{-1})
UptNH4lake	Uptake of ammonia in the lake (in % of measured value)
UptNO3lake	Uptake of Nitrate in the lake (in % of measured value)
Sdep2010	Deposition of S in 2010 (Gothenburg Protocol) (eq ha^{-1} a^{-1})
NOxdep2010	Deposition of NO_x in 2010 (Gothenburg Protocol) (eq ha^{-1} a^{-1})
NH3dep2010	Deposition of NH_3 in 2010 (Gothenburg Protocol) (eq ha^{-1} a^{-1})
TLstatus	–1: no TL is calculated 0: safe & non-exceedance in 2010 >=1: Target load information is given in Table 2
EUNIScode	EUNIS code (C1=standing waters; C2=running waters)

Documentation

Please send with the data a document containing a description of the sources of the data and the methods used. To make it as clear as possible you could make a table like the UK contribution to the CCE reports. For the methodology it is best to make only references for the agreed methods (Mapping Manual) and list the choices and/or adaptations that you made.