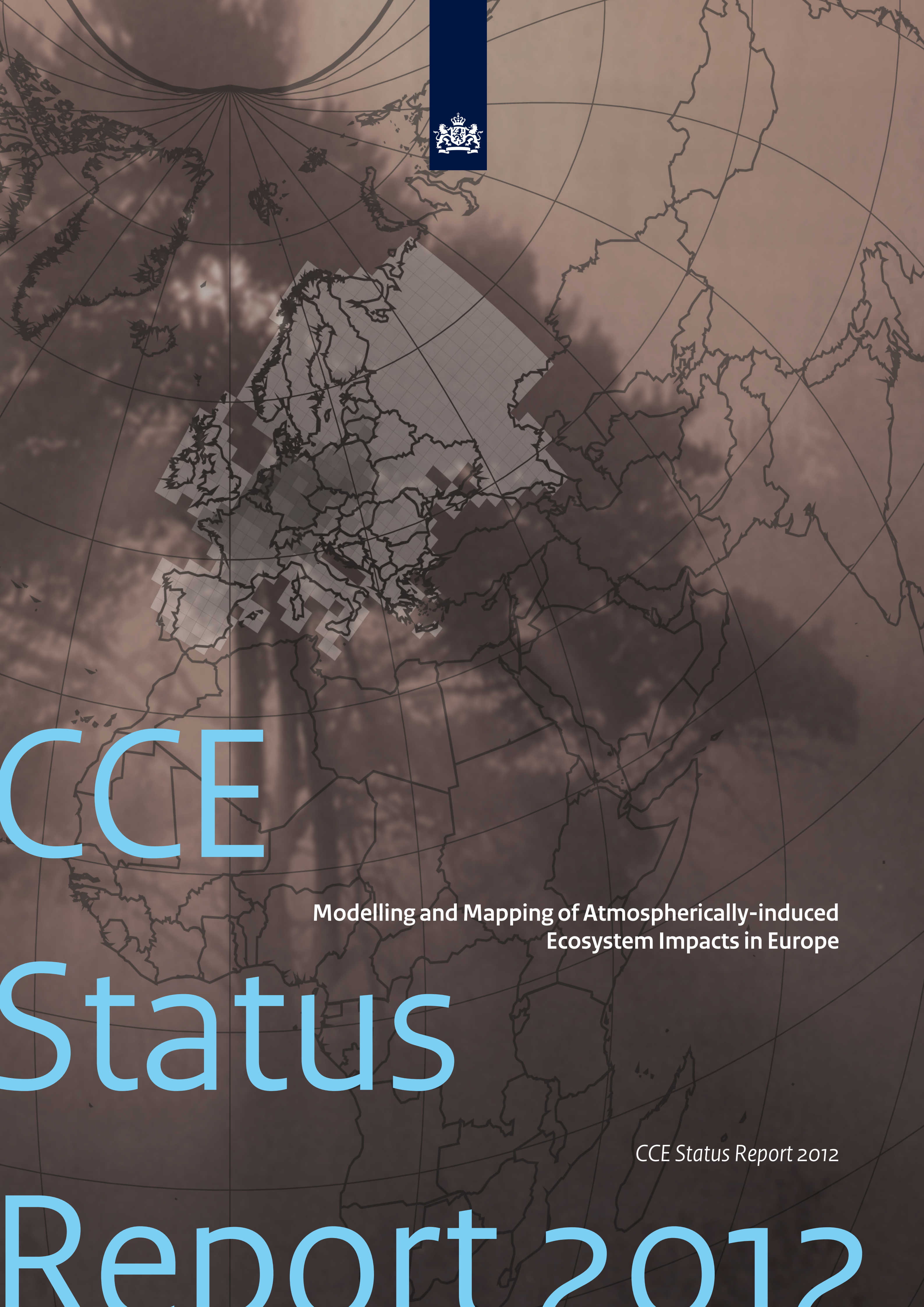

CCE Status Report 2012

Modelling and Mapping of Atmospherically-induced Ecosystem Impacts in Europe

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Modelling and Mapping of Atmospherically-induced Ecosystem Impacts in Europe

CCE Status Report 2012

M. Posch, J. Slootweg, J.-P. Hettelingh (eds)

The work reported here has been performed by order and for the account of the Directorate for Climate and Air Quality of the Dutch Ministry of Infrastructure and the Environment, for the account of the European Commission (a) LIFE III Programme within the framework 'European Consortium for Modelling Air Pollution and Climate Strategies (EC4MACS)' and (b) under the Seventh Framework Programme, Theme [ENV.2011.1.1.2-1], Grant agreement no. 282910 "Effects of Climate Change on Air Pollution Impacts and Response Strategies for European Ecosystems", and for the account of (the Working Group on Effects within) the trust fund for the effect-oriented activities under the Convention on Long-range Transboundary Air Pollution.

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Summary

The revision of the Gothenburg Protocol, concluded in 2012, foresees the further reduction of air pollution (by sulphur, nitrogen, volatile organic compounds and – for the first time – particulate matter), with positive effects on the environment and human health. To this end, the revised Protocol requires EU member states to meet stricter emissions ceilings for these four air pollutants from 2020.

In Chapter 1, the effects of these emission reduction commitments on acidification, eutrophication and biodiversity indicators are described. As one of its tasks, the Coordination Centre for Effects (CCE) maintains and updates the European database on critical loads of acidity and nutrient nitrogen.
The negotiations were based on critical loads data from 2008; however, the latest updates to the critical loads database are now available on a much finer spatial resolution – and these are described in Chapter 2. The availability of both the 'old' and the 'new' critical loads database, together with the results from the updated atmospheric transport model, allows the 'old' and 'new' data to be compared – as also reported in Chapter 1. Reassuringly, the results based on calculations using these two datasets do not differ greatly, although nutrient nitrogen remains a problem: critical loads of nutrient nitrogen are exceeded on 62% of the ecosystem area in the EU-27 countries. Also in Chapter 1, the authors of the report examine which (uniform) emission reductions are needed to virtually eliminate the exceedance of critical loads in the whole of Europe.

In 2001, the National Emission Ceilings (NEC) Directive of the EU also used critical loads in its design. In Chapter 3, the results of a study for and with the European Environment Agency (EEA) are reported, thereby providing answers to the question of whether the goals of the NEC Directive – with respect to critical loads – are achieved. This study was performed using both the data and models that were available during the negotiations of the Directive ('old knowledge') and current knowledge on critical loads and deposition models. The main conclusion is that nitrogen remains a major problem.

The further development and application of soil and vegetation models, as also pursued in the project entitled "Effects of Climate Change on Air Pollution Impacts and Response Strategies for European Ecosystems" (ECLAIRE) under the seventh Framework Programme, have been carried out to enable the assessment of vegetation changes due to air pollution and climate change. The current state of (regional-scale) modelling of forest growth and vegetation change is described in Chapters 4 and 5, respectively. The suitability of these (and other) such models to predict changes in floral diversity has been investigated by several countries within the framework of the 2011/12 Call for Contributions issued by the CCE to the National Focal Centres of the CCE (see also Chapter 2).

This CCE Status Report is part of the Workplan 2012–13 of the Convention on Long-range Transboundary Air Pollution (LRTAP) in support of integrated assessment in Europe. This Workplan assesses policy options for the (further) reduction of nitrogen and sulphur depositions, as well as of particulate matter and greenhouse gases, in the context of environmental and health effects.

Rapport in het kort

Modellering van effecten op ecosystemen door luchtverontreiniging

CCE Status Report 2012

In 2012 is het Gothenborg Protocol (1999), dat de uitstoot van luchtvervuilende stoffen reguleert, aangescherpt. Desondanks blijft de hoge depositie van stikstof op de bodem in de toekomst een risico vormen voor de natuur in Europa. Bij het aangescherpte beleid is er in 2020 een teveel aan stikstof op 62 procent van het natuuroppervlak van de 27 lidstaten van de Europese Unie. Zelfs als alle beschikbare technische maatregelen worden ingevoerd, zou dat 38 procent zijn. Een hoge stikstofdepositie verstoort onder andere de chemische samenstelling van de bodem, waardoor de variatie in plantensoorten afneemt. De verzuring is de afgelopen decennia als gevolg van het Gothenborg Protocol sterk afgenomen, maar verdwijnt niet volledig (nog 4 procent in heel Europa). Dit blijkt uit het jaarlijkse statusrapport van het Coordination Centre for Effects (CCE) van het RIVM.

Effecten van beleidsopties voor luchtvervuiling geëvalueerd

Het protocol is onder andere tot stand gekomen door op Europese schaal in kaart te brengen wat de effecten en kosten zijn van diverse beleidsopties om de uitstoot van luchtvervuilende stoffen te verminderen(geïntegreerde analyse). Het gaat hierbij om de effecten van onder meer stikstof- en zwaveloxides en fijnstof op gezondheid, klimaat en milieu, en biodiversiteit. Het CCE draagt bij aan de geïntegreerde analyse met kennis over zogeheten kritische belastingsgrenzen voor de neerslag van stikstof en zwavel. Deze grenzen geven per ecosysteem aan welke maximale vervuiling ze kunnen verdragen. De waarden worden regelmatig geactualiseerd door de landen als meer kennis of gegevens beschikbaar komen.

De kritische belastingsgrenzen worden op verschillende manieren bepaald. De laatste jaren wordt daarbij gewerkt aan modellering die de invloed van stikstofdepositie op de vegetatie weergeeft. Hierbij wordt duidelijk hoe de biodiversiteit door luchtverontreiniging en klimaatverandering verandert.

Europese richtlijnen verzuring niet gehaald

Ook de Europese richtlijn uit 2001 voor nationale emissieplafonds (NEC) maakt gebruik van geïntegreerde analyse. Met de toenmalige kennis van onder andere kritische belastingsgrenzen zouden de gestelde doelen voor verzuring in 2010 zijn bereikt. Volgens de nieuwste inzichten is dat echter niet het geval.

Contents

Part 1
Progress CCE

1 Assessing Effects of the Revised Gothenburg Protocol

Jean-Paul Hettelingh, Maximilian Posch, Jaap Slootweg, Anne-Christine Le Gall[1]

1.1 Introduction

At its 30th session (Geneva, 30 April–4 May 2012) the Executive Body agreed to amendments to the Revised Gothenburg Protocol (RGP) to 'Abate Acidification, Eutrophication and Ground-level Ozone' (Gothenburg, 30 November 1999). This revision implies the further reduction of pollutants that affect human health, acidification, eutrophication and climate change (Reis et al. 2012).

This chapter focuses on the final analysis of the risk of acidification and eutrophication based on country and sea emissions established under the RGP. Effects of other emission scenarios that were elaborated in support of the revision process can be found in the CCE Status Report 2011 (Posch et al. 2011). These assessments were based on the critical load database of 2008 (CL50) and the EMEP dispersion model that were used to address atmospheric depositions, concentrations and exceedances on a 50×50 km² grid (EMEP50). Impacts presented in this chapter may be (slightly) different from impact assessments of early RGP scenario-versions, as presented at the 41st session of the Task Force on Integrated Assessment Modelling (Bilthoven, 7–9 May 2012). The reason for this is that country emissions for reference and target years were subject to changes (by Parties) in the second half of 2012.

The EMEP50 model was recently revised to cover a 28×28 km² grid (EMEP28; Simpson et al. 2012). In anticipation of the increased resolution of the EMEP model, National Focal Centres under the ICP Modelling and Mapping of Critical Levels & Loads, and Effects, Risks and Trends (ICP M&M) responded to a CCE call for data in 2010 to update the scale (and protection requirements as appropriate) of their contribution to the European critical load database (CL28; see Posch et al. 2011).

This chapter summarises the air pollution effects of emissions from the RGP by addressing exceedances computed with old (i.e., EMEP50 and CL50) as well as new (EMEP28 and CL28) scientific information. The expected change of biodiversity in 2020 under RGP in specified EUNIS areas is briefly summarised as well.

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1.2 Acidification under the RGP with 2008 knowledge

The use of the EMEP50 deposition model to compute exceedances of critical loads for acidification from the 2008 database (CL50) yields areas at risk that have markedly diminished since 1980. Figure 1.1 illustrates the trend of all ecosystems at risk, from a large area with high exceedances (red shading) in 1980 to a relatively small area with relatively low exceedances (blue shading) in 2020. Exceedance peaks in 2020 are scattered over the southern part of the Dutch–German border area and Poland.

Figure 1.1 also shows that a major part of Europe flips from high risk in 1980 (> 1,200 eq $ha^{-1}a^{-1}$; red) to low risk in 2020 (<200 eq $ha^{-1}a^{-1}$; light blue) or non-exceedance (grey). The size of the shaded area in a grid cell reflects the area at risk in proportion to the total ecosystem area within the EMEP grid. The trend of the Average Accumulated Exceedance (AAE) for acidification in Europe and in EU27 (Figure 1.2) decreases sharply between 1980 and 2000. This is also reflected in the trend of the area at risk of acidification (Figure 1.3), which decreases from about 43% in 1980 to around 4% in RGP2020 (i.e. in 2020 once the RGP is implemented) in European ecosystems classified according to EUNIS. For the EU-27 these percentages are 45% and 7%, respectively. Finally, assuming that maximum feasible emission reduction techniques (MFR) would be implemented by 2020, the risk of acidification could be still further reduced (see below).

1.3 Eutrophication under the RGP with 2008 knowledge

Eutrophication (computed with CL50 and EMEP50) continues to be a serious threat to European ecosystems. In 1980 critical loads of nutrient nitrogen were exceeded in about 67% of the European ecosystem area (80% in the EU27), which is expected to decrease to cover around 42% (62% in the EU27) under RGP2020 (Figure 1.4).

While Figure 1.5 shows the area at risk remaining high, it is informative to see that the trend of AAE undergoes a significant reduction between 1980 and 2020 (Figure 1.4). This reduction may delay the propagation of effects to various elements of biodiversity, but will stand in the way of recovery.

Figure 1.1 Areas where critical loads for acidification (2008 database) are exceeded by acid depositions (EMEP50 model) caused by emissions between 1980 (top left) and 2020 (bottom right), the last projected under the Revised Gothenburg Protocol (RGP)

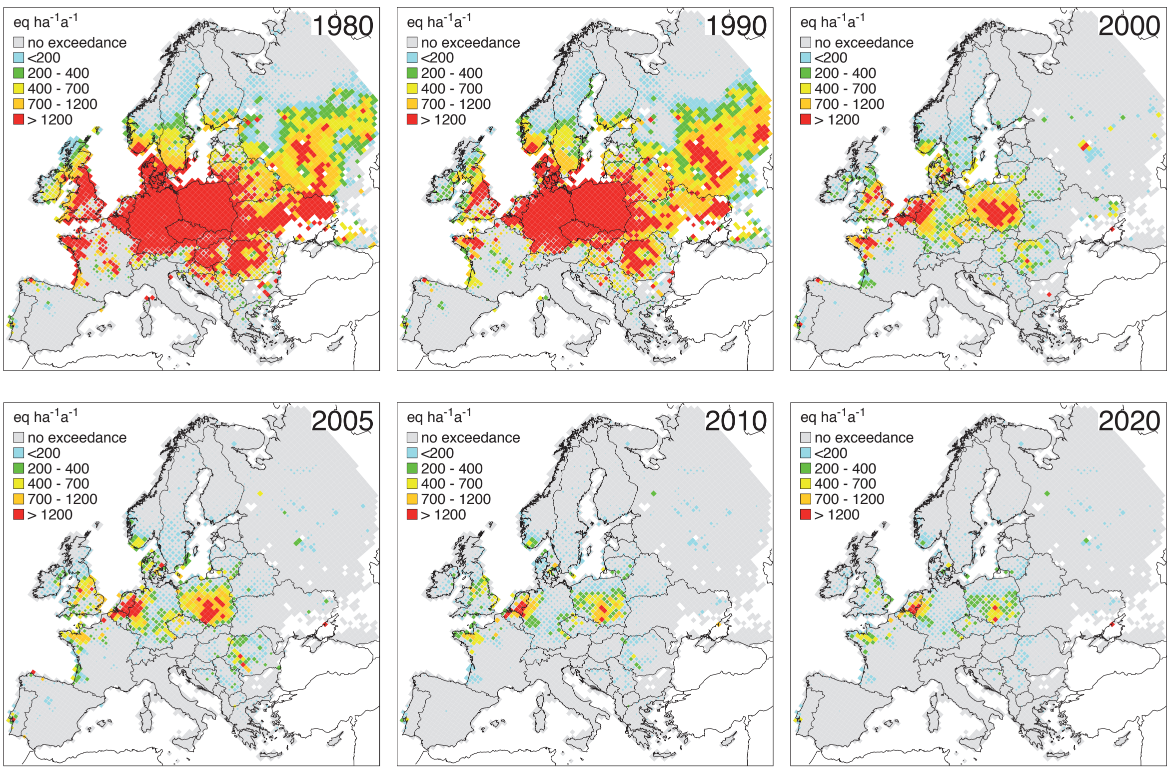


Figure 1.2 Trend between 1980 and RGP2020 of the Average Accumulated Exceedance (AAE) for acidification in the EU-27 and in Europe.

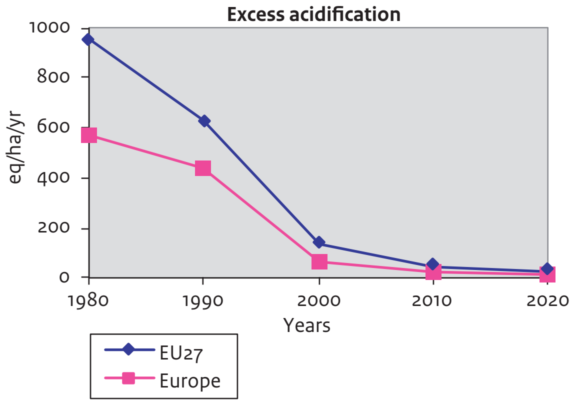


Figure 1.3 Trend between 1980 and RGP2020 of the area where critical loads for acidification are exceeded in the EU-27 and in Europe.

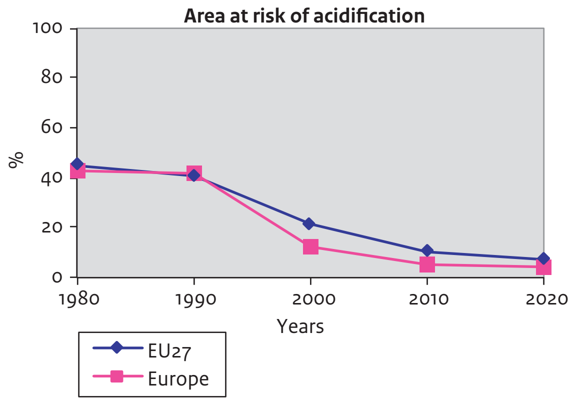


Figure 1.4 Trend between 1980 and RGP2020 of the Average Accumulated Exceedance (AAE) for eutrophication in the EU-27 and in Europe

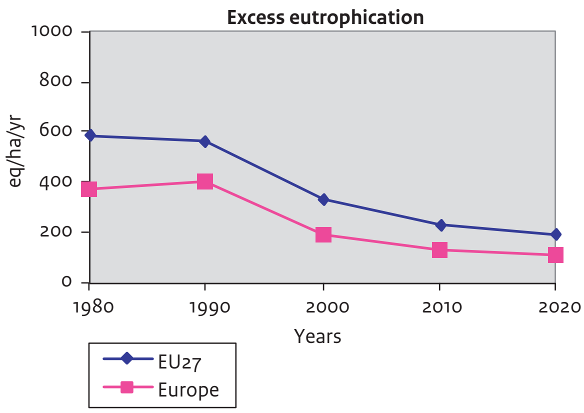
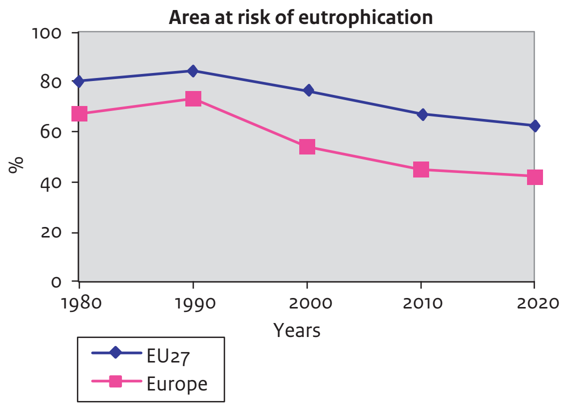


Figure 1.5 Trend between 1980 and RGP2020 of the area where critical loads of nutrient nitrogen are exceeded in the EU27 and in Europe



The trend between 1980 and RGP2020 of the distribution over Europe of areas where critical loads for eutrophication are exceeded confirms the continued stress to European ecosystems, in Central Europe in particular (Figure 1.6). The broad Central European area of high exceedances in 1980 (red shading) is markedly reduced in 2020, but still occurs in western France and the border areas between the Netherlands, Belgium and Germany, as well as in northern Italy.

Finally, the result of a (hypothetical) implementation of Maximum Feasible Reductions (MFR) of emissions of acidifying and eutrophying pollutants would yield a further increase of areas that are protected, while areas with high exceedances of critical loads would further decrease (Figure 1.7).

Figure 1.7 illustrates that, even under maximum (technically) feasible reductions of nitrogen emissions, the deposition of nitrogen continues to put a large area at risk (light blue shading on the right-hand map), implying that the potential of technical measures alone is not sufficient to achieve non-exceedance of critical loads for eutrophication.

1.4 Effects of applying uniform reductions to achieve protection

The integrated assessment, e.g. by means of the GAINS model, of alternatives to distribute emission reductions among European countries includes the minimization of the costs of emission reductions subject to environmental and health targets. These analyses have shown that it is difficult to attain these targets with technical (end-of-pipe) measures. Therefore, from an impact point of view alone, it is interesting to explore the further reductions of acidifying and eutrophying emissions that are necessary to have depositions decrease to or below critical loads.

Figure 1.6 Areas where critical loads for eutrophication are exceeded by nutrient nitrogen depositions caused by emissions between 1980 (top left) and 2020 (bottom right), the last projected under the Revised Gothenburg Protocol (RGP).

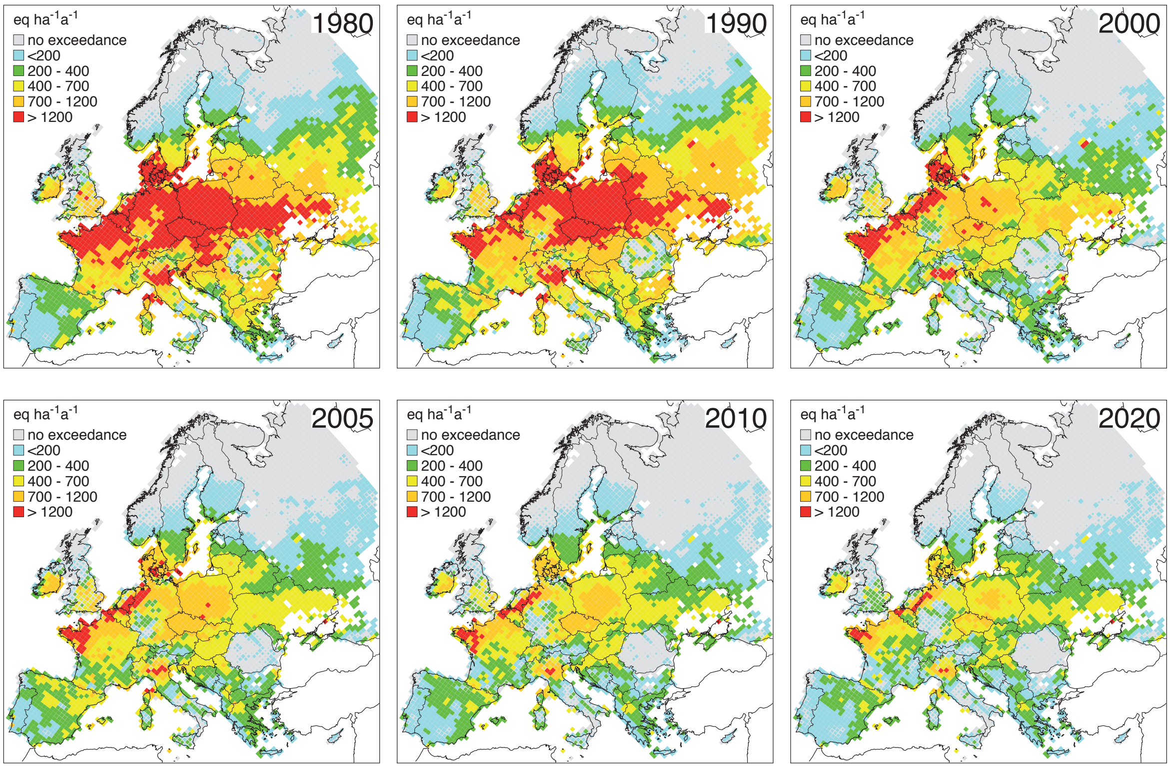
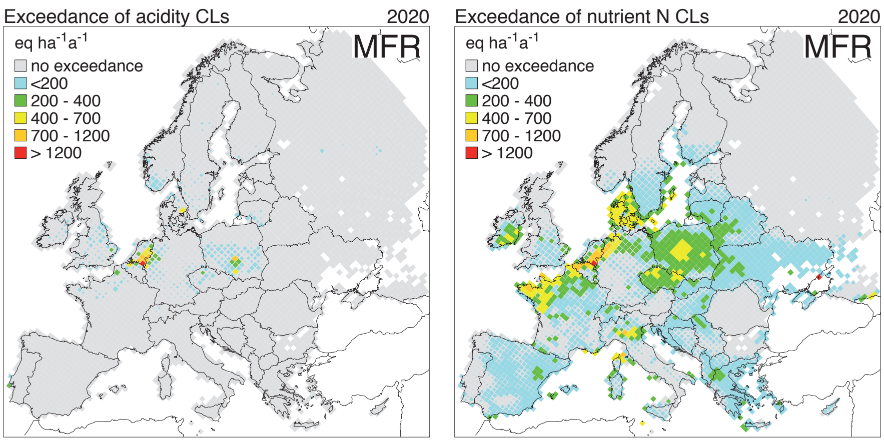


Figure 1.7 Areas where critical loads for acidification (left) and eutrophication (right) are exceeded by sulphur and nitrogen depositions under the Maximum Feasible Reduction (MFR) emission scenario.



In the following the relationship is explored between uniform emission reductions over European countries (incl. shipping) and acidification as well as eutrophication effects. Using critical loads from the 2008 database, Figure 1.8 shows the percentage of the ecosystem area in Europe for which critical loads of nutrient N, CLnutN, are exceeded (left) and their exceedance (AAE in eq ha^{-1}yr^{-1}, right) under uniform reductions of total nitrogen emissions in 2020 (as agreed under the RGP scenario). The same quantities are also shown if only NO_x emissions (NH_3 emissions kept constant) or only NH_3 emissions (NO_x emissions kept constant) are reduced uniformly. The depositions for each of the uniformly reduced emissions are computed with the source-receptor matrices of the EMEP50 dispersion model.

At 70% reduction of total nitrogen emissions the exceedance is close to zero (Figure 1.8, right) whereas the area where critical loads are exceeded (Figure 1.8, left) still covers about 2%. However, it is obvious that the magnitudes of the exceedances are very low in those remaining areas. Looking at the impacts of reductions of individual nitrogen species, it is interesting to note that a 100% reduction in NH_3 emissions leads to 10% of the area remaining at risk, whereas 100% reduction of NO_x emissions still leaves about 15% of the European ecosystem area at risk (Figure 1.8, left). The fact that the reduction of NH_3 emissions is more effective than that of NO_x is confirmed in terms of the AAE (Figure 1.8, right).

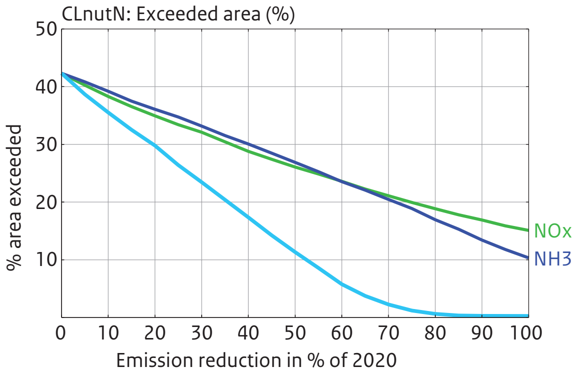
When a similar analysis is conducted for acidity (Figure 1.9) it turns out that the exceedance of acidity CLs is close to zero at 60% reduction of both sulphur and nitrogen compounds (Figure 1.9, right), whereas the exceeded area is still about 0.7% (left). However, if N emissions alone are reduced by 100%, still slightly more than 1% of the European ecosystem area remains at risk of acidification (Figure 1.9, left) with an AAE of slightly less than 2 eq $ha^{-1}yr^{-1}$.

1.5 A tentative assessment of the change of biodiversity

The derivation of dose-response relationships (D-R functions) is based on a literature review prepared for the review and revision of empirical N critical loads (Bobbink and Hettelingh 2011).

The assessment of changes in biodiversity using these D-R functions on a regional scale is based on the extrapolation of the functions over the EUNIS classes E, F2 and G3 (Hettelingh et al. 2008, 2009, in prep.). In 1990, the area where more than 5% of biodiversity is at risk is clearly larger than in 2020 (Figure 1.10). In 1990 the area covers 288,000 km^2 in the EU27 (24% of the EUNIS areas E+F2+G3). In 2020 under the RGP this area is reduced to 68,400 km^2 (about 6% of these EUNIS classes).

Figure 1.8 European ecosystem area exceeded (in %; left) and exceedance (AAE in eq $ha^{-1}a^{-1}$; right) of CLnutN as function of uniform emission reductions (RGP 2020=100%) of NO_x (green lines), NH_3 (blue) and total N (turquoise).



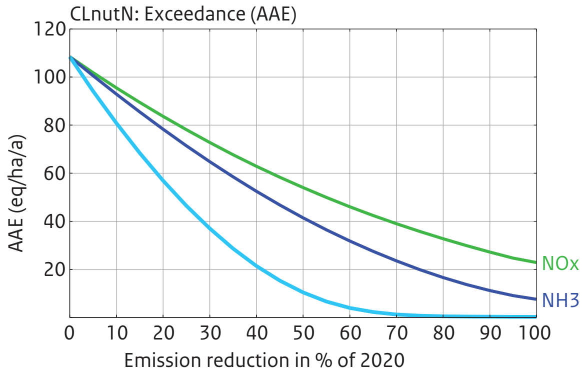
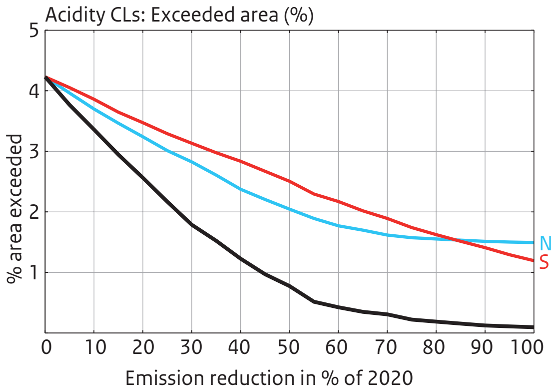


Figure 1.9 European ecosystem area exceeded (in %; left) and exceedance (AAE in eq $ha^{-1}yr^{-1}$; right) of acidity CLs as function of uniform emission reductions (RGP 2020=100%) of total N (turquoise line), total S (red) and total S+N (black). Note the much smaller scale on the vertical axes than in Figure 1.8.



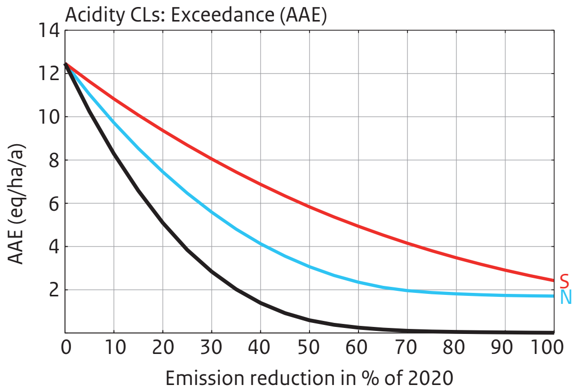
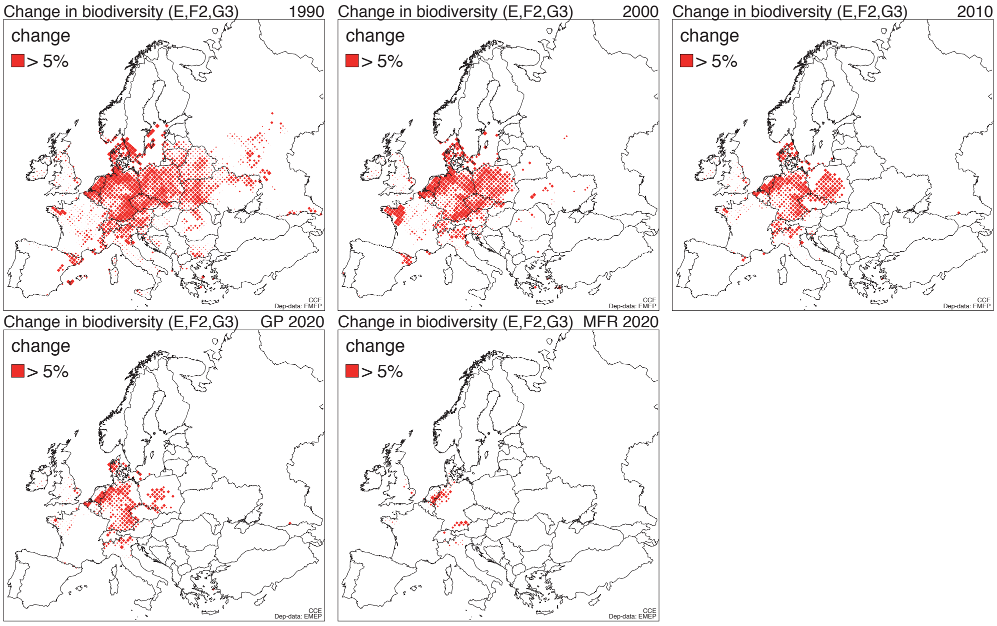


Figure 1.10 Changes (red shading) by more than 5% in species diversity in EUNIS classes E and F2 and in similarity in EUNIS class G3 in 1990 (top left), 2000 (top middle), 2010 (top right) and in 2020 under the Revised Gothenburg Protocol (bottom left) and Maximum Feasible Reductions scenario (bottom right).



1.6 Acidification and eutrophication under the RGP with 2012 knowledge

Figure 1.11 illustrates the exceedance of critical loads using the European database that was updated under the ICP M&M in 2011/12 (CL28) and the recent EMEP model (EMEP28).

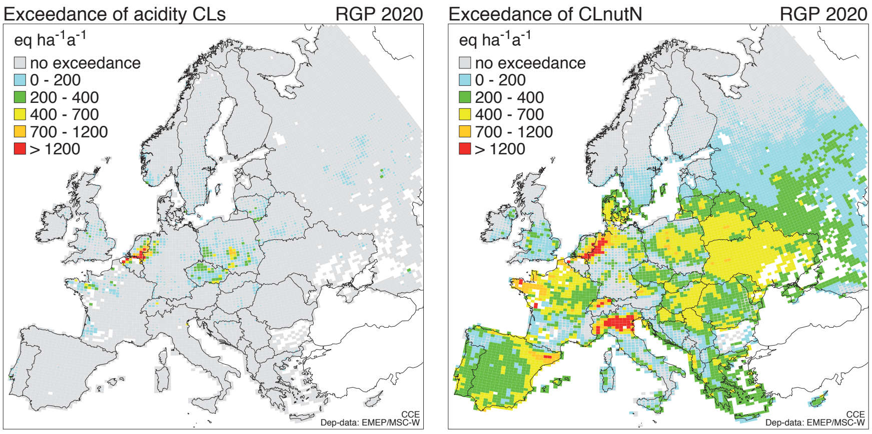
The areas at risk of both acidification and eutrophication under RGP in 2020 computed with CL28 and EMEP 28 (Figure 1.11) reveal a similar pattern to that shown in Figures 1.1 and 1.6, respectively. Areas with relatively high exceedances continue to be found in the bordering area of the Netherlands and Germany (acidification) and in the north of Italy and western France (eutrophication). However, in comparing the result of new to old methods, in particular with respect to the risk of eutrophication, lower exceedances are found in e.g. the United Kingdom, France and Poland, and higher ones in Romania, Russia and Spain. Changes are due to updated critical loads sent by NFCs and an update of the background database (Reinds et al. 2008) that the CCE uses for countries that do not submit data. Whether or not to use the background database when a country only partially submits data, e.g. critical loads for acidity but not for eutrophication, will need to be considered in an appropriate session of the TF M&M meeting and be confirmed by the WGE.

It turns out that 7% of the EU27 area (4% in Europe) is at risk of acidification and 62% at risk of eutrophication (42% in Europe) when using CL50 and EMEP50. When the exceedances are computed using CL28 and EMEP28 these percentages become 4% and 57% in the EU-27 (3 % and 50% in Europe, respectively). Russia did not submit new critical loads. Therefore, the background database was used to obtain higherresolution European critical load maps. This, in combination with the EMEP28 model, leads to an increased risk of eutrophication in Russia and, consequently, also in Europe compared with the risk computed with 2008 data.

1.7 Summary and conclusions

The revision of the Gothenburg Protocol improves the protection against the risk of acidification, eutrophication and changes in biodiversity in 2020. When using the critical loads database of 2008 (as prescribed by the Executive Body at the start of the negotiations) in combination with the EMEP model on a 50x50 km^2 grid the area at risk of acidification covers 7% of the ecosystem area in the EU27 in 2020 (22% in 2000) while the risk of eutrophication extends over 62% (76% in 2000) of the ecosystems in the EU27. Over the whole of Europe these areas cover 4% (12% in 2000) and 42% (54% in 2000) respectively. Applying more stringent emission reductions reduces the risk further. For example, the application of

Figure 1.11 Areas where critical loads (CL28) for acidification (left) and eutrophication (right) are exceeded by acid depositions (EMEP28) caused by emissions in 2020 projected under the Revised Gothenburg Protocol.



Maximum Feasible Reductions in 2020 would yield a marked reduction of the area at risk of acidification down to 3% in the EU27 (1% in Europe), and of eutrophication of to about 38% in the EU27 (22% in Europe).

This chapter has also described the results when using new critical loads in combination with the most recent dispersion model by EMEP. Thus, using this combination on the new grid (i.e. 28×28km^2), it turns out that the areas at risk of acidification and eutrophication in Europe under GP2020 cover about 3% and 50% respectively. The risk of eutrophication in Europe is computed to increases by more than 10% when using the new model combination. For the EU27 the difference between the old and new models is less pronounced, i.e. 7% (old) compared to with 4% (new) for acidification and 62% (old) against 57% (new) for eutrophication. Both old and new model computations confirm the persistence of a significant risk of eutrophication.

The assessment of changes in biodiversity in this chapter was limited to an illustrative application of dose-response functions for specified EUNIS classes, indicating that a considerable European area remains subject to a change of more than 5% under the Revised Gothenburg Protocol. Ongoing research, including under the ECLAIRE project (FP7) of the EC, aims to extend the application of dynamic models to identify additional endpoints to assess the change of biodiversity.

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2
Summary of National Data

Jaap Slootweg, Maximilian Posch, Jean-Paul Hettelingh

2.1 Introduction

At its 30th Session (Geneva, 27–29 September 2011), the Working Group on Effects requested the CCE to issue a Call for Contributions. The focus was to be on the use and testing of the dynamic modelling of changes in plant species diversity. This, and a meeting with experts from within the community, led to a call for (see Appendix A for the complete text):

i. An overview of endpoints considered by the NFCs;
ii. Application of biodiversity indices as summarised in the CCE Status Report 2010;
iii. Comparison of simulation results using different models;
iv. Comparison of simulation results using different sites;
v. Policy relevance: NFCs are invited to include nature protection areas (such as Natura 2000 areas) in their model testing;
vi. Review the possibilities to use EUNIS classes, habitat classes and eco-regions as a basis for regionalisation;
vii. Enlargement of the Veg database.

Countries also had an opportunity to update their critical load data.
The CCE prepared a spreadsheet with the AICHI targets (www.cbd.int/sp/targets/) and the EU's SEBI2010 (ec.europa.eu/environment/nature/biodiversity/comm2006/pdf/2020/1_EN_ACT_part1_v7[1].pdf) indicators for NFCs to use as a reference to indicate the relevant endpoints for the countries. Software including the VSD+ model, with the Veg module was also made available by the CCE. An Access version had been prepared to import site data, run VSD+ and Veg and calculate biodiversity indices. For technical reasons not all NFCs were able to apply the Access software.

2.2 NFC responses

Twelve countries replied to (part of the) call; see Table 2.1 for a list.

Both Bulgaria and Lithuania re-sent data submitted earlier (see previous Status Reports). These submissions are not included in this report.

Endpoints
Only Austria, Germany and Switzerland reflected on the matter of biological endpoints, and Ireland explicitly stated that 'national indicators and indices of biodiversity

Table 2.1 Summary of NFC responses to the Call for Contributions

Country	Endpoints	Sites	CL update	Nat report
AT	Report	14		X
CH	Report	32*		X
DE	Table+Report	4	X	X
FR		27*		X
IE		4	X	X
IT		1		X
NL		3		X
NO				X
PL			X	X
RO		5		X
SE			X	X
SI		2		X
Total 12	3	9 countries	4	12

*Sites and model runs are described in the NFC reports (see Part 3), but not all were submitted to the CCE

are, as yet, undefined but will be discussed during 2012'. None of the responses related indicators to indices, but all see a role for soil-vegetation modelling in the future to quantify biodiversity indicators.

Soil-vegetation modelling for sites

NFCs were called upon to investigate their measurement sites in order to improve soil-vegetation modelling, focusing on *comparison of simulation results using different models* and *comparison of simulation results using different sites.* The Dutch collaborating institution (Alterra) has been very helpful in testing the VSD software and evaluating the Dutch and other sites.

We received data, ready to perform model runs, from nine countries. Austria tested VSD+ and from the resulting soil chemistry applied the BERN and Veg vegetation models. Germany applied VSD+ in combination with BERN. They compared the resulting species compositions to the initial composition and to reference species compositions from Natura2000 sites. France used ForSAFE-Veg on 27 sites, submitted one of them, and did a sensitivity analysis to identify important input factors. They also analysed the effects for the CLE and the MFR deposition scenarios in combination with the A2 and B1 climate scenarios corresponding to high and low global warming, respectively, on all sites. Ireland and Romania submitted site data without (much) comment.
The Dutch compared the SMART2 model with VSD+, especially the fractions of nitrogen in the soil that decomposes or immobilises. Italy is working on completing the data and calibrating of ICP Forest Level-II plots. Slovenia applied VSD+Veg on two sites. They found it hard to use the GrowUp software to model uptake as part of the VSD+ input preparations, mainly because there are no clear-cuts in the natural areas they focus on. They also found poor matches of their Veg results with actual species compositions. Switzerland made comparisons of VSD, VSD+ and ForSAFE with Veg. They found strikingly poor results for nitrate concentration using VSD+ and poor results regarding species composition for all model combinations A systematic bias occurred with respect to the number of species; On average the modelled number of species exceeded that of the observed number of species by an order of magnitude. However, the distributions of Czekanowski indices for all the sites were very similar across the models.

More details and results can be found in the national reports (Part 3 of this report) on the testing of soil vegetation models.

Regionalisation

No regionalised datasets with vegetation modelling were submitted to the CCE, but some NFCs (Germany, Sweden and Switzerland) included considerations in their national reports. Generally, looking at the comments from testing by experts at site level in recent years one can summarise that modelling the abundance of species at a site is very difficult, especially with many species under consideration, and that stratifying by (detailed) EUNIS could be helpful in reducing the number of considered species.

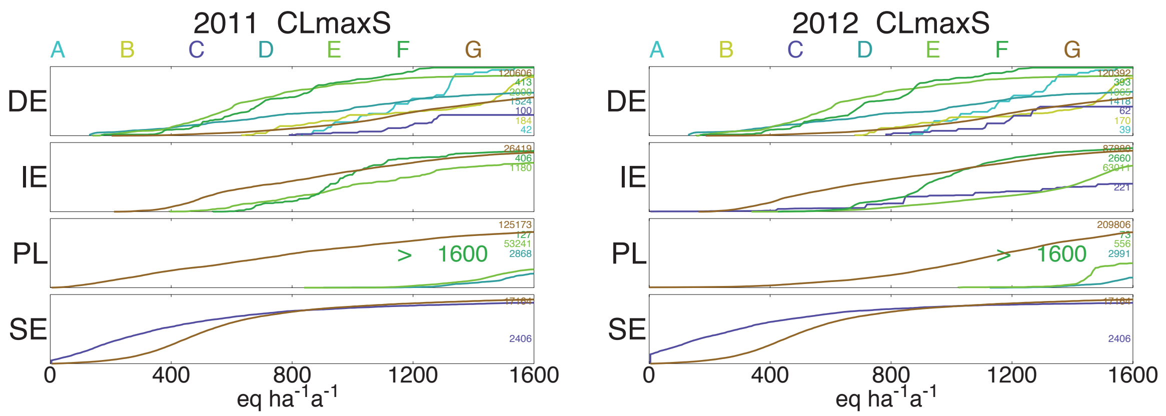
Updated critical loads

Germany, Ireland, Poland and Sweden updated their critical loads. Each of these four countries had submitted critical loads in 2011; thus there is no change in countries for which the European background database is used. In the Annex to this chapter Table 2.A shows the complete set of ecosystems (numbers and area) by ecosystem type (EUNIS code) and origin (national or background database), per country and for eutrophication, acidity and

Table 2.2 National 5×5 km² datasets within the European database and year of their submission

Country Code	Nutrient N	Empirical N	Acidity
AT	2011	2011	2011
BE (Flanders)	2011	2011	2011
BG	2011	2011	2011
CH	2011	2011	2011
CZ	2011	2011	2011
DE	2012	2011	2012
FI	-	2011	-
FR	2011	2011	2011
IE	2012	2012	2012
IT	2011	-	2011
NL	2011	2011	2011
NO	-	2011	2011
PL	2012	2011	2012
SE	2012	2012	2012
SI	2011	2011	2011

Figure 2.1 Cumulative distribution functions of updates for CLmaxS in 2011 and 2012, colours indicate EUNIS codes A to G



empirical critical loads of N.
In 2011 it was not possible to convert previously (before 2011) submitted national data due to the smaller grid size now used. Therefore, only national data submitted in 2012 or 2011 are incorporated in the European database. This is indicated in Table 2.A by numbers printed in bold. The critical load data from all other countries are taken from the background database. A clearer indication of the origin of the dataset is Table 2.2, which shows the year of the latest submitted dataset.

Figures 2.1 and 2.2 show the cumulative distributions for 2011 and 2012 of CLmaxS and CLnutN, respectively, for the countries that submitted updated critical loads. It should be noted that changes between 2011 and 2012 in CLmaxS are small; forests (EUNIS code G) in Poland are considered less sensitive than before, Ireland included aquatic ecosystems (EUNIS code C) and Sweden assessed their aquatic ecosystems to be more vulnerable than in 2011, resulting in very low values for some ecosystems.

The most noticeable national updates for CLnutN are grasslands in Poland (EUNIS code E). In addition, wetlands (EUNIS class D) in Poland and Germany are less sensitive than in 2011. This is mainly explained by updates in the limits for the acceptable nitrogen concentration. This is demonstrated in Figure 2.3, which shows the values of $[N]_{acc}$ per EUNIS class in 2011 and 2012.

Figure 2.2 Cumulative distribution functions of updates for CLnutN in 2011 and 2012, colours indicate EUNIS codes A to G

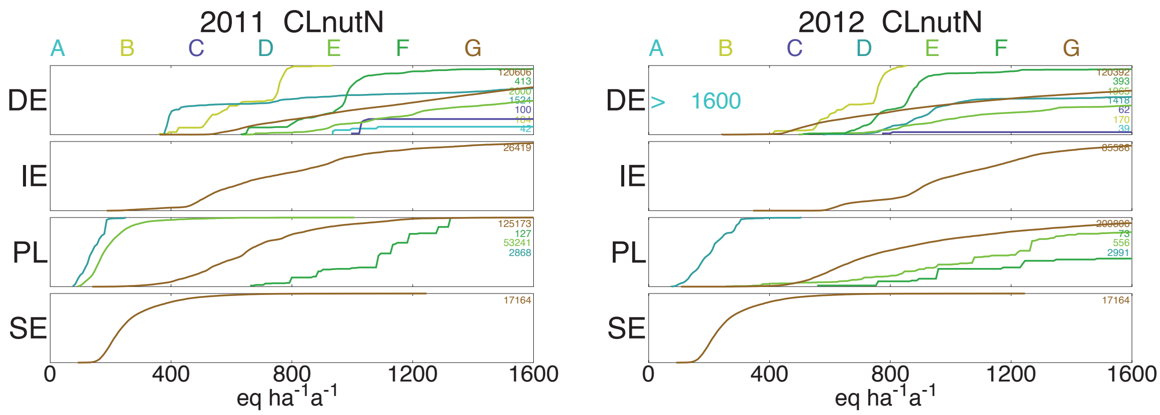


Figure 2.3 Cumulative distribution functions of updates for $[N]_{acc}$ in 2011 and 2012, colours indicate EUNIS codes A to G

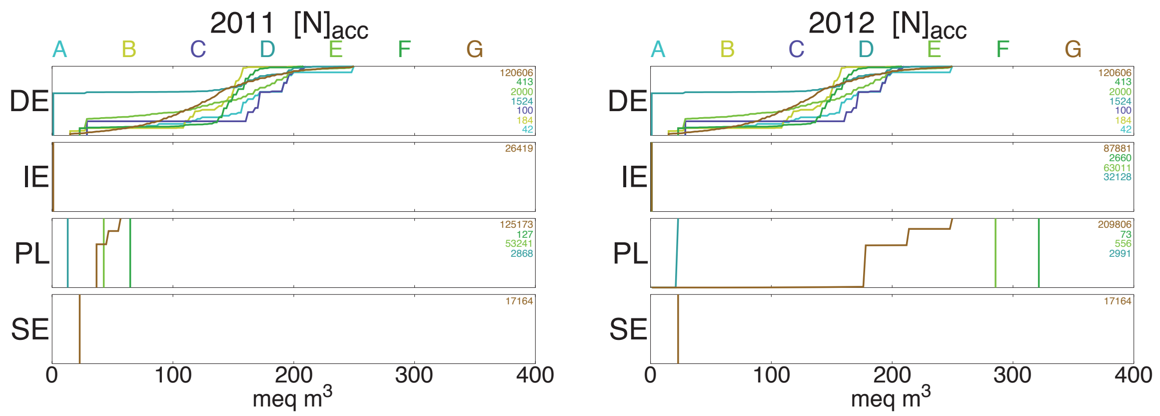


Figure 2.4 shows the previous and the new 5th percentile maps for the critical loads for modelled nutrient N (CLnutN), the empirical critical loads of N (CLempN) and the maximum critical load of S (CLmaxS). Although the resolution of the data is 5×5 km^2, the maps are aggregated and plotted on the 25×25 km^2 grid for the purpose of 'readability'.

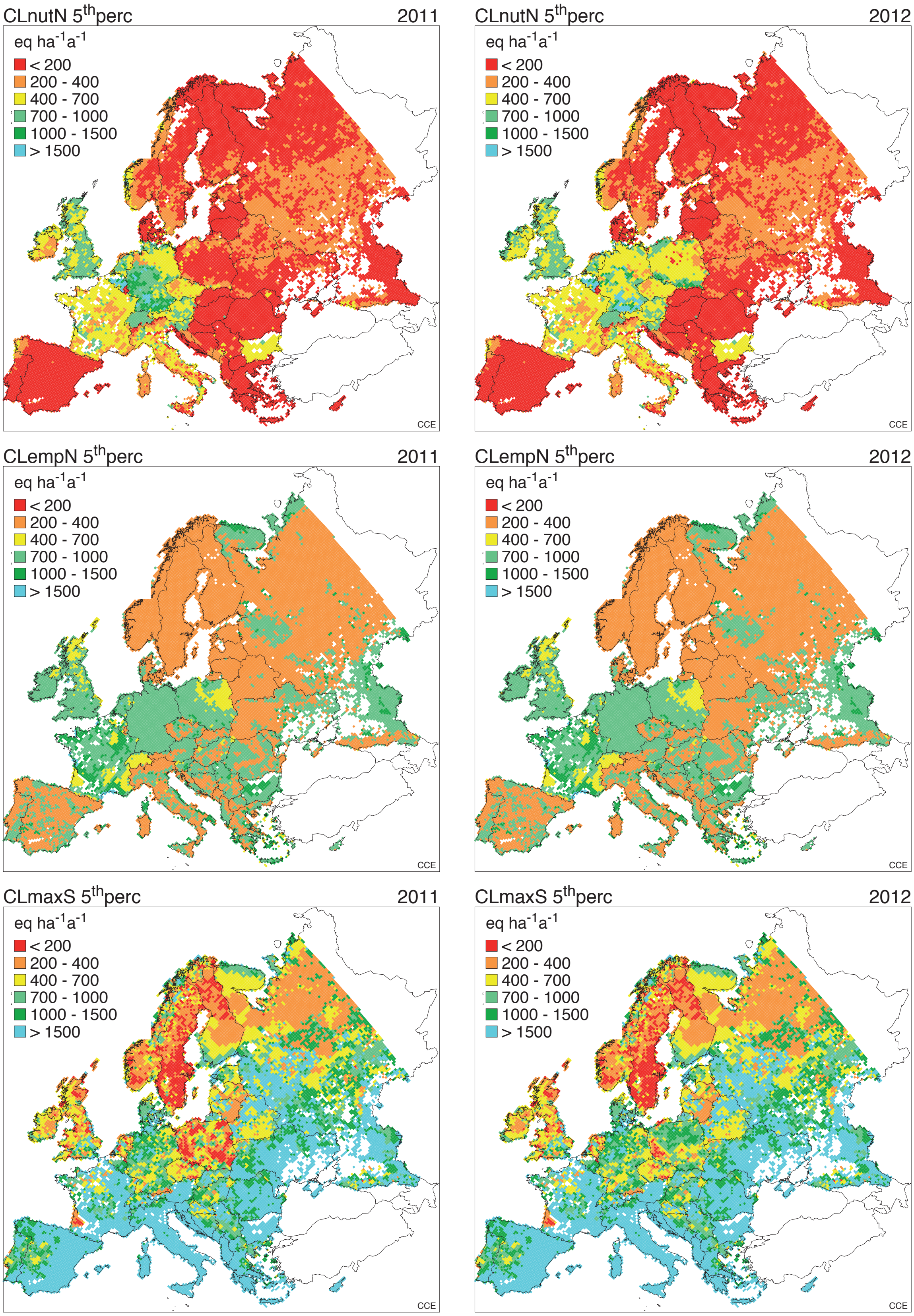
The maps show that the 5th percentile critical loads (i.e. protecting 95% of ecosystems) for CLnutN changes mostly in Poland, Germany and Ireland. There are no changes for CLempN, and no striking differences for CLmaxS between 2011 and 2012, except in Poland.

Remarks of NFCs regarding their critical loads

Germany updated its long-term annual mean (1980–2010) of temperature and precipitation and three-year average for base cation depositions, which have a minor effect on the critical loads. Ireland added critical loads of acidity for surface waters, refined the terrestrial receptor habitat ecosystem map, revised base cation and N uptake for managed forests and updated its empirical critical loads based on the 2010 revisions. Poland improved the ecosystems map regarding grasslands, and their base cation (and Cl) depositions, but above all, harmonised the acceptable N concentration with the German NFC, resulting in much higher critical loads.

Furthermore, France updated their ecosystem map, but made no submission of updated critical loads. Details can be found in the national reports in Part 3.

Figure 2.4 5[th] percentile of CLnutN (top), CLempN (middle) and CLmaxS (bottom) in 2011(left) and 2012 (right)



Annex 2.A

Table 2.A Number of ecosystems (# ecords) and their area for which critical loads have been submitted (**bold**) or are taken from the background database in Europe

Country Code	EUNIS Class	Modelled Nutrient N		Empirical N		Acidification	
		# ecords	Area (km²)	# ecords	Area (km²)	# ecords	Area (km²)
AL	C			67	126		
	D	9	9			9	9
	E	3,213	6,183	2,137	4,410	3,213	6,183
	F	1,921	4,022	478	930	1,921	4,022
	G	2,571	6,347	2,571	6,347	2,571	6,347
AT	**D**			**2,486**	**272**		
	E			**21,824**	**18,954**		
	G	**36,130**	**37,125**	**28,031**	**39,789**	**496**	**6,336**
BA	C			74	129		
	D	24	38			24	38
	E	5,452	8,850	4,364	6,863	5,452	8,850
	F	1,701	2,527	1,069	1,426	1,701	2,527
	G	9,350	19,344	9,350	19,344	9,350	19,344
BE	**D**			**65**	**58**		
	E			**9**	**6**		
	F			**422**	**180**		
	G	**28,530**	**5,541**			**26,206**	**5,458**
BG	**A**			**481**	**170**		
	B			**482**	**136**		
	C			**3,640**	**1,280**		
	D			**1,690**	**162**		
	E			**3,106**	**233**		
	F			**1,333**	**48**		
	G	**6,481**	**42,660**	**6,480**	**42,646**	**6,481**	**42,660**
BY	D	808	2,718			808	2,718
	E	1,680	3,442	1,680	3,442	1,680	3,442
	F	70	104	70	104	70	104
	G	16,683	57,360	16,683	57,360	16,683	57,360
CH	**C**			**49**	**42**	**100**	**86**
	D			**2,099**	**1,546**		
	E			**13,158**	**10,432**		
	F			**1,734**	**1,584**		
	G	**10,608**	**9,625**	**1,429**	**891**	**10,608**	**9,625**
CS	E	5,578	12,639	5,578	12,639	5,578	12,639
	F	733	1,463	619	1,299	733	1,463
	G	10,428	25,796	10,428	25,796	10,428	25,796
CY	C			15	5		
	E	611	495	186	143	611	495
	F	678	845			678	845
	G	642	1,189	642	1,189	642	1,189
CZ	**G**	**6,971**	**2,203**	**6,971**	**2,203**	**6,971**	**2,203**

Table 2.A Number of ecosystems (# ecords) and their area for which critical loads have been submitted (**bold**) or are taken from the background database in Europe

Country Code	EUNIS Class	Modelled Nutrient N		Empirical N		Acidification	
		# ecords	Area (km²)	# ecords	Area (km²)	# ecords	Area (km²)
DE	**A**	**39**	**35**	**19**	**17**	**39**	**35**
	B	**170**	**151**			**170**	**151**
	C	**62**	**56**			**62**	**56**
	D	**1,418**	**1,275**	**520**	**467**	**1,418**	**1,275**
	E	**1,965**	**1,779**	**1,180**	**1,072**	**1,965**	**1,779**
	F	**393**	**352**	**331**	**295**	**393**	**352**
	G	**120,392**	**108,500**	**103,330**	**93,102**	**120,392**	**108,500**
DK	C			899	303		
	D	1,476	331	601	172	1,476	331
	E	3,401	1,070	2,133	674	3,401	1,070
	F	696	368	696	368	696	368
	G	4,575	2,508	4,575	2,508	4,575	2,508
EE	C			680	180		
	D	2,385	1,131	1,027	738	2,385	1,131
	E	8,467	5,695	3,752	2,642	8,467	5,695
	F	351	81	351	81	351	81
	G	18,530	18,799	18,530	18,799	18,530	18,799
ES	C			5,084	1,227		
	D	594	505	44	6	594	505
	E	131,061	83,535	60,803	39,197	131,061	83,535
	F	68,463	50,479	9,492	7,399	68,463	50,479
	G	112,565	78,609	112,519	78,549	112,565	78,609
FI	**A**			**191**	**72**		
	B			**36**	**3**		
	C			**3,643**	**6,294**		
	D	21,679	18,932	**5,720**	**10,347**	21,679	18,932
	E	35,346	37,772	**84**	**101**	35,346	37,772
	F	4,584	9,449	**881**	**5,629**	4,584	9,449
	G	110,907	176,945	**14,238**	**18,367**	110,907	176,945
FR	**B**			**711**	**2,761**		
	D	**580**	**5,125**	**580**	**5,125**	**580**	**5,125**
	E	**350**	**1,550**	**350**	**1,550**	**350**	**1,550**
	G	**26,742**	**169,529**	**26,745**	**169,533**	**26,742**	**169,529**
GB	**C**			**2,163**	**550**		
	D	**4,580**	**4,581**	**3,992**	**4,452**	**4,580**	**4,581**
	E	**55,662**	**85,885**	**53,913**	**84,916**	**55,662**	**85,885**
	F	**17,479**	**25,506**	**17,479**	**25,506**	**17,479**	**25,506**
	G	**16,096**	**13,808**	**16,096**	**13,808**	**16,096**	**13,808**
GR	C			793	238		
	D	915	149			915	149
	E	42,333	22,701	15,418	8,218	42,333	22,701
	F	22,095	16,330	82	5	22,095	16,330
	G	28,509	19,154	28,509	19,154	28,509	19,154

Table 2.A Number of ecosystems (# ecords) and their area for which critical loads have been submitted (**bold**) or are taken from the background database in Europe

Country Code	EUNIS Class	Modelled Nutrient N		Empirical N		Acidification	
		# ecords	Area (km²)	# ecords	Area (km²)	# ecords	Area (km²)
HR	C			121	208		
	D	80	130			80	130
	E	7,245	11,520	4,618	7,925	7,245	11,520
	F	1,236	1,697	574	760	1,236	1,697
	G	8,043	17,380	8,043	17,380	8,043	17,380
HU	C			1,594	582		
	D	2,579	730	220	104	2,579	730
	E	20,137	8,515	14,595	7,305	20,137	8,515
	G	19,691	14,600	19,691	14,600	19,691	14,600
IE	**A**			**223**	**16**		
	C					**221**	**841**
	D			**32,617**	**5,098**		
	E			**63,036**	**6,974**	**63,011**	**6,971**
	F			**2,693**	**354**	**2,660**	**352**
	G	**85,586**	**5,256**	**93,838**	**5,558**	**87,880**	**5,355**
IT	B	**73**	**54**			**68**	**37**
	C			1,869	354		
	E	**18,617**	**8,832**	33,895	17,490	**18,585**	**8,826**
	F	**6,515**	**3,260**	10,574	3,808	**6,491**	**3,230**
	G	**83,712**	**119,727**	79,795	67,408	**83,616**	**119,499**
LT	C			1,407	711		
	D	1,290	408	716	317	1,290	408
	E	8,461	4,553	4,951	3,245	8,461	4,553
	F	88	28	88	28	88	28
	G	18,747	14,576	18,747	14,576	18,747	14,576
LU	C			29	6		
	E	679	372	594	357	679	372
	G	1,516	784	1,516	784	1,516	784
LV	C			1,210	442		
	D	1,696	1,189	1,229	1,091	1,696	1,189
	E	14,455	11,916	8,381	8,355	14,455	11,916
	G	24,935	21,973	24,935	21,973	24,935	21,973
MD	E	546	1,768	546	1,768	546	1,768
	F	334	73	334	73	334	73
	G	906	1,697	906	1,697	906	1,697
MK	C			51	71		
	D	2	2			2	2
	E	2,986	4,790	1,831	2,891	2,986	4,790
	F	1,011	1,708	914	1,534	1,011	1,708
	G	3,212	7,009	3,212	7,009	3,212	7,009
NL	**A**	**1,096**	**69**	**456**	**29**	**976**	**61**
	B	**4,385**	**275**	**4,385**	**275**	**3,467**	**218**
	D	**3,182**	**199**	**3,182**	**199**	**2,908**	**182**
	E	**15,107**	**944**	**15,107**	**944**	**9,489**	**593**
	F	**5,788**	**362**	**5,788**	**362**	**5,551**	**347**
	G	**44,027**	**2,753**	**43,942**	**2,747**	**91,525**	**5,720**

Table 2.A Number of ecosystems (# ecords) and their area for which critical loads have been submitted (**bold**) or are taken from the background database in Europe

Country Code	EUNIS Class	Modelled Nutrient N		Empirical N		Acidification	
		# ecords	Area (km²)	# ecords	Area (km²)	# ecords	Area (km²)
NO	**C**			**5,228**	**19,001**	**13,598**	**30,1873**
	D	271	641	**113**	**689**		
	E	3,872	6,964	**4,044**	**8,946**		
	F	48,692	166,533	**13,742**	**174,400**		
	G	33,060	67,267	**16,858**	**85,042**		
	H			**866**	**3,945**		
	I			**3,575**	**12,663**		
PL	**D**	**3,193**	**1,012**	**2,131**	**974**	**3,193**	**1,012**
	E	**556**	**348**	**32,588**	**12,005**	**556**	**348**
	F	**73**	**43**	**68**	**43**	**73**	**43**
	G	**209,806**	**94,640**	**146,622**	**73,045**	**209,806**	**94,640**
PT	C			663	100		
	D	69	7			69	7
	E	20,789	10,890	7,757	3,624	20,789	10,890
	F	7,990	3,709	4,460	2,112	7,990	3,709
	G	23,245	18,136	23,245	18,136	23,245	18,136
RO	C			1,360	911		
	D	15	9	15	9	15	9
	E	29,966	27,254	26,567	25,564	29,966	27,254
	F	4,899	2,732	4,899	2,732	4,899	2,732
	G	43,414	66,771	43,414	66,771	43,414	66,771
RU	E	67,631	334,153	67,631	334,153	67,631	334,153
	F	9,915	56,792	9,915	56,792	9,915	56,792
	G	224,416	1,139,212	224,416	1,139,212	224,416	1,139,212
SE	**C**					**17,249**	**52549**
	D			**13,883**	**44,044**		
	F			**4,141**	**28,256**		
	G	**17,164**	**233,411**	**41,967**	**298,737**	**17,164**	**233,411**
SI	**F**			**325**	**164**		
	G	**17,364**	**10,826**	**17,364**	**10,826**	**17,364**	**10,826**
SK	C			408	113		
	D	289	31	12	1	289	31
	E	8,981	3,254	8,261	3,093	8,981	3,254
	F	4,663	1,069	4,663	1,069	4,663	1,069
	G	23,441	18,196	23,441	18,196	23,441	18,196
UA	C			3	9		
	E	6,573	21,151	6,573	21,151	6,573	21,151
	F	531	1,096	531	1,096	531	1,096
	G	25,503	70,095	25,503	70,095	25,503	70,095
Grand Total		2,260,076	3,838,591	1,923,543	3,660,891	2,275,530	3,931,323

3 Assessing NEC Directive Objectives for Acidification and Eutrophication with 2001 and Present Knowledge

Maximilian Posch, Jean-Paul Hettelingh, Jaap Slootweg

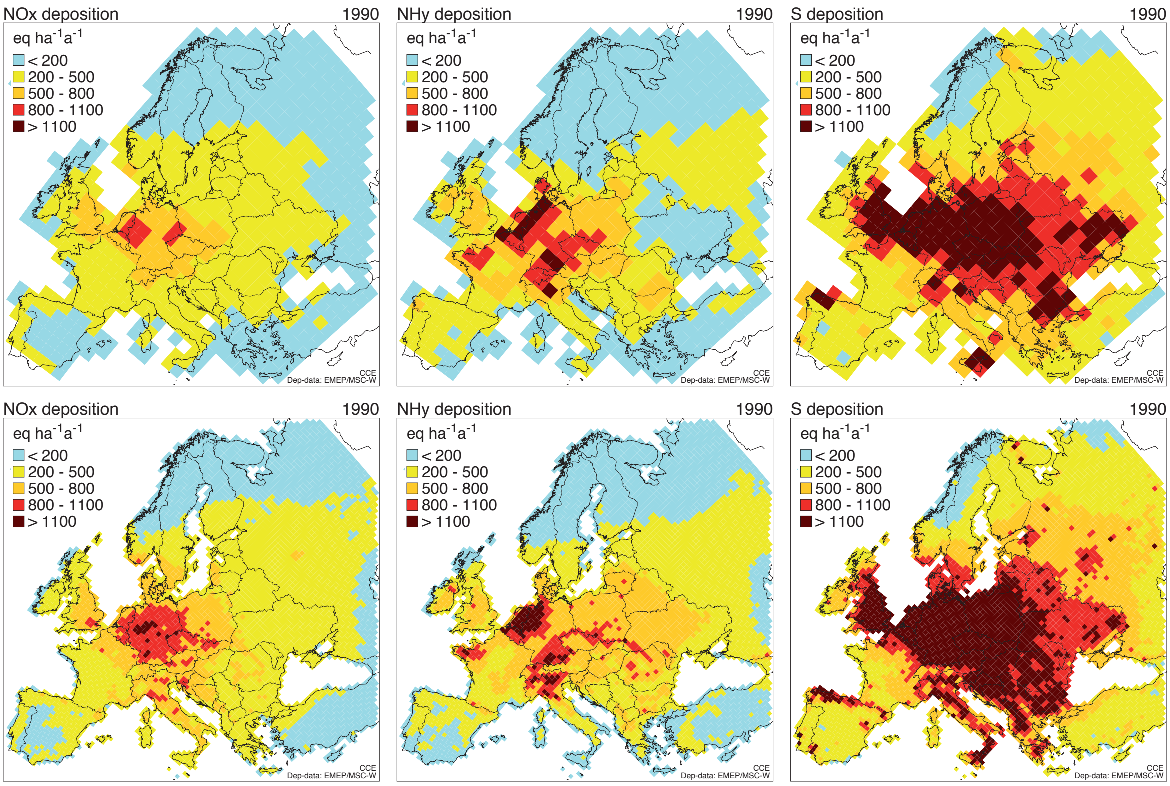
3.1 Introduction

In 2001 the European Parliament and the Council adopted the National Emission Ceilings (NEC) Directive, regulating EU Member State emissions of acidifying and eutrophying pollutants as well as ozone precursors (EC 2001). The required emission reductions in each Member State were determined by objectives for environmental and human health. In a recent study (EEA 2012), carried out on behalf of the European Environment Agency (EEA), it has been investigated whether the (interim) environmental objectives have been met by EU Member States. In this chapter we summarise the results of that study with respect to the acidification and eutrophication targets; for results concerning the ground-level ozone objectives the reader is referred to the EEA report (EEA 2012).

The environmental objectives of the NEC Directive were set with the support of scientific methodologies and data available until 2001 for the modelling of atmospheric dispersion and deposition of acidifying and eutrophying pollutants, and the computation of critical thresholds (as well as the concentration of ground-level ozone). Using this scientific knowledge, non-exceedance of critical loads of acidification was to be achieved in more than 50 percent of terrestrial and aquatic ecosystem areas 'in each grid cell' of the dispersion model, compared with the situation in 1990 (EC 2001, article 5a). The eutrophication target was that the EU area (the 'community area') with depositions of nitrogen (N) in excess of the nutrient N critical loads was to 'be reduced by about 30 percent compared with the situation in 1990' (EC 2001, Annex 1, footnote 1).

Scientific and technological knowledge used to assist in setting the above-mentioned objectives ('**old**' knowledge) has improved since the adoption of the NEC Directive in 2001. The frame of reference expressed in the Directive's text as 'the situation in 1990' was based on an integrated assessment of (a) 2001 estimates of historical emissions for 1990 and projections for 2010, (b) a dispersion model version available in 2001 computing only grid-average depositions (and concentrations) on a 150×150 km² grid (the EMEP150 grid) used for 15 (instead of the current 27) Member States and (c) the European critical load database of 1998 addressing mostly terrestrial ecosystems with an emphasis on forest soils and aquatic ecosystems. The same knowledge has been used in support of the Protocol 'to abate acidification, eutrophication and ground-level ozone' to the LRTAP Convention (UNECE 1999). In contrast, '**present**' knowledge includes data from national emission inventories for 1990 and 2010, a dispersion model modelling ecosystem-specific depositions on a 50×50 km² grid (the EMEP50 grid), a critical loads database that distinguishes ecosystems following the European Nature Information System (EUNIS; Davies and Moss 1999), and improved critical loads, of nitrogen in particular.

Figure 3.1 Total (wet+dry) 1990 grid-average deposition of NOx (left), NHy (centre) and S (right) (all in eq ha−1a−1) computed with old (lagrangian model; top) and present knowledge (eulerian model; bottom)



3.2 Old and present scientific knowledge

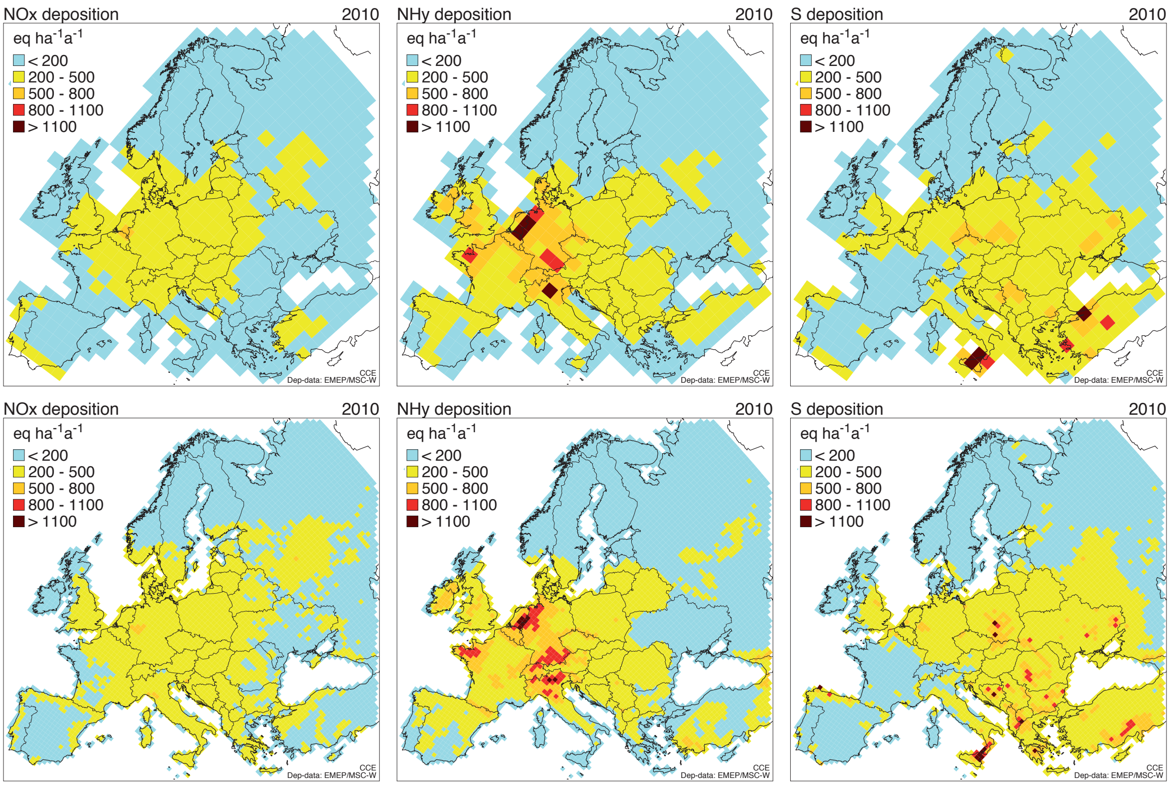
In this section methods and data available in 2001 – which were used to support the development of the NEC Directive (old knowledge) – are compared with those available now (present knowledge).

3.2.1 Emissions and atmospheric transport

The emission data used in the computation of atmospheric dispersion and impacts for 1990 and 2010 underwent changes over the last 10 years due to the introduction of climate and energy policies, emission reductions driven by the economic transition of Eastern European countries, and the extension of the EU from 15 to 27 Member States. Scientific knowledge on emissions (e.g. new sources, improved emission factors) has developed since the NEC Directive was agreed. New insights have become available with respect to emission factors of road transport, agriculture and consumers. Moreover, Member States have improved their emissions inventories. Over the past years increasingly detailed activity data have been provided and more detailed methodologies for calculating emissions applied. For details regarding emission data see Annex 1 of the EEA Report (EEA 2012).

In 2001 the single-layer lagrangian EMEP atmospheric dispersion and transport model (Eliassen et al. 1982, EMEP 1998) was used for calculating annual average depositions (and concentrations) on the EMEP150 grid. The model did not provide land cover-specific depositions (except sea areas); only grid-average depositions were available. To reduce the influence of a single meteorological year, depositions were averaged over 12 years (1985–1996) of meteorological data. Currently the more sophisticated multi-layer eulerian EMEP model (Tarrasón et al. 2003, Simpson et al. 2012) is used, with meteorology averaged over five years (1996–98, 2000, 2003). This model has been used to establish relationships between European country emissions and specific ecosystem depositions (forests, semi-natural vegetation, open land) on the EMEP50 grid in the form of so-called source-receptor matrices.
Figure 3.1 compares the deposition in 1990 of oxidised and reduced nitrogen as well as sulphur computed with the lagrangian model of 1998 (old knowledge) and with the eulerian model (present knowledge).

Figure 3.2 Total (wet+dry) 2010 grid-average deposition of oxidised (left) and reduced (centre) nitrogen, and sulphur (right) computed with old (lagrangian model; top) and present knowledge (eulerian model; bottom)



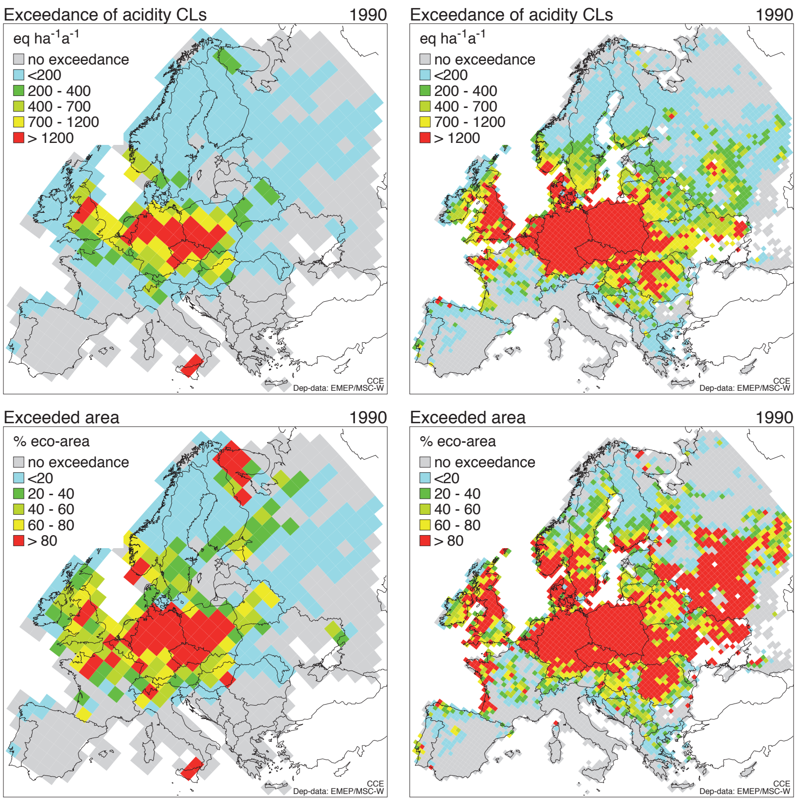
It can be seen that the eulerian dispersion model shows larger areas of high deposition, particularly for nitrogen. As depositions decrease substantially between 1990 and 2010 due to emission reduction, differences between the lagrangian and eulerian model persist. Both models reveal considerably smaller areas with high depositions in 2010 (Figure 3.2), but the eulerian model better identifies the location of peak depositions, especially for S. Figure 3.2 also shows that between 1990 and 2010 NO_x depositions have been reduced more than NH_y depositions.

3.2.2 Critical loads of N and S

During the past two decades, critical loads of nitrogen and sulphur have been used under the LRTAP Convention and the NEC Directive to support effects-based emission reduction agreements (Hettelingh et al. 1995, 2001, 2007). The critical load database of 1998 was used for the support of the NEC Directive and the Gothenburg Protocol to the LRTAP Convention, while the 2008 database was used for the review and revision of Gothenburg Protocol. The 1998 database of critical loads (Posch et al. 1999) was improved over the years (e.g. Slootweg et al. 2008) thanks to updates submitted by National Focal Centres. For countries that did not submit critical loads data to the 2008 database critical loads were taken from the so-called European background database (Posch et al. 2005; see also Reinds et al. 2008), which for the whole of Europe now includes about 700,000 receptors. The update was necessary for a number of reasons including the need to increase the resolution of mapped critical loads to the EMEP50 grid and the introduction of EUNIS classes (Davies and Moss 1999). Compared with the European background data used in 1998, which covered only forest ecosystems (EUNIS G), semi-natural vegetation (EUNIS classes D, E and F) is now also included. This leads to a broader range of critical loads for nitrogen in particular, based on a range of critical nitrogen concentrations in soil solution varying between 0.2 and 6.5 gN m^{-3} (De Vries et al. 2007). The present critical load database covers an area of about 4.22 Tm^2 of ecosystems for which critical loads for acidity were computed, and 3.86 Tm^2 with critical loads for eutrophication.

A critical load is said to be exceeded – and the area is said to be at risk (of acidification and/or eutrophication) – if the deposition is greater than the critical load ('outside' the critical load function in case of acidification). The 'average accumulated exceedance' (AAE; Posch et al. 2001) can be computed for a single ecosystem (in which case it is simply

Figure 3.3 Exceedances (AAE, in eq ha–1a–1) of the critical loads of acidity (top) and areas (percent of ecosystem area in a grid cell) at risk of acidification (bottom) in 1990 computed with the lagrangian model combined with the 1998 critical load database (old knowledge; left) and eulerian model combined with the 2008 critical load database (present knowledge; right)



the exceedance), a grid cell, or a whole region/country for which critical loads and deposition values are available; it is the area-weighted average of individual exceedances over all ecosystems in the respective (mapping) unit.

Figure 3.3 maps the exceedance (AAE) for acidification as well as the ecosystem areas at risk (i.e. areas with an AAE > 0) in 1990. In comparison with applying old knowledge, exceedances computed with the eulerian model using ecosystem-specific depositions combined with the 2008 critical loads database show a larger area at risk and higher exceedances, extending to Eastern Europe in particular. Results for 2010 (Figure 3.4) indicate that the risk of acidification is markedly reduced compared with 1990 – in terms of both magnitude and extent. However, grid cells where the risk of acidification (bottom right map) persists (non-grey shaded area) are found in many of the Western and Central European countries.

3.3 Results

Are acidification objectives met?

Applying the methods and data summarised in the previous chapter, Figure 3.5 shows the locations of the grid cells where the area at risk of acidification has been reduced by more than 50 % (green shading), as required under the NEC Directive. Blue shading indicates grid cells where the critical loads are no longer exceeded. Yellow shading indicates that the exceedances are close to zero.

Assessing the goals of the NEC Directive with the old knowledge shows that there are only four grid cells in the EU-27 where the area at risk of acidification has not reduced by more than 50% in comparison with 1990 (Figure 3.5, left): one in northern Germany (also EU-15), one at the Hungarian–Romanian border and two in Sicily, but those are due to volcanic emissions. Using present knowledge, however, there are many EMEP150 grid cells, mostly in western and eastern EU countries, that do not meet the Directive's requirements (Figure 3.5, centre). The right-hand map in Figure 3.5 shows the present knowledge on the EMEP50 grid, showing that there are many more acidification 'hot spots' that are averaged out on the EMEP150 grid.

Figure 3.4 Exceedance (AAE, eq $ha^{-1}a^{-1}$) of the critical loads of acidity (top) and areas (percent of ecosystem area in a grid cell) at risk of acidification (bottom) in 2010 computed with the lagrangian model combined with the 1998 critical load database (old knowledge; left) and eulerian model combined with the 2008 critical load database (present knowledge; right)

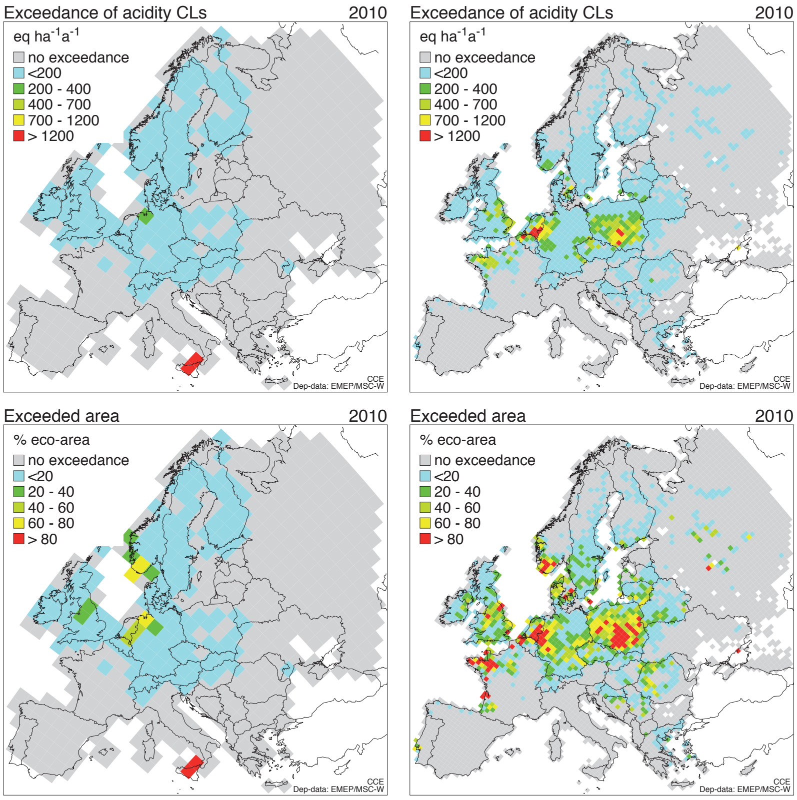
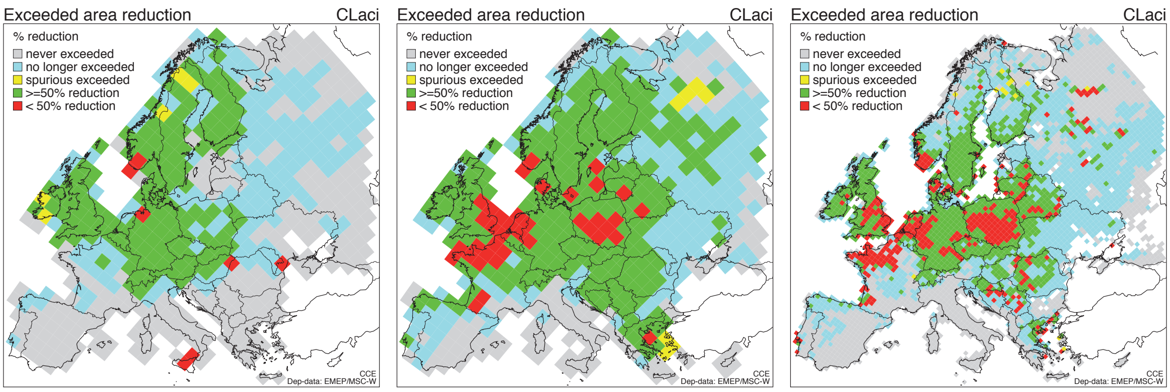


Figure 3.5 Grid cells where the area at risk of acidification has been reduced by more than 50% (green) and grid cells where the NEC Directive requirements are not met (red) according to old knowledge (left), and present knowledge summarised on the EMEP150 grid (centre) and on the EMEP50 grid (right) (blue are grid cells where critical loads are no longer exceeded, and yellow cells indicate an exceedance close to zero)

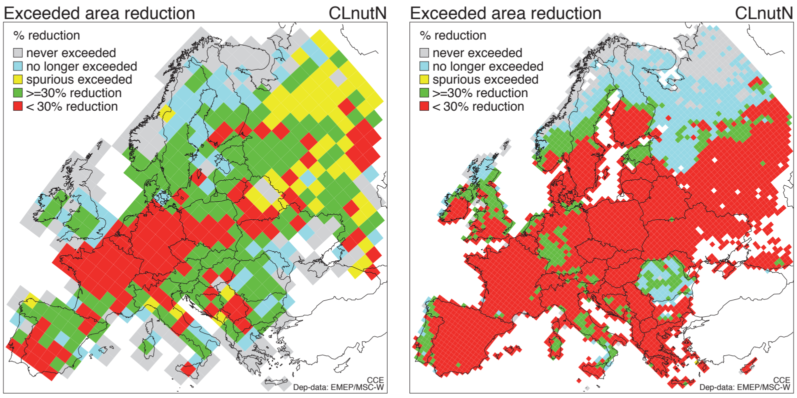


The conclusion from Figure 3.5 is that old knowledge confirms the achievement of the NEC Directive objectives for acidification in almost all grid cells. However, when present knowledge is used, they are violated in many grid cells spread over EU Member States.

Are eutrophication objectives met?

For the risk of eutrophication we included a grid-specific assessment for reasons of completeness and comparability to the analysis of acidification. It shows that the area at risk of eutrophication is reduced by less than 30% (red shading) in most grid cells of EU area, both under old and present knowledge (Figure 3.6).

Figure 3.6 The location of grid cells where the area at risk of eutrophication is reduced by more (green shading) and less (red shading) than 30% in comparison with the 1990 situation when using old (left) and present (right) knowledge



However, when looking at the community area as whole – as stipulated in the NEC Directive – it turns out that, using old knowledge, the reduction of the area at risk of eutrophication (Table 3.1) is reduced by about 30% in the EU-15 as a whole (34% in the EU-27). Of course, the distribution of the eutrophication protection over Member States varies: in 11 EU-27 Member States less than 30% reduction of the area at risk of eutrophication is achieved (Table 3.1). However, the use of present knowledge confirms the violation of NEC Directive objectives also at community level. In this case, the computed reduction of the community area at risk turns out to be less than 30% (22.8% in the EU-15 and 22.5% in the EU-27; not tabulated).

3.4 A sensitivity analysis

To gain insight into the relative influence of the changed atmospheric dispersion model and the updated critical loads, a sensitivity analysis is performed whereby (a) the average depositions instead of ecosystem-specific depositions computed with the eulerian model are used for calculating the AAEs in both 1990 and 2010, and (b) NEC Directive objectives are reviewed using the 2008 critical load database in combination with average depositions computed with the lagrangian and eulerian model.

When old knowledge on atmospheric transport (lagrangian model) is combined with new knowledge on critical loads (2008 database) a few more grid cells do not meet the Directive's objectives for acidification

Figure 3.7 The location of grid cells where the area at risk of acidification is reduced by more than 50 % (green shading) in comparison with the 1990 situation and grid cells where the NECD requirements are not met (red shading) when combining new (2008) critical loads with the lagrangian model (left) and with average (instead of ecosystem-specific) depositions computed with the eulerian model (right)

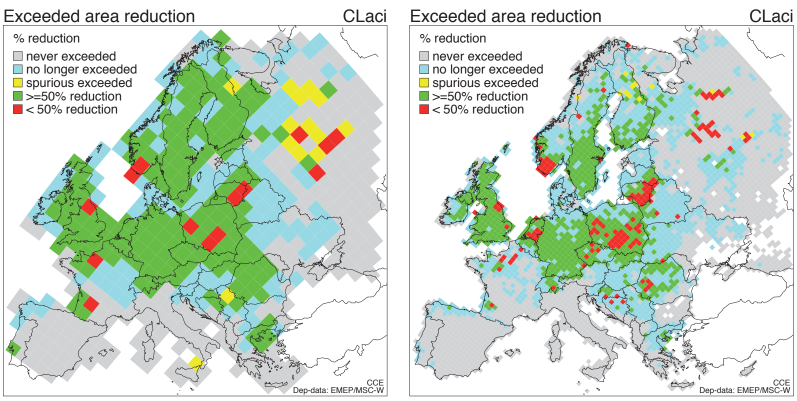


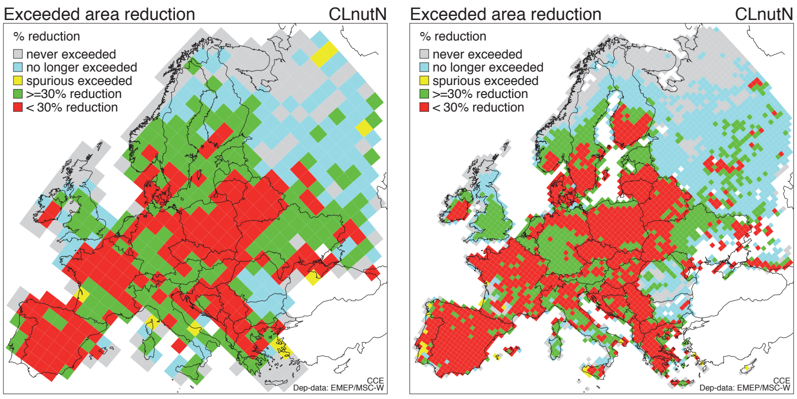
Table 3.1 The percentage of the area at risk of eutrophication in European countries in 1990 and 2010 as well as the relative change, using old knowledge (compare Figure 3.6, left).

Country	Area at risk of eutrophication in 1990 (%)	Area at risk of eutrophication in 2010 (%)	Change (%)
Austria	87	49	-44
Belgium	100	87	-12
Denmark	69	36	-48
Finland	53	22	-58
France	95	79	-17
Germany	100	90	-10
Greece	22	2	-93
Ireland	9	3	-66
Italy	49	30	-39
Luxembourg	100	95	-5
Netherlands	98	92	-7
Portugal	50	38	-24
Spain	57	34	-41
Sweden	15	6	-62
United Kingdom	14	1	-93
EU-15	60	42	**-30**
Bulgaria	73	14	-81
Czech Republic	100	76	-24
Estonia	63	18	-72
Hungary	38	38	-2
Latvia	100	21	-79
Lithuania	100	75	-25
Poland	98	72	-27
Romania	41	9	-79
Slovakia	100	46	-54
Slovenia	43	31	-26
EU-27[1]	66	44	**-34**
Albania	15	5	-67
Belarus	16	14	-11
Bosnia & Herzegovina	72	53	-26
Croatia	10	6	-37
Norway	15	2	-89
Macedonia	54	46	-15
Russia	13	8	-38
Switzerland	87	64	-27
Ukraine	73	46	-36
Europe	30	20	**-35**

[1]No data for Cyprus and Malta.

(Figure 3.7). However, combining new knowledge on critical loads with grid-average depositions computed with the eulerian model gives a smaller number of grid cells that violate the NEC Directive objectives in comparison with the 1990 situation when using present knowledge (Figure 3.5, right). This is a consequence of underestimating depositions onto forests. A comparable picture emerges when carrying out the same analysis for eutrophication (Figure 3.8; compared with Figure 3.6, right).

Figure 3.8 The location of grid cells where the area at risk of eutrophication is reduced by more (green cells) or less (red cells) than 30 % in comparison with the 1990 situation when combining new (2008) critical loads with the lagrangian model (left) and with average (instead of ecosystem-specific) N depositions computed with the eulerian model (right)



3.5 Concluding remarks

According to old knowledge, the acidification objective is met in almost all grid cells, while the eutrophication objective – which was formulated on the European Union area as a whole – is met both for the EU-15 and for the EU-27. While acidification has been markedly reduced, eutrophication, which in the NEC Directive is only a footnote, is now recognised as a major environmental problem, especially in the context of its potential impact on biodiversity. However, according to present knowledge, both the acidification and the eutrophication objectives are violated. Considering the rapid change in the science available for policy support, it is recommended that science is employed also in the implementation phase of policy agreements.

Acknowledgements
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Part 2

Progress in Modelling

4
GrowUp: A tool for computing forest Growth, nutrient Uptake and litterfall

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4.1 Introduction

The GrowUp application is a tool to simulate forest **Grow**th, litterfall and nutrient **Up**take in forest stands, including the effects of forest management. GrowUp output can be directly read by the VSD+ model (version 1.0 or later) (Bonten et al. 2010) and thus permits investigation of the effects of changes in forest growth and management on soils.

It requires user input on site characteristics (country, nitrogen deposition) and on forest growth and management (planting, thinning and clear-cutting) to compute time series of base cation (Bc) and nitrogen (N) uptake and carbon (C) and N in litterfall. These time series can be exported to a VSD+ compatible data file; the associated VSD+ input file can be updated accordingly. Furthermore, GrowUp contains a background database with N and Bc contents of various tree compartment as well as biomass expansion factors to calculate the mass of tree compartments (branches, leaves and roots) from stem growth for various tree species and regions.

Figure 4.1 gives an overview of the approach used in GrowUp to calculate growth, uptake and litter input. The steps in this approach are described in more detail below.

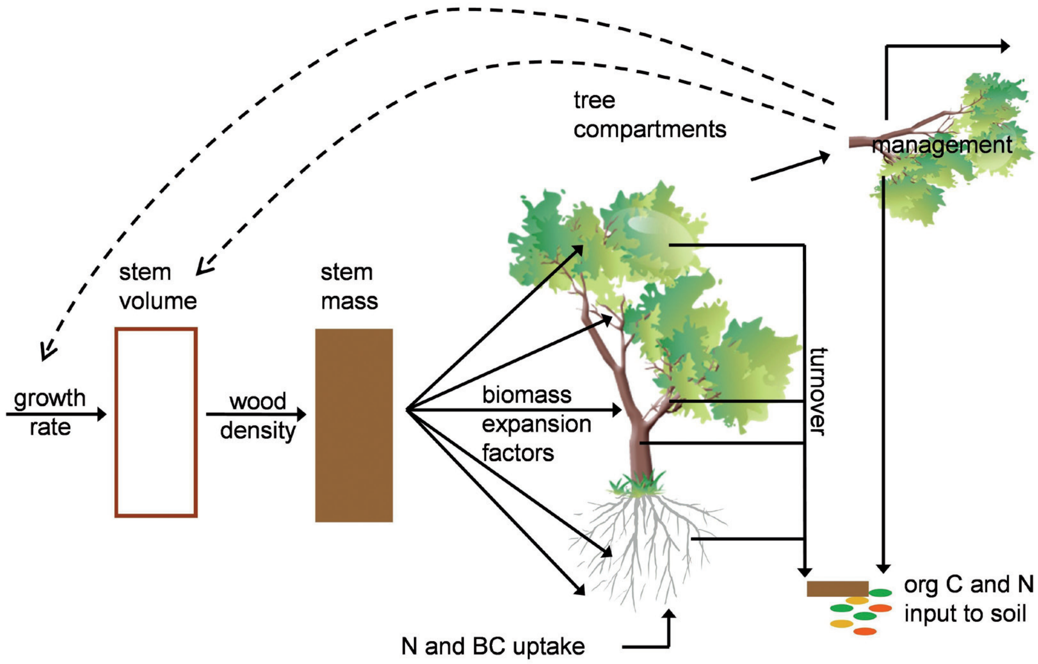
4.2 Stem growth and forest management strategies

Forest growth and management are defined for so-called cohorts. A cohort consists of growth rates and management actions for all trees at the plot belonging to the same species. Cohorts can be used to define consecutive time series of forest growth, if e.g. one species is planted after another is harvested, or for a succession of the same species if growth rates change over time (e.g. for simulations that span several hundreds of years). Cohorts can also be used to model mixed stands that consist of multiple cohorts each with its own species, growth rates and management.

GrowUp includes two different management types:
- planting and clear-cutting (even-aged forests);
- natural rejuvenation (uneven-aged multi-species forests).

The different management strategies also determine how stem growth is calculated in GrowUp and consequently which input for stem growth is required.

Figure 4.1 Approach used in GrowUp to calculate forest growth, litterfall and nutrient uptake



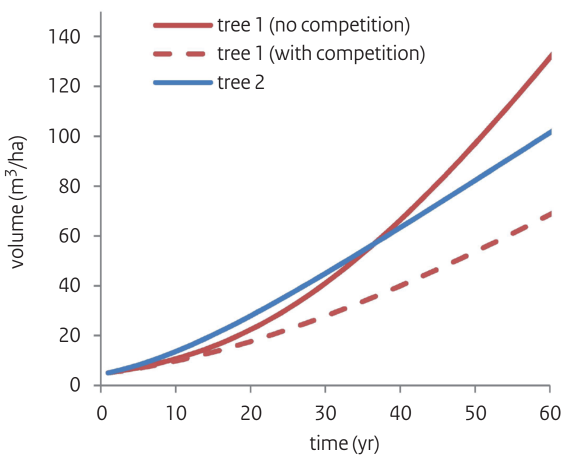
Planting and clear-cutting management
For the planting and clear-cutting management yearly stem growth is calculated by interpolating user-defined time series of growth rates (in m^3/yr). Different cohorts of trees can be grown simultaneously or adjacent in time. Each cohort has its own growth rates and management actions. Management actions are can be planting, thinning and clear-cutting. At planting, the biomass starts to grow with an initial age of two years, assuming that two-year-old seedlings are planted. Initial stem biomass is computed as a function of the age of the stand at the start of the run.

Natural rejuvenation
For natural rejuvenation yearly stem growth is calculated using a Michaelis-Menten type growth curve, which includes competition with other tree species. The growth of a tree species *j* is calculated as follows:

$$growth_j = gr_{max,j} \cdot \frac{V_j}{K_{gr,j} + \sum_{i=1}^{n} V_i} \tag{4.1}$$

where V_j is the stem volume of tree species *j* (m^3/ha); $gr_{max,j}$ its maximum growth rate (assuming no competition; $m^3/ha/yr$), and $K_{gr,j}$ is the stem volume at which the tree species reaches half of its maximum growth rate (m^3/ha). The stem volumes of all species present in the first year of the calculation have to be defined by the user. This type of equation takes into account that the growth of a tree species is inhibited by the presence of other tree species. Figure 4.2 gives a hypothetical case for the growth of tree species without and with competition of another tree species using the above equation.

Figure 4.2 Tree growth calculated by GrowUp in an uneven-aged forest with and without competition (tree 1)



4.3 Litterfall and uptake

Biomass of tree compartments

Growth of the different compartments (branches, leaves, roots) is calculated using yearly interpolated biomass expansion factors (BEFs):

$$(4.2)\quad biomass_{compartment\ i} = biomass_{stems} \cdot BEF_{compartment\ i}$$

For leaves, the amount of biomass is limited by a user-defined maximum value. This has been done because it is assumed that leaf biomass does not increase after canopy closure.

Litterfall

To calculate litter production, we use turnover coefficients per compartment, and sum over all compartments (stems, branches, leaves and roots):

$$(4.3)\quad litterfall = \sum_{compartment=1}^{m} biomass_{compartment} \cdot turnover\ \ coeffcient_{compartment}$$

Management can also affect the input of litter to the forest floor. Harvest can be stem-only harvest, where branches and leaves are left at the forest site, or whole-tree harvest or even harvesting with root removal. To include the effects of these management actions, the user can define in the harvesting actions which tree compartments are removed or left at the site. Biomass that is left at the site is added to the amount of litterfall.

Default values for BEFs and turnover coefficients are included in GrowUp. These default values are taken from the EFISCEN database (Schelhaas et al. 2007), but they can be modified by the user.

Nutrient uptake

The uptake of nitrogen (N) is treated differently than the uptake of base cations (Ca, Mg, K). N uptake is the total uptake, which is calculated as the sum of nitrogen losses through litterfall and the storage of nitrogen in the tree compartments. For base cations we assume that they are immediately released after litterfall and therefore neglect cycling through litterfall. This means that Bc uptake is only the storage in tree compartments. Consequently, when tree compartments are left after cutting or thinning, Bc uptake will be reduced by the amount of cations in the biomass that is left on the forest floor. In some cases this will give a negative Bc uptake, thus a net positive flow of base cations from the tree biomass to the forest soil.

Nutrient storage is calculated by multiplying the actual growth per compartment by the contents of nutrients of that compartment. In addition, for the N contents in leaves, ctN_{leaves}, (in %) we assume that they depend on N deposition according to:

$$(4.4)\quad ctN_{leaves} = ctN_{leaves,min} + (ctN_{leaves,\max} - ctN_{leaves,min}) \cdot \left(1 - e^{-expNlfdep \cdot Ndep}\right)$$

Where $ctN_{leaves,min}$ and $ctN_{leaves,max}$ are the minimum and maximum N contents in leaves (%), *expNlfdep* is an exponent for the relation between N in litterfall and N deposition, and *Ndep* is the N deposition (eq $m^{-2}yr^{-1}$). Default values of $ctN_{leaves,min}$, $ctN_{leaves,max}$ and *expNlfdep* are included in GrowUp for different tree species. These default values have been derived from a European database of leaf contents and deposition (De Vries et al. 2000).

4.4 Model input and output

Input

The required inputs for GrowUp consist of:

a. time series of forest growth (for even-aged forests) or growth function parameters (for unevenaged forests);
b. biomass expansion factors (BEFs) and maximum amount of leaves: default values of BEFs are included in GrowUp for different regions and tree species. These values can be modified by the user.
c. turnover rates of tree compartments. Defaults are included for different tree species and can be modified by the user.
d. nutrient (N, Ca, Mg, K) contents of tree compartments. Default values are included for different tree species, which can be modified by the user.
e. time series of management actions: planting (even-aged forests only), thinning and clear-cutting, i.e. the year in which the action takes place, the fraction of biomass that is removed (thinning only), and which residues are left at the plot (thinning and clear-cutting).
f. the initial distribution of the stem volumes of the various tree species for uneven-aged forests.

Output

The model output consists of:

- annual organic C and N input to the soil, which is the total of litter fall, root turnover and residues from cutting or thinning (g $m^{-2}yr^{-1}$);
- time series of the total uptake of N (eq $m^{-2}yr^{-1}$);
- time series of the net uptake of Ca, Mg and K (eq $m^{-2}yr^{-1}$);

Figure 4.3 Example of the GrowUp input window

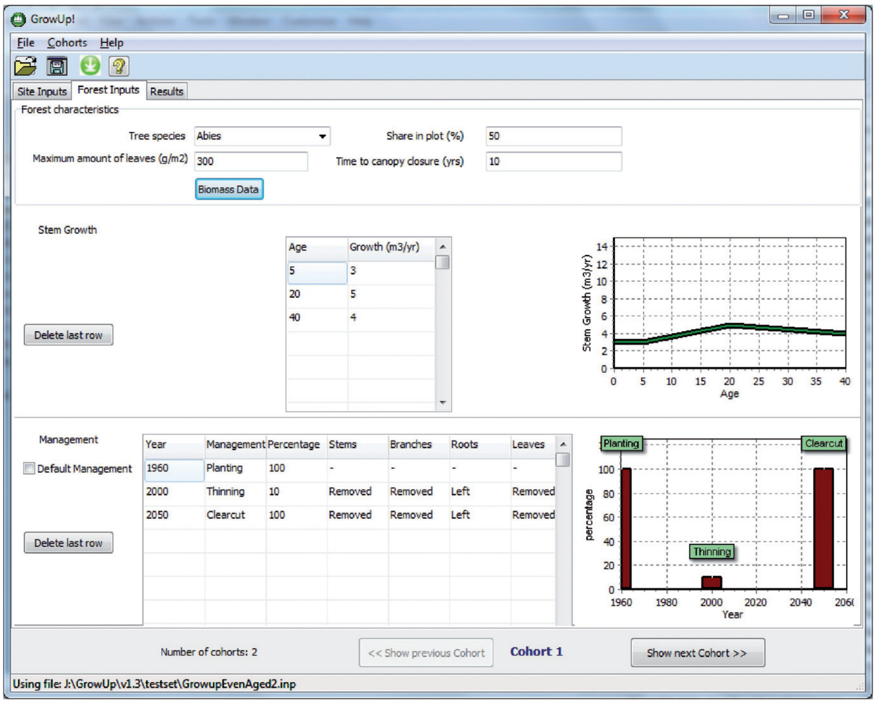


Figure 4.4 Example tree characteristics from default database

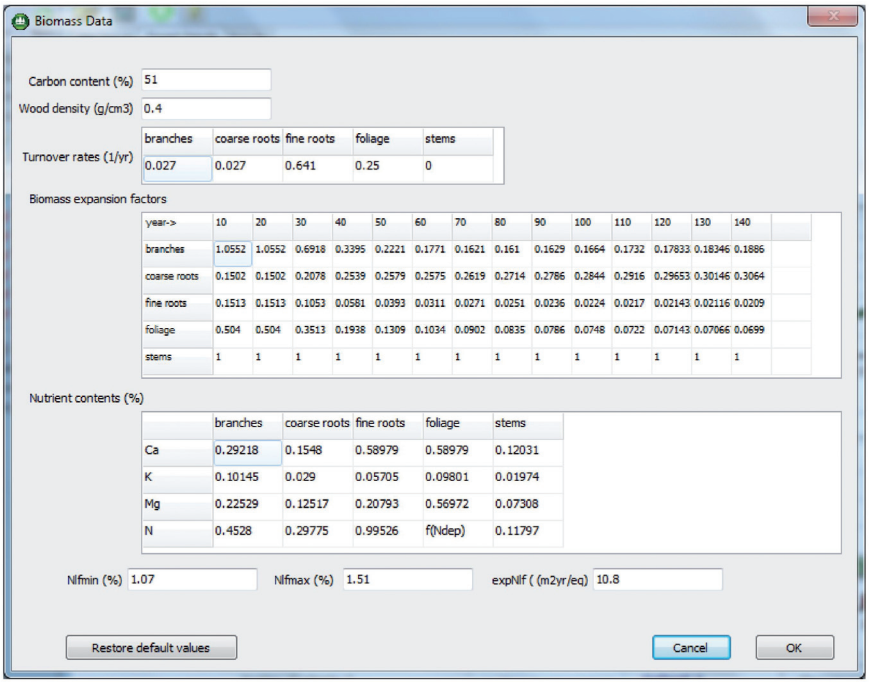
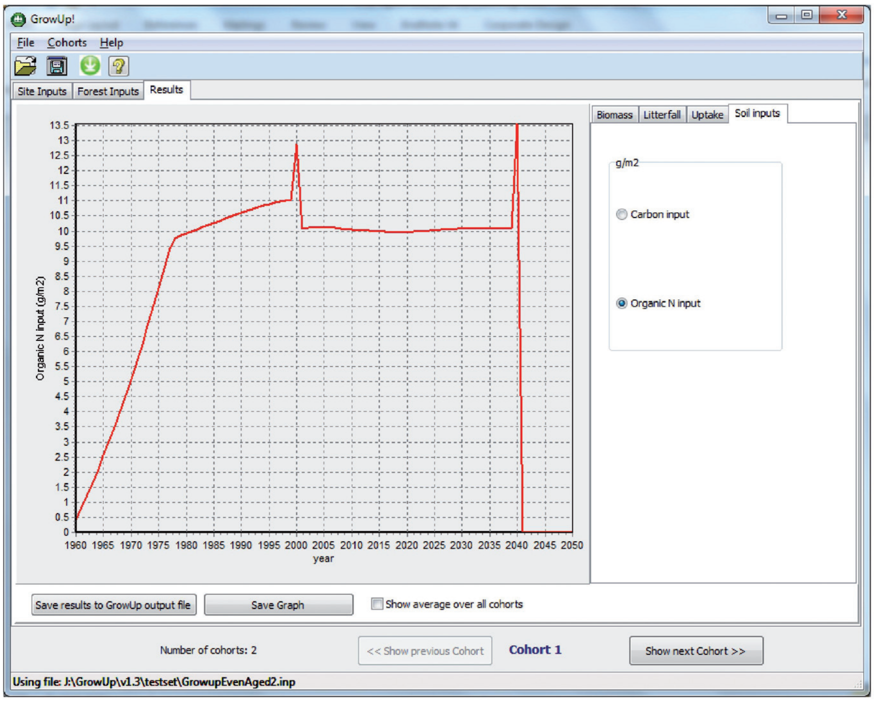


Figure 4.5 Example of graphical output of GrowUp (here: N in litterfall)



The user interface (see below) gives additional graphical output for the amount of biomass and turnover per tree compartment both for each cohort separately and for the sum for all cohorts.

4.5 User interface

GrowUp has a graphical user interface to assist the user in organising the input and output. Figure 4.3 shows an example of an input window. Here stem growth and management action can be defined. Stem growth, in m^3 per year, must be manually entered in the 'Stem Growth' table. The line graph at the right-hand side is the visualisation of the input growth. The management (planting, thinning, clear-cutting) of the forest plot can be specified in the 'Management' table. In this table the year of the management action, the percentage of the plot to which the action applies, and the fate (left at site or removed) of the tree compartments (stems, branches, leaves and roots) can be specified. To the right of the table the management actions are displayed in a bar graph.

Figure 4.4 shows an example of the BEFs, turnover rates and nutrient contents (which can be modified by the user).

Figure 4.5 gives an example of graphical output from the GrowUp user interface. The graph shows N in litterfall over time. The two sharp peaks in this example are caused by cutting residues that have been left at the site.

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5
Combined effects of air pollution and climate change on species diversity in Europe: First assessments with VSD+ linked to vegetation models

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5.1 Introduction

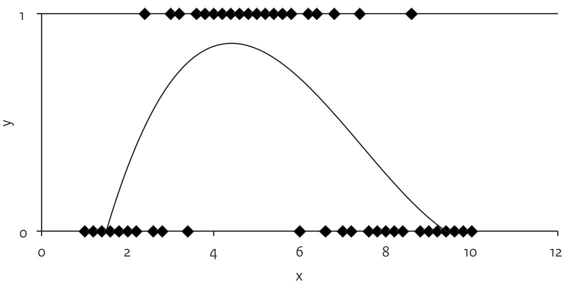
In this chapter we describe the effects of future changes in deposition and climate on potential plant species diversity, using results from a combined soil-vegetation model. The soil model VSD+ was coupled to the PROPS vegetation model to link changes in soil conditions (acidity and nitrogen status) to changes in potential plant species occurrence, expressed in simple biodiversity indices. Comparing results from different scenarios for climate and deposition reveals the relative importance of the two factors on modelled floristic biodiversity. VSD+ was also linked to the Veg model to examine the influence of different vegetation model concepts on computed diversity indices.

5.2 Methods

5.2.1 The VSD+ model

The VSD+ model is a single-layer dynamic soil chemistry model including cation ion exchange and carbon (C) and nitrogen (N) dynamics (Bonten et al. 2009). VSD+ was developed as an extension of the VSD model (Posch and Reinds 2009), which itself is the simplest extension of the steady-state Simple Mass Balance (SMB) model to a dynamic model with a one-year time step. VSD was especially designed to calculate the effects of deposition on soil acidification on a regional/national scale in support of the review of effects-based Protocols under the LRTAP Convention. More recently the effects of nitrogen deposition on biodiversity, greenhouse gases emissions (notably N_2O) and carbon sequestration have also become policy-relevant. To calculate these effects, VSD has been extended with an explicit calculation of the C and N balance. This extended VSD, named VSD+, calculates C and N dynamics using four soil organic matter pools that contain C and N. The model includes N mineralization or immobilisation as the net result of organic matter decomposition and further contains N uptake, nitrification, denitrification and N leaching. Organic matter turnover, nitrification and denitrification are dependent on pH, soil moisture and soil temperature and thus include effects of climate (change) on soil chemistry and nutrient cycling. VSD+ can calculate not only soil acidification but also

Figure 5.1 Example of occurrences of plant species against an abiotic parameter *x*. When the value is 1, the species occurs and with value 0 it doesn't.



parameters like N availability, C/N ratio of the soil, C sequestration, and NO_3 and NH_4 concentrations in the soil solution.

5.2.2 The PROPS model

The PROPS model estimates the probability of plant species occurrence as a function of environmental factors. The model was fitted to data using a logistic regression technique (e.g. Ter Braak and Looman 1986). In this technique, it is not the occurrence of a species that is estimated, but the probability. The problem of fitting a model that estimates probabilities is that you cannot observe a probability in the field. In the observed relevés, the plant species occurs or does not occur (Figure 5.1: every dot with y-value equal to 1 indicates that the plant species is present (for parameter *x*); when the species is not present the value is 0). The fitted function is an estimate for the occurrence probability of the plant species.

Since a probability has a value between 0 and 1, its so-called logit-transform, $z = \text{logit}(y) = \log(y/(1-y))$, is used (varying between $-\infty$ and ∞), which is approximated (fitted) by a quadratic polynomial. If three explaining variables (environmental factors) x_1, x_2 and x_3 are used, the occurrence probability is thus modelled as:

(5.1) $$z = \text{logit}(y) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \gamma_1 x_1^2 + \gamma_2 x_2^2 + \gamma_3 x_3^2 + \delta_{12} x_1 x_2 + \delta_{13} x_1 x_3 + \delta_{23} x_2 x_3$$

where α is a constant ('intercept'), β_j (j=1,2,3) the (regression) coefficients of the linear terms, γ_j the coefficients for the quadratic terms, and δ_{ij} (i<j) the coefficients for the interaction terms. Obviously, the probability *y* is obtained from the logit-value *z* as $y = 1/(1+\exp(-z))$. With one explanatory variable and for small *y* the shape of the curve (Eq. 5.1) is almost that of a Gaussian curve.

Using this regression model, the explanatory variables have to be normalised to:

(5.2) $$x_{norm} = \frac{x - x_{mean}}{x_{std}}$$

where *x* is the (log-transformed) value of the explanatory variable, x_{mean} is the average value and x_{std} the standard deviation of the explanatory variable from the database that is used to fit the model.

5.2.3 The PROPS database

The database for PROPS consists of over 40,000 vegetation relevés. At some of the sites soil parameters such as pH and C/N ratio have been measured as well. To fit the model, only the relevés for which the soil pH was measured in either water, calcium chloride extract or potassium chloride extract were used. The pH values in potassium chloride and calcium chloride extract were recalculated to pH values in water extract. This resulted in a database of about 6,000 relevés.

For this dataset the annual temperature, the precipitation excess and the nitrogen and sulphur deposition were obtained from the CRU meteorological dataset (Mitchell et al. 2004) and from EMEP model results (Simpson et al. 2003), using data from the grid cell corresponding to the location of the relevé. Because the PROPS database contains only a few measurements of N-related parameters such as NO_3 concentration and C/N ratio, these parameters were modelled with VSD+. These model results were linked to the relevés based on proximity between the measurement site and the modelling unit and similarity between modelled and measured pH. Several combinations of environmental factors were tested to fit the response curves, including pH, modelled nitrate concentration, modelled N availability, N deposition, temperature, and precipitation surplus. For the simulations described here, the model with measured soil pH, temperature and log-transformed N deposition was used (Figure 5.2), i.e. no use was yet made of VSD+ results.

The model was fitted for those species which occur in at least 50 different relevés in the database; this yielded species-specific estimates of regression parameters (Eq. 5.1) for about 250 species. Each species was assigned to a EUNIS class based on expert knowledge.

To check the plausibility of the model, the combination of pH, N deposition and temperature that yields the highest probability (modal value) were checked. The pH values for highest probability were reasonable, although for a number of species somewhat higher than the optimal values for the species in a Dutch database (Wamelink et al.

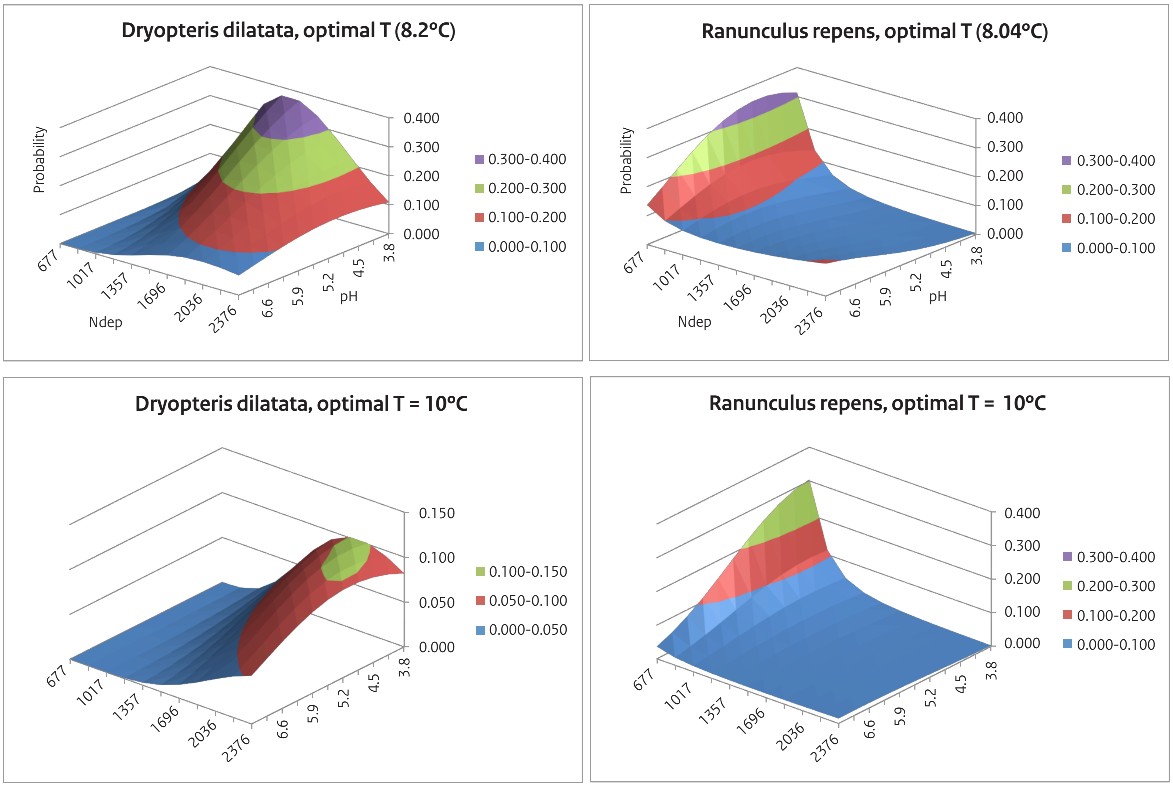


Figure 5.2 Probability of occurrence (response surfaces) of two species as a function of pH and N deposition for optimal (top graphs) and sub-optimal (lower graphs) temperatures.

2005). The range in N deposition for highest probability also seemed reasonable, but for some species highest probability occurs at the minimum or maximum value of the N deposition in the database, which means that the fitted responses are either continuously decreasing or increasing (Figure 5.2, lower left). The same is true for the response to temperature for a number of species. Both for N deposition and for temperature it is likely that the range of N deposition and temperature is too small in the database to find the 'tails' in the probability functions. Only if the database can be enhanced with relevés with more extremes in N deposition and temperature can this issue be resolved.

5.2.4 The Veg model

The Veg model estimates the composition of the ground vegetation community using the abiotic conditions at a particular site (Belyazid et al. 2011b). For each plant, the model evaluates whether site conditions (N and Ca concentrations in the soil solution, soil solution pH, soil moisture, air temperature and light intensity reaching the ground vegetation) are suitable for the plant to occur at the site. Functions are defined for each plant species that give the 'response' of a plant (range 0–1) to these environmental factors based on expert knowledge. The response is translated into the ground area occupied by each plant including the competitiveness of the species (based on root distribution and shading). Veg has been applied to sites in conjunction with the soil models ForSAFE (Sverdrup et al. 2012) and VSD (Belyazid et al. 2011a).

5.2.5 Indices

To evaluate changes in species diversity, two different indices were computed, the Czekanowski index and the Simpson index. The Czekanowski index is a similarity index and can be written as:

$$CzI = 1 - \frac{\sum_{i=1}^{n} |x_i - y_i|}{\sum_{i=1}^{n} (x_i + y_i)} \tag{5.3}$$

where x_i and y_i (i=1,...,n) denote two sets of (plant) abundances either at two different points in time or from two different 'measurements' (model outputs) (at the same time). This index always lies in the range between 0 and 1, and it is 1 only if the two sets are identical.

Diversity indices, such as the Simpson index, are defined for a set of abundances x_i, i=1,..,n at a given location and point in time, with the x_i normalised to one. The Simpson index is computed as:

$$SiI = 1 - \sum_{i=1}^{n} x_i^2 \qquad (5.4)$$

For n species this index obtains its maximum, 1–1/n, if all x_i are equal, i.e. x_i=1/n. When many species occur with about equal coverage (high diversity), the index is high: if ten species occur that each cover 10% of the site, *SiI* = 0.9. When one species dominates the site, the index is low: if ten species occur with one species occupying 73% of the sites and the other nine species each covering 3%, *SiI* = 0.46. The index also decreases with decreasing numbers of species: four species with equal coverage yields *SiI* = 0.75. More details on diversity and similarity indices can be found in Posch et al. (2010).

5.3 Data

5.3.1 Geographical databases

The required input data for the VSD+ PROPS/Veg model application consist of spatial information describing climatic variables, base cation deposition and weathering, soil characteristics, nutrient uptake and N transformations and were derived combining global maps of soils, land cover and forest growth regions. To cover the entire geographical area of interest, several thematic maps had to be combined:

(a) Land cover: We used the Global Land Cover 2000 project map at 1 km resolution (Bartholome et al., 2002). Forests (EUNIS code 'G') and (semi-)natural vegetation (codes 'D', 'E' and 'F') were considered in this study.

(b) Soils: The European Soil Database v2 polygon map (JRC, 2006) at a scale 1:1M was used for Europe including the entire Russian territory, Belarus and Ukraine. For the other countries, the less detailed FAO 1:5M soil map (FAO 1988) was selected.

(c) Forest growth: Average forest growth for other European countries was derived from a database of the European Forest Institute (EFI), which contains growth data for a variety of species and age classes in about 250 regions in Europe (Schelhaas et al. 1999).

Overlaying these maps and merging polygons with common soil, vegetation and region characteristics within blocks of 0.05°×0.05° resulted in about 7.4 million computational units. In the standard model runs, we used only computational units larger than 0.5 km^2, reducing their number to 1.9M, occupying about 90 percent of the total area.

The soil maps are composed of so-called soil associations, each polygon on the map representing one soil association. Every association, in turn, consists of several soil typological units (soil types) that each occupy a known percentage of the soil association, but with unknown location within the association. The soil units on the maps are classified into more than 200 soil types (European Soil Bureau Network, 2004), with associated attribute data such as soil texture, parent material class and drainage class. Six texture classes are defined, based on clay and sand content (FAO-UNESCO 2003). The drainage classes, which are used in the estimates of the growth and litterfall of natural grasslands, are derived from the dominant annual soil water regime (FAO-UNESCO 2003, European Soil Bureau Network 2004).

5.3.2 Meteorology and hydrology

The annual water flux through the soil at the bottom of the rooting zone is required to compute the concentration and leaching of compounds. The bottom of the root zone was set at 50 cm, except for lithosols, which were assumed to have a soil depth of 10 cm only. The leaching rate was estimated from meteorological data and soil properties using the model MetHyd (Slootweg et al. 2010). Long-term (1961–1990) average monthly temperature, precipitation and cloudiness were derived from a high-resolution European database that contains monthly values for the years 1901–2001 for land-based grid cells of 10’´10’ (approx. 15´18 km^2 in central Europe) (Mitchell et al. 2004). MetHyd also computed reduction functions for nitrification, denitrification and mineralization required for VSD+.

5.3.3 Base cation deposition and weathering

Base cation deposition for Europe was taken from simulations with an atmospheric dispersion model for base cations (Van Loon et al. 2005). Weathering of base cations was computed as a function of parent material class and texture class and corrected for temperature, as described in the Mapping Manual (ICP M&M 2012).

5.3.4 Nutrient uptake and litterfall

The net growth uptake of base cations (Bc) and nitrogen by forests was computed by multiplying the estimated annual average growth of stems and branches with the element contents of Bc and N in these compartments based on an extensive literature review by Jacobsen et al. (2002).

Forest growth and litterfall (as an initial estimate for later calibration) in EU countries were derived from the European Forest Information Scenario Model (EFISCEN v3.1). EFISCEN simulates the development of forest resources at scales from provincial to European level (Schelhaas et al. 2007). Data from national Forest Inventories are used to construct the initial age class distribution and growth functions. EFISCEN computes litterfall using computed growth and biomass expansion factors. Historic and future growth was obtained by scaling the reference growth from EFISCEN, $G_{ref,}$ using functions that describe the influence of (changes in) environmental factors such as climate and N deposition and soil macro-nutrient availability (P, Ca, Mg, K), according to:

$$G = G_{ref} \cdot f_{climate} \cdot f_{Ndep} \cdot f_{nutlim} \quad (5.5)$$

where the *f*-factors describe the reduction or enhancement of growth due to climate, N deposition and nutrient limitations, respectively. The model concept is based on the C-fix model (Veroustraete et al., 2002) but extended with effects of N deposition and base cation supply; details can be found in Reinds et al. (2009a) and in De Vries and Posch (2011).

Net growth uptake of N and Bc for natural grassland was set to zero, assuming no harvest takes place and all nutrients are cycled; net growth of heathlands was set to 0.4 kg m^{-2} based on data of Coquillard et al. (2000). Litterfall of grassland and heathland vegetation was computed as a function of soil texture and soil wetness, based on Dutch datasets, and varies between 0.25 and 0.55 kg m^{-2} for grass and 0.06 and 0.17 kg m^{-2} for heathlands.

5.3.5 Soil data and model initialisation

Soil data such as cation exchange capacity (CEC), constants for H-Bc and Al-Bc exchange and the equilibrium constant for $AlOH_3$ dissolution were computed from soil characteristics such as soil type and soil texture using transfer functions (ICP M&M 2012, Reinds et al. 2009b) and tabulated data (De Vries and Posch 2003). Initial total C pool, initial N pool and litterfall rate, needed for VSD+, were calibrated for about 20,000 units with varying soil type, soil texture, species group and location within the EMEP grid by grouping simulation units with comparable characteristics. For litterfall, the mean value for the initial estimate in the calibration (proposal distribution) was set to the value from the EFISCEN model with a standard deviation of 50%. For initial C and N pool, uniform proposal distributions were assumed with lower values close to zero and the upper value at 95% of the current values. Current C and N pools for these 20,000 sites were obtained from about 6,000 ICP Level I plots (Van Mechelen et al. 1997) by grouping measured values for combinations of country, soil type, soil texture and tree species group (deciduous, conifers) and assigning them to the 20,000 units based on these soil and vegetation characteristics.

Calibration was performed using a Bayesian approach as described in Reinds et al. (2008). The calibration was tested with various proposed distributions for initial C and N pool and turned out to be robust: simulated C and N pools in the year 2050 were almost identical for different proposed distributions of initial C and N. Initial values in 1880 for C pool and C/N ratio for VSD+ in the scenario analysis were obtained for each of the 1.9M simulation units by extracting from the calibration set the unit with the highest similarity in the environmental factors (soil type, tree species, etc.). Initial base saturation was assumed to be in equilibrium with the inputs to the soil in 1880.

5.4 Climate and deposition scenarios

The climate change scenario used was based on IPCC SRES A1 (Nakícenovíc et al. 2001). The A1 scenario represents a future world of continuing globalisation and rapid economic growth, low population growth, and the rapid introduction of new and more efficient technologies everywhere (Strengers et al. 2005). The A1 scenario was chosen since recent studies have shown that observed climate change over the last decades has accelerated and is consistent with the projections given in the A1 scenario (Rahmstorf et al. 2007). A reference climate set was created by computing the mean monthly temperature, precipitation and cloudiness of the period 1961–1990. Future scenarios for the same climatic variables were obtained for the three reference years 2005, 2030 and 2050 by averaging values for the periods 1991–2020, 2021–2040 and 2041–2060, respectively. Values between these periods were obtained by linear interpolation. This procedure provides a smoothed trend, which allows for better comparisons with the reference period 1960–1990 but ignores strong inter-annual variability in future climate. Future CO_2 air concentrations consistent with the above-mentioned scenarios were obtained from Carter (2007). Next to the A1 scenario we also evaluated a scenario with 'no further climate change' (CON), i.e. using the 1960–1990 data for the future years.

Historic N and S deposition data were taken from Schöpp et al. (2003). Scenarios of N and S deposition were obtained from the eulerian atmospheric transport model of EMEP/MSC-W (Tarrasón et al. 2007). For 2020 two emission scenarios were used reflecting current legislation (CLE) and maximum (technically) feasible reductions (MFR), developed for the Thematic Strategy on Air Pollution of the EU (Amann et al. 2007). From 2020 onwards, deposition was assumed constant. We also made simulations with the N and S deposition assuming no change compared with 2010 ('constant deposition', CD).

Figure 5.3 (from left to right) N deposition in Europe in 1990 and 2010, current legislation (CLE) in 2050 and maximum feasible reductions (MFR) in 2050.

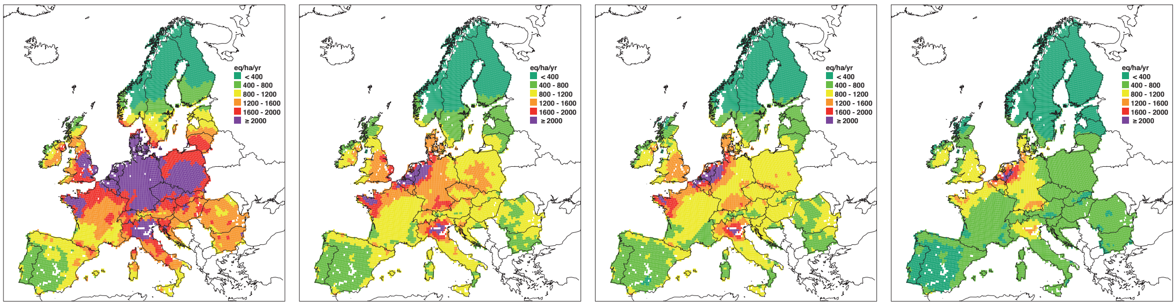
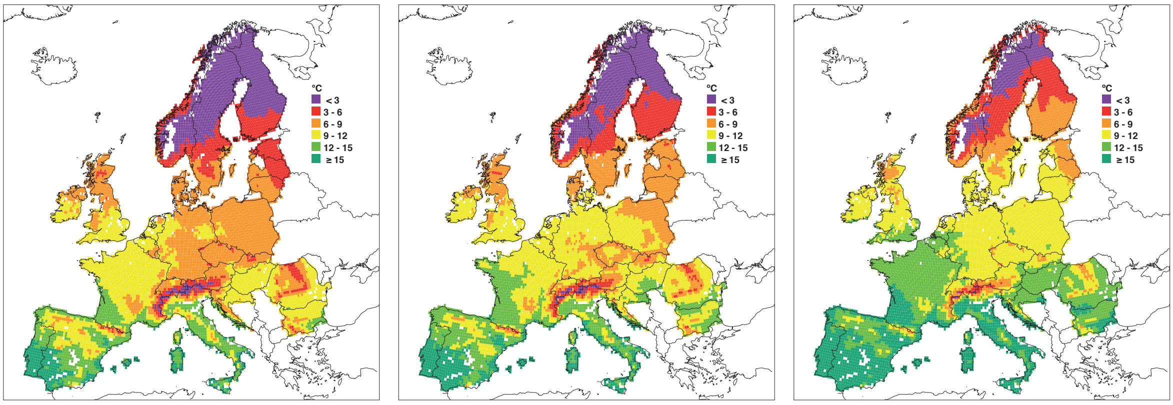


Figure 5.4 Median grid temperature in 1990, 2010 and 2050 under the A1 climate scenario.



To assess the influence of climate change and air pollution separately and in conjunction, six scenario runs were made combining the three deposition scenarios and two climate scenarios.

5.5 Results

5.5.1 Abiotic conditions

Current legislation (CLE) on air pollution strongly reduces the N deposition in Europe, compared with 1990 (Figure 5.3). Major reductions were achieved between 1990 and 2010, reductions between 2010 and 2050 by CLE are less pronounced.

If all technical abatement measures are implemented (MFR), a further reduction towards 2050 is possible and N deposition in almost the whole of Europe is below 1,600 eq $ha^{-1}yr^{-1}$.

Climate warming under the A1 climate change scenario accelerates after 2010 (Figure 5.4). In 2050 the temperature in large parts of Europe is 2–4 degrees higher than in 1990, with most pronounced changes occurring in southern Europe and in the eastern parts of Scandinavia.

Recovery from acidification in Europe is significant between 1990 and 2010, due to the major emission reductions in S and N. VSD+ simulations show that after 2010 the pH further increases in the acidified (central) part of Europe, but differences between the CLE and MFR scenario are limited if we examine the median pH values (Figure 5.5). However, strongly acidified soils (the 5th percentile pH per grid cell) do recover much better under MFR than under CLE (Figure 5.6).

Comparing results for the MFR scenario in 2050 under the A1 climate scenario with results obtained with a simulation with constant climate (CON), reveals that in large parts of Europe differences are small, but in Scandinavia recovery under the A1 scenario is significantly better than under CON. This is most likely caused by increased weathering rates, due to the increased temperature in these regions. This is in line with results from an earlier study in which the VSD model was applied to Europe (Reinds et al. 2009a).

Figure 5.5 Median pH in 1990 and 2010, CLE 2050 and MFR 2050 under the A1 climate scenario

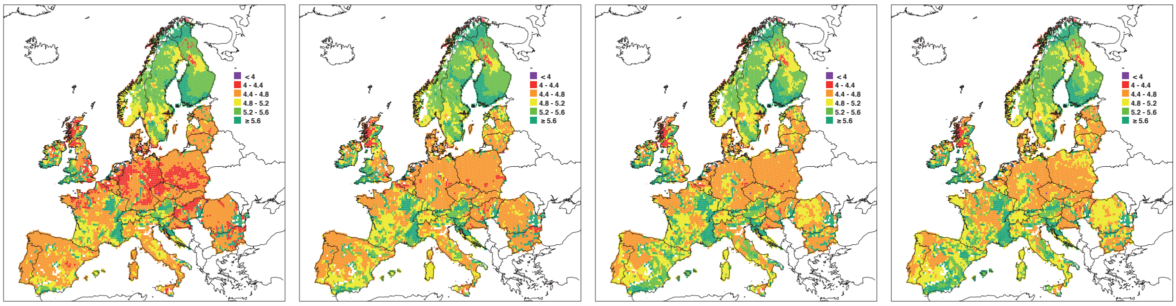


Figure 5.6 5th percentile pH in 1990, CLE 2050 and MFR 2050 under the A1 climate scenario

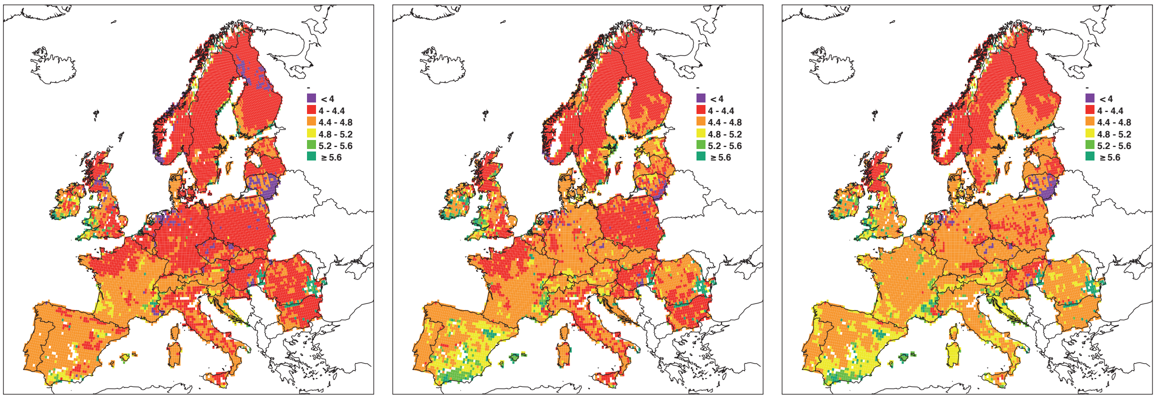
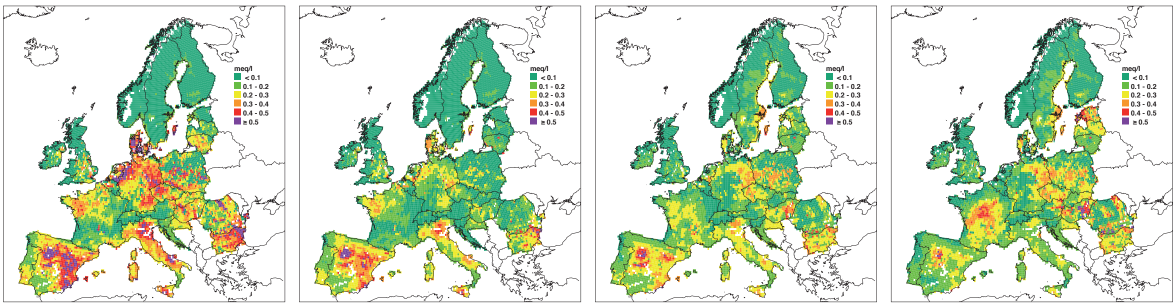


Figure 5.7 Median NO_3 concentration in 1990 and 2010 CLE 2050 and MFR 2050 under the A1 climate scenario



The simulated nitrate concentration in 2050 in Central and Western Europe under the MFRA1 scenario is much lower than the concentrations in 1990 (Figure 5.7).

However, in some other parts of Europe that become significantly drier and warmer under the A1 climate scenario, such as central France and parts of Sweden, nitrate concentrations increase due to increased N mineralization and a decrease in precipitation surplus (less dilution). Climate change also increases growth in some regions, leading to higher uptake, which compensates for the increased N mineralization. The net effect varies over Europe: in some regions climate change reduces N concentrations, in others N concentrations increase. Since the net growth of grassland was assumed zero, climate change always increases the NO_3 concentrations in the simulations for grasslands due to increased mineralization (Figure 5.8).

Figure 5.8 Cumulative frequency distributions for NO_3 concentrations in forests (left) and natural grasslands (right) in 2050 under the A1 (MFR-A1) climate scenario and without climate change (MFR-CON).

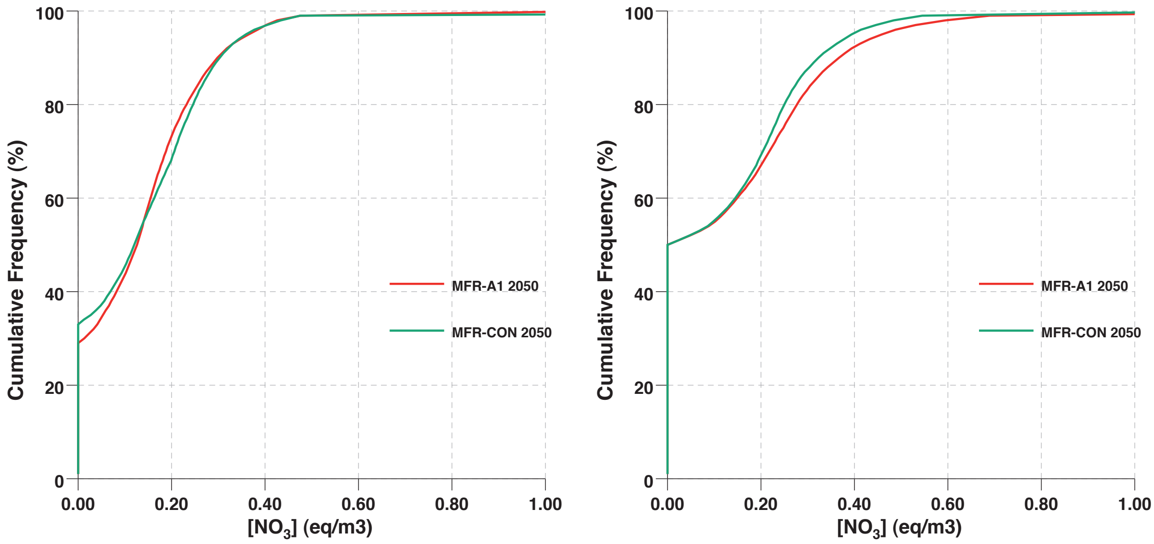
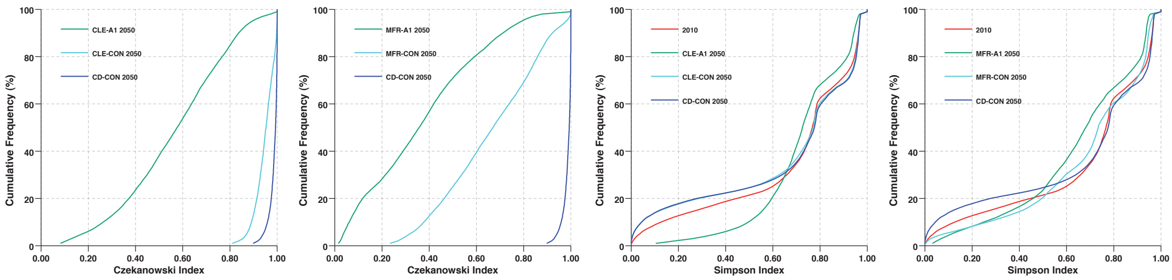


Figure 5.9 Cumulative frequency distributions of the Czekanowski index (panels a and b) and Simpson index (panels c and d) for forest vegetation for 2050 computed by the PROPS model for the CLE (a and c) and MFR (b and d) deposition scenarios, all for the A1 and CON climate scenarios. The Czekanowski index is with respect to 2010; the distribution of the Simpson index for 2010 is shown as red line.



The above examples show that in order to fully include the combined effects of deposition reductions and climate change on soil chemistry, a model like VSD+ is required that is able to also include climatic effects on N mineralization.

5.5.2 Changes in floristic diversity

Computed future changes in biodiversity indexes for forests and for vegetations vary with climate and deposition scenario (Figures 5.9 and 5.10). It should be noted, however, that these are tentative first results. The PROPS model needs further enhancements and a proper validation before more reliable estimates can be made. Furthermore, simulated changes in species composition are potential changes, as the actual change will depend on dispersal capacity and may also be dependent on environmental factors not included in the model.

If we assume constant climate (CON) and constant deposition (CD), the simulated Czekanowski index, a measure for dissimilarity between two species compositions (using the year 2010 as the reference year), is close to 1 in 2050 for whole of Europe. That it is not always 1 shows that even with constant climate and deposition inputs, the soil pH still changes between 2010 and 2050, indicating that soil pH is not always in equilibrium with the inputs in 2010. If we assume constant climate and CLE, the index decreases, but only slightly: CLE depositions in 2050 are close to those in 2010 (see Figure 5.3). With MFR depositions, but constant climate, the computed Czekanowski index changes significantly both for forests and for natural grasslands, showing the effect of strongly decreasing N deposition on species composition. If both climate and N deposition change, the Czekanowski index decreases sharply indicating that climate change in the PROPS model strongly changes occurrence probability in

Figure 5.10 Cumulative frequency distributions of the Czekanowski index for natural grasslands for 2050 computed by the PROPS model for the CLE (left) and MFR (right) deposition scenarios, for both the A1 and the CON climate scenarios. The Czekanowski index is with respect to 2010.

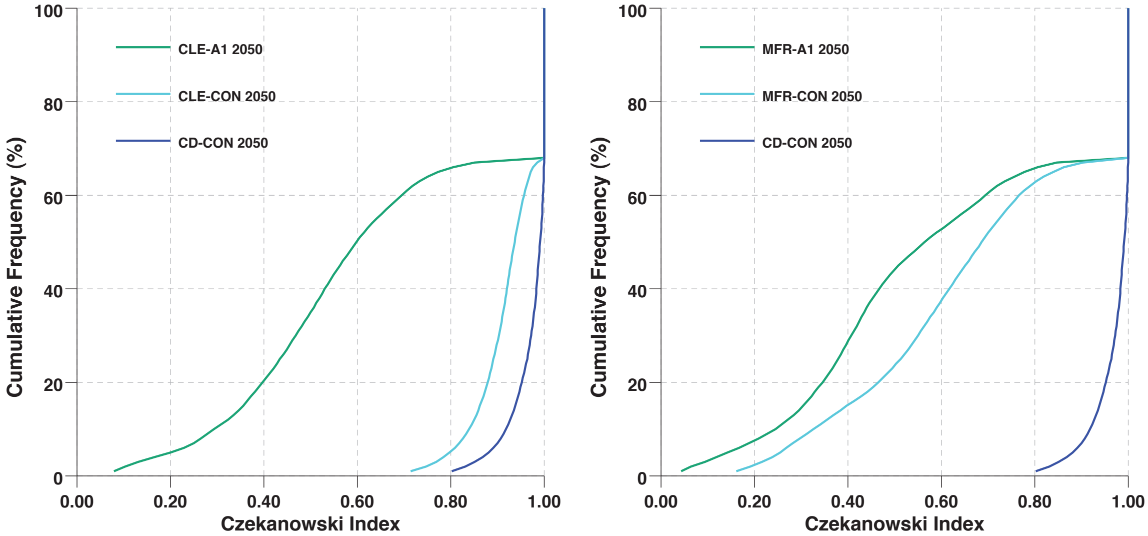
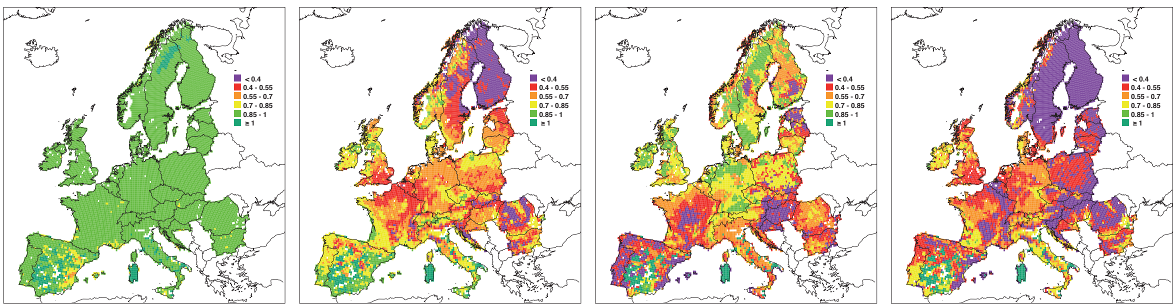


Figure 5.11 Maps of the median Czekanowski index per grid cell forest computed by the PROPS model for 2050 for CLE-CON, CLE-A1, MFR-CON and MFR-A1 scenarios (left to right)



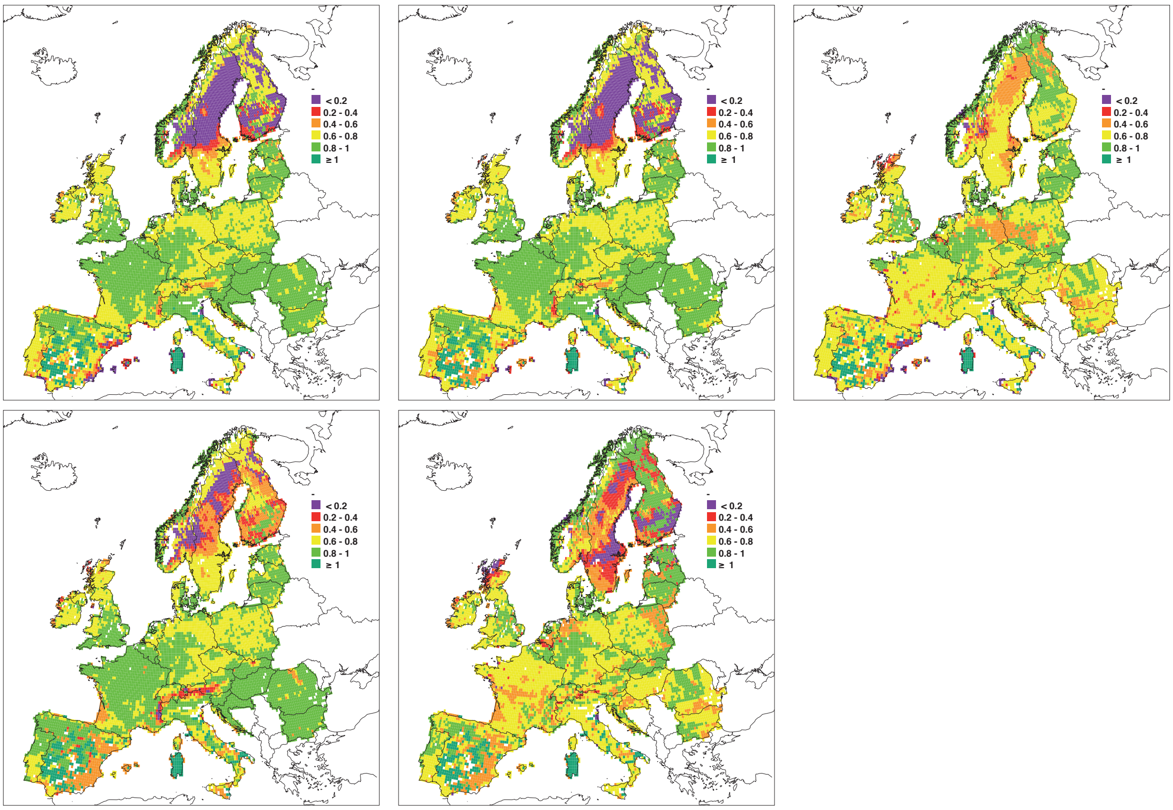
those areas with pronounced temperature change in 2050 (Figure 5.11).

Cumulative frequency distributions of the Simpson index show that according to PROPS climate change under A1 in combination with the CLE deposition scenario will (strongly) decrease diversity in parts of Europe by 2050, but will somewhat increase it in other parts (Figure 5.9c). With constant climate and CLE, the index hardly changes between 2010 and 2050: although there is a (limited) change in the vegetation composition (indicated by a small change in the Czekanowski index, Figure 5.9a), the share of the different species within the vegetation seems to remain almost constant. This simulated decrease in diversity because of climate change is much less pronounced if deposition simultaneously decreases strongly (MFR) (Figure 5.9d).

The median Simpson index shows the well-known natural north–south gradient in Europe (Figure 5.12): highest values (indicating high diversity) in the south and low values in parts of Scandinavia. A similar gradient was observed in this index when derived from observations at Intensive Monitoring plots in Europe (De Vries et al. 2001). In all scenarios, potential species richness in Scandinavia increases compared with CLE-CON, because of temperature increase, but under MFRA1 the median index per grid is lower than under CLE-A1, which may indicate that for some species the decrease in N inputs reduces their occurrence probability.

The Simpson index is less sensitive to changes in deposition and climate than the Czekanowski index (Figure 5.9, and compare Figures 5.11 and 5.12). The Czekanowski index decreases with any change in composition between two observations, whereas the Simpson index decreases only when species become more

Figure 5.12 Maps of the median Simpson index per grid cell for forest computed by the PROPS model for 2010 (upper left), the CLE-CON and CLE-A1scenarios (top row, centre and right) and the MFR-CON and MFR-A1 scenarios (bottom row)



dominant or fewer species can occur. The disadvantage of the Czekanowski index is that it reflects *any* change in composition: an increase and a decrease in the number of species both lead to a lower index. When the target is to preserve a certain species composition, this index is very valuable. In general, however, we think that the Simpson index (or any other index with similar characteristics) is likely to give more ecologically-meaningful results.

A straightforward comparison of results using PROPS with results from the Veg model cannot be made, as the indices strongly depend on the (number) of species assigned to each ecosystem. For Veg, the species number is generally (much) higher than for PROPS, hampering a comparison of computed indices. Nevertheless, since Veg uses NO_3 concentrations to simulate effects of N availability to probability occurrence and PROPS uses N deposition, a first comparison reveals that simulated changes by Veg are less pronounced than those by PROPS. This is in line with the results from VSD+ simulations shown in Figures 5.3 and 5.7: although the N deposition in Europe changes substantially, changes in NO_3 concentrations are much less pronounced.

5.6 Conclusions

The combined VSD+ PROPS model turned out to be a valuable tool for evaluating changes in climate and deposition on soil chemistry and species diversity. Validation of the VSD+ model has shown that it is capable of simulating soil chemistry and C and N dynamics in forests (Bonten et al. 2009), but a validation of C and N dynamics in natural grasslands is still needed. The same holds for the simulated effects of temperature changes on mineralization: within the FP VII project ECLAIRE a validation of VSD+ on sites with temperature manipulations is foreseen. The PROPS model used in this study is a very first version of the model with some shortcomings. For a substantial number of species, the range in abiotic conditions is not broad enough to make a reliable response curve. As a consequence, responses show a continuous increase or decrease with changing environmental factors. More datasets need to be added to the PROPS database to construct better responses and the analysis of explanatory environmental variables should be increased to include e.g. drought stress. In this version of PROPS we have used N deposition as a driver. It is likely, however, that species occurrence probability is more strongly related to N availability or N concentration (De Vries et al. 2010). Observations of N concentrations are scarce, however, and N availability cannot be measured. Using simulated values from VSD+ could be an option, but this needs a careful analysis as there is a risk of circular reasoning if the same model is later used to evaluate scenarios.

Comparing results from PROPS with those from Veg showed that PROPS probably overestimates the effects of N on species diversity as changes in N deposition are much greater than in soil N concentration, the latter being a more likely driver for change. The comparison between the two vegetation models also showed the need for a better assignment of species to vegetation classes or habitat types. In the current setup, the set of species used per vegetation type is too large, which influences the magnitude of the diversity indices. It needs to be examined whether the procedure developed by Mücher et al. (2009) yields a more precise allocation of species to EUNIS classes.

In this study we computed both Czekanowski and Simpson indices. The Czekanowski index yields a measure for the change in species composition; we have used the year 2010 as an arbitrary reference year. Since the Czekanowski index decreases with any change in species composition, it is difficult to interpret, unless conservation of a certain state is the target. Defining such a state, however, is not straightforward. The Simpson index is likely to be more useful, as an increase has an ecological meaning: increase in number of species or more evenness in the species distribution as a result of changes in deposition and climate change. Combining the Simpson index with other indices could further improve the relevance of diversity modelling for air pollution and climate policies. Future work should thus be targeted to the use of indices that include wanted/unwanted species and red list species (Van Dobben et al. 2010). This requires information on target species and red list species per EUNIS class.

Acknowledgements

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Part 3
NFC Reports

This part brings together the Reports by the National Focal Centres (NFCs) documenting their country's submission of data and assessments in response to the CCE's Call for Contributions, issued in 2011/12 (see also Appendix A).

The reports have not been thoroughly edited, but sometimes shortened (e.g., general descriptions of models, such as SMB or VSD) and minor corrections and harmonisations have been carried out. However, the responsibility for the substance of the National Reports remains with the National Focal Centres and not with the National Institute for Public Health and the Environment.

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Status

Endpoints

Although the risk of adverse effects of excess N deposition in designated conservation areas and for endangered species is obvious, the problem is not currently recognized as a top priority issue in Austria. Firstly, air pollution experts in Austria are not linked effectively to conservation practitioners. Secondly, knowledge about the effects of N deposition in some important habitats is very rare. There are very few studies in alpine areas, especially in calcareous grasslands, and none in Austria. In particular, studies on short-range impacts near farms are missing. As a result, and though Article 17 reporting included air pollution as a frequent pressure, the Article 11 monitoring scheme does not address the issue. There is a general need for a broader monitoring system that is effect related because currently effect-monitoring is restricted to forests. The work done under the LRTAP Convention, and particularly the progress in dynamic soil-vegetation models are a means for better addressing air pollution effects on biodiversity. The participation at the COST Action "Nitrogen deposition and Natura 2000 (Hicks et al. 2011) has stimulated further discussion about nitrogen driven biodiversity effects in protecting Austrian's conservation areas and particularly in Natura 2000 sites. Further we elaborate on EU 2020 targets in relation to SEBI headline indicators where we think that dynamic soil-vegetation modelling is useful.

1 - As in many other European countries acidification and eutrophication effects on biodiversity from airborne sources is not well implemented in the current implementation of the EU Flora-Fauna-Habitats directive. In Austria, the article 17 reporting in the year 2007 includes 66 habitats and 172 species listed in the annexes of the FFH directive (http://eea.eionet.europa.eu/Public/irc/eionet-circle/habitats-art17report). Nitrogen deposition exceeds the critical loads at the majority of the area and particularly in forests (Umweltbundesamt 2008). Very few knowledge exists regarding alpine habitats and other natural and semi-natural grasslands. Neither the current status of nitrogen deposition and related effects in the Natura 2000 network were assessed nor will the future monitoring of the conservation status include a "nitrogen component". There is thus a strong need to implement air pollution effects and the respective monitoring.

2 - As a first step critical load exceedance in Natura 2000 habitats, as derived from static model approaches or empirical critical load estimates, can be used. This assessment should be complemented by additional dynamic model approaches linking soil and vegetation development. Potentially these tools can evaluate the conservation status of Natura 2000 habitats by calculating the deviation from a reference state under different emission scenarios. In addition the extinction risk of priority species can be assessed. However, there are two major caveats to do so: a) very few detailed soil data exists for many priority habitats such as wetlands, dry grassland, alpine habitats; b) linking soil conditions to plant species occurrence has still to be improved and many more species have to be parameterised. So far the focus is on forest species which do not comprise many threatened species.

3 – In order to implement steps 1 and 2 a considerable raising of awareness of the effects of nitrogen deposition on biodiversity is needed, as well as training regarding assessment tools.

4 – Though current activities to improving soil-vegetation models focus on biodiversity they still have a high potential to assess other ecosystem services. Linking airborne effects on ecosystem functions (acidification of water bodies, nitrate leaching, etc.) with biodiversity is indispensable for the development of balanced adaptation measures to combat environmental pressures.

Soil-vegetation modelling for sites

In response to the 2011 Call for input data to test dynamic modelling of vegetation changes in selected sites in a country, the dynamic model VSD+ (including the Veg-module and BERN for some plots) was calibrated for 12 permanent soil-vegetation plots from the ICP Forests (level II) and the ICP Integrated Monitoring program. This is an extension of the last year's work where only 6 plots of the ICP Integrated Monitoring site Zöbelboden were used. These sites cover the major climates and bedrock conditions of Austria (Figure AT.1). In addition they experience different amounts of nitrogen and sulphur inputs. Both intensive soil and vegetation data is available for all sites for model evaluation. Based on VSD+ outputs vegetation development was modelled with the Veg-module of VSD+, and for two sites with the BERN model.

Figure AT.1 Overview of the 6 ICP Forests sites and the ICP Integrated Monitoring site used for dynamic soil-vegetation modelling in Austria. The detail shows the 8 plots used from the IM site Zöbelboden. See Table AT.1 for site codes and description.

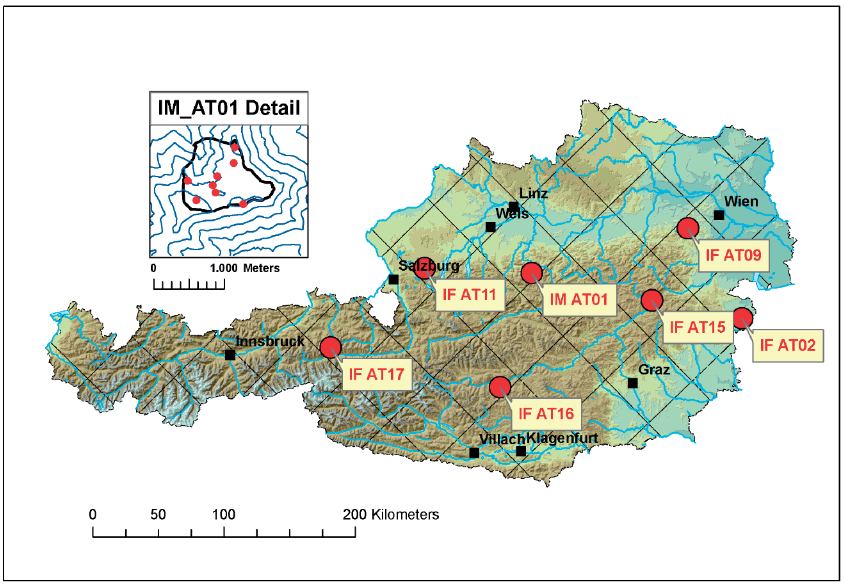


Table AT.1 Site description of the ICP Forests and the ICP IM sites used for dynamic soil-vegetation modelling in Austria. Temp: mean annual temperature; Prec: annual precipitation. The LTER Zöbelboden sites are from ICP Integrated Monitoring, all other sites form ICP Forests.

Code	Name	Elevation [m]	Temp [°C]	Prec [mm]	Deposition[a] [kg/ha/a]	Description
IF AT02	Unterpullendorf	290	9.6	630	N: 7-14; S: 4-7	84 year old oak forest; 95 cm deep pseudogley on loess
IF AT09	Klausen-Leopoldsdorf	510	8.2	804	N: 7-19; S: 4-9	70 year old beech forest; 65-135 cm deep brown soil on silicate-sandstone
IF AT11	Mondsee	860	8.1	1521	N: 9-22; S: 4-12	Afforestation (15 year) after spruce forest; 70-95 cm deep brown soil on silicate-sandstone
IF AT15	Mürzzuschlag	715	6.0	933	N: 5-10; S: 3-7	58 year old spruce forest; 35 cm deep ranker on marl, limestone and schist
IF AT16	Murau	1540	5.0	918	N: 1-6; S: 2-6	120 year old spruce-larch forests; 70-95 cm deep podsol-brown soil on gneiss and mica schist
IF AT17	Jochberg	1050	5.7	1358	N: 2-9; S: 2-5	75 year old spruce forest; 35 cm deep ranker on marl, limestone and schist
IM AT01_1	LTER Zöbelboden	908			N: 11-17; S: 3-7	112 year old spruce, beech forest; 30 cm deep carbonate brown soil on loam (bedrock is dolomite)
IM AT01_27	LTER Zöbelboden	900				112 year old spruce, beech forest; 20 cm deep carbonate brown soil on loam (bedrock is dolomite)
IM AT01_28	LTER Zöbelboden	918			N: 18-28; S: 5-14	112 year old spruce, larch forest; 50 cm deep pseudogley on loam (bedrock is dolomite)
IM AT01_33	LTER Zöbelboden	829	7.2	1500–1800	N: 11-17; S: 3-7	192 year old beech forest; 10 cm deep rendsina on dolomite
IM AT01_40	LTER Zöbelboden	801				212 year old beech, spruce forest; 20 cm deep carbonate brown soil on loam (bedrock is dolomite)
IM AT01_44	LTER Zöbelboden	795				192 year old beech forest; 10 cm deep rendsina on dolomite
IM AT01_50	LTER Zöbelboden	878			N: 18-28; S: 5-14	112 year old spruce, larch, beech forest; 50 cm deep pseudogley on loam (bedrock is dolomite)
IM AT01_60	LTER Zöbelboden	910				112 year old spruce, beech, larch forest; 30 cm deep pseudogley on loam (bedrock is dolomite)

[a]Minimum and maximum annual forest throughfall deposition between the years 1996 and 2010 including S and inorganic N.

Regionalised soil-vegetation modelling

We were not able to input our data into the VSD-Veg Access database due to a bug which was reported.

Soil-vegetation modelling for sites

Data sources

Dynamic models were calibrated for 6 ICP Forests sites and the ICP Integrated Monitoring site Zöbelboden. Nested within the 90 ha catchment area of the ICP IM site separate models were calibrated for 6 plots (for 2 plots calibration was not successful) (Figure AT.1). Soil, soil water and deposition measurements were carried out at all sites. For the ICP IM site deposition and soil water data was taken from two intensive plots, which are typical for the two gross site types of the area and was allocated to the respective permanent plots. Long-term meteorological measurements are available from non-forest patches of all sites (Figure AT.1).

Site description:
The ICP Forests and Integrated Monitoring sites are the best known forest ecosystems in Austria. They span an altitudinal range from 290 to 1540 m a.s.l., a mean annual temperature between 5 to 9.2 °C and precipitation between 600 and 1800 mm. They are characterised by different soil and bedrock conditions and exposed to contrasting amounts of deposition. All sites were, at least historically, managed. The main tree species are Norway spruce and European beech (Figure AT.1, Table AT.1). See Neumann et al. (2001) for details of the ICP Forests sites and the Austrian report in the 2011 CCE Status Report for the ICP Integrated Monitoring site Zöbelboden.

Parameter setting for VSD+:
Most of the sites are characterized by a high proportion of coarse fraction but the chemical soil parameters were analyzed from the fine fraction (<2 mm). This fact was taken into account by reducing the soil depth by the respective depth of the coarse fraction. All further parameters (CEC, base saturation, etc.) were calculated with the reduced soil depth.
We used modelled (from CCE) deposition of NO_3, NH_4 and SO_4, which is approximately double the throughfall deposition measured at the sites. Deposition of base cations was taken from van Loon et al. (2005) for the year 2000. An increase of 70% was assumed from 1880 to 2000 and 50% from 1970 to 2000 (Hedin et al. 1994). A further decrease of 10% until 2009 was estimated from the throughfall data. The hydrology of the ICP IM site was taken from modelled data (Brook90). The Methyd model was applied for all ICP Forests sites.
Base cation uptake as well as C and N input from above and belowground tree biomass was modelled with the model GrowUp. Management was defined by a standard forest yield model and field data. Tree species specific biomass data were not changed but the C and N input had to be decreased by 70-90% in order to be in the measured range (see discussion below). The following pairs of parameters were calibrated with VSD studio: lgKAlBC and lgKHBC, Cpool_0 and CNrat_0, Ca_we and Mg_we.
The Veg model was only applied to the ICP IM site data. Only those species were selected which occur in the 8 modelled plots resulting to 68 species (from totally 140 species). All effects on vegetation were included with PAR and soil water capacity taken from measured values. BERN was applied separately for two plots of the ICP IM site Zöbelboden (IM_AT01_01 and IM_AT01_44) with the results of VSD+ (particularly the C:N ratio and base saturation). In order to evaluate Veg and BERN model runs observation data from the years 1992, 2005 and 2010 were used. We restricted the species to those occurring in the understorey and scaled the sum of the cover values to one in the modelled and the observed data. The Czekanowski index was then calculated as a measure of model performance. The simulation period was set to 1900 as the starting year and 2050 as the final year.

Results and discussion

Dynamic soil modelling:
We were not able to calibrate Cpool_0 and CN_0 for two out of 14 plots. The reason is that with the default biomass settings larch is producing very high amounts of litterfall in the first years of development so that the C pool accumulates towards much higher values than the measured values. For all other plots VSD+ did model the C pool and the C:N ratio in the range of measured values, though with an overestimation. On average, the topsoil C pool was overestimated by 3800 g/m² and the C:N ratio by 4 units (Figure AT.2). It has to be mentioned that GrowUp models much too high amounts of litterfall. We scaled the GrowUp (Clf, Nlf) results to the field measurements or realistic values respectively. Nevertheless, the C pool remains too high in the model results over the entire simulation period.
The variation of the soil solution pH values and SO_4 concentrations is well reconstructed by VSD+. With regard to absolute values, the predicted soil water pH value is approximately 0.4 units lower than the measured values. All but one modelled SO_4 concentration is in the range of the measurements. The SO_4 concentration of one site is strongly overestimated (IF_AT11) but this is a result of forest management because the forest has been cleared and replanted only some years before the soil measurements. NO_3 concentration in soil solution is not well modelled by VSD+. Strong over- and underestimations occur (Figure AT.3). A part of the differences is most probably due to measurements from only one to 4 years. However, overall the model results are not satisfactory, which might not only stem from VSD+ but also from the weak representation of N input and uptake by GrowUp (see discussion above).
The nested subplots within the ICP IM site LTER Zöbelboden serve as a tool to evaluate how VSD+ is covering the regional variation of soil biochemistry as a result of tree species composition, forest management, and soil condition. In addition, measured evaluation data exists for a representative number of years (17 years for soil solution chemistry). C pools and C:N ratios are characterized by a high variation within the ICP IM site.

Figure AT.2 Comparison of modelled and measured topsoil C pool and C:N ratio of 12 plots of the ICP Forests (triangles) and IM (squares) sites in Austria. Soil chemical measurements stem from the years 1992, 1996, and 2005. The C pool of Plot IF_AT11 is not shown (measured: 20868, modelled: 22371 g/m²).

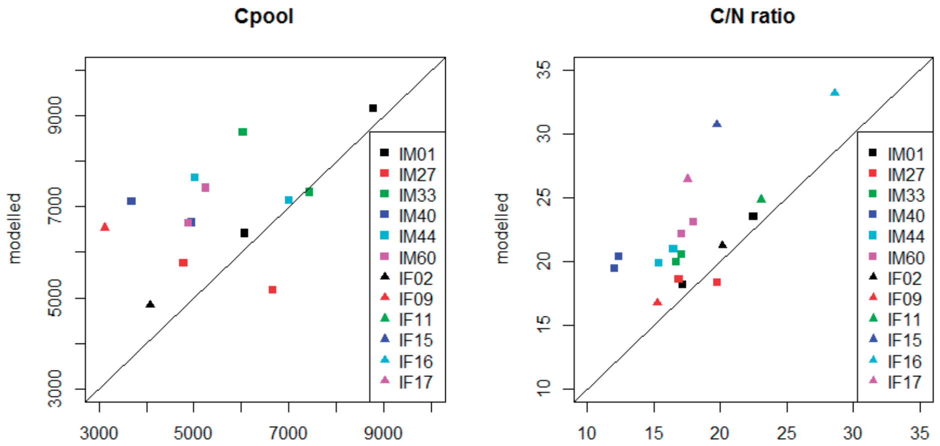
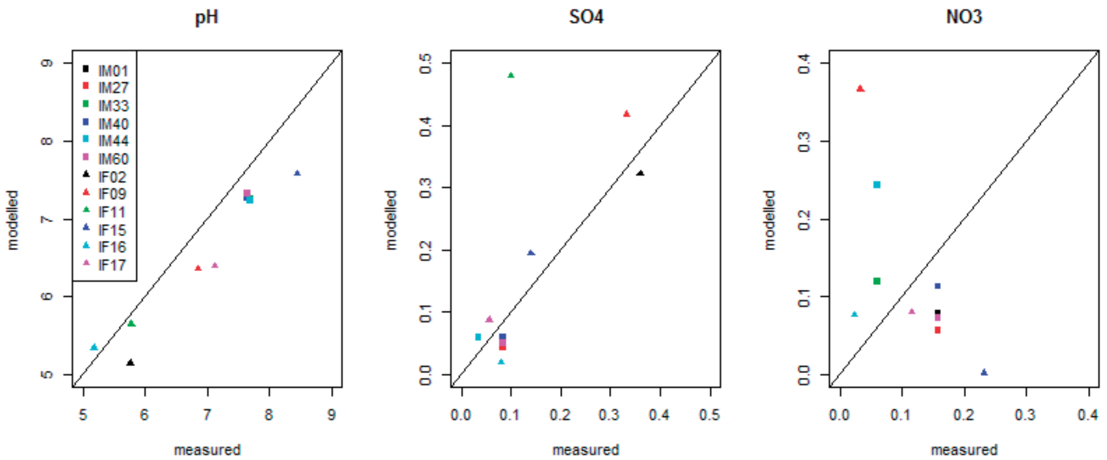


Figure AT.3 Comparison of modelled and measured soil water pH values, SO_4-S and NO_3-N concentrations of 12 plots of the ICP Forests (triangles) and IM (squares) sites. Measured mean values from as much as possible years were used (from 1 to 17 between values between 1993 and 2009).



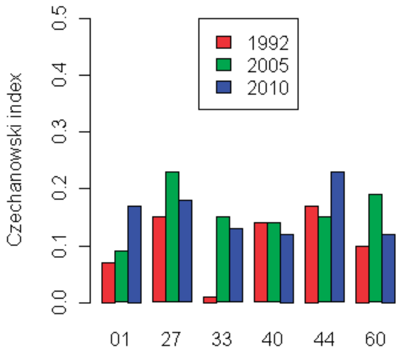
The model results fit this variation to some extent. The predicted soil water pH value is approximately 0.3 units lower than the measured values. Averaged over all plots SO_4 and NO_3 concentrations in the soil water are in the range of the modelled values. Also the modelled N leaching to the groundwater is in the range of measured rates. The results show that VSD+ satisfactorily models the average biochemistry of the site but the pattern of variation within the site as given by the different subplots at the Zöbelboden is only covered with regard to some parameters (C pool, C:N ratio).

Dynamic vegetation modelling:

We tested the Veg module with observation data from the ICP IM site from the years 1992, 2005 and 2010 and a subset of species occurring in the 90 ha area.

Two contrasting subplots of the ICP IM site LTER Zöbelboden serve for a comparison of the dynamic vegetation models Veg and BERN. Both are driven by the results of VSD+. The comparison of Veg and BERN is limited by the different conceptual framework of these models. Whereas Veg is applying a species-wise fundamental niche approach, i.e. predicting all species which fit the existing site conditions, BERN first links the existing plant community to the pristine plant community and second, models the dominance structure of the respective species related to this community. Thus, the potential species pool (the Veg approach) is pre-filtered to achieve an ecological species pool to start with in BERN.

Figure AT.4 Comparison of modelled and observed plant species composition of 6 plots of three years of the ICP IM site Zöbelboden. Only understorey species are considered. Left plot: Veg results; right plot (BERN results. The numbers at the x-axis indicate different plots from IM_AT01_01 to IM_AT01_60.



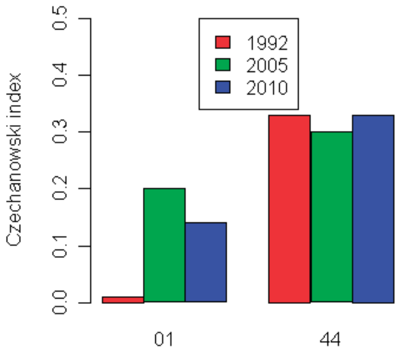
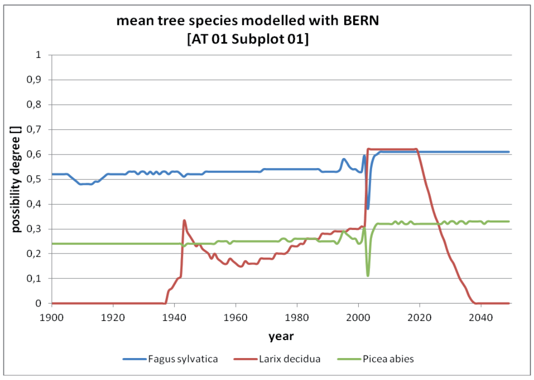
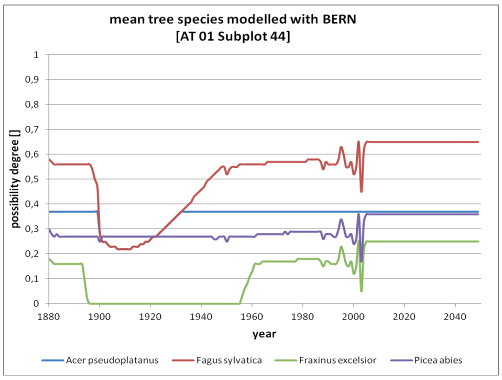


Figure AT.5 Results of BERN tree species occurrence of two plots of the ICP IM site Zöbelboden. ICP IM site Zöbelboden. Left: IM_AT01_01; right: IM_AT01_44.





Veg:

It is not new that Veg, and also BERN, is predicting much more species to occur than are observed. This is also the case when the full list of species is restricted to those occurring at the site. Obviously the environment and competition is a very strong filter on potentially occurring forest species. Most of the observed species are predicted by Veg. However, when comparing modelled with observed species composition the Czekanowski index rarely is above 0.2, which is low (Figure AT.4). At sites with less forest management predictions are better than at sites where the current tree species have been changed from the potential ones (e.g. from beech to spruce).

BERN:

As for Veg, species numbers exceed strongly the occurring species although almost all species are predicted to occur which were recorded at the plots. In contrast to the Veg module of VSD+, the BERN model is explicitly predicting the potential tree species composition and the potential community. For both plots, subplot 01 and subplot 44, the *Helleboro nigri-Fagetum* is predicted as the most possible community with *Fagus sylvatica* followed by *Picea abies* as the most possible species (Figure AT.5). For subplot 44 a higher proportion of additional deciduous tree species are predicted. This is well in line with the potential communities and the tree species composition of the plot. The understorey species composition is, at least for the subplot 44, better predicted than it is done by Veg. The dominant species of subplot 44 such as *Carex alba* or *Calamagrostis varia* are modeled as being dominant (Veg did not predict *Carex alba*). On the other hand a number of subordinate species are predicted which do not occur. As a result, the Czekanowski index is still quite low and for subplot 01 not satisfactorily (Figure AT.4). The forest of subplot 01 is an old spruce plantation and not dominated by the potential tree species. The effects of management on understorey species composition are rather difficult to predict.

Model testing – Conclusion:
The results of testing the soil-vegetation model VSD+, Veg and BERN revealed a number of limitations which are relevant for the suitability of these tools to deriving reliable indicators for biodiversity issues. VSD+ has certainly improved compared to the version of the last years call. Soil acidification is modelled rather satisfactorily but the N cycle still needs improvement. With regard to our experiences with the models we recommend: (i) the improvement of GrowUp with respect to the growth and biomass distribution. In particular, the estimation of litterfall is much too high; and (ii) clarifying the default values used in VSD+, particularly those defining the mineralization rates (kmin*), the SOM quality (frhu*, CN_*).
Vegetation simulation with Veg remains unsatisfactory; major questions to be solved include the transformation from potential to actual species occurrence and the proper handling of forest management which exert strong control on understorey vegetation? The model BERN produces better results but still, effects of forest management are difficult to predict.

Data sets submitted

We include all input data for VSD+ and Veg. The VSD input files are coded according to Table A.1. All ancillary input files are referenced in the VSD input files (paths have to be updated). We also include the GrowUp input files and the Methyd input files where these models were used.
VSD_input.zip – all VSD input files and ancillary files
VEG_input.zip – Veg Parameters for all subplots of IM_AT01 and the species list which is an extraction of the CCE list (parameters were not changed)
GrowUp.zip – GrowUp input files
Methyd.zip – Methyd input files (only ICP Forest sites)
Anx1_BiodivTargets_vs_SEBI_Austria_final.xls – Endpoints

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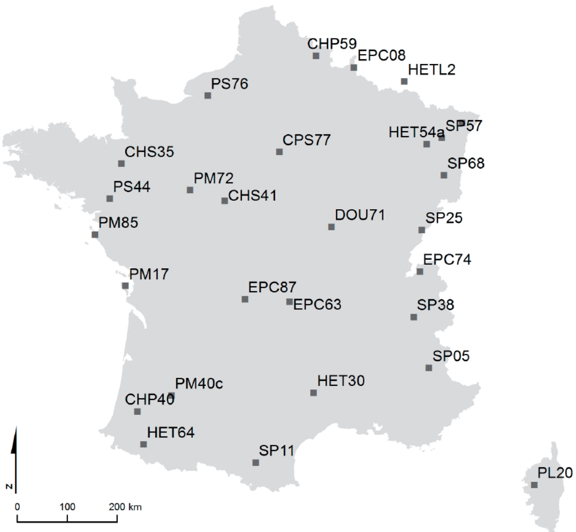
Introduction

The objectives of the 2012 Call for Data deal with soil and vegetation modelling. Since the last call for data, the French NFC focussed on the following points: (i) firstly, we performed a model sensitivity analysis to estimate the influence of input factors on ForSAFE-Veg outputs; (ii) secondly, we analyzed the vegetation response to the combined impact of climate change and atmospheric deposition scenarios; (iii) thirdly, we established the correspondence between French vegetation units and EUNIS European classification; and (iv) finally, we investigated a method to evaluate the acidifying potential in precipitation taking into account the respective contribution of sulphur and nitrogen deposition and its evolution over the period 1995–2008.
To reach these objectives, we used data from the forest sites belonging to the French ICP forest network (RENECOFOR, National network of forest health survey from the National Forest Office, Figure FR.1). On these sites, many variables were measured since 1993, and were namely relative to atmospheric bulk deposition, climate (e.g. temperature, precipitation), soil characteristics (e.g. pH, ions concentration in solution) and vegetation (specific richness and cover).

Figure FR.1 Location of the 27 French ICP forest sites. The letters used to identify the sites reflect the dominant tree species of the forest stand. CHP=Quercus robur, CHS=Quercus petraea, CPS77=mixed Q. robur/ Q. petraea, DOU=Pseudotsuga menziesii, EPC=Picea abies, HET=Fagus sylvatica, PL=Pinus laricio, PM=Pinus pinaster , PS=Pinus sylvestris, SP=Abies alba (Ponette et al. 1997).



Sensitivity analysis of ForSAFE-Veg

Methods and data:
ForSAFE-Veg is a coupled biogeochemical (ForSAFE) and ecological (Veg) model. The Veg module requires outputs from ForSAFE to be implemented and to provide in return outputs concerning the ecological response of vegetation species (Figure FR.2).

Coupled mechanistic models are often complicated to run because of the excessive number of inputs required (Sverdrup et al. 2007). Therefore, it is important to identify the main input variables that will have the greater influence on the outputs. These main variables should consequently be measured precisely, particularly when considering the model calibration step. On the other hand, it is also a key issue to identify the input variables having less influence as they can be fixed to an averaged value or even be suppressed to simplify the model (Saltelli et al. 2000).
For these reasons, firstly a sensitivity analysis was performed on ForSAFE for French forest environmental conditions in order to determine the input variables having the strongest effect on biogeochemical outputs, using the Morris screening method (Morris 1991, Campolongo et al. 2007). The influence of four types of inputs (relative to 1) climate, 2) atmospheric deposition, 3) soil characteristics

Figure FR.2 Scheme of ForSAFE-Veg functioning.

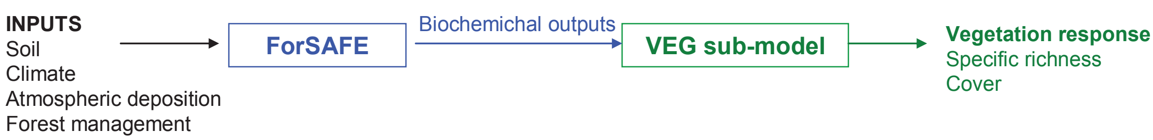


Table FR.1 Input factors tested in the sensitivity analysis performed on ForSAFE.

Input category	Input data tested	Abbreviation
Climate	Mean monthly temperature	Tmean
(six input factors)	Minimal monthly temperature	Tmin
	Maximal monthly temperature	Tmax
	Monthly precipitation	Precipitation
	Monthly radiation	Rad
	Monthly day length	day L
Atmospheric deposition	Chloride	Cl
(eight input factors)	Sulphur	SO_4
	Nitrate	NO_3
	Ammonium	NH_4
	Calcium	Ca
	Magnesium	Mg
	Potassium	K
	Sodium	Na
Soil characteristics	First soil horizon thickness	Z
(ten input factors)	Bulk density	Dens
	Specific surface area	Spec. area
	CO_2 pressure	p CO_2
	Gibbsite solubility coefficient	Gibb coef
	Basic cations (= cation exchange capacity, base saturation rate)	BC
	Organic matter (= data relative to carbon and nitrogen)	SOM
	Water (= field capacity and saturation, wilting point, percolation)	Water
	Roots proportion	Roots
	Mineralogy	Mineralo
Forest management	Dominant species associated to one management scenario	Management
(one input factor)		

and 4) forest management) was evaluated on some ForSAFE outputs (pH and nitrogen parameters) that are important regarding vegetation response (Table FR.1). Secondly, the sensitivity of vegetation response to input parameters was also tested using statistical correlations between the same input factors described above and the vegetation cover.

Results:

The influence of the input factors was evaluated on soil pH and outputs related to nitrogen cycle, i.e. NO_3, C/N, N in litterfall, N assimilation and N mineralization. The input factors were classified depending on their strong, medium or negligible influence, determined using the Morris method (Table FR.2). As we can see, pH is mainly associated to soil characteristics (base cations, bulk density, thickness of the first horizon, water content), and then to climatic and forest management factors. Na and Cl are also influential, but because of their sea-salt origin, this can be interpreted as the mimic of soil water leaching, which is already integrated in both soil water and precipitation. Concerning nitrogen concentrations and fluxes, the water fluxes and forest management are strongly influent, closely followed by climatic factors. Nitrogen deposition has a lighter influence, even on nitrogen parameters. An analysis site per site (performed on 15 French ICP Forest sites in total) showed that the temporal variability of pH and nitrogen outputs are generally more strongly linked to management practices, such as clearcuts or thinning, than to nitrogen deposition. The light influence of nitrogen deposition could be explained by the strong interaction existing between nitrogen deposition and the canopy, as modelled by the ‘canopy budget’ models (Staelens et al. 2008). Thus, the amount of nitrogen reaching the soil (i.e. nitrogen having an impact on soil nitrogen characteristics) can be significantly different from the amount of nitrogen contained in bulk deposition, which is the input factor considered here.

The correlations between the input factors and the vegetation characteristics showed that vegetation ecological response is influenced by soil water and climatic factors. If total nitrogen (NO_3 and NH_4) deposition was found to have some influence on soil nitrogen outputs parameters, no statistical effect was detected on the vegetation ecological response. This might indicate that the model is not sufficiently sensitive to atmospheric deposition. Nevertheless, these sensitivity analyses do not take into account the dynamic behaviour simulated by

Table FR.2 Influence of input factors on ForSAFE outputs, i.e. pH, NO_3 in soil solution, C/N ratio, N content in litterfall, N assimilation and N mineralization. The input factors having a strong and a medium influence are shown whereas negligible factors are not shown. A specific colour was used to distinguish factors related to climate, atmospheric deposition, soil and forest management. Factors were listed in their decreasing order of influence (as determined by the Morris method).

pH	NO3	C/N	N litter	N assimilation	N mineralisation
BC	Water	Water	Management	Water	Water
Dens	Management	Precipitation	Water	Management	Precipitation
Z	Precipitation	Tmin	Precipitation	Rad	Management
Water	Tmean	Tmean	Tmin	Tmin	Tmin
Precipitation	Tmin	Management	Rad	Precipitation	Rad
Mineralo	Rad	Rad	Tmax	Tmax	Tmax
Spec. area	Tmax	Tmax	Tmean	Tmean	Tmean
Management	Z	Z	NH_4	NH_4	Z
Roots	NH_4			Z	Roots
Tmin	Roots			Roots	NH_4
Cl	BC				
Tmean	Day L				
Rad					
Na					

Input factor with a strong influence	
Input factor with a medium influence	

ForSAFE. Then, the influence of the variation in nitrogen deposition on ecological response may not be evaluated since it is not instantaneous and occurs after a certain time lag. Consequently, an improving of ForSAFE-Veg may be necessary, including a sensitivity analysis of equations and parameters driving simulations. Moreover, some parameters like soil water content or management practices were identified to be significant parameters influencing the outputs that should be considered carefully.

Vegetation response to climate change and atmospheric deposition

The French NFC has also investigated the impact of climate change on vegetation cover under the CLE (Current European Legislation) and MFR (Maximum Feasible Reduction) deposition scenarios. Two climate scenarios were tested: A2 and B1, corresponding to high and low global warming respectively, as illustrated in Figure FR.3.

As a first approach, climate scenarios were compiled on one ICP French forest site (EPC08, dominated by *Picea abies*). Then, running ForSAFE-Veg, the response of grasses, mosses and herbs cover was analysed over the period 2010–2100.
Results (Figure FR.4) showed that the temperature increase linked to climate warming, led to a decrease of mosses cover and to a lesser extent to grasses cover. On the contrary, herbs cover remains quite stable, or even seems to increase under the warmest climate scenario.

From 2050, two vegetation response groups are distinguishable: the decrease of grasses and mosses cover and the increase of herbs cover registered under MFR-A2 and CLE-A2 are more pronounced than the ones registered under MFR-B1 and CLE-B1. Therefore, by 2050, the influence of global warming on grasses, mosses and herbs cover tends to be stronger than the influence of nitrogen deposition, particularly when considering mosses cover. Nevertheless, for B1 climate scenario by 2100, MFR was found to limit moss and grass cover (these groups being nitrogenous) and to favour herb cover more than CLE, indicating a clear long-term nitrogen deposition impact. These first results encourage carrying on in this way, combining climate and nitrogen deposition scenarios. However, predictions on vegetation require some improvement on the French and European vegetation databases. Currently, the French vegetation database is in process of being improved in three ways that consist to : i) reduce the number of indices describing the ecological behaviour of each species; ii) improve the parameters calibration ; and iii) create functional groups to pool together species characterised by a similar ecological behaviour. With this latest approach, the forest ecosystem response to deposition and climate scenarios could be accentuated. Using functional groups enables to improve the detection of tenuous change in vegetation under nitrogen deposition. The creation of these functional groups is in progress using hierarchical classification methods done by French experts. Moreover, we propose that a database based on such functional groups would be extrapolated to other European countries.

Figure FR.3 Temperature projections (a, from http://www.epa.gov/climatechange/science/futuretc.html) and nitrogen scenarios (b) to the year 2100.

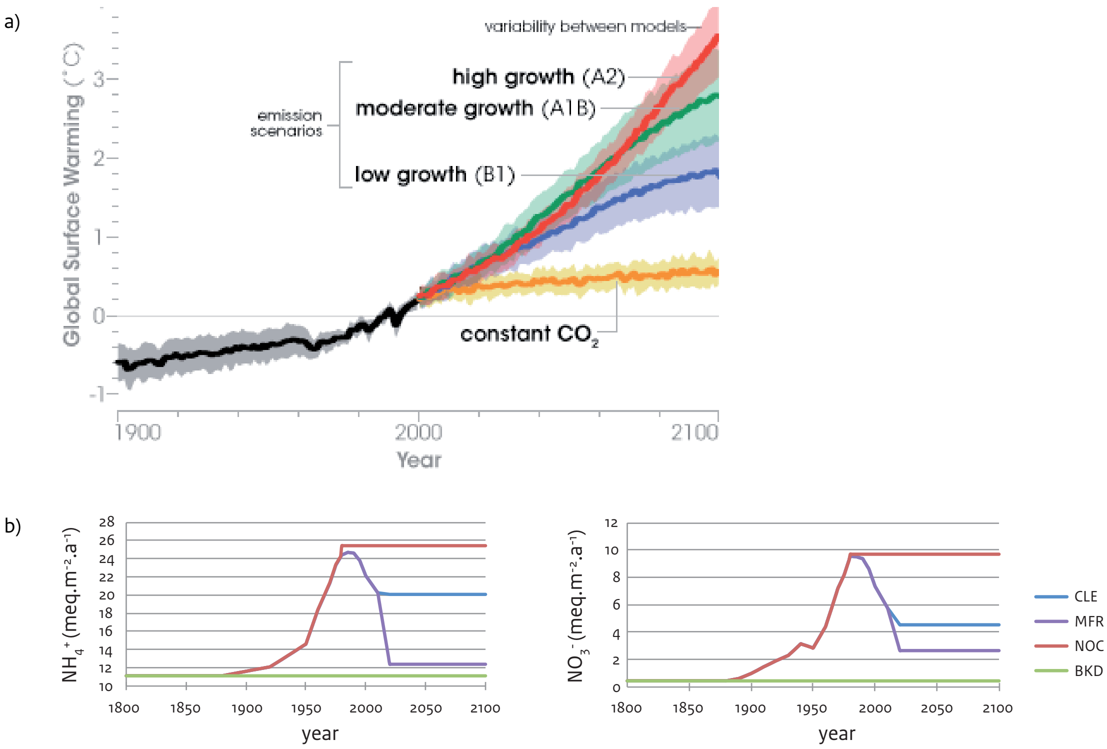
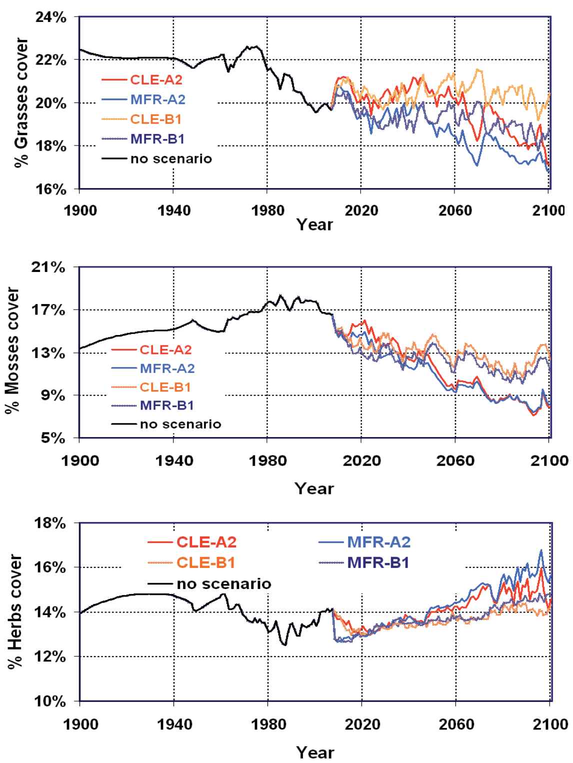


Figure FR.4 Grasses, mosses and herbs cover (%) response to different nitrogen deposition (CLE, MFR) and climate (A2, B1) scenarios, from 2010 to 2100.



Update of the French ecosystem map

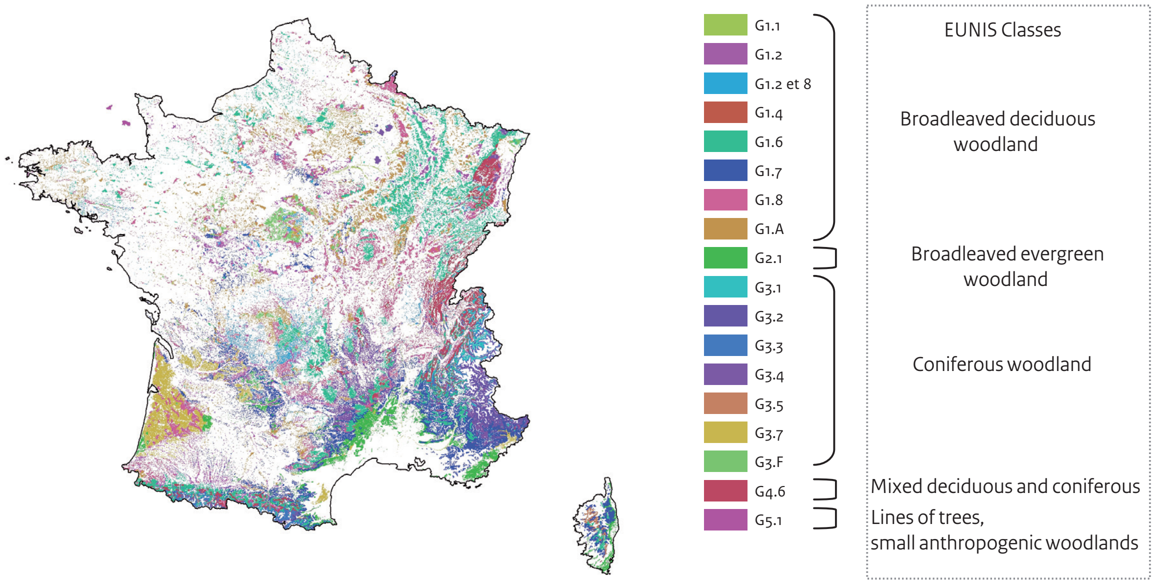
A new digital vegetation map has been produced by the French NFC that will be the new reference to calculate critical loads (Leguédois and Probst 2008, Leguédois et al. 2011). To enable the updated calculation of critical loads, the French NFC is working on a methodology combining soil, geology, potential vegetation and Corine landcover to extract semi-natural and natural ecosystems. The merge of all these layers is required to update parameters for each ecosystem (BC weathering, BC uptake) from the French critical load database (Party 1999).

The French forest map was translated into EUNIS classification to enable better collaboration with other countries and harmonization at the European scale. Moreover, it enables future regionalisation of models used by NFCs (VSD+Veg, ForSAFE-Veg) to determine critical loads at the national scale. The translations have been done by French experts on five EUNIS levels (Table FR.3, Figure FR.5)

Table FR.3 Example of EUNIS – French classification of vegetation.

	EUNIS CLASSES				
French vegetation cartographic unit	Level 1	Level 2	Level 3	Level 4	Level 5
[*Quercus suber*] well drained	G	G2	G2.1	G2.11	G2.111 and 114
[*Quercus suber*] well drained facies [*Myrtus sp.*]	G	G2	G2.1	G2.11	G2.111 and 114
[*Pinus halepensis*], [*Pinus negra*], [*Pinus pinea*] calcareous	G	G3	G3.7	G3.72, 73, 74	G3.722 to 724, 733, 734, 743 and 744
[*Fagus sylvatica*] acid soils	G	G1	G1.6	G1.61	G1.611
[*Quercus ilex*] hills and submountain	G	G2	G2.1	G2.12	G2.121 to 123
[*Pinus sylvestris*] hills	G	G3	G3.4	G3.42	G3.421, 422 and 425
[*Pinus sylvestris*], [*Quercus robur*] hills	G	G3	G3.4	G3.42	G3.422
[*Picea abies*],[*Pseudotsuga menziesii*],[*Abies alba*], [*Larix decidua*]	G	G3	G3.F	G3.F2	G3.F21
[*Pinus sylvestris*], [*Pinus pinaster*], [*Pinus negra*], [*Pinus halepensis*]	G	G3	G3.F	G3.F1	G3.F12
[*Castanea sativa*], [*Fagus sylvatica*], [*Quercus rubra*], [*Quercus cerris*], [*Eucalyptus sp.*]	G	G1	G1.C and G1.D	G1.C2, C4 and D1	--------------------
[*Quercus pubescens*] intermediate stage and grassland	G	G1	G1.7	G1.71	G1.714
[*Quercus pubescens*] facies [*Rubus ulmifolius*], associated grassland	G	G1	G1.7	G1.71	G1.714
Mixed [*Quercus pubescens*], [*Quercus ilex*]	G	G2	G2.1	G2.12	G2.121 to 123

Figure FR.5 EUNIS classes for French forest map based on potential vegetation map and Corine landcover 2006.



Acidifying Potential (AP) on 27 French ICP sites

In France, sulphur emission decreased by 90% between 1980 and 2009, whereas NO_x emission decreased by 41% and NH_4 remains quite stable (Mathias 2008). However, nitrogen deposition levels and trends remained contrasted over the French territory. The respective influence of those compounds on soil and water acidification and/or eutrophication has changed over the period. Namely the acidity relative to sulphur has proportionally reduced compared to that relative to nitrogen compounds. It is thus important to characterize the acidity deposition and its evolution over these last decades to quantify the respective acidifying potential due to nitrogen and sulphur.

The AP of atmospheric deposition was used to determine the deposition acidity according to the equilibrium between acid and neutralizing contributing parts to deposition (Sicard 2006). This formulation includes acid deposition of nitrate and sulphur counter-balanced by base cations deposition:

$$\text{nss-AP} = \underbrace{[\text{nss-}SO_4^{2-} + NO_3^{-} + \text{nss-}Cl^{-}]}_{\text{Acidifying Part}} - \underbrace{[\text{nss-}Ca^{2+} + \text{nss-}K^{+} + \text{nss-}Mg^{2+}]}_{\text{Neutralizing Part}} \quad \text{Eq.1}$$

where 'nss' stands for 'non sea-salt', assuming Na^+ as 100% originating from marine deposition to correct SO_4^{2-}, Cl^- and base cations.

With this approach, the acidity of atmospheric deposition was determined by considering the chemical equilibrium in precipitation and not only the H^+ concentration that does not mirror completely the AP. NH_4^+ can on one way neutralize the acidity in precipitation, but on the other way can be nitrified in soil and thus contribute to its acidification. Consequently, as a first approach, ammonium deposition was not taken into account in the formulation (Brydges and Summers 1989, Sicard 2006). The French NFC is investigating the role of NH_4^+ deposition in the AP.

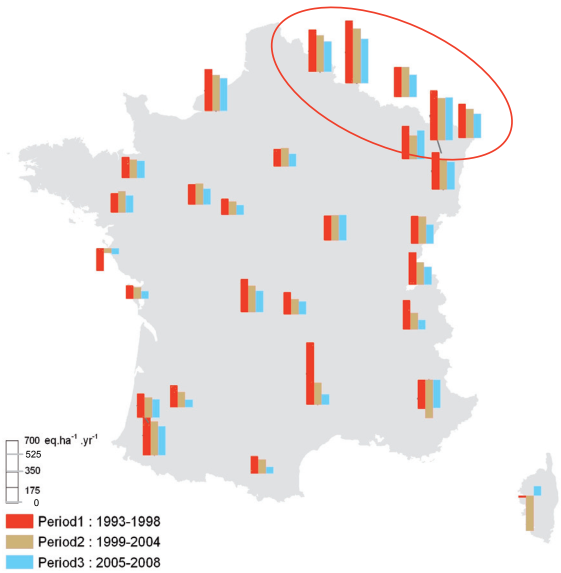
Data sources:

The French NFC and the Ecole des Mines de Douai considered the atmospheric deposition registered on the French ICP forest sites to determine the trends in deposition and to model critical loads of acidity. Deposition time series were from 27 sites from the ICP Forest RENECOFOR network between 1993 and 2008 (Croisé et al. 2002). To calculate the AP, the deposition reaching the soil is needed in order to include the canopy exchanges (biomass uptake and release and dry deposition) (Moncoulon et al. 2004, Probst and Leguédois 2008). But to the complexity of these processes, the deposition reaching the soil was estimated using a simple ratio between throughfall and bulk deposition measured on sites (throughfall/bulk) (Moncoulon et al. 2004). The AP was calculated for three periods: 1993–1998, 1999–2004, and 2005–2008.

Results:

At the national scale, the AP decreased from 1993 to 2008 (Figure FR.6). The AP of atmospheric deposition was significant in all the studied sites except in Corsica, Southern Alps and Atlantic coast, where three sites are characterised by negative values of AP. This is due to the low contribution of acidifying compounds (Atlantic coast) or to a high neutralizing part linked to the significant contribution of base cations deposition (calcareous dust from erosion particularly in the south-eastern sites). Particularly, high APs were still registered in the north-

Figure FR. 6 Acidifying Potential for 27 French ICP Forest sites for three periods (orange: 1993–1998; red: 1999–2004; blue: 2005–2008) in eq ha^{-1} yr^{-1}.



eastern part of France. In this region, the significant reduction of sulphur deposition registered since 1980's was counterbalanced by nitrogen deposition in the acidification processes (Figure FR.6). In the south-western part of France, the high AP is linked to a local high sulphur and nitrogen deposition related to the contribution of an industrial activity (natural gas extraction).

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The French NFC thanks Carole Obeidy and Benjamin Javaux particularly for their contribution in the sensitivity analysis performed on ForSAFE-Veg, Harald Sverdrup and Salim Belyazid for their implication in our common project to improve ForSAFE-Veg, the CCE for fruitful exchanges and the French experts mentioned in the collaborating institutions for the setup of the Veg-table.
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Introduction

The response of the German NFC to the Call for Contributions (see Appendix A) focuses on (i) an overview of biological endpoints, (ii) application of biodiversity indices, (iv) comparison of simulation results using different sites, (v) include nature protection areas (such as NATURA 2000 areas) in model testing, (vi) review the possibilities to use EUNIS classes, habitat classes and eco-regions as a basis for regionalisation, and (viii) submit an update of the critical load database in the format of the 2010 Call for Data.

Critical loads of sulphur and nitrogen for terrestrial ecosystems

Critical loads are calculated following the methods described in the Mapping Manual (ICP Modelling & Mapping 2010). New data of long-term annual means of temperature and precipitation (1980–2010) were available and a new approach for critical (acceptable) nitrogen concentrations could be derived. About 35% of German territory is covered by forests and other (semi-) natural vegetation for which critical loads of acidity and nutrient nitrogen are computed (see Table DE.1). The German critical load database consists of 124,439 grid cells of 1×1 km^2.

Critical loads of acidity:
The calculation of critical loads of sulphur and nitrogen for forest soils and other (semi-)natural vegetation was conducted according to the simple mass balance equations (eqs. 5.22 and 5.26) of the Mapping Manual. For

Table DE.1 Selected receptors for critical load computation in Germany ('Others' are EUNIS classes with a proportion of the receptor area less than 1%).

EUNIS Code	Proportion of the receptor area [%]	Proportion of German territory [%]
G4.6	14.7	5.15
G3.1C	10.2	3.57
G1.91	10.0	3.48
G1.63	9.6	3.34
G1A.16	8.8	3.08
G1.61	8.7	3.05
G3.42	7.8	2.74
G1.87	5.4	1.87
G1.66	5.2	1.81
G4.8	3.6	1.26
G3.1D	3.1	1.09
G4.71	2.0	0.71
G1.41	2.0	0.70
G1.65	1.4	0.50
G4.4	1.1	0.39
G1.221	1.0	0.35
Others	5.4	1.86

base cation and chloride deposition 3-year means (2005–2007) were used in order to smooth large variations of this parameter due to meteorological influences.
The critical load calculation for each grid cell of the dataset was done by using 3 different chemical criteria (Figure DE.1, y-axis): the critical aluminium concentration (Al, eq. 5.29), the critical base cation to aluminium ratio (Bc/Al, eq. 5.31) and the critical pH-value (pH, eq. 5.35). The minimum value determines the $CL_{max}(S)$ for a grid cell. In Figure DE.1 at 'Forellenbach', for example, the critical aluminium concentration was the most sensitive criteria.

In comparison with the 2011 data submission (CCE 2011) only small changes can be observed concerning the critical loads of acidity in terms of sulphur (Figure DE.3) and nitrogen (Figure DE.4). This is mainly caused by the updated long-term annual mean (1980–2010) of temperature and precipitation. Ecosystems with high risk for acidification (critical load below 1 keq $ha^{-1}a^{-1}$) were identified for about 20 % of the receptor area.

Critical loads of nutrient nitrogen:
The calculation of critical loads of nutrient nitrogen is described in detail in the Mapping Manual (eq. 5.5). Different criteria and, consequently, different protection targets were used for acceptable N concentrations in soil solution for the critical load computation (Figure DE.1, x-axis). Following the Manual (Chapter 5.3.1.2 and Table 5.7) the limit can be set by the EC target to avoid pollution of ground water. Ranges describe the sensitivity to frost and fungal diseases (Sensitivity min, Sensitivity max) or the impact on fine root biomass or length (Fine root min, Fine root max). The elevated nitrogen leaching / N saturation is given by a constant value (N_le). To protect in total ecosystem functions and services named as "ecosystem integrity" (ESI) a national approach was derived. Using all available information on vegetation, soil units, and impact sensitivity a matrix was formed combining this with values for acceptable N concentrations (Figure DE.2). Applying this approach the $CL_{nut}(N)$ reflects always the most sensitive compartment of the ecosystem (see Figure DE.1, ESI value). The regional distribution of resulting critical loads of nutrient nitrogen is shown in Figure DE.5.
In addition to the calculation of critical loads with the steady-state mass balance approach empirical critical loads of nitrogen, $CL_{emp}(N)$, were assessed for the national dataset following the updated and reviewed values (Bobbink and Hettelingh 2011, Figure DE.6).

Figure DE.1 Example of Critical Load Function

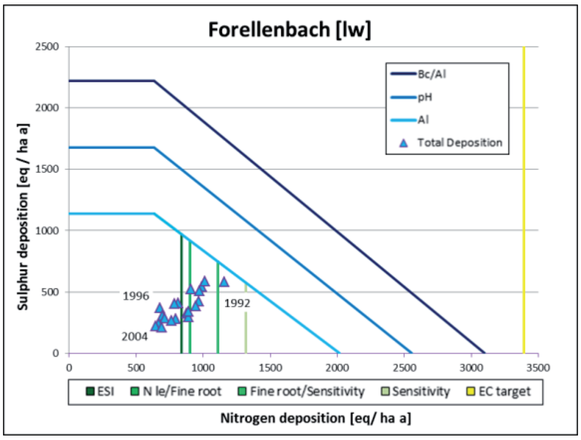


Figure DE.2 Deriving critical N concentrations

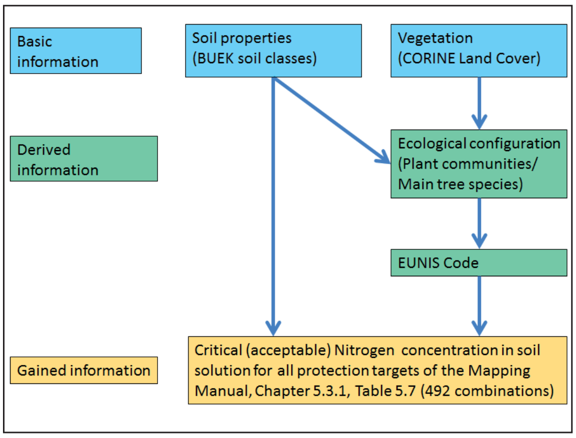


Figure DE.3 $CL_{max}(S)$

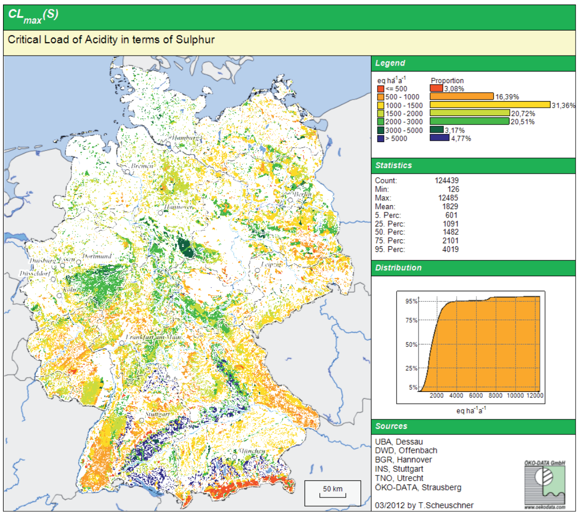


Figure DE.4 $CL_{max}(N)$

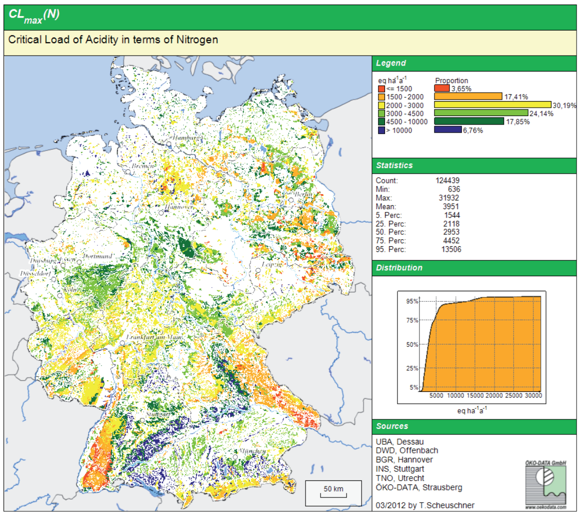


Figure DE.5 $CL_{nut}(N)$

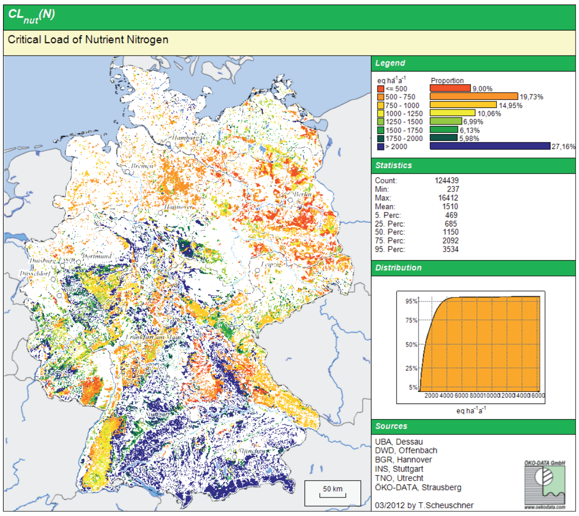
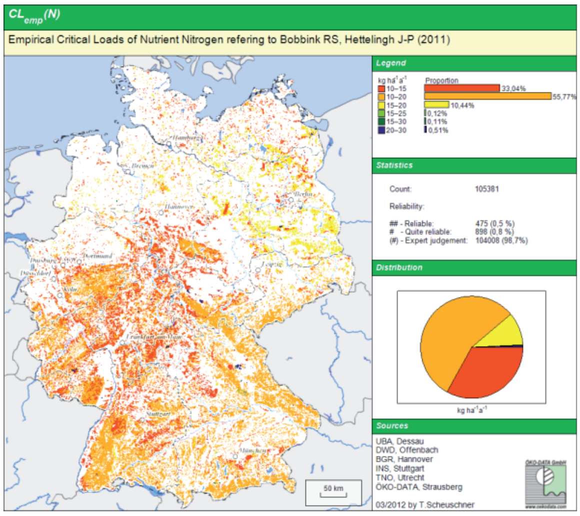


Figure DE.6 $CL_{emp}(N)$

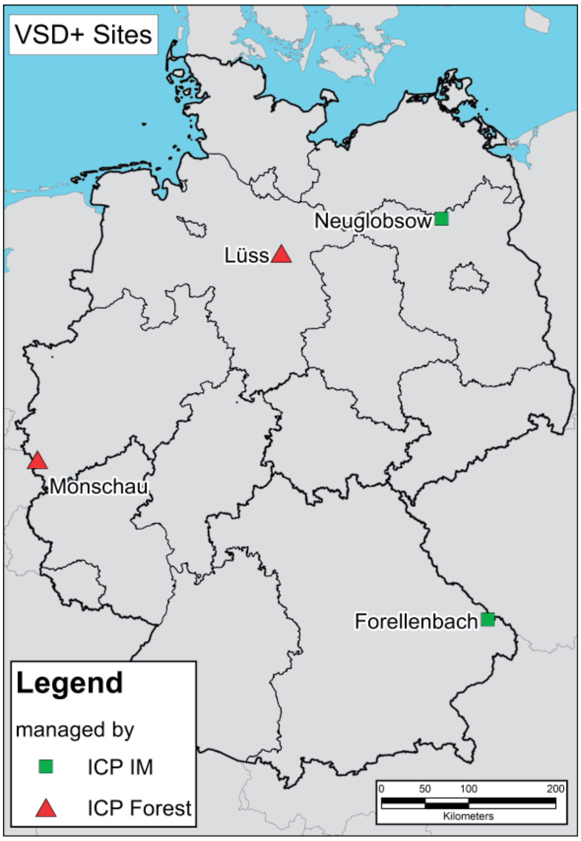


Site-specific soil and vegetation model runs at selected plots

Description of selected VSD+ sites:
The German NFC participated in test runs of the (then) latest version of the VSD+ model. Version 3.6.1.2 features a more sophisticated approach to include the matter fluxes of the litterfall. The VSD+ model was applied to 4 selected sites in Germany. Two plots are sites of the ICP Integrated Monitoring and two are managed by the ICP Forests Level II project. The 4 sites represent different combinations of vegetation types and soil classes. They are also located in quite different landscapes and climate regions (see Figure DE.7). The German sites for the VSD+ model application represent not only different ecosystems but also different environmental and soil chemical conditions. The selected plots are also located in regions with different levels of air pollution.

Input parameters:
The data set for deposition was derived by data from the MAPESI project (MAPESI 2011) and measurements on the plot (ICP IM plot 'Forellenbach'). Even though the MAPESI project provides several time steps only the values for 2007 were chosen. These values were used to create modelled nitrogen deposition time series, where the originally given times series of the VSD+ model was the reference. The same was done for the sulphur deposition. The uptake parameters were estimated assuming only extensive land use. The values for litterfall (dry mass, C + N content) were derived from measurements but the input

Figure DE.7 Selected sites for the VSD+ model runs.



time series was adapted to reflect a lower litterfall flux during the forest maturing period (first 40 years). The water content of the soil, the percolation and reduction factors of the nitrification, denitrification and mineralization was derived, applying the 'MetHyd' (v1.3) tool provided by the CCE.

Decision on biological endpoints for modelling

The way of receiving different endpoints and relating the results of soil chemical and plant response modelling to SEBI indicators and EU biodiversity targets is illustrated in Figure DE.8 and will be discussed in the following. The starting point is always the information about the occurring vegetation and the protection status of the area (or the plot that represents an area). By adding information about soil properties the first endpoints can be defined. These chemical endpoints are the well documented Critical Limits for the different chemical criterions and accepted nitrogen leaching (see above). The next step (Critical Load and Exceedances) produces the first direct links to SEBI and EU biodiversity indicators. The definition of biological endpoints depends on the protection status. The NATURA 2000 areas already define habitat types and these habitat types can be linked to plant species and/or plant communities. Usually national approaches for nature conservation also follow the concept of defining an area and aims (biological endpoints) for the protection. If no protection is implemented the biological endpoint is vague and probably subjective; so only the occurring plant species composition can be examined.

After running the soil chemical and biological models (in this case VSD+ and BERN) the results can be analyzed regarding the expected occurrence, vitality or possibility of plant species. By counting the numbers of species which occur or have a certain level of possibility a first impression of biological diversity can be shown. This result might be proposed to be a indicator for "Status and trends of the components of biological diversity".

Much more important is the integration of the previous defined biological endpoints. These endpoints are supposed to be deterministic and an analysis regarding the similarity of these two sets of plant species should produce results for several SEBI indicators. The information about the development of the vitality of specified members of habitat type might be proposed as indicator for "Ecosystem integrity and ecosystem goods and services" (ESI).

Application soil chemical and vegetation response model

The focuses of this study was the modelling of the soil chemistry (using VSD+) and link the results to a vegetation response model (BERN). The model output for pH and the C:N was chosen to model trends of possibility for plant species and/or plant communities. Figure DE.9 show the typical results for pH and C:N ratio for the ICP IM plot 'Forellenbach'. This plot has measured pH values (in soil solution) for almost 2 decades (blue X, with standard deviation bars) and various measurements of soil carbon and nitrogen. These measured values are needed for the calibration and affect the model results directly (see the increasing oscillation were the pH measurements happen).

The BERN model calculates the possibilities of plant species and communities by using fuzzy functions for 7 different site factors (soil water content, base saturation or pH, C:N ratio, climatic water balance, vegetation period, solar radiation and temperature). These functions represent the realized ecological niche under pristine or semi-natural conditions. In this study only the pH and C:N ratio was used since the focus was on highlighting the reaction of the vegetation model to the soil chemical model. The other site factors were considered as fixed on the best fitting value. Figure DE.10 shows the pure number

Figure DE.8 Flowchart for endpoint discussion.

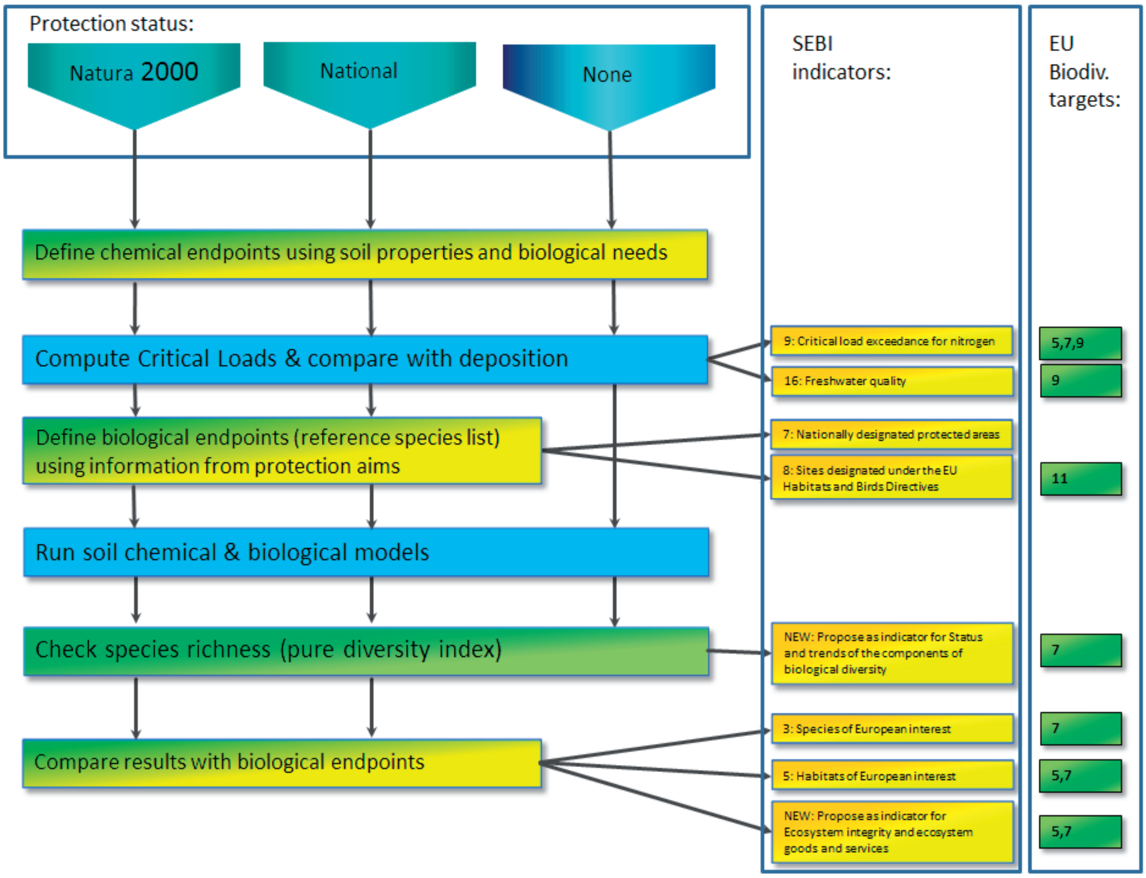
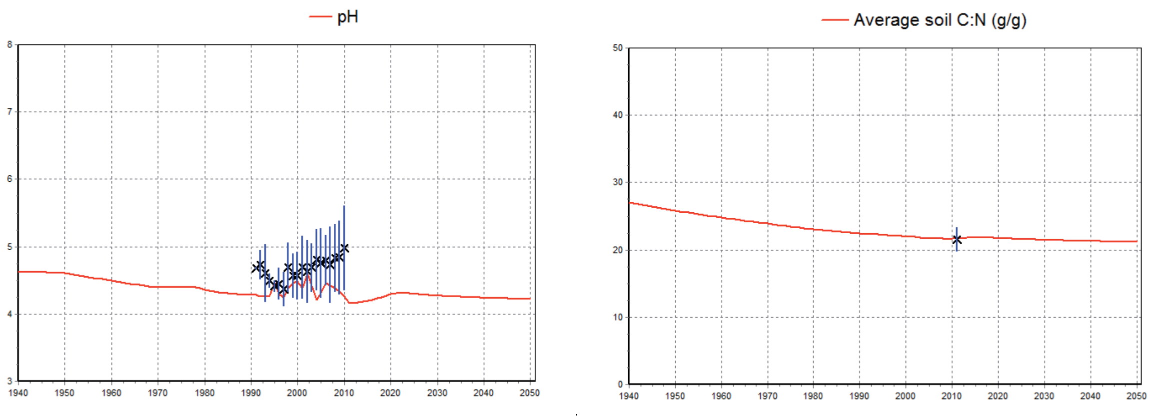
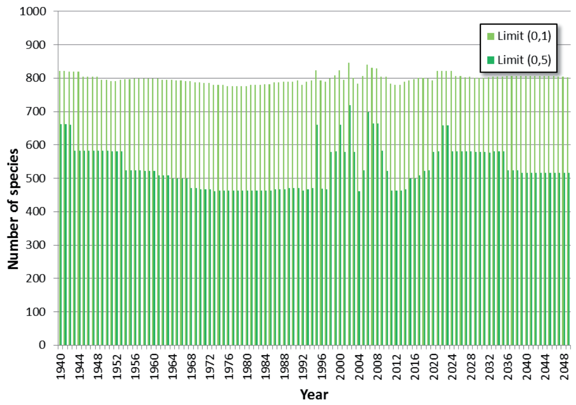


Figure DE.9 pH (left) and C:N ratio (right) modelled with the VSD+ model on the ICP IM plot 'Forellenbach'.



of species with different possibility thresholds in time. A possibility below 0.1 marks a high level of plant physiological stress and great risk of damage to the plant or dysfunctions for a plant community. Values above 0.5 indicate full regeneration capabilities for plant species or plant communities. The decreasing trend of pH (4.6 to 4.4) and C:N ratio (28 to 22) till 1990 is reflected by a decreasing number of species with high possibility (650 to 480). The VSD+ modelled pH reacts quite strong in the years between 1990 and 2010 while the C:N shows only little altering. The modelled possibility of plant species reacts to this alteration (the plants with high possibilities stronger than the plants with lower values).

Figure DE.10 Number of plant species with possibility of 0.1 and 0.5 at the ICP IM plot 'Forellenbach'.



Different sets of plant species and plant communities were analysed regarding their site potential. The setup of these sets represents also different levels of information which can be provided by such study (Figure DE.11). The first set is the combination of all plants found in different years of plant surveys at the observed area. Since this selection represents some kind of conservation aim it will be called 'conservative selection'. The members of the second set of plant species are plant species which can be expected in the plant community which is directly linked to the NATURA 2000 habitat type. Such plant collection can be derived if the analysed plot is located in a nature protection area. Since this plant collection doesn't necessarily represent the currently occurring plant species it will be called 'deterministic selection'. The last set is the collection of all plant communities which are expected to be in the recent NATURA 2000 habitat type 9110.

Figure DE.12 shows the assemblage of the results for the other modelled plots. The ICP IM Site 'Neuglobsow' was modelled twice, assuming deciduous forest and coniferous forest. Due to limitation in space only the results for "Number of species" and the "conservative selection" are documented in this report.

Figures DE.11 and DE.12 include the Sørensen index as described in the CCE Status Report, Annex 4A p.53 (CCE2011). The calculation was done by using the BERN modelled possibility and the chosen list ('conservative' or 'deterministic selection') of plant species. By including the possibility of the plant species not only the presence and absence alter the Sørensen index, but also the condition of the occurring species will affect the results.

Figure DE.11 Conservative (top left), deterministic (top right) selection and plant communities of NATURA 2000 habitat 9110 for ICP IM plot 'Forellenbach'.

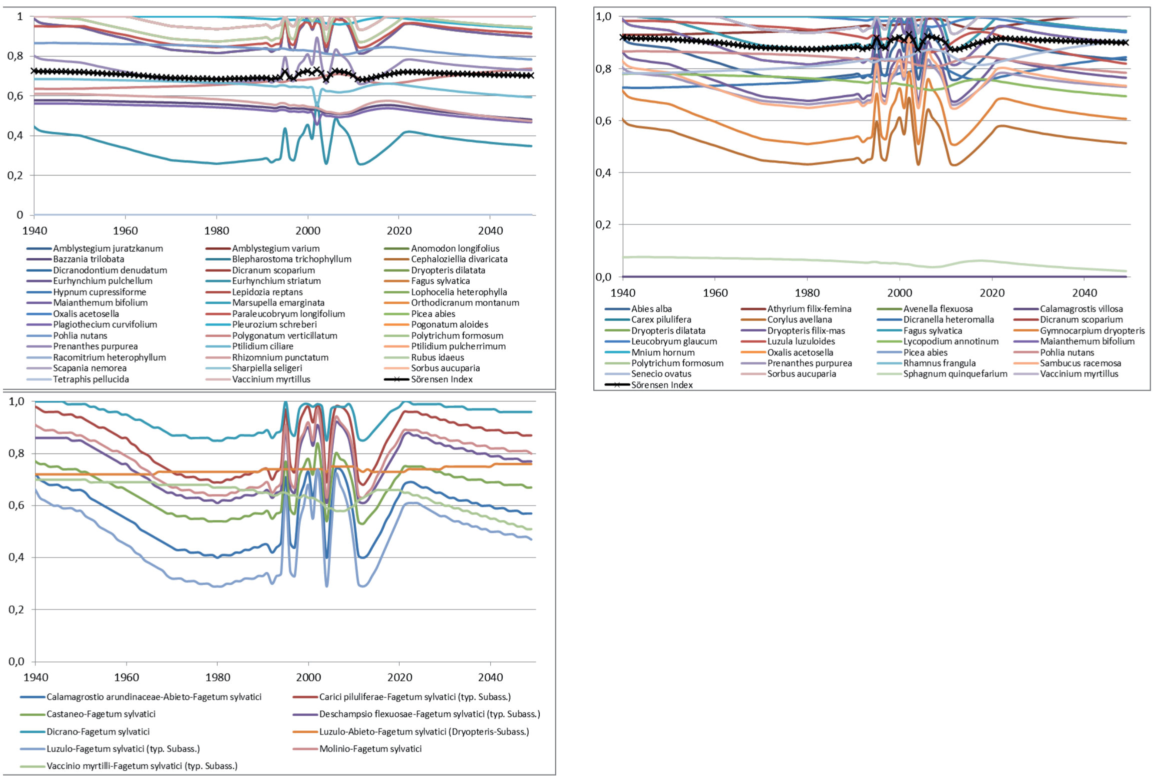
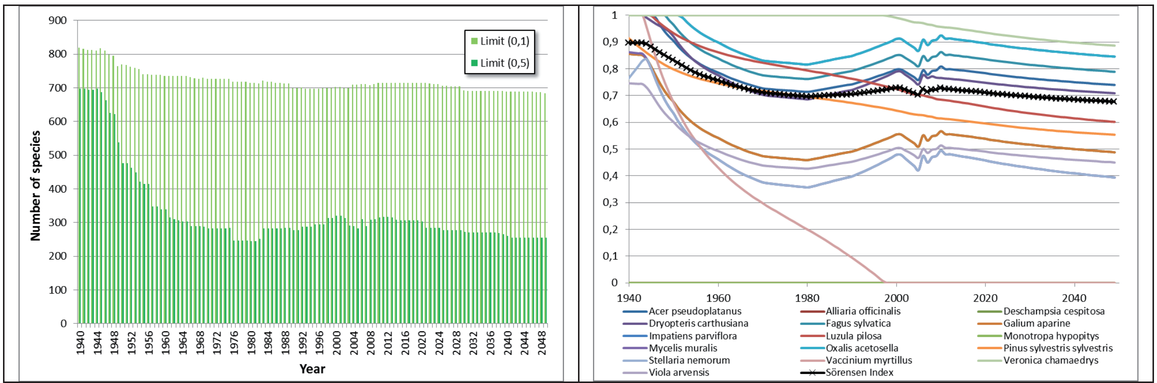
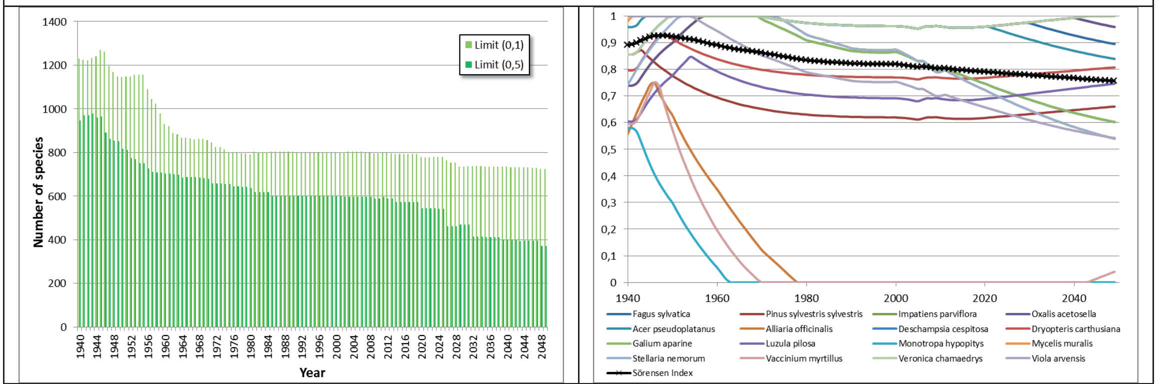


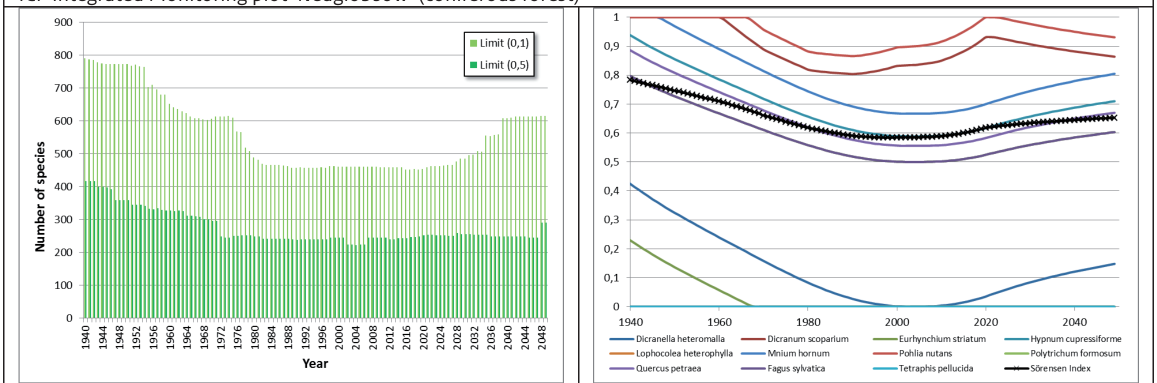
Figure DE.12 Number of plant species (left) and conservative selection (right) for 'Neuglobsow' (deciduous forest), 'Neuglobsow' (coniferous forest), 'Lüss' and 'Monschau'.



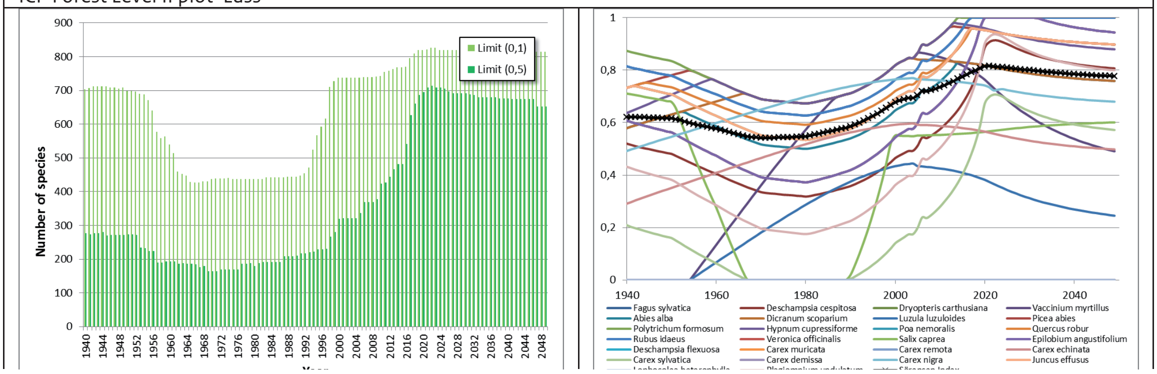
ICP Integrated Monitoring plot 'Neuglobsow' (deciduous forest)



ICP Integrated Monitoring plot 'Neuglobsow' (coniferous forest)



ICP Forest Level II plot 'Lüss'



Conclusions and recommendations

The critical load approach already offers a number of tools to parameterize SEBI and EU biodiversity targets. As shown in the first section the breakdown back to the original approach already increases the level of information for the acidity term. The adaptation of the original critical nitrogen concentration (proposed by the ICP Modelling & Mapping) by adding information of soil properties might be a useful guideline to create a harmonized approach for the Critical Load computation which automatically fit to SEBI and EU biodiversity targets. As described in Figure DE.8 dynamic modelling of soil chemistry and plant response might be very useful to describe biodiversity targets. Obviously, the determination of the biological endpoint is the most crucial part. This report proposes a method including the information of the European wide protection approach and is focused on the distinction between protection (NATURA 2000 or national) and no protection. It follows the concept that a deterministic goal can only be defined when a target (plant species list/ plant community/ habitat type) is set. An area that is under no specific protection simply does not have a deterministic goal and any definition of a biological endpoint tends to be subjective, thus only a conservative analysis appears to be meaningful.

Acknowledgement:
The cooperation between the NFC M&M and the partners from the ICP IM was very fruitful and constructive. Especially the excellent cooperation with Burkard Beudert (ICP IM 'Forellenbach') and Hubert Schulte-Bisping (ICP IM 'Neuglobsow') should be emphasized.

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Introduction:
The 2012 CCE 'Call for Contributions' issued by the ICP Modelling and Mapping focused on the application and testing of dynamic soil-vegetation models. The call contained seven tasks: (a) an overview of endpoints considered by the NFCs, (b) application of biodiversity indices as summarized in the CCE Status Report 2010, (c) comparison of simulation results using different models, (d) comparison of simulation results using different sites, (e) policy relevance: inclusion of nature protection areas in model testing, (f) regionalisation: review the possibilities to use EUNIS classes, habitat classes and eco-regions, and (g) enlarge the Veg-database. In addition, NFCs were allowed to submit updates of their critical load database in the format of the 2010 'Call for Data'. The Irish NFC submitted a response as outlined below.

Dynamic soil-vegetation modelling:
In response to the Call, the Irish NFC (D. Dodd [EPA] and J. Aherne [Trent University]) organised a meeting with the National Parks and Wildlife Service (NPWS, i.e., national habitat experts) on January 30, 2012, to discuss the 'Call for Contributions' and specifically 'endpoints'. The NPWS indicated that national indicators and indices of biodiversity are, as yet, undefined, but will be discussed during 2012.

Data and input files were prepared for four sites, which were part of the ICP-Forest Level-II monitoring network. These sites were selected to test the MetHyd-GrowUp-VSD+Veg soil-vegetation modelling framework, owing to the availability of long-term deposition, throughfall and soil solution hydrochemistry data. The input data files were submitted to the CCE as an Access database using the supplied template (importVSD.mdb) to facilitate testing of the Access version of VSD+Veg.

Updates to critical load database:

Several significant updates were applied to the national critical loads database; critical loads of acidity for surface waters was added incorporating national data-sets on acid sensitive lakes monitored under the Water Framework Directive (see Figure IE.1 [left]). The national terrestrial receptor ecosystem habitat map was refined (Figure IE.1) following discussion with national habitat experts. The protection status for each ecosystem was derived from national maps of Nature Reserves, Natural Heritage Areas (NHA), Special Areas of Conservation (SAC) and Special Protection Areas (SPA). A variable yield class was incorporated into revised base cation and nitrogen uptake for managed forests (ranging from 14.25 to 27.5 m^3 $ha^{-1}a^{-1}$) based on estimates for Sitka spruce on different soil types (following Farrelly et al. 2010). Empirical critical loads of nutrient nitrogen were assigned to all receptor ecosystems under the critical load habitat map (see Figure IE.1) based on output from the Workshop on the 'Review and Revision of Empirical Critical Loads and Dose-response Relationships' (Bobbink and Hettelingh 2011). Revised critical loads data (see Figure IE.2) were submitted for habitats E, F and G, and C (see Figure IE.1) in response to the Call.

State of Ireland's Environment (SoE):

The Irish Environmental Protection Agency's 2012 assessment of Ireland's Environment included average accumulated exceedance of critical loads of acidification, and eutrophication during 1990, 2000 and 2020 illustrating the significant reductions in the area and magnitude of exceedance for acidity [URL: www.epa.ie/whatwedo/assessment/soe].

Figure IE.1 Acid sensitive lakes (critical loads of acidity) and receptor ecosystem habitat map (derived from the Teagasc-EPA Soils and Subsoils Mapping Project, and CORINE 2000 and 2006 [URL: gis.epa.ie]).

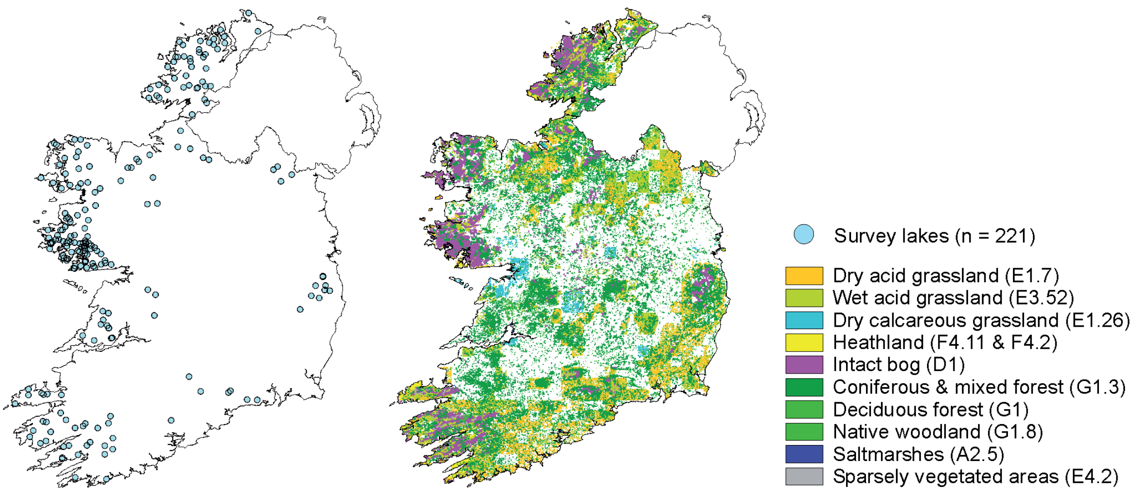
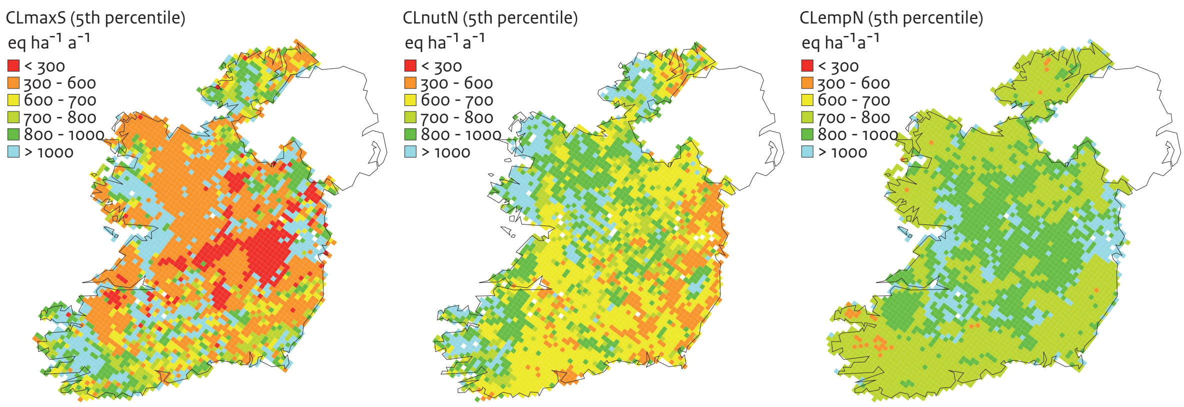


Figure IE.2 Maximum critical loads of sulphur (left), nutrient nitrogen (middle) and empirical nutrient nitrogen (right) for terrestrial receptor ecosystems (see Figure IE.1).



Future activities:
The Irish NFC will continue to support activities under the LRTAP Convention, with a greater focus on dynamic soil-vegetation modelling.

Acknowledgements:
Financial support for the development of critical loads for Ireland was provided by the Irish Environmental Protection Agency under the Climate Change Research Programme (CCRP) 2007–2013. The NFC greatly acknowledges M. Posch for the production and provision of national critical load maps (Figure IE.2).

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Introduction

For the 2012 Call, data to run VSD+Veg have been collected. First we focused our attention on a ICP Forest Level-II plot (LOM1-Val Masino), located on the alpine arc at 900-1190 m a.s.l. and characterized by a spruce forest vegetation. This site was chosen for its high naturalistic value (protected by Habitat and Bird Directive), high sensitivity (low critical load) and high pollutant exposure (critical loads were exceeded in the year 2000). The aim was to find out which kind of data was essential to run the model, and what was their availability. Furthermore results of a statistical analysis for the same site are presented to underline the correlation between biodiversity indices, like Shannon and Evenness, with chemical and climatic parameters.

Site information

Table IT.1 Main characteristics of the site 10-LOM1 (Val Masino).

Latitude	46° 14’ 16”
Longitude	09° 33’ 16”
Altitude	1190 m
Lithological substrate	granite
Soil	humic cambisol
Main species	Picea abies
Plant community	Veronico urticifoliae-Piceetum
Total number of species	111
Forest age	80 yr

Figure IT.1 Exceedances and ConEcoFor sites (red: LOM1 – Val Masino).

Dynamic soil-vegetation modelling

Measured data used for modelling (VSD application and statistical analysis) were provided by the Italian National Forest Service (Corpo forestale dello Stato) and collected in the framework of the National Programme for Forest Ecosystems Monitoring (CONECOFOR) by Aldo Marchetto (CNR Institute for Ecosystems Study). The input

Table IT. 2 Parameters collected for VSD application (1900–2100) at site LOM1 (gray: calibrated; yellow: measured; green: estimated; uptake and litterfall zero; data read from files not shown).

thick	0.00527
bulkdens	0.905
Theta	0.14
pCO2fac	20.202
CEC	197.535
bsat_0	0.555
Excmod	2 (Gapon)
lgKAlBC	1.844038963
lgKHBC	4.45821428
lgKAlox	8
Cpool_0	1882.877784
CNrat_0	30
RCOOmod	0
cRCOO	0.01
RCOOpars	0.96 0.9 0.039
TempC	8
percol	0.877658
Ca_we	0.0605774
Mg_we	0.0293022
K_we	0.0189125
Na_we	0.0390745
rf_min	1
rf_nit	1
rf_denit	0.3
bsatobs	2000 34 1
CNratobs	2000 18 1

parameters are shown in Table IT.2. Where measurements were not available, default values provided by VSD tables or literature data were used. To calibrate, additional data were needed, which were obtained by running a Growth model or the MetHyd model, both imbedded in the betaVpV02.access software.

Biodiversity indicators

Results of a statistical analysis are presented for the same site to underline the correlation between biodiversity indices, like Shannon and Evenness indices, with chemical and climatic parameters. Evenness and Shannon indices have been calculated for layer 3 (herbaceous layer, less than 0.5m tall), because it responds faster to pollutant deposition. Table IT.3 shows the list of species in each layer. The Evenness index is a measure of biodiversity, quantifying how equal the community numerically is, whereas the Shannon index analyses how species abundance is distributed among all species inside the community.

Table IT.3 List of species in each layer (plot 10).

Species	Layer	Coverage
Abies alba	1	0.63
Picea abies	1	1.06
Larix decidua	1	0.34
Betula pendula	1	0.63
Fagus sylvatica	1	0.42
Sorbus aucuparia	1	0.13
Sorbus aria	1	0.13
Acer pseudoplatanus	1	0.13
Abies alba	2	0.30
Picea abies	2	0.48
Betula pendula	2	0.03
Corylus avellana	2	0.03
Fagus sylvatica	2	0.19
Sorbus aucuparia	2	0.03
Sorbus aria	2	0.03
Laburnum alpinum	2	0.13
Acer pseudoplatanus	2	0.03
Fraxinus excelsior	2	0.03
Lonicera nigra	2	0.03
Polypodium vulgare	3	0.03
Phegopteris connectilis	3	0.05
Asplenium trichomanes	3	0.03
Athyrium filix-femina	3	0.06
Gymnocarpium dryopteris	3	0.11
Dryopteris filix-mas	3	0.18
Dryopteris affinis	3	0.05
Dryopteris dilatata	3	0.11
Abies alba	3	0.03
Picea abies	3	0.03
Betula pendula	3	0.03
Fagus sylvatica	3	0.03
Anemone nemorosa	3	0.03
Pulsatilla montana	3	0.03
Ranunculus montanus	3	0.03
Thalictrum aquilegiifolium	3	0.03
Saxifraga cuneifolia	3	0.04
Rubus idaeus	3	0.05
Potentilla erecta	3	0.03
Fragaria vesca	3	0.03
Sorbus aucuparia	3	0.03
Sorbus aria	3	0.03
Laburnum alpinum	3	0.03
Oxalis acetosella	3	0.75
Geranium phaeum	3	0.03
Euphorbia dulcis	3	0.03
Acer pseudoplatanus	3	0.03
Viola reichenbachiana	3	0.06
Viola biflora	3	0.03
Vaccinium myrtillus	3	0.07
Fraxinus excelsior	3	0.03
Ajuga reptans	3	0.04
Veronica urticifolia	3	0.03
Veronica officinalis	3	0.03
Veronica chamaedrys	3	0.03
Melampyrum sylvaticum	3	0.03
Lonicera nigra	3	0.03
Solidago virgaurea	3	0.05
Homogyne alpina	3	0.03
Senecio ovatus	3	0.03
Prenanthes purpurea	3	0.09
Hieracium murorum group	3	0.18
Maianthemum bifolium	3	0.07
Luzula nivea	3	0.05
Luzula pilosa	3	0.03
Luzula luzulina	3	0.03
Festuca altissima	3	0.07
Festuca heterophylla	3	0.03
Milium effusum	3	0.03
Carex pallescens	3	0.03

Correlations between biodiversity indices and other site parameters are presented in Figure IT.2. Statistical correlations are significant for $p < 0.05$. Figure IT.2 shows some significant correlations found with nitrogen or sulphur deposition and base cation deposition (Ca and SO_4).

Figure IT.3 shows the increasing trends for Shannon and Evenness indexes in the period from 1998 to 2010, whereas in the Figure IT.4 there is a decreasing trend for N and S depositions.

Conclusion

High levels of critical loads exceedances were found for LOM1 in the year 2000. Measured data show that nitrogen and sulphur depositions were progressively decreasing from 2000 to 2010. For the same period the Shannon-Wiener index H' and Evenness index J showed and increasing trend. In LOM1 we found a significant relationship between measured total N deposition (BOF) and sulphur depositions estimated by EMEP and H' index or J value, but not with climatic variables (temperature, relative humidity etc.).

Figure IT. 2 Correlation matrix between biodiversity(H’ and J) and chemical parameters (significant correlations in boxes).

	NOx_dep	SO2_dep	NH3_dep	Dep N tot BOF	Dep N tot BSC	ph	Alk	SO4	Ca	Mg	K	tot N	Bc	P	Tmin	Tmax	Tmean	Rhday	RH night	H'	Hmax	J
NOx_dep	1.000																					
SO2_dep	0.977	1.000																				
NH3_dep	0.971	0.945	1.000																			
Dep N tot BOF	0.498	0.545	0.495	1.000																		
Dep N tot BSC	0.798	0.797	0.766	0.709	1.000																	
ph	-0.260	-0.340	-0.096	-0.275	-0.058	1.000																
Alk	-0.097	0.010	-0.028	0.473	0.254	-0.011	1.000															
SO4	0.882	0.890	0.934	0.708	0.813	-0.115	0.266	1.000														
Ca	0.714	0.734	0.816	0.547	0.658	0.211	0.100	0.852	1.000													
Mg	0.422	0.394	0.548	0.228	0.313	0.229	0.158	0.588	0.520	1.000												
K	0.102	0.064	0.202	0.361	0.320	0.189	0.610	0.378	0.122	0.639	1.000											
tot N	0.491	0.365	0.518	0.063	0.188	-0.005	-0.229	0.390	0.151	0.647	0.369	1.000										
Bc	0.675	0.677	0.803	0.599	0.687	0.258	0.287	0.892	0.933	0.724	0.468	0.297	1.000									
P	0.320	0.304	0.332	0.791	0.644	0.064	0.292	0.496	0.439	-0.105	0.204	-0.145	0.431	1.000								
Tmin	-0.493	-0.599	-0.504	-0.132	-0.245	0.211	-0.101	-0.487	-0.598	-0.168	0.329	0.043	-0.418	0.149	1.000							
Tmax	0.001	0.012	-0.029	0.586	0.203	-0.125	-0.110	0.093	0.144	0.034	0.010	-0.097	0.133	0.534	0.341	1.000						
Tmean	-0.208	-0.245	-0.236	0.396	0.053	-0.007	-0.128	-0.135	-0.143	-0.045	0.148	-0.057	-0.075	0.476	0.688	0.917	1.000					
Rhday	-0.595	-0.476	-0.548	-0.032	-0.285	0.115	0.673	-0.322	-0.189	-0.194	0.170	-0.640	-0.126	-0.125	-0.092	-0.174	-0.174	1.000				
RH night	-0.233	-0.106	-0.202	0.361	0.044	-0.016	0.587	0.058	0.237	-0.096	0.054	-0.618	0.211	0.194	-0.362	0.140	-0.046	0.828	1.000			
H'	-0.873	-0.933	-0.838	-0.745	-0.837	0.399	-0.171	-0.881	-0.743	-0.279	-0.104	-0.112	-0.688	-0.518	0.517	-0.242	0.033	0.298	-0.129	1.000		
Hmax	0.588	0.519	0.639	-0.081	0.378	0.352	-0.476	0.405	0.506	0.489	-0.039	0.524	0.460	-0.044	-0.162	-0.034	-0.095	-0.703	-0.604	-0.306	1.000	
J	-0.917	-0.960	-0.893	-0.684	-0.846	0.316	-0.079	-0.893	-0.778	-0.346	-0.093	-0.198	-0.720	-0.476	0.509	-0.222	0.045	0.401	-0.014	0.987	-0.457	1.000

Figure IT.3 1998–2010 trend of Shannon (H’) and Evenness (J) indices.

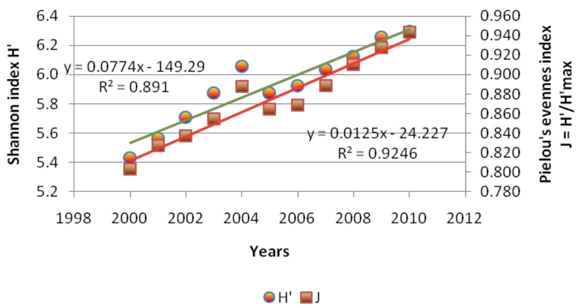
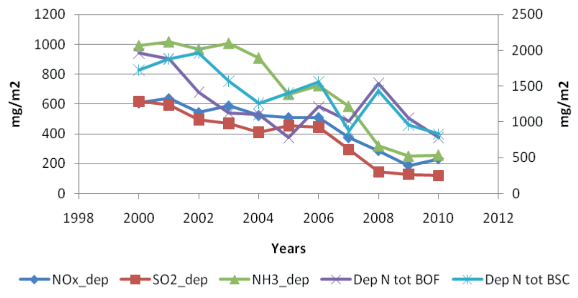


Figure IT.4 1998–2010 trend in N and S deposition.



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Introduction

The 2012 Call for Contributions focused on the use and testing of the dynamic modeling of changes in plant species diversity. This work is not only important for the LRTAP Convention, but also for the support of strategies of the European Commission on air quality and biodiversity.

In this report the following topics of the Call are addressed:

- Targets, indicators and indices used in the application of the Dutch dynamic models, including those mentioned in the 2010 CCE Status Report;
- Comparison of simulation results using different models, including comparisons at different sites and its relevance for nature policy.

First, a short description is given on the status of the Dutch critical load database.

The critical load database

In 2011 no update was made to the Dutch critical load database. Thus, as described in the 2011 CCE Status Report, the current Dutch dataset on critical loads of acidity and nutrient nitrogen contains critical loads for the protection of forests (soils), plant species composition in terrestrial ecosystems and plant species composition in small heathland lakes. The dataset for heathland lakes only refers to critical loads for nutrient nitrogen. The methods for calculating these critical loads have been described in Albers et al. (2001) and in various CCE reports since 2001.

The current dataset also contains empirical critical load for nitrogen, as updated in 2011. Empirical critical loads are assigned to the different types of nature targets used in

Dutch nature policy and modelled with SMART2-MOVE. No critical loads were set for those types of nature targets for which no empirical ranges were available (i.e. fluvial, riparian or swamp woodlands and reed lands). The procedure for assigning empirical critical loads has been described in the 2011 CCE Status Report (Van Hinsberg et al. 2011).

Research in 2011–12 focused on the low critical loads for sulpher on loess and peat soils in the current dataset. The evaluations focused on the paramatrisation of weatherring rates in these soils, the critical pH values used for nature target types on these soils, and the seepage maps used in model runs. Based on the evaluation it seems that the current seepage maps are, at least partly, the cause of (unrealistic) low critical load values in peat soils. Many nature target types on peat soils require base cation rich seepage. Instead of values around 0.01 m yr^{-1}, as present in the current map, values of 0.0365 m yr^{-1} were used by Van Dobben et al. (2004, 2006) to calculate critical loads for some nature target types on peat soils. In the current dataset seepage values were used from mapped information, whereas Van Dobben (2004, 2006) used optimal values, reported for sites with nature targets present. Using higher values for seepage had large effects on the calculated maximum critical S deposition; CLmaxS was five times higher with high seepage fluxes than at low seepage. Results show that the current seepage map, in which high seepage is rare, needs to be checked and possibly updated. On the other hand it is clear that lowering of the groundwater tables has occurred in many Dutch nature areas, thereby lowering the seepage. In conclusion, it seems that the CLmaxS in wet peat soils are highly uncertain. However, as yet, no update was submitted to the CCE.

Targets, indicators and indices used in dynamic modelling

In the Netherlands there is a long history of using dynamic soil-vegetation models in making environmental assessments (Kros et al. 1998). The major backbone of this modelling has been the SMART2-MOVE model. The MOVE model has been used to assess changes in plant species occurrence due changes in soil conditions by different deposition scenarios. The output of the MOVE model was translated into indicators which related to Dutch nature policy targets. As Dutch nature policy has defined target species and nature target (habitat)types (Bal et al. 2001), the model has been used to calculate the change in occurrence of target species within the different nature target types (Van Hinsberg and Kros 2001). In this approach the species occurrence is used to indicate habitat quality, as in indicators from the Habitat Directive, the Water Framework Directive and the Convention of Biological Diversity (i.e. mean species abundance and trends in the abundance of a selected group of species). In all these approaches habitat quality is measured with a given set of species (see also Van Dobben et al. 2011). As such, the indicator is different than just the number of species since invasive or undesired species are not involved. For example, the quality in dry heath is computed as the occurrence of target species and not in terms of all species (which would also include grass, scrub, and tree species which increase when deposition exceeds critical loads).

Thus, modelling was based on maps of nature target (habitat) types (including target areas) and definitions of sets of target species used in Dutch nature policy and management. A similar approach can be used for assessing habitat quality of the protected European habitats with so-called typical species. Use of other indices like the Simpson-index or other mathematical measures of biodiversity are not (often) used in policy assessments in the Netherlands. It seems that simpler, easily interpretable, indicators often serve better as effective boundary objects between science and policy.

The drawback of this approach is that the focus is often on rare species. Most Dutch target species are rare and placed on the Red List (Bal et al. 2001). For making regression models like MOVE or PROPS for rare species, larger databases with vegetation relevees are needed. Species competition models also work better for the dominant species in the vegetation, modelling the competition-free space for rare species probably should also include other species. In the Netherlands the focus is on calculating the probability of occurrence of typical species with regression models, as shown in Van Hinsberg et al. (2011).

To inform the CCE on the approach a file of all Dutch target species per nature target type was submitted to the CCE.

Comparison of simulation results using different models

In response to the Call a comparison has been made between SMART2 and VSD+. As described earlier, the Dutch NFC has mostly used the SMART2-MOVE model in dynamic modelling for the Convention. In recent years, Alterra has invested much in the improvement of VSD+ modelling. The SMART2 model has been linked with a vegetation growth model (SUMO; Wamelink et al. 2009), but this more complex model has not yet been used for work under the Convention.

The main difference between VSD+ and SMART2 is the organic matter module. In SMART2, there is an 'inert' organic pool in the mineral layer and an organic pool in the litter layer. The pool in the mineral layer does not decompose, but immobilizes nitrogen. The pool in the litter layer is able to decompose. A part of the fresh litter is decomposed within one year, the remaining part moves to the old litter pool with a decomposition rate of 0.05 yr^{-1} in forests and 0.3 yr^{-1} in grassland and heather vegetations. Nutrients (N, K, Ca, and Mg) become available for the vegetation due to the decomposition of organic matter. In contrast, VSD+ distinguishes four organic matter pools, all with their own specific C:N-ratios and decomposition rates. Fresh litter is divided over the two fresh litter pools (easy and slowly decomposable pools), depending on the N-content of the fresh fallen litter. Both pools partly decompose and partly turn into the other organic pools.

In response to the Call the models were compared at different sites. Both SMART2 and VSD+ were run at a dry forest plot in Zeist, a wet grassland in Lemselermaten, and a wet heath in Korenburgerveen. These plots are located in protected nature areas with different nature targets. Dry forests on sandy soils, wet grasslands and wet heath are all important nature target types with respect to present areas within the Natura 2000 and the Dutch Ecological Network. The three plots have been described in Van Hinsberg et al. (2011). Where possible the same parameterization was used in both models.

In the dry forest plot SMART2 and VSD+ gave comparable results and similar fits to measurements, except for C:N-ratio and the nitrate concentration. SMART2 calculated a decreasing C:N-ratio, due to immobilization, leading to low nitrate concentrations in soil moisture. Whereas, VSD+ calculated an increasing C:N-ratio and a closer fit with recent measured C:N-ratios.

At the grassland site, there was a marked difference in the C-pool calculations. Here, SMART2 calculated a strong increase of the C-pool, whereas in VSD+ the increase was much smaller. Like at the forest plot, SMART2 calculated a deceasing C:N-ratio due to N-immobilization. However, both calculated pH and nitrate concentration are comparable between both models and very close to available recent measurement.

At the heath plot the differences between both models were large. Trend lines of the C-pool, the C:N-ratio, nitrate concentration and pH were all different. In comparison with measurement VSD+ performed better. By calibrating the reduction functions for mineralization and nitrification of SMART2 the results became more similar. Results show that the reduction functions of SMART2 have other effects than in VSD+, especially for wet vegetations.

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Methods and data

Norway has not updated data to the Call for Contributions in 2012. The last update was to the Call for Data in 2011, where the resolution of the critical loads and dynamic modelling data in the national data base were updated to fit the new EMEP 5×5 km² grid, and the empirical critical loads were updated according to the report from the 'Workshop on the review and revision of empirical critical loads and dose-response relationships' (Noordwijkerhout, 23-25 June 2010).

Critical loads for surface waters:
The database for critical loads for surface waters is based on a grid net defined as 0.5° latitude by 1° longitude, with each grid square divided into 16 sub-grids (Henriksen 1998). The chemistry of surface water within a sub-grid was estimated by comparing available water chemistry data for lakes and rivers within each grid. Available water chemistry includes results from the national 1500-lake survey conducted in 1995 (Skjelkvåle et al. 1996). The

chemistry of the lake that was judged to be the most typical was chosen to represent the grid. If there were wide variations within a sub-grid, the most sensitive area was selected, if it amounted to more than 25% of the grid's area. Sensitivity was evaluated on the basis of water chemistry, topography and bedrock geology. Geology was determined from the geological map of Norway (1:1 million) prepared by the Norwegian Geological Survey (NGU). In the 2011 update to 5×5 km^2 grid, the original grids were split, with no further data collection.

The methodology for Norway was described by Henriksen (1998) and the application later updated in Larssen et al. (2005, 2008). The base cation fluxes were estimated with the SSWC model using the observed sea-salt corrected (Cl^- as tracer) base cation concentrations. Mean annual runoff data were taken from runoff maps prepared by the Norwegian Water Resources and Energy Directorate (NVE). Land type characteristics (lake area, catchment area, forest area, bare rock area) were measured from maps.

A variable ANC_{limit} as described by Henriksen and Posch (2001) is used, but adjusted for the strong acid anion contribution from organic acids after Lydersen et al. (2004). For the F-factor, the sine function of Brakke et al. (1990) has typically been used, but in recent applications $[BC]_0^*$ has instead been taken from hindcasts from MAGIC-model runs used for calculating target loads (Larssen et al., 2005). Nitrogen removal in harvested biomass was estimated by Frogner et al. (1994) and mapped for entire Norway according to forest cover and productivity. All uptake rates were kept constant and assumed constant removal from harvest and no change from climate, eutrophication or other factors. The de-nitrification factor (f_{de}) was kept constant at 0.1 and the fraction of peat in the catchments ignored in the national scale applications. Mass transfer coefficients were kept constant at 5 m yr^{-1} and 0.5 m yr^{-1} for N and S, respectively, and chosen as the mid-value of the ranges proposed by Dillon and Molot (1990) and Baker and Brezonik (1988), respectively.

Dynamic modelling of surface water acidification:
Modelling of aquatic ecosystems (lakes) have been carried out for the entire country using the MAGIC model (Cosby et al. 1985, 2001). The model was calibrated to observational data from 990 of the 1007 statistically selected lakes in the 1995 national lake survey (Skjelkvåle et al. 1996). (17 lakes of the total 1007 lakes in the survey were disregarded due to very high phosphorus concentrations (and ANC) from local pollution, extremely high sea salt concentrations or inconsistencies in the catchment characteristics data available.) The model was calibrated to observed water chemistry for each of the lakes and to soil base saturation from nearest available (or most relevant) sample. In the automatic calibration routine of MAGIC the following switches were set: BC optimizer (weathering calibration): on, SO_4 adsorption optimizer: off, soil pH optimizer: on, N dynamics optimizer: off (this means that nitrogen uptake in the catchment was assumed proportional (with a constant proportion) to the input at all times).

Atmospheric deposition history was provided by CCE for EMEP grid cells and a sequence for each grid cell assigned to the lakes with each cell. After calibration, all 14 scenarios were run for all 990 lakes. In order to get a reasonable coverage within each EMEP grid cell, the calibrated lakes were then used to assign scenarios to all grid cells (1/4×1/8 degree) in the Norwegian critical loads database (2304 cells) using a matching routine called 'MAGIC library' (IVL 2007) (see also country report for Sweden). The 2304 grid cells were matched to the 990 lakes to which the model was calibrated according to a Euclidian distance routine based on water chemistry and location. Each of the 2304 grid cells was thus assigned a MAGIC modelled lake. Input data and data sources are described in the 2008 CCE Status Report.

Empirical critical loads for nitrogen:
The vegetation map of Norway was updated with the new empirical critical loads from the workshop in Noordwijkerhout (23-25 June 2010) (Bobbink and Hettelingh 2011). Affected areas were EUNIS codes C1, G3 and G4, in which the empirical critical loads were reduced to 3 kg, 5 kg and 5 kg N $ha^{-1}yr^{-1}$), respectively. Inside EMEP 5×5 km^2 grid cells, each vegetation type was given a unique Site-ID, a summarized area and geographical coordinates. The value from the mid point of the new EMEP grid cell was used for the cell.

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Critical loads data

Modelled critical loads:
In response to the 2012 CCE Call for Contributions the Polish NFC is submitting calculation results of the following critical load function parameters: $CL_{max}(S)$, $CL_{min}(N)$, $CL_{max}(N)$ and $CL_{nut}(N)$ for six terrestrial habitats identified according to the EUNIS classification: broad-leaved, coniferous and mixed forests as well as natural grasslands, moors and heath land and mire, bog and fen habitats. The spatial resolution applied is determined by 1 km² grid squares which contains 1 ha or more of the habitat. Following the wish of the CCE the 5×5 km² EMEP grid structure has been introduced. Critical loads were calculated based on the Simple Mass Balance model. In general the input parameters were estimated in accordance with the Mapping Manual procedures with some exceptions. In comparison to the 2011 CCE Call for Data the following changes or updates of input data have been introduced:

1. The recent version of the Corine Land Cover 2006 map was applied to map the areas of the selected habitats and the considered protected areas. However, within the updating process some of the land use classes were removed due to not fitting to the ecosystems definitions in the European Nature Information System (EUNIS). Updated translation of the Corine Land Cover classes into EUNIS habitat types does not include transitional woodland shrubs (code 3.2.4) and pastures (code 2.3.1) previously included into EUNIS ecosystem E. Now the ecosystem E is dominant in less than 1% of the EMEP grid covering Poland with the applied resolution, what is more coincident with the data provided by Polish Central Statistical Office.
2. The last 5-year period average monitored atmospheric deposition data for Ca, Mg, K, Na and Cl were used.
3. Another important change in the calculation of critical loads of nutrient nitrogen was the modification of the acceptable nitrogen concentrations (N_{acc}) values. Earlier, the N_{acc} suggested in the Mapping Manual (Mapping Manual 2004), substituted in 2007 with revised empirical values, were used. The N_{acc} values were updated by applying a new approach assuming variable acceptable nitrogen concentrations, dependent on the length of growing season. This approach was adopted from the German NFC method presented in the CCE Progress Report 2007 (Nagel 2007). For the lower threshold value of the growing season, N_{acc} empirically determined in Scandinavia were used, while for the upper threshold N_{acc} reported for the Netherlands were taken. The values of N_{acc} between both threshold values of the growing season were calculated by simple linear functions.
4. The main source of soil data was the II-level Forest Monitoring System operated by the Forest Research Institute within the National Monitoring of Environment funded by the Chief Inspectorate of Environment Protection. Data from 148 forest monitoring sites were regionalized to fit to a grid system with a 1 km² grid cell.
5. Recent base cations and chloride deposition data were provided by the Institute of Meteorology and Water Management, Wroclaw Branch, the operator of the due section of the National Monitoring of Environment funded by the Chief Inspectorate of Environment Protection.

Critical load maps:

The resulting critical load maps for $CL_{max}S$ and $CL_{nut}N$ are shown in Figures PL.1 and PL.2.

Figure PL.1 Maximum critical loads of sulphur for Polish terrestrial ecosystems.

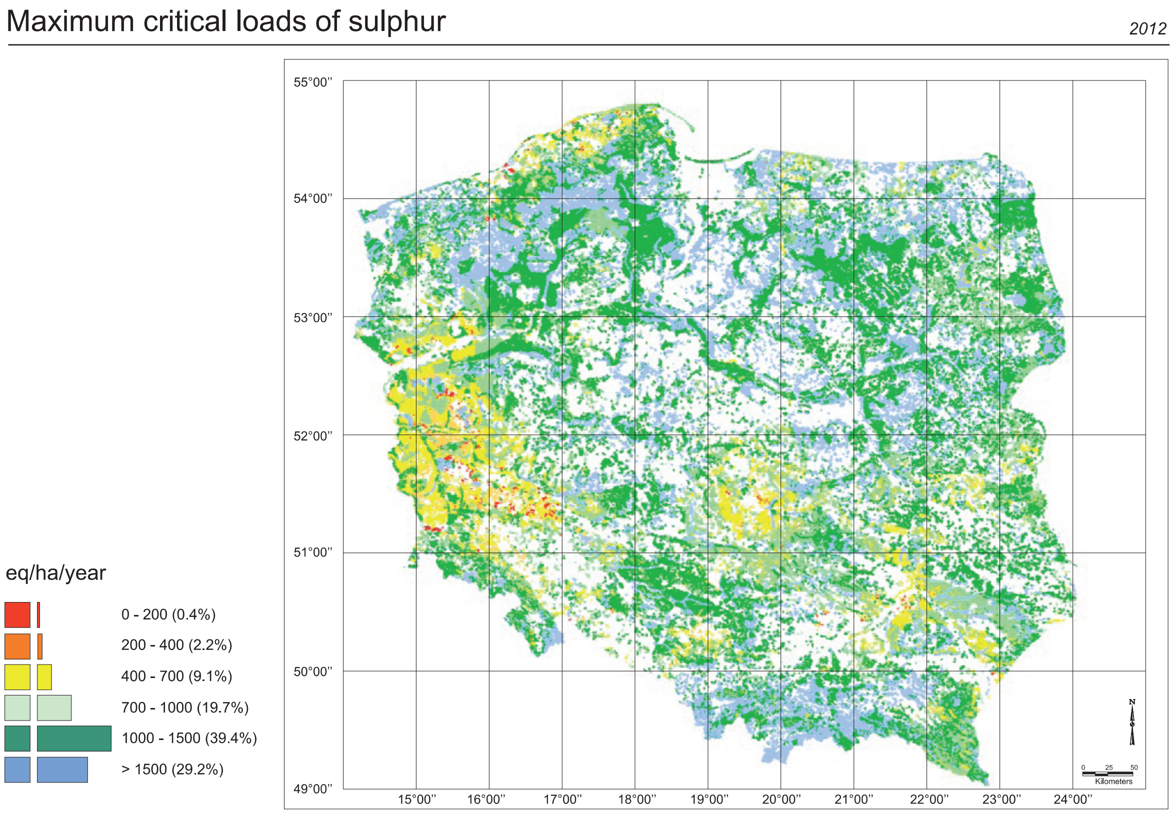
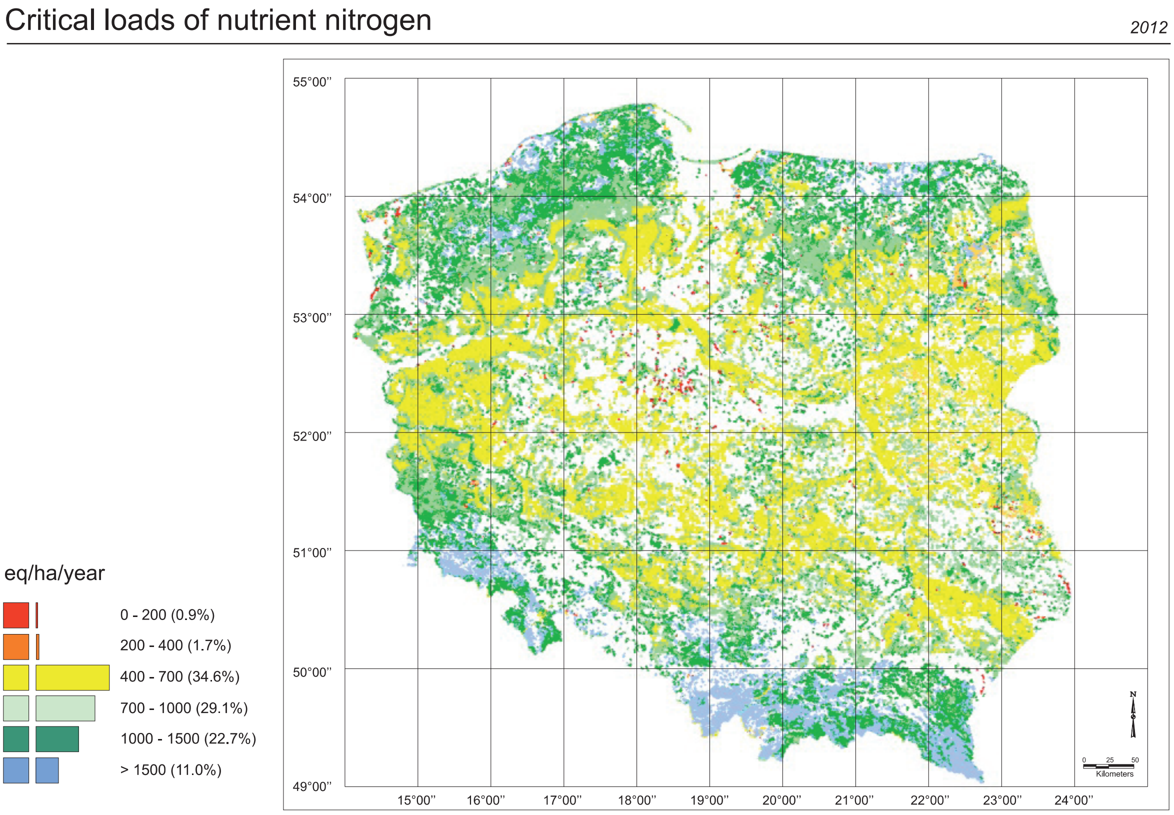


Figure PL.2 Critical loads of nutrient nitrogen for Polish terrestrial ecosystems.



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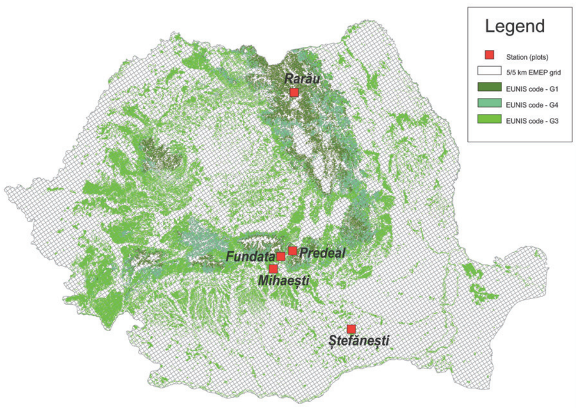
Status

In response to the Call of January 2012, a new dataset of critical loads was provided. The dataset concerns five forest sites belonging to the Romanian ICP Forest Level-II plots (see Figure RO.1 and Table RO.1).

Critical loads of acidity

Data sources were the biometrical, soil and atmospheric deposition measurements performed in the framework of ICP Forest network. Climate data were obtained from the National Meteorological Administration of Romania and from the book "Clima României" (2008).

Figure RO.1 Location of the selected sites..



The calculations and assumptions are generally in accordance with the Mapping Manual (ICP M&M (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 RO.2.

Table RO.1 Romanian plots and their location.

Plot name	Latitude N	Longitude E	Altitude (m)	i50	j50	i5	j5	Tree species	Tree age in 1991
Ştefăneşti	44°30'34"	26°10'38"	86	93	57	923	570	*Quercus robur, Tillia*	90
Predeal	45°30'25"	25°35'21"	1185	90	57	897	574	*Picea abies, abies alba*	94
Rarău	47°28'34"	25°32'21"	1400	86	60	856	599	*Picea abies, abies alba*	70
Fundata	45°25'59"	25°16'11"	1300	90	57	895	569	*Fagus sylvatica*	50
Stâlpeni	45°01'47"	24°59'33"	500	90	56	900	561	*Quercus petraea*	72

Table RO.2 Data description, methods and sources for the CL of acidity calculation.

Parameter	Term	Unit	Description
Critical load of acidity	$CL_{max}S$	eq ha^{-1} a^{-1}	Manual, eq.5.22
	$CL_{min}N$	eq ha^{-1} a^{-1}	Manual, eq.5.25
	$CL_{max}N$	eq ha^{-1} a^{-1}	Manual, eq.5.26
Acid neutralisation capacity leaching	nANCcrit	eq ha^{-1} a^{-1}	Manual, eq.5.31
Chemical criterion used	crittype		molar Al/Bc (1)
Critical value for the chemical criterion	critvalue		1
Thickness of the soil	thick	m	Depending on soil inventory data
Average bulk density of the soil	bulkdens	g cm^{-3}	Measured for each horizon and calculated with eq. 6.22
Total deposition of calcium	Cadep	eq ha^{-1} a^{-1}	Calculated with Ulrich (1983) and Bredemeier (1988) model (cited by de Vries et al. 2001), using bulk deposition and throughfall data for the 1998–2009 period
Total deposition of magnesium	Mgdep	eq ha^{-1} a^{-1}	Idem
Total deposition of potassium	Kdep	eq ha^{-1} a^{-1}	Idem
Total deposition of sodium	Nadep	eq ha^{-1} a^{-1}	Idem
Total deposition of chloride	Cldep	eq ha^{-1} a^{-1}	Idem
Weathering of base cations	Bcwe	eq ha^{-1} a^{-1}	Mapping Manual 5.3.2.3, eq. 5.39; Table 5-14 (WRc=20 for calcareous soils; factor 0.8 for Na reduction)
Net growth uptake of base cations	Bcupt	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) (no uptake from unmanaged protection forests)
Amount of water percolating through the root zone	Qle	m a^{-1}	$Qle=P-0.25\cdot(1+T_{air}/10)$; equation recommended by H-D Nagel after Michalzik et al. (2001)
Equilibrium constant for the Al-H relationship (log_{10})	lgKAlox		8, default value from Manual
Exponent for the Al-H relationship	expAl		3 (gibbsite equilibrium)
Partial CO_2-pressure in soil solution as multiple of the atmospheric CO_2 pressure (-)	pCO2fac		[$log_{10}pCO_2 = -2.38 + 0.031\cdot Temp$ (°C)]; atmospheric CO2 pressure = 0.0003767 atm (for the period 1998–2009),
Total concentration of organic acids	cOrgacids	eq m^{-3}	0.01
Acceptable amount of nitrogen immobilised in the soil	Nimacc	eq ha^{-1} a^{-1}	Decreasing from 5 kg N in the highlands (< 5° C mean Temp) to 1 kg N in the lowlands (> 8° C mean Temp); CCE Report (1993)
Net growth uptake of nitrogen	Nupt	eq ha^{-1} a^{-1}	[average yearly yield rate * N content], from ICP Forest biometrical data. N contents from Manual, Table 5.8
Denitrification fraction	fde	(0≤fde<1)	From 0.1 to 0.7 according to soil drainage, Manual, Table 5.9. Values estimated according to the quantity of soil water percolation
EUNIScode of ecosystem	EUNIScode		Information from biodiversity experts
Type of nature protection (SAC, SPA...)	Protection		Site Rarău is on the border of ROSPA0083, Natura2000 Rarău-Giumalău site

Critical loads of nutrient nitrogen

Table RO.3 Data description, methods and sources for the CLnutN calculation.

Parameter	Explanation and Unit	Description
CLnutN	Critical load of nutrient nitrogen (eq ha^{-1} a^{-1})	Manual, equation 5.5
cNacc	Acceptable (critical) N concentration (eq m^{-3})	For conifers and deciduous trees, according to Manual, Table 5.7
Qle	Amount of water percolating through the root zone (m^3 ha^{-1} a^{-1})	See Table RO.2
Nleacc	Acceptable nitrogen leaching (eq ha^{-1} a^{-1})	Manual, equation 5.6 (Nleacc=Qle*cNacc)
Nimacc	Acceptable amount of nitrogen immobilised in the soil (eq ha^{-1} a^{-1})	See Table RO.2
Nupt	Net growth uptake of nitrogen (eq ha^{-1} a^{-1})	See Table RO.2
fde	Denitrification fraction ($0 \le fde < 1$) (-)	See Table RO.2
Measured	On-site measurements included?	all sites: no measurements (0)
EUNIS code	EUNIS code of ecosystem	Information from the biodiversity experts: G1, G3, G4
Protection	Type of nature protection (SAC, SPA, ...)	See Table RO.2

Empirical critical loads

The Romanian CORINE landcover 2006 dataset is the main data source for this study. EUNIS-codes are applied and CLempN values are assigned to the habitats according to the recommendations made at the 'Workshop on the review and revision of empirical critical loads and dose-response relationships' (Bobbink and Hettelingh 2011). The minimum value of the recommended range is used as CL (Tables RO.4 and RO.5).

Table RO.4 Ecosystem, CORINE 2006 code, EUNIS code, recommended CL range and applied CLempN value.

Ecosystem	CLC2000	EUNIS	CLNrange	CLemp(N)
Broadleaved deciduous woodland	311	G1	10-20	10
Coniferous woodland	312, 322	G3	10-15	10
Mixed deciduous and coniferous woodland	313, 324	G4	10-20	10

Table RO.5 Data description, methods and sources for the CLempN calculation.

Variable	Explanation and Unit	Description
CLempN	Empirical critical load of nitrogen	values used: see table RO.4
EUNIS code	EUNIS code of ecosystem	CORINE Landcover 2006; see Table RO.4
Protection	Type of nature protection (SAC, SPA, ...)	See Table RO.2

Results

Table RO.6 Results of critical loads calculation for the five plots (in eq ha^{-1}a^{-1}).

Variable	Plot name				
	Stefanesti	Predeal	Fundata	Mihaesti	Rarau
$CL_{max}S$	7091	2942	2202	1684	4192
$CL_{min}N$	355	819	907	1298	418
$CL_{max}N$	23992	4496	3660	4105	5658
$CL_{nut}N$	441	922	1091	1500	525
nANCcrit	4611	2273	1581	1270	2855

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Updated soil-vegetation dynamic modelling of ICP Forest Level-II plots

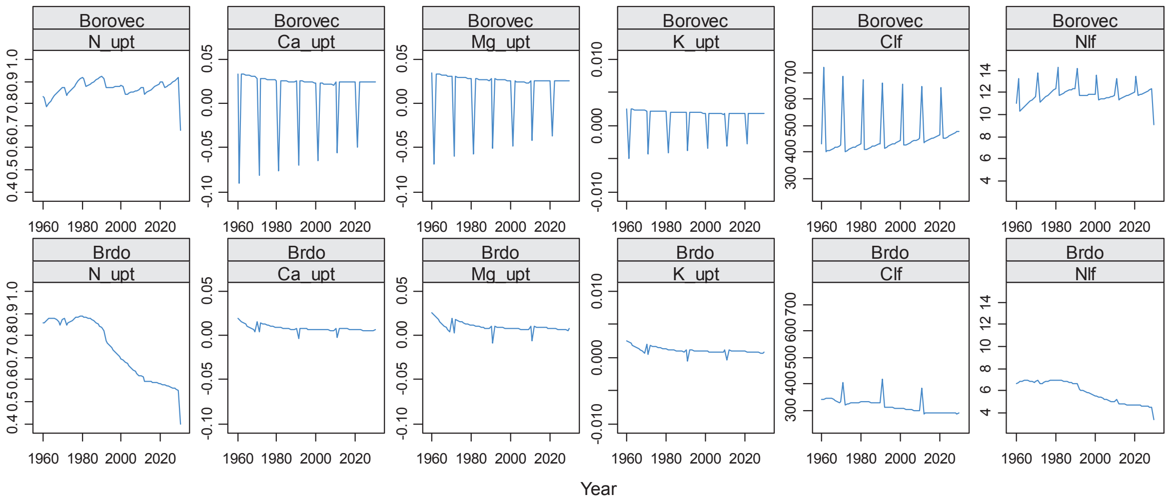
Sites used for modelling:
Two ICP level-II plots in Slovenia were selected for this exercise. Both sites are contrasting in soil conditions: site 'Brdo' is acidophilous a species-poor Scots pine forest and the 'Borovec' site is a beech forest lying on carbonate bedrock. Soil acidification due to N and S deposition can only be relevant for the 'Brdo' site, where the soil is acidic. Carbon and nitrogen pool modelling is reasonable for both sites. Detailed information on sites is shown in Table SI.1.

Forest growth and nutrient uptake calculations:
For forest growth simulation and nutrient uptake GrowUp tool was used, which simulates, using the biomass increment data and forest management information, growth of trees and of their specific compartments (stems, branches, coarse and fine roots), litterfall and uptake of N, Ca, Mg and K. The tool is not particularly intended for forests where no clearcuts but rather selective tree harvest is performed. In Slovenia and some other countries the close-to-nature management with self-regeneration of trees which results in uneven-aged forests is by far the most widespread management type. In this respect our results of GrowUp simulation might not be relevant for the whole forest rotation but are fairly realistic for the shorter VSD+ modelling period (1960–2020). One cohort was used

Table SI.1 Site information for the two Level-II plots in Slovenia.

Site	Borovec	Brdo
Location	45°32'12" N, 14°48'16"E	46°17'14"N, 14°24'17"E
Altitude	705 m	471 m
Biogeographic region	Dinaric	Pre-Alpine
Soil	Rendzic leptosol, (eutric cambisol)	Dystric cambisol
Mean pH of topsoil	6.6	4.1
Bedrock	Limestone	Fluvioglacial gravels and sands
Plant community	Lamio orvalae-Fagetum	Vaccinio myrtilli-Pinetum
Dominant tree species	Fagus sylvatica	Pinus sylvestris
Stand age	80 yrs	100 yrs

Figure SI.1 GrowUp results for "Borovec" and "Brdo" sites for the period 1960–2030. Uptakes of N, Ca, Mg and K (in eq m^{-2}) together with carbon and nitrogen added to soil as litterfall (in g m^{-2}) are shown.



for both sites. For tree increments national data of forest inventories were used. For management information forest management plans of particular region were taken into account.

Meteorological and hydrological data pre-processing:

To calculate precipitation surplus, soil water content and reduction factors of mineralization, nitrification and denitrification MetHyd model was used. For meteorological data monthly average temperature and precipitation of the nearest station of national meteorological network for the period 2009–2011 were used. Soil hydrological data (water content at wilting point, saturation and field capacity) were estimated using soil physical data (texture class, organic matter content, bulk density). MetHyd results were imported into VSD+ input file. Only averages of modelled results were used in VSD+ model runs.

VSD+ modelling:

Dynamic modelling of acidification/eutrophication was performed using latest version of VSD+ (Bonten et al. 2011, Reinds 2009). Certain input parameters were updated after the previous call for data. The on-site measurements included in current calculations were: pH, carbon and nitrogen contents, soil bulk density, base saturation, cation exchange capacity, soil temperature, C:N ratio of soil, humus and litter, wood increments and litterfall, rainfall, water content. Some data (detailed chemical parameters of equilibrium equations, weathering rates, mineralization rates, and transfer fractions of the litter-soil-microbes system, mineral content of stems) were not obtained during level II measurements and default values within VSD+ or literature data were used. For historic depositions of pollutants and base cations EMEP data were used. Model calibration was performed using the observed values of C and N pools, C:N ratio and base saturation for year 2004. As a criterion for $CL_{nut}N$ the N concentration in leachate was used ($[N]_{acc}$=0.0143 eq m^{-3}) (Posch et al. 1993).

Table SI.2 Input values for VSD+ dynamic model for two Level-II plots of Slovenia. For details on parameters and units see VSD+ manual (Bonten et al. 2011).

Site: BOROVEC													
period	thick	bulkdens	Theta	pCO2fac	CEC	bsat_0	Excmod	lgKAlBC	lgKHBC	expAl	lgKAlox	Cpool_0	CNrat_0
1960 2030	0.40	1.31	0.38	18.8	78.8	0.99	Gapon	0.16	3.8	3	7.9	7000	18
RCOOmod	cRCOO	RCOOpars	TempC	percol	Ca_we	Mg_we	K_we	Na_we	SO2_dep	NOx_dep	NH3_dep	Ca_dep	Mg_dep
Oliver	0	0.96 0.9 0.039	7.2	0.93	0.9	0.45	0.25	0.25	EMEP	EMEP	EMEP	EMEP	EMEP
K_dep	Na_dep	Cl_dep	kmin_fe	kmin_fs	kmin_mb	kmin_hu	frhu_fe	frhu_fs	frhu_mb	CN_fe	CN_fs	CN_mb	CN_hu
EMEP	EMEP	EMEP	8.7	0.07	1	0.002	0.0002	0.28	0.95	17	290	9.5	15.6
knit	kdenit	Nfix	Nupeff	rf_min	rf_nit	rf_denit	N_gupt	Ca_upt	Mg_upt	K_upt	P_upt	NIf	CIf
4	4	0.05	1	0.6862	0.6862	0.5247	GrowUp!	GrowUp!	GrowUp!	GrowUp!	0	GrowUp!	GrowUp!
bsatobs	Cpoolobs	Npoolobs	CNratobs	pHobs									
0.935	9510	510	18.5	6.3									
Site: BRDO													
period	thick	bulkdens	Theta	pCO2fac	CEC	bsat_0	Excmod	lgKAlBC	lgKHBC	expAl	lgKAlox	Cpool_0	CNrat_0
1960 2030	0.40	1.3	0.39	21	9.75	0.15	Gapon	0.16	3.8	3	7.9	4000	15
RCOOmod	cRCOO	RCOOpars	TempC	percol	Ca_we	Mg_we	K_we	Na_we	SO2_dep	NOx_dep	NH3_dep	Ca_dep	Mg_dep
Oliver	0.0044	0.96 0.9 0.039	8.2	1.04	0.025	0.01	0.025	0.025	EMEP	EMEP	EMEP	EMEP	EMEP
K_dep	Na_dep	Cl_dep	kmin_fe	kmin_fs	kmin_mb	kmin_hu	frhu_fe	frhu_fs	frhu_mb	CN_fe	CN_fs	CN_mb	CN_hu
EMEP	EMEP	EMEP	8.7	0.05	1	0.0005	0.0002	0.28	0.95	17	320	9.5	10.6
knit	kdenit	Nfix	Nupeff	rf_min	rf_nit	rf_denit	N_gupt	Ca_upt	Mg_upt	K_upt	P_upt	NIf	CIf
4	4	0.1	1	0.8022	0.8022	0.5528	GrowUp!	GrowUp!	GrowUp!	GrowUp!	0	GrowUp!	GrowUp!
bsatobs	Cpoolobs	Npoolobs	CNratobs	pHobs									
0.935	6900	390	17.2	4.1									

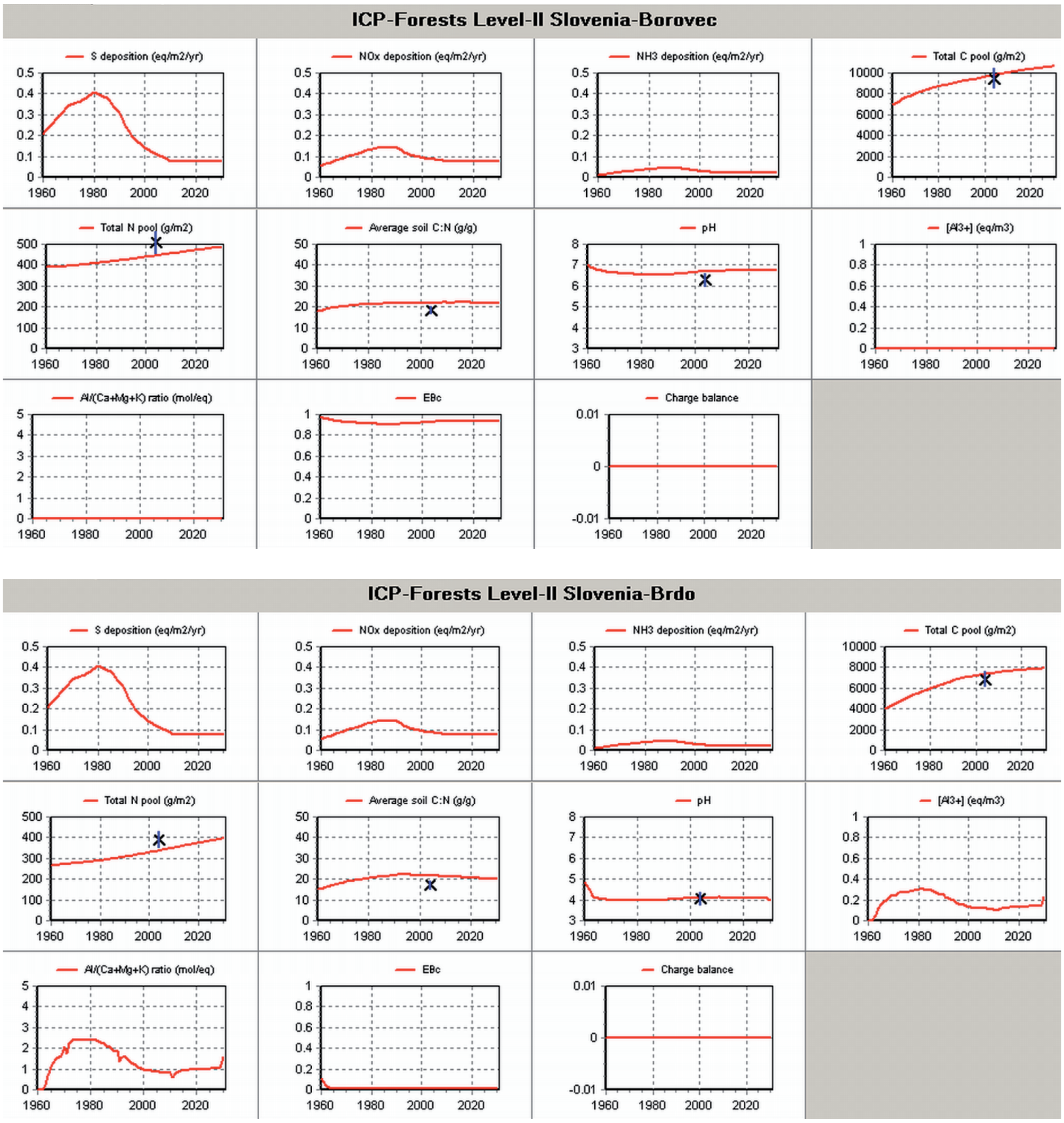
Model results were fairly consistent with the observed values of soil C pool, soil C:N ratio and pH. Results of the VSD+ model showed no exceedances of critical loads of acidity for none of the investigated sites. For carbonate soil of 'Borovec' it is an expected result and much higher depositions are possible without acidification effects. Critical loads for 'Brdo' site is a lot lower but deposition is still within the boundary of CL function.

For eutrophication no exceedances were found for 'Borovec' site ($CL_{nut}N$ = 1303 eq ha^{-1}yr^{-1}, $N_{dep,EMEP}$ = 970 eq ha^{-1}yr^{-1}), but small exceedances were estimated for the 'Brdo' site ($CL_{nut}N$ = 833 eq ha^{-1}yr^{-1}, $N_{dep,EMEP}$ = 850 eq ha^{-1}yr^{-1}). Similar results were also found when comparing critical loads of nutrient nitrogen to measured N deposition (bulk deposition) in the period 2004–2011. Measured average annual depositions were 693.6 and 897.4 eq ha^{-1}yr^{-1} for 'Borovec' and 'Brdo', respectively.

Biological effects modelling using Veg:

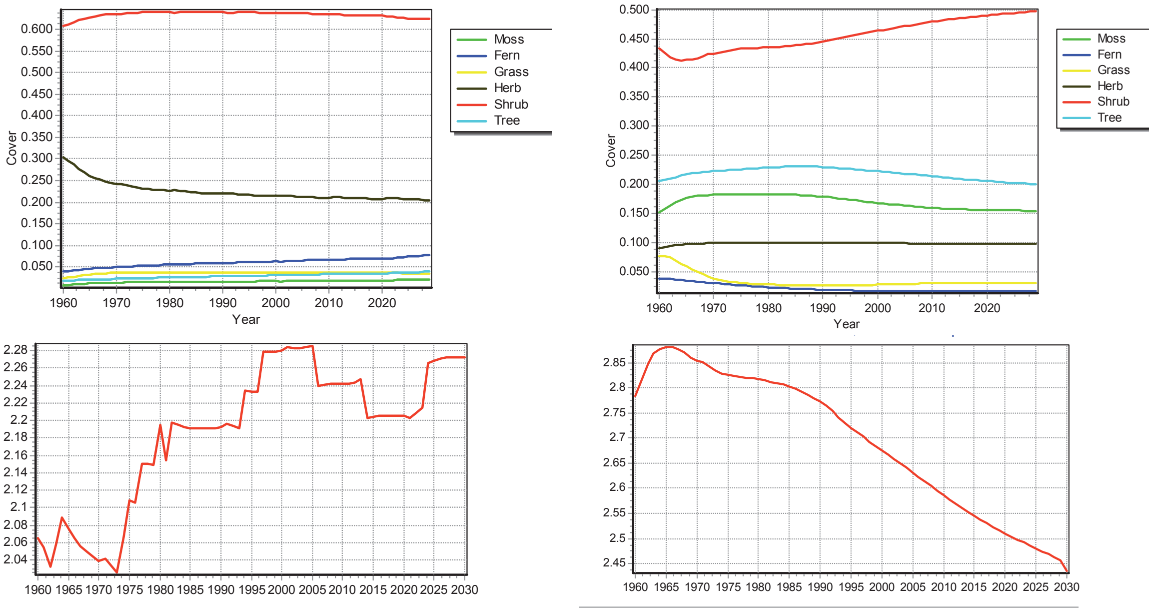
In a last step the Veg model, developed by Sverdrup et al. (2007) was used in conjunction with VSD+ to estimate deterioration/improvement of soil to host certain plant species. At each study site four 10×10 m² vegetation surveys were performed in 2004 and species inventory of the site was used for Veg model run. Species missing in database obtained from CCE were not included in model run. There were 6 out of 31 and 28 out of 83 species missing in this database for 'Brdo' site and 'Borovec' site, respectively. Included were 55 species for 'Borovec' and 25 species for 'Brdo' site. The most dominant species of both sites were included in model run.

Figure SI.2 Results of VSD+ dynamic model for the 'Borovec' and 'Brdo' sites for the period 1960–2030.



Despite being confident to use Veg model after good VSD+ model fit to the observed values, the results of Veg are somewhat contradictory. The dynamics of functional groups and diversity showed no large response during simulation period, but when investigating the dynamics of individual species large fluctuations were discovered for many species. Cover of some species was also highly over- or underestimated which questions the reliability of Veg results. Dominant forest management type (selective cutting) in Slovenia precludes large shifts in plant community composition during forest growth. Spatial and temporal heterogeneity of forest stands subjected to such management is generally lower as it is the case for the management using clearcuts. For model to approach real community initial cover estimates of species should be used instead of assembling the community using merely species niche characteristics.

Figure SI.3 Veg module output (cover of functional groups and Shannon index of diversity) for 'Borovec' site (left) and 'Brdo' site (right).



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Introduction

Sweden welcomed the Call for Contribution issued by the CCE in 2011/12. From the Swedish perspective the ecosystem effects of air pollution are high at the scientific and political agenda together with several other major issues such as health effects of air pollution or effects of climate change. Despite the declining deposition of S and N through the two last decades, the impact on ecosystems is of major concern, both with respect to acidification and eutrophication of soils and waters, together with ground level ozone concentrations and biodiversity changes.

The call for contribution consisted of the following parts:
1. NFC report with the endpoints of interest of your country that relate to critical loads and a
National Report of your contribution (for inclusion in the CCE Status Report)
2. Complete sets of input data to the soil-vegetation model runs carried out for your sites
3. Results of soil-vegetation model runs for ecosystem

(EUNIS) types
4. In case you have updated your critical loads data, you are invited to submit the updated tables according the instructions from the 2011 Call for Data.

The Swedish NFC responded to the following 3 parts of the Call:

- critical loads were updated for lakes;
- revised and extended table with Veg parameters including EUNIS classification of majority of plants was produced;
- this report includes a note on regionalisation of vegetation model outputs in Sweden.

Critical loads – Lakes

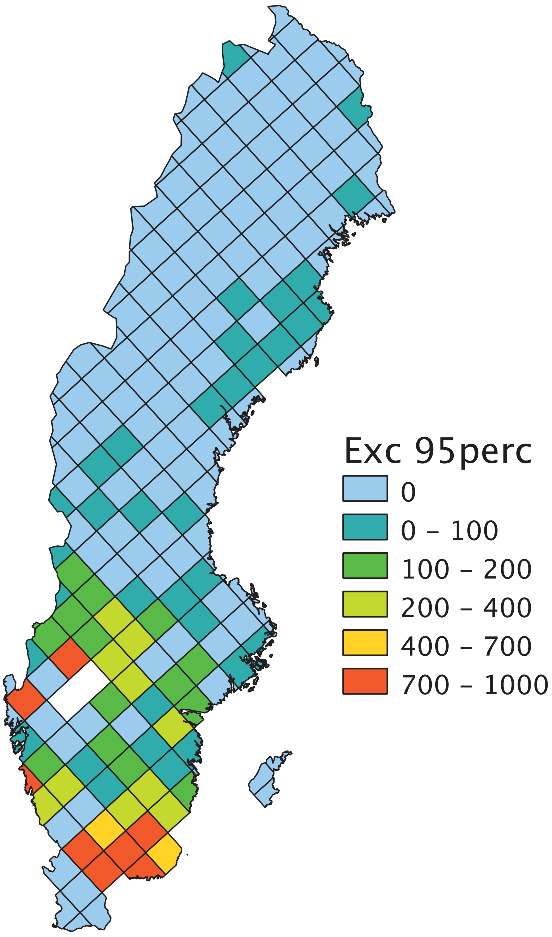
The lakes with submitted critical loads are part of a Swedish national surveillance monitoring of lakes 2007, 2008 and 2009 (Grandin 2007). Lake water chemistry was measured at 2410 lakes with area > 1 ha selected by a stratified random selection. Lakes affected by liming (N=458) were corrected by using the average Ca:Mg ratio from non limed reference lakes within 20 km distance and the Mg concentration of the liming agent (Fölster et al. 2011).

For freshwaters the critical loads were calculated using the first-order acidity balance (FAB) model as described in Posch et al. (1997) and Rapp et al. (2002) with some modifications described below. The BCle used in the FAB-model was the calculated BC concentration 2100 according to MAGIC simulations using the CLE scenario. Thus the F-factor for estimating the weathering rate was not used. The calculations of nitrogen immobilisation were based on Gundersen et al. (1998). Nitrogen immobilisation was set to 100% for deposition up to 2 kg N/ha, 50% for the part of the deposition exceeding 2 kg/ha up to 10 kg/ha and 0% for the deposition exceeding 10 kg N/ha. In addition to this, leaching of organic nitrogen calculated from the lake concentration of Total Organic Nitrogen (TON), was regarded as non-acidifying. The chemical threshold, ANClimit, was calculated individually for each lake to a value corresponding to a change in pH of 0.4 units from reference conditions calculated by MAGIC (Moldan et al. 2004). This threshold is used as a definition of acidification in the Swedish Environmental Quality Criteria and for the fulfilment of Good Ecological Status within the EU Water Frame Directive (Fölster et al. 2007). When MAGIC was not run on the lake itself, the data used in the FAB model was taken from a similar lake within a database of MAGIC simulated lakes by a matching procedure (MAGIC library, www.ivl.se/magicbibliotek). Less than 5% of the lakes did not get any match, since no similar lakes were in the library. Those lakes were in most cases well buffered and unlikely to be acidified even at a very high deposition. CLmaxS, CLminN CLmaxN, nANCcrit, critvalue and nmBCo was then set to the same values as for the lake with the highest critical load (ID=647139-138602) to ensure that the critical load for those lakes were not exceeded in further calculations and interpolations. The above described procedure of using MAGIC model and its extension MAGIC library was used in the same fashion as in the previous submission of CL data from Sweden. In 2011 the library of lakes modelled with MAGIC was expanded to present day 2900 lakes. MAGIC model was re-calibrated at all lakes in library using latest lake chemistry, latest land use and hydrological data and also the latest deposition estimates according to EMEP (past deposition) and COB deposition scenario (the future). The principal reason for re-submitting critical loads calculation for lakes is the re-calibration of the MAGIC library. The MAGIC library is being used on national level for acidification assessment and for critical load calculations. Therefore it is desirable to use the same calculations as a basis also for critical loads calculations in the context of the LRTAP Convention.

Interpolation to the 5×5 km² grid:
The total area of Sweden is regarded as ecoarea for lakes, since the lake water quality is a result of processes in the catchment. The nine largest, and in all cases well buffered lakes, are excluded from the total area. Sweden contains approximately 18,000 5×5 km² squares. Provided that there are close to 100,000 lakes in Sweden there are in average close to 5 lakes in each 5×5 square. The 2410 sampled lakes were distributed over 2106 of the 5×5 km² squares. In most cases there was one modelled lake per 5×5 km² grid cell. The ecoarea was then set to 25 km². For lakes within squares with more than one lakes, the ecoarea was set to 25 km² divided by the number of lakes within that square. For the approximately 16,000 squares with no modelled lakes inside the CL data were calculated by a linear interpolation between the lakes with calculated CLs. For each square the average value of the square was selected. Squares along the coast distant from any measured lake were not interpolated.

For the lakes, the median critical load of S deposition is 282 eq/ha/yr, the Nmin is 356 eq/ha/yr (i.e. the amount of N deposition that is taken up by the ecosystem and does not cause any acidification) and the Nmax is 859 eq/ha/yr (i.e. the maximum amount of N deposition the ecosystem could take without unacceptable acidification, if the S deposition is zero). The differences between lakes are large. A number of lakes will not recover from acidification and many lakes that not become acidified under present day conditions. The area with exceedance of critical loads was 17% in 2010 (Figure SE.1).

Figure SE.1 Exceedance of CL for lakes in Sweden in 2010. For each square the 95 percentile of exceedance is given, i.e. the exceedance of the 5% of the area with the highest exceedance.



Update and revision of the vegetation parameterisation table for use with the Veg module

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The ground vegetation composition module Veg builds on the definition of abiotic niches for representative plant species (Sverdrup et al. 2007). The abiotic niches are summarised in a vegetation parameterisation table, which has evolved to include representative plants from a range of European ecosystems. For each representative species present in the table, specific responses to nitrogen, soil acidity and alkalinity, temperature, moisture and light intensity are given, in addition to root depth, shading height and palatability.

The vegetation parameterisation table revised in 2010 and 2011 and documented in Belyazid et al. (2011a) forms the basis for the changes presented here. The changes to the new tables comprise the following:
1. Revision of the representative vegetation species present in the table based on new inputs from Switzerland and Sweden;
2. Revision of internal parameters consistency based on expert knowledge;
3. Linkage of species to the European Nature Information Systems (EUNIS) classes based on the current content of the EUNIS database.
Points 1 and 2 are based on a review of the table by habitat experts in Sweden, Switzerland and France during 2011 and early 2012. The changes were concerned with revising and

modifying the list of representative plants as well as changing names to up-to-date synonyms where relevant, based on expert opinions and local floras (Klötzi 1965, Landolt 2010, Lauber 1998, Mossberg and Stenberg 2010, Anderberg and Anderberg 2012). The response parameters were also modified based on an internal consistency test (so that for example plants with high pH_{half} values cannot have a low calcifuge limitation). Point 3 was concerned with linking the plants from the vegetation table to their respective EUNIS classes, based on the online EUNIS database hosted by the European Environmental Agency at http://eunis.eea.europa.eu/index.jsp

The matching of each species name from the Veg list with its corresponding EUNIS classes was done manually for one species at a time, due to the absence of a database in a format that allows for automatically extracting the classes over a large sample. The EUNIS classification is denoted by EUNIS codes, which are classified hierarchically from level 1 (general habitat types) to level 8 (specific habitats) (Davis et al. 2004). There are 10 level 1 categories in EUNIS denoted from A to J. Of relevance to ground vegetation modelling are habitats: B: Coastal Habitats Marine, D: Mires and Bogs, E: Grasslands and lands dominated by forbs, mosses or lichens, G: Woodland, forest and other wooded land, H: Inland un-vegetated and sparsely vegetated habitats, and I: Regularly or recently cultivated agricultural, horticultural and domestic habitats.

The matching of representative plant species to EUNIS codes was done to the fourth level of the EUNIS hierarchy, in comparison to the level used for the empirical critical loads revision (Bobbink and Hettelingh 2011). EUNIS levels beyond level 4 (levels 5 to 8) were reported only if a specific plant name was not matched by a level 4 or lower (1 to 3), or if the plant name was linked to a higher level not included in any of the matching lower levels. For example, *Fraxinus excelsior* was matched in EUNIS class D2.3B (level 3), but also in EUNIS class G3.D42 (level 5). In this case, both levels are reported because G3.D42 is not a branch of D2.3B. In case a plant name was not matched by a level 4 EUNIS class or lower, it was matched with whatever higher levels were available. *Luzula sylvatica* for example is only matched in EUNIS class E1.29114 (level 7).

Reflections on the regionalisation of the Swedish method to estimate critical loads of atmospheric N deposition based on changes in the composition of plant communities

Salim Belyazid

In an exercise testing the possibility of estimating critical loads of Nitrogen deposition based on plant community changes (CLvegN), three prerequisites were defined: 1- identifying a reference plant community (corresponding to a 'clean' reference atmospheric deposition), 2- selecting a target population (a subset of the plant community of interest for protection from adverse effects), and 3- defining a critical level of unacceptable change due to atmospheric deposition (Belyazid and Moldan 2009). Based on a set of clearly defined assumptions regarding the three prerequisites above, Belyazid et al. (2011b) demonstrated the feasibility of this method by estimating preliminary critical loads of N deposition at multiple specific sites.

As with the other methods for estimating critical loads, a set of assumptions is adopted to make the dynamic CLvegN useable on a regional scale. These assumptions can be divided into two groups: 1- theoretical and 2- practical. The group of theoretical assumptions includes the definitions of the target population and the critical limit. These are the assumptions describing the value given to the biological indicators to be protected from harmful effects due to deposition. The practical assumptions refer primarily to the modelling strategy, and include the assumption of site independence on a large geographical scale as well as the assumption of future climate and land use scenarios.

On the theoretical assumptions, Van Dobben et al. (2010) provide an inclusive summary of the possible criteria to be used for weighting specific plants in a community to provide an index of biodiversity status. If plants are weighted by their occurrence under the reference deposition scenario, it would imply that a large change in a dominant plant will also show as important for the entire community, thus contributing more to the overall population response. Meanwhile, a large change in a marginal species may contribute only marginally to the total area cover, and thereby be negligible in the overall response of the plant community to atmospheric deposition. Over a large geographical scale, it may be necessary to identify different target populations for different ecosystems, habitats, or specific ecotypes.

Belyazid and Moldan (2009) tested the feasibility of narrowing the target population to a desired section of the plant community, and concluded that it was technically feasible to derive CLvegN for any plant community subset of interest. How to define this subset is still subject to debate (Van Dobben et al. 2010). A starting point could be to make use of the existing European classifications documented within the Natura 2000 and EUNIS databases (http://ec.europa.eu/environment/nature/natura2000/index_en.htm, http://eunis.eea.europa.eu/index.jsp). These European classifications relate specific species to specific habitat types, and can be used to narrow the CLvegN method to focus on plants of interest for a given habitat.

The other theoretical challenge of the method above consists in setting a critical limit for change on a regional scale. The method up to now assumes a fixed critical limit of vegetation change. This limit may need to be set differently depending on the target population and habitat of interest. For example, if the target population is a dominant association responsible for a prominent ecosystem function (ex. Sphagnum in bogs), the critical limit could be set at the level of loss of Sphagnum dominance beyond which the latter's contribution to ecosystem functioning is marginalised. On the other hand, if we are concerned about the conservation of a Drosera (sundew) species in the bogs, even a low critical limit could imply the additional weakening of an already marginal species. Obviously, this exercise involves setting a value of change in plant communities in order to decide if marginal or dominant plants (or any other association in between) should be protected, and by how much they should be allowed to change before their change is declared harmful.

On a regional scale, the theoretical assumptions described above imply that the target population and the critical limits may have to be defined in a variable manner over the landscape, depending on the specific ecosystem of interest at each geographical location. At the same time, considering the large number of sites required for a meaningful regionalisation, some aggregations in setting the former limits will have to be carried out. Again, the existing habitat classifications may offer a good starting point.

On the practical assumptions, the primary weakness of the CLvegN method currently is in its assumption mutual independence between the modelled sites. This assumption is also used in current dynamic critical loads estimates (as for CLnutN). The mutual independence of sites implies that to achieve regionalisation, current methods are limited to modelling a large number of sites to produce a sufficiently tight geographical cover, which allows for mapping. Regarding CLvegN estimates, this assumption also implies instantaneous plant dispersion and colonization. The models are today unable to handle the geographical aspect of plant colonisation and dispersion form one geographical region to another. While it may be acceptable to assume that within long enough time periods plants will ultimately fill their ecological niches in given locations where they did not exist before, it remains erroneous to assume that this colonisation is independent of the flora in neighbouring sites. It may be conceptually possible to devise a procedure by which to describe the migration of plants between different geographical areas, but the methods remain far from having testable prototypes of such dispersal and colonisation modules. This requirement brings in a new dimension in dynamic modelling which has until now not been considered, namely the interdependence of ecosystems on a geographical scale.

The updated table contains 415 representative plant species. 350 of these species were successfully matched in the EUNIS database (84.3% of the total plants in the Veg table). Out of the matched species, 31 names were linked to a level higher than 4, meaning that they are specific to narrower habitat types.

The available EUNIS classification of plant names may have been insufficient for the purpose of this exercise, as plants are currently connected to habitat types based on the habitats' description according to EUNIS or the definition given in Annex I of the EU's Interpretation Manual (Doug Evans, pers. comm.). This means that some plants may be matched with fewer habitats than their actual distributions. It remains to the users of the table to make sure their plants of interest are linked to the EUNIS classes of relevance, for example following the method described by Rodwell et al. (2002).

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Biodiversity targets and endpoints

Biodiversity strategy Switzerland:
Switzerland, not being a member state of the EU, develops its biodiversity strategy on the basis of national assessments of the biodiversity status, the current legislation and the 'Aichi targets' of the Convention on Biodiversity (CBD). In April 2012 the Federal Council adopted the 'Biodiversity Strategy Switzerland' (BSS) (see www.bafu.admin.ch/biodiversitaet/10372/10395/index.html; in German, French or Italian). It recognizes the need for action and formulates ten strategic goals, which should be pursued, in coherence with CBD and the EU biodiversity strategy, until 2020.

With respect to air pollution, the BSS document explicitly mentions the adverse effect of agricultural ammonia emissions to biodiversity in general and specifically to forests, water and wetlands. Furthermore, it mentions the threat to forest biodiversity by depositions of air pollutants, especially nitrogen, and the progressing eutrophication of bogs and fens.
In the EU, the Natura 2000 areas represent a framework for habitat conservation. In Switzerland, there are comparable conservation areas of high priority, which are protected on a national level by different federal ordinances and their related spatial inventories: e.g. raised bogs, fens, species-rich dry grassland, alluvial meadows, spawning areas of amphibians. In addition, the ecological

value of forest land is a target (among others) of forestry policy and legislation.

Effects of N deposition in Switzerland, a field study:
Results of this study were presented this year at the CCE Workshop in Warsaw by Kohli, Roth and Rihm. The aim of the study was to investigate the effect of atmospheric N deposition on species richness and species dissimilarity in the alpine regions of Switzerland.
For the analyses we used the data from the Biodiversity Monitoring of Switzerland (BDM) (see www.biodiversitymonitoring.ch/en/data/indicators/z/z9.html). Fieldwork for this study was conducted from 2006 to 2010. During that period all the sample plots of 10 m^2 from the BDM were surveyed for the presence of vascular plants. We classified the species into species groups indicating two fertility levels, i.e. eutrophic species and oligotrophic species. Data for modelled atmospheric N deposition was provided by the Federal Office for the Environment. To explore the effect of N deposition on the species richness we used generalized additive models. To test for an effect of N deposition on species composition, we calculated the mean Simpson-index as a measure of the species dissimilarity between the recorded species of different sample plots.
On the 122 mountain hay meadows plots (E2.3), the species richness ranged from 35 species to 82 species with an average of 47.6 species. On 93% of the plots, total N deposition exceeded the minimum value of 10 kg ha^{-1} yr^{-1} of the empirical critical load range set for this ecosystem, and on 38% of the plots N deposition even exceeded the maximum value of 20 kg ha^{-1} yr^{-1} of this range. Species richness and species dissimilarity were highest on plots with low N deposition and decreased with higher N deposition. The species richness of generally rare oligotrophic species decreased with increasing N deposition. In contrast, the species richness of common eutrophic species tended to increase with nutrient deposition. Therefore we conclude that N deposition in the range of critical loads results in floristic homogenization.
In grassland, five species showed a significantly enhanced probability of occurrence with increasing N deposition (e.g. *Trifolium repens*). Eight characteristic plant species of hay meadows (e.g. *Sanguisorba minor* s.l.) and three typical species of alpine pastures (e.g. *Thymus serpyllum* agg.) showed a significantly decreased probability of occurrence with increasing N deposition.
The species richness on the 97 mixed Abies-Picea-Fagus-woodland (G4.6) plots ranged from two species to 74 species with an average of 21.9 species. N deposition exceeded the minimum value of 10 kg $ha^{-1}yr^{-1}$ of the empirical critical load range at all plots. On 85% of the plots, even the maximum value of this range was exceeded. Species richness of plants in mixed forest was highest on plots with low N deposition and decreased with higher N deposition. The species dissimilarity also decreased with increasing N deposition. Even though, no effects on the species richness within the eutrophic species were found by increased N deposition, there seemed to be a turnover of species. On plots with high N deposition, this turnover led to the floristic homogenization of mixed forest.
Ten species in the woodland showed a significantly enhanced probability of occurrence with increasing N deposition (e.g. *Rubus fruticosus* agg.) and five species showed a significantly reduced probability of occurrence with increasing N deposition (e.g. *Mercurialis perennis*).
In summary, we found negative relations between N deposition and species richness and species dissimilarity in mountain hay meadows and to a lesser extent in mixed Abies-Picea-Fagus-woodland. Since we used data collected over a large spatial scale, we argue that the pattern we found must be very general.

Endpoints to be used in dynamic modelling:
Under these circumstances, the assessment of species diversity by means of dynamic modelling would preferably cover forest land, grassland, wetland and other habitats that are relevant for biodiversity. However, the application of the dynamic models VSD and ForSAFE linked with the module Veg is so far limited in Switzerland to forest soils and forest ecosystems. For this submission, 32 forest sites are modelled. For those sites, soil profile data as well as vegetation relevés are available, thus allowing for validation of model results.
At this stage, the ecological endpoints assessed by the dynamic model application include the following indicators for the forest ground flora:
- evolution of species composition, number of plant species;
- relative shift of species groups (nitrogen and acidity).
- In the future, further specific assessments could be useful, such as:
- dissimilarity of flora between sites (e.g. Simpson-index);
- occurrence of red list species;
- effects of climate change on flora.

The number of species calculated with Veg might be difficult to interpret because the result mainly depends on the extent of the species list that is used as an input. Therefore, we decided to add further information to the vegetation list (see below) in order to classify the species according to their indicator values for nitrogen and acidity. We expect that this will allow for clearer presentation and interpretation of the vegetation output from dynamic modelling. As most of the red list species belong to the oligotrophic species group, the evolution of this group is a good indicator for the protection of red list species with regard to atmospheric N deposition.
Results of the Swiss biodiversity monitoring network and

the case study summarized in the previous chapter show that looking at absolute numbers of species can be misleading, e.g. when common species become even more common, which is at least partially the case in Switzerland. Therefore an index like the Simpson-Index must be used as a measure for the species dissimilarity between the observed species of different sites. A decreasing dissimilarity would indicate a trend to floristic homogenization.
With regard to EU-targets and SEBI-indicators the following statements can be made in this context:

- In Switzerland, air pollution is probably not the dominating driver for changes in biodiversity, but its influence is considerable (Kohli et al. 2011) and must not be neglected.
- The application of dynamic models can reveal the impact of air pollution on biodiversity and thus increase the stakeholders' awareness for the need of air pollution reductions. But further development and validation of the models is needed.
- In a simpler way, also maps of critical load exceedances can potentially increase the awareness for the risk of biodiversity loss by air pollution. Exceedance maps for critical loads of nitrogen exist also for several non-forest ecosystem types (EKL 2005).

The collaboration between biodiversity experts on the one hand and modellers on the other hand is very fruitful for both.

Upgrade of the vegetation species list

During the last year, the vegetation table so far used in the ForSAFE-Veg and VSD-Veg models was modified and extended at the European level. The changes made were sometimes not comprehensible and consistent, which made it difficult to apply it in national modelling. In addition, we wanted to have the possibility for classification of the species in groups according to their characteristics related to nitrogen and acidity. Therefore, checks, corrections and extensions were carried out as described here. The upgraded tables (grndvegCH_120319.xls and grndvegEU_416_120319.xls) are provided with this submission.

Species list:
The table from the Salvan expert workshop (Belyazid et al. 2011; grndveg-372_110514) was the basis for introducing changes. The indicator values from Landolt (Landolt 2010) were merged to this table. When entries were available for a single species or an aggregate species, the information of the aggregate species was inserted except when the aggregate species lacked a parameterisation, which was available at the single species level or when the species name explicitly specified *sensu stricto*.

Also, a column was inserted with information on when and by whom a plant species was introduced to the table (parameterisation source). It was not possible to trace all entries, but the following groups were made:

- Landolt 1: species introduced at a 1st workshop with Prof. E. Landolt (2007);
- French: species introduced at French workshops (2010-11);
- Landolt 2: species introduced at a 2nd workshop with Prof. E. Landolt (2010);
- Landolt 2/table: some parameters were specified after the 2nd workshop with Landolt using his list;
- Burger, Burger 2: species introduced by T. Burger 2012 (see below);
- Empty: not assigned, origin not identified.

This information should also be tracked for future changes to the species list. For several plant species, the parameter values were changed since the species were initially inserted in the list. Thus, the information in this column cannot track the complete history of the table.

Groups of species such as 'Hylocomium mosses' or 'Sphagnum mosses' were removed as they are now represented by single species and are difficult to handle in a vegetation comparison. Also, some species had two entries of synonym names. This was corrected.
Another two columns were inserted. ICP Forests marks the 25 most important species listed by ICP Forests. The list of the Institute for Applied Plant Biology (IAP) indicates plant species observed in the relevés of the IAP observation plots. This information was then used to restrict the table to plant species actually observed or to species which had been chosen by Landolt at the first workshop as being representative for the model work. Thus, 93 entries were removed and a new list created. After this, Thomas Burger (Burger & Liechti Forstingenieure) checked this list for representativeness for Swiss forest vegetation. He introduced 62 species which are marked with 'Burger' or, the species he recommended introducing eventually, with 'Burger 2' (grndvegCH_280212). He recommended also removing some species but this was not followed in all cases. Species either recommended by Landolt in the first workshop, those on the list of the 25 most important species in ICP Forest or red listed species (two cases) were let in the table. This led to removal of another 11 species. The new Swiss list contains now 348 entries.

Parameterisation:
During parameterisation of these species it was noted that the entries of the original tables are very inhomogeneous and partly contradictory. E.g., the k_+ values for nitrogen were not consistent with the background documentation in the ForSAFE manual. They took values up to 30, whereas the ForSAFE manual suggest k_+ values for up to 2.0. In addition, the k_{Ca} parameterisation for calcifuge plants

Table CH.1 Classes for the promoting effect of N (k+).

Class	k_+ (mgN L^{-1})	Description	Landolt class
0	0	N fixing plants, need no external N input	all members of the family *Fabaceae*
1	0.1	Plants requiring very little N (<1 kgN $ha^{-1}yr^{-1}$)	1
2	0.4	Requiring small amount of N (~2 kgN $ha^{-1}yr^{-1}$)	2
3	0.8	Intermediate requirement of N (~4 kgN $ha^{-1}yr^{-1}$)	3
4	1.5	Substantial requirement of N (~8 kgN $ha^{-1}yr^{-1}$)	4
5	2.0	Very high requirement of N (>12 kgN $ha^{-1}yr^{-1}$)	5

identified calcifugity even in some lime indicating plants (e.g. Daphne mezereum). It was therefore decided to go through the whole table and make changes also for the existing species. This was done for the Swiss list. On the European level, B. Nihlgård from Lund University, Sweden, made the revisions of the entries.

Nitrogen:
The k_+ values were set as recommended in the background documentation of ForSAFE (Table CH.1) based on the Landolt classes. The k_- values were revised by B. Nihlgård based on ecological knowledge of the individual species. Up to now, the *w* parameter indicating the slope of the N response (0: very slow, 3 fast response) was not yet revised. It was set to 1 (the most frequent entry) when no further information was available.

Acidity:
Initially, the R value from the Landolt list ('Reaktionszahl') was used to assign an entry for pH_{half}. However, it turned out that the existing list was also inconsistent, assigning e.g. calcifugity to some lime indicating species. It was therefore decided to go through all entries and comparing them with field observations from the IAP observation plot and from the dataset published by WSL on their website: www.wsl.ch/forest/soil/products/zeiger/start/startseite.php.
Both the entry for pH_{half} and the calcifugity were checked in this way. In many cases the pH_{half} was reduced as the species was actually observed also on more acid soils. The main classes of calcifugity were assigned (allowing intermediate values) as shown in Table CH.2. For the European list, B. Nihlgård made a similar revision.

Table CH.2 Classes for calcifugity.

Calcifugity class	Description
0	no calcifugity
50	high calcifugity
100	very high calcifugity
1000	occasionally observed on lime soils but usually occurs on acid soils

Humidity, light:
The humidity parameterisation was not changed. The new species were parameterised by inserting average values for the existing species in the same humidity class by Landolt (F, 'Feuchtezahl'). The same procedure was used for the light class. This procedure ignored some inconsistencies in the table. Both tables still need revision – a few corrections were introduced by B. Nihlgård.

Plant height:
The plant height given in the Flora Helvetica (Lauber and Wagner 1998) was inserted (minimum of the range given). For trees and shrubs an estimated annual growth was inserted. This information was not available for other perennial species and could not be checked.

Root class:
Landolt's table gives also information on root depth. This class was translated into the scores needed by ForSAFE as shown in Table CH.3. In a few cases this information was missing. Information from a similar species was then inserted.

Table CH.3 Classes for root depth.

ForSAFE class	assigned Landolt class
0 = plants with no roots (mosses for example)	mosses
1 = Shallow roots (<0.1m)	1
2 = Intermediate rooting depths (between 0.1m and 0.4m)	1.5–2.5
3 = Deep roots (>0.4m)	≥3

Age:
The age given in Landolt's table (maximum age) was inserted. The compatibility with previous entries could not be checked.

Grazing:
Grazing classes were assigned by Thomas Burger based on a publication by Klötzli (1965) on feeding of roe deer and on observations by Burger as shown in Table CH.4.

Table CH.4 Grazing classes.

Class	Description	Parameter in model
0	Toxic or inedible, never eaten	0
1	Avoided, but eaten in times of shortage	0.7
2	Acceptable, eaten when better food is scarce	2.3
3	Good, generally browsed on	9
4	Very sought after, heavily grazed on	32

Red List species:
The entry from the Landolt list was taken for labelling red list species, together with its nomenclature as shown in Table CH.5.

Table CH.5 Red list codes.

Code	Red List nomenclature
EX	extinct
RE	regionally extinct
CR	critically endangered
EN	endangered
VU	vulnerable
NT	near threatened

Classes for data evaluation:

To allow grouping of plants, nitrogen and acidity sensitivity was grouped as shown in Table CH.6. The aim is to compare N and acidity groups after the model runs instead of single species.

Table CH.6 Groups of sensitivity to nitrogen and acidity.

N group	Landolt N class	sensitivity to N
1	1	high
2	2, 3	medium
3	4, 5	low
acidity group	**Landolt R class**	**sensitivity to acidity**
1	1	high
2	2, 3, missing	medium
3	4, 5	low

Soil-vegetation modelling for sites

Model setup:

The three soil chemistry-vegetation model chains VSD-Veg (version Salvan1105), VSD+Veg (version 3.6.1.2) and ForSAFE-Veg (version WKLWF1203; runs provided by S. Belyazid, C&C AB, Malmö, Sweden) were used to simulate the evolution of the soil chemistry and ground vegetation composition at 32 forest monitoring sites of the Institute for Applied Plant Biology (IAP, Schönenbuch). Input for the soil chemistry modelling was derived from a harmonized database, and flux data required by the VSD models (nutrient fluxes, weathering) were drawn from a MakeDep/SAFE simulation. All model runs were calibrated with respect to measured current base saturation (calibrated Gapon exchange coefficients), and VSD model runs were additionally calibrated regarding current organic carbon and nitrogen pools.

Soil solution chemistry:

Figures CH.1 to CH.3 summarize the evolution of selected parameters of the soil solution chemistry in the course of time at the 32 sites, and compare the time-series obtained from the three geo-chemical models using parameter ratios and Czekanowski (Cz) indices. The concentration and ratio graphs are plots of percentiles covering 80% of the values returned (lower level 10, upper level 90 percentile), while the Cz index expresses the similarity of two simulations of a parameter as one value per year. For the comparison, the multi-layer ForSAFE results were recalculated to annual root zone layer data by averaging the monthly moisture weighted soil layer averages.
Chloride and sulphate are treated as tracer ions (only hydrological processes considered) by the models and therefore soil solution concentrations are roughly in the same range, since deposition input is the same in all models. ForSAFE underestimates chloride and sulphate concentrations by on average 50% and 48% essentially as a result of differences in the modelled (ForSAFE) and input (VSD, VSD+) evapotranspiration. The Cz indices are correctly close to 1 for VSD and VSD+ chloride and sulphate predictions and range from 0.52 to 0.67, if ForSAFE time series are considered as reference.
Soil solution nitrate concentrations are extremely variable among the sites and in the course of time, and scatter over a range of up to almost 9 orders of magnitude. There are substantial model-dependent discrepancies in the predictions due to differences in the conceptualization and implementation of N-processes in the models. VSD returns particularly low nitrate concentrations in the early phase of the modelling, while the displayed 80% of the ForSAFE results fall between only 4 and 73 $\mu mol_c L^{-1}$. The low Cz indices also exemplify that solution nitrate concentrations simulated by the models are completely dissimilar.
Solution base cation concentrations range over 2 orders of magnitude (4 orders of magnitude if the total population is considered) and VSD+ returns the largest scatter. Weathering rate and deposition input is the same in VSD and VSD+ simulations, but cation exchange, as a function of the total solution chemistry, alters the solution base cation concentrations. VSD and VSD+ treat sodium as a tracer ion, its concentration only being driven by deposition, weathering and water fluxes, which are input and therefore equal in both model applications. In

Figure CH.1 Summary of modelled soil solution chemistry of 32 forest monitoring sites as obtained from applying VSD, VSD+ and ForSAFE (FS). Concentration ranges (column 1), site-specific ratios of parameter values from each of two models (column 2) and Czekanowski indices (CzI) of parameter value series from each of two models (column 3).

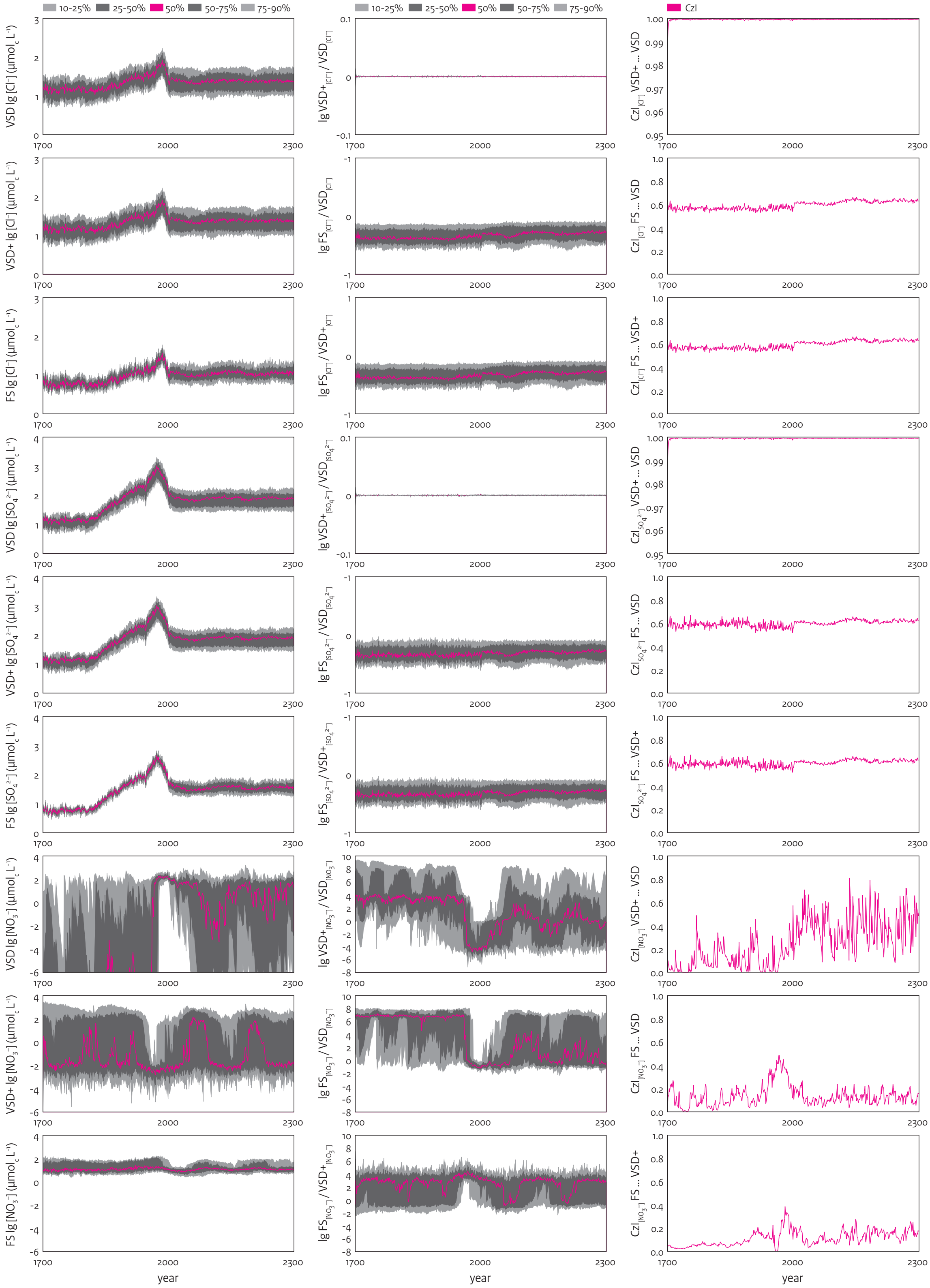


Figure CH.2 Continued from Figure CH.1.

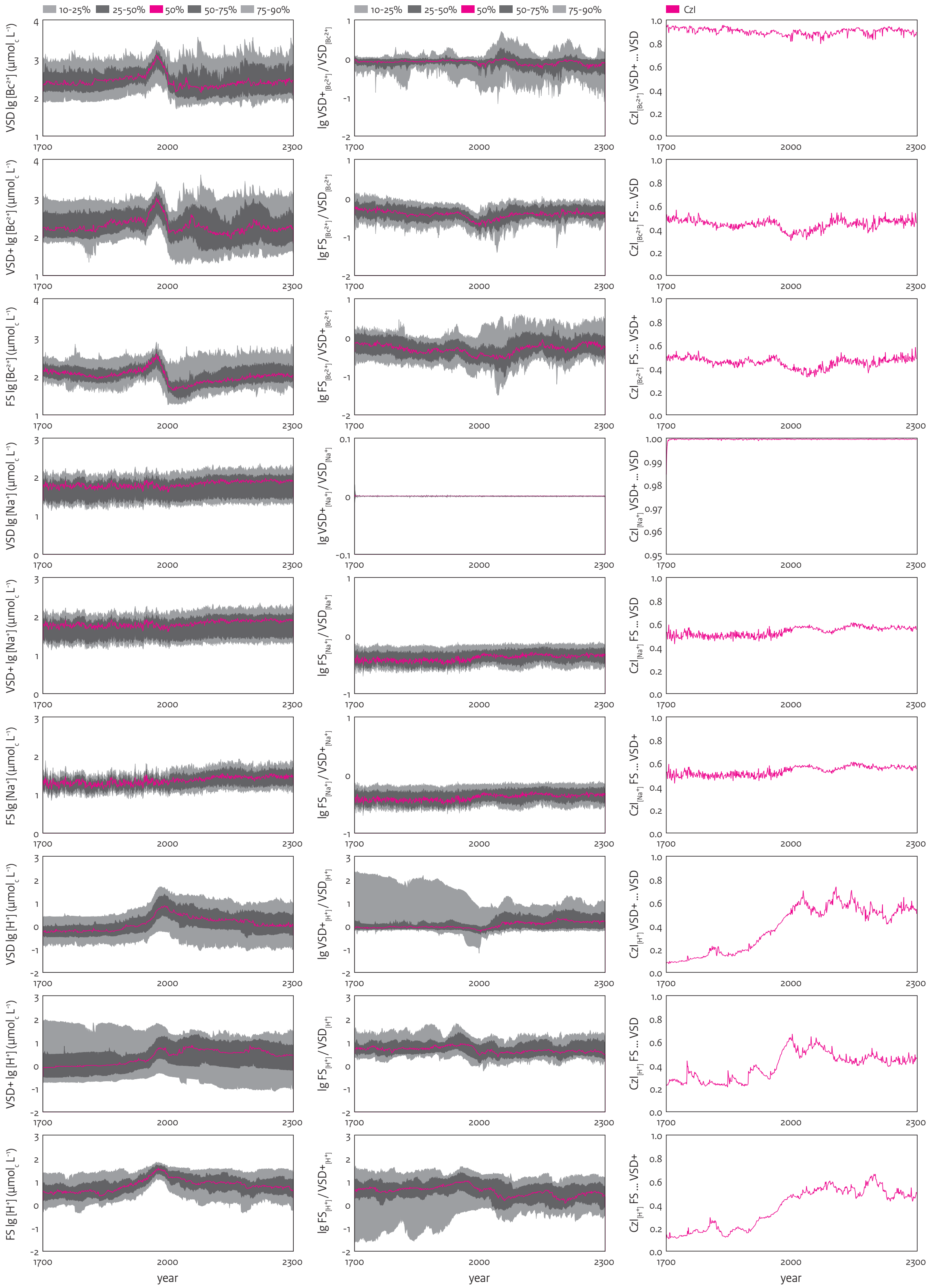
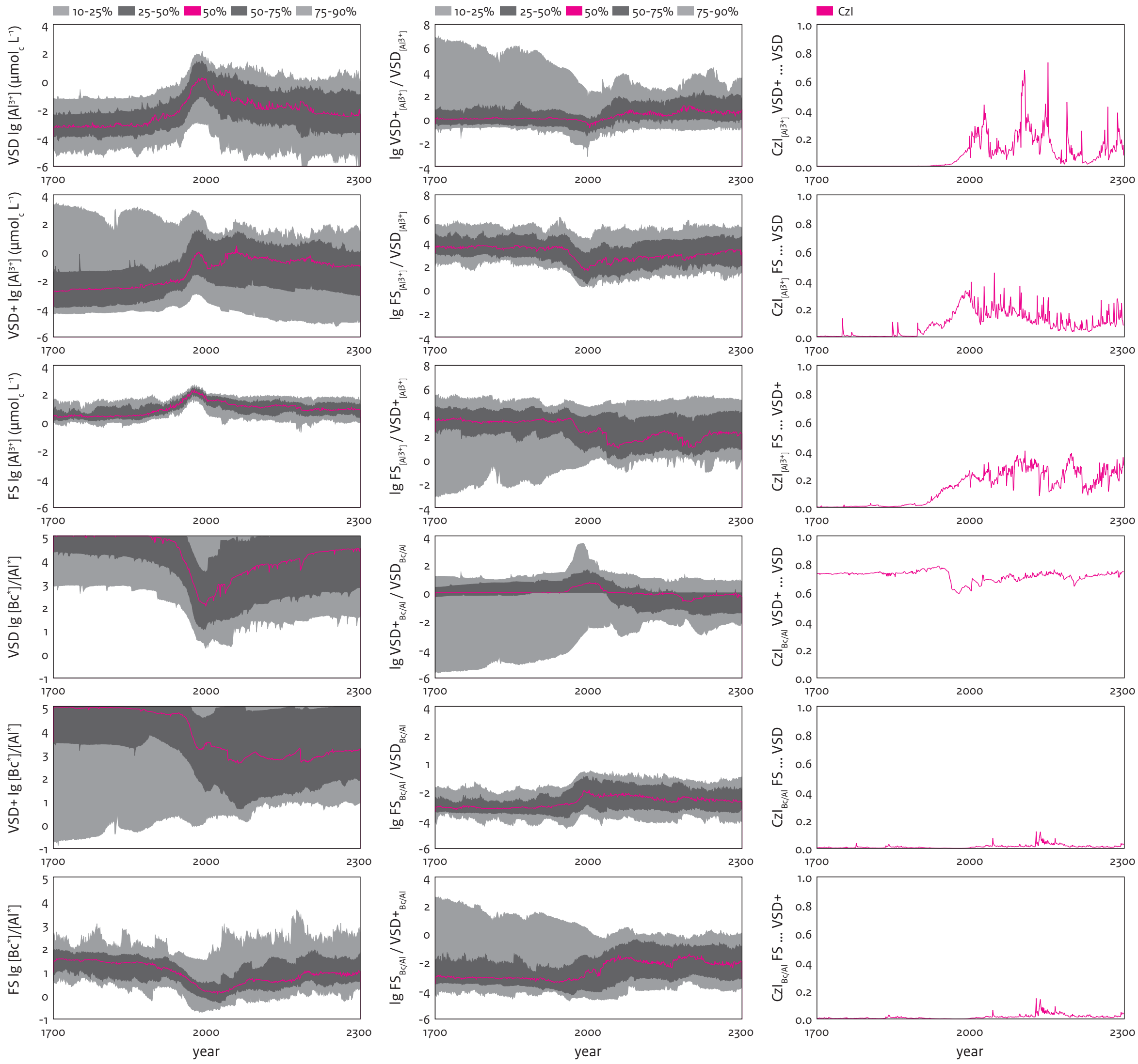


Figure CH.3 Continued from Figure CH.1.



ForSAFE the weathering flux is calculated within the model and the sodium concentrations are on average only 45% of the VSD and VSD+ predictions. This divergence is slightly larger than the previously observed deviation of tracer ions. Since ForSAFE compared to VSD and VSD+ also tends to underestimate solution base cation concentrations (which are however additionally conditioned by uptake and cation exchange), we suspect that weathering rates are somewhat lower in ForSAFE. Solution hydrogen and aluminium ion concentrations (as well as base cation to Al ratios (Bc/Al)) are internally calculated, mutually dependent and contingent on the concentrations of the other ions in solution. ForSAFE consequently predicts, as a result of elevated nitrate concentrations, generally higher hydrogen ion and Al concentrations and lower Bc/Al than VSD and VSD+. The discrepancies usually span several orders of magnitude and the obtained simulations are often completely dissimilar (low Cz indices).

The IAP monitors the soil solution composition at the 32 sites. Soil solution was usually sampled bi-weekly by means of lysimeters from up to 3 different soil depths. For the comparison with simulation data, for each ion the median concentration was calculated of both the annual model and the bi-weekly observation data for the site-specific monitoring period (maximum span from 1998 to 2008). To keep a certain consistency regarding soil compartment thickness, the measurements for the soil depth closest to the respective limit of the soil compartment used for modelling were taken.

The VSD models generally reproduce soil solution concentrations of chloride (Figure CH.4A) and sodium (Figure CH.4C) acceptably well, implying reasonable

Figure CH.4 Comparison of measured and modelled median ion concentrations in soil solution of the root zone of the 32 sites.

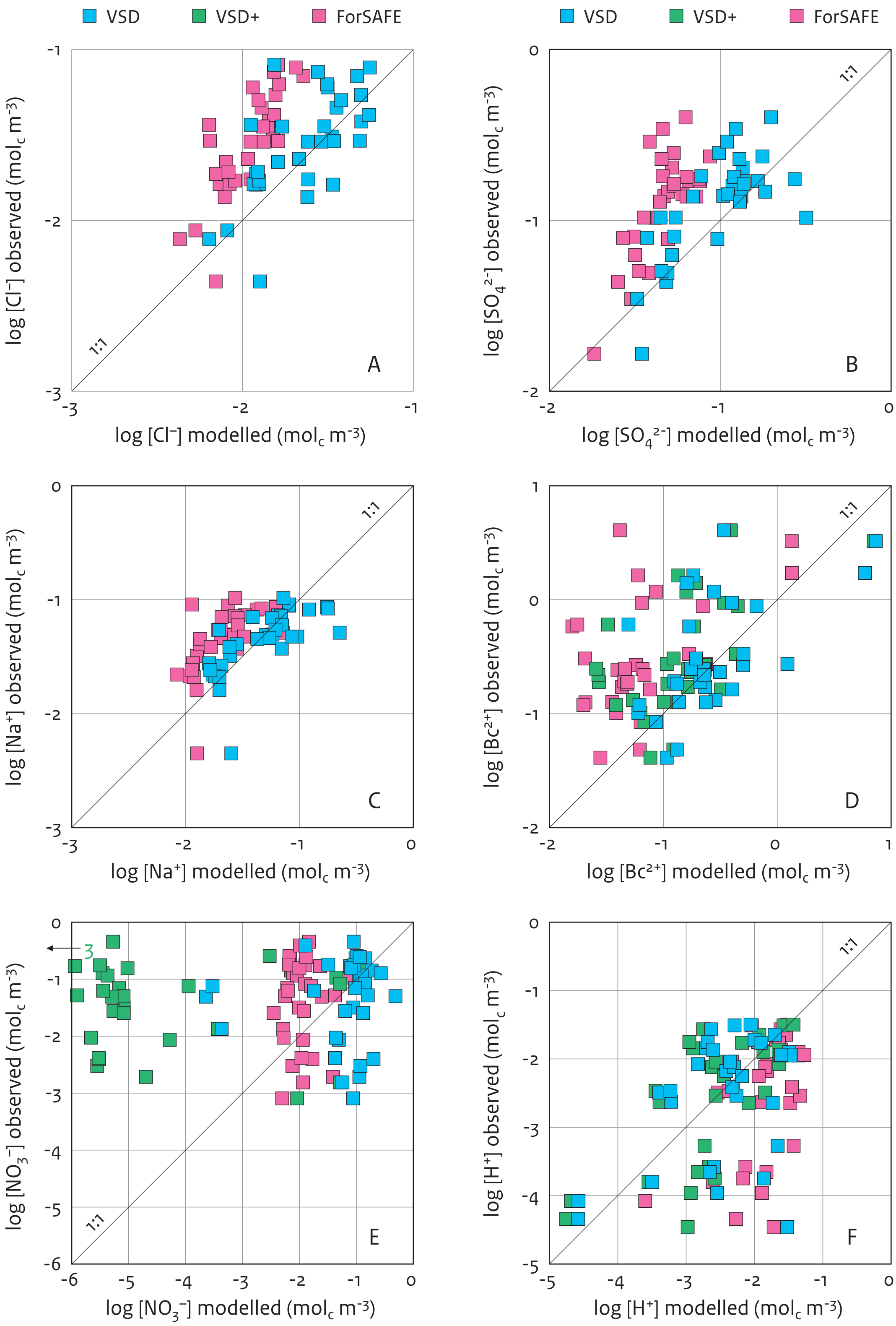


Figure CH.5 Similarity of measured and modelled ion concentrations in soil solution of the 32 sites illustrated by Czekanowski index classes: 0-0.2: red; 0.2-0.4: orange; 0.4-0.6: yellow; 0.6-0.8: green; 0.8-1.0: blue.

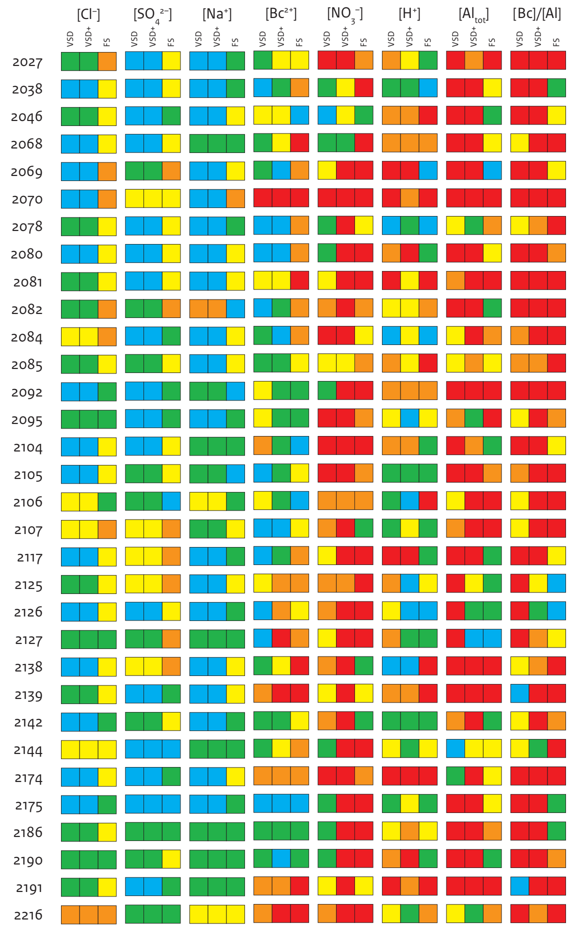
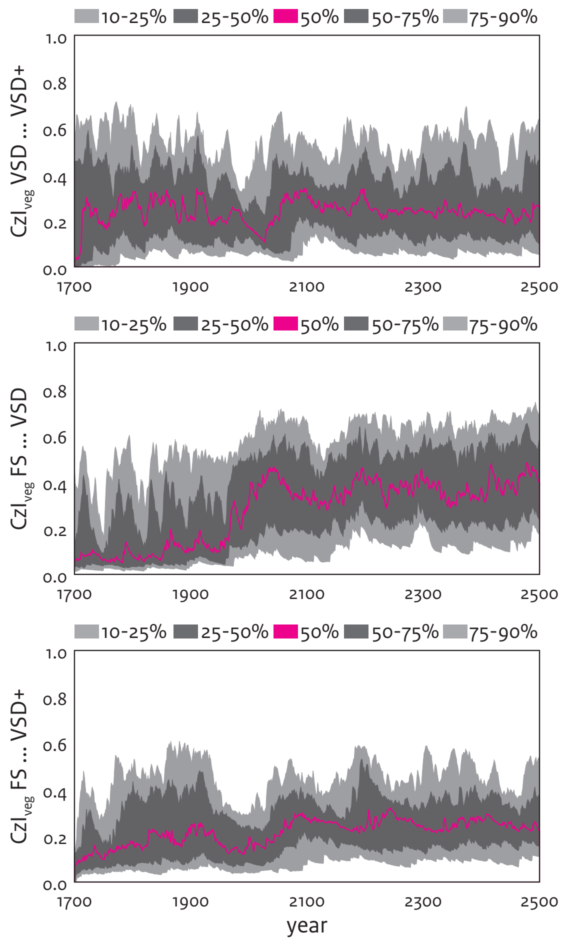


Figure CH.6 Similarity of VSD, VSD+ and ForSAFE (FS) simulations of the ground vegetation composition.



assumptions regarding hydrology, weathering and deposition fluxes of these ions. Sulphate concentrations (Figure CH.4B) are only slightly underestimated by these models either due to underestimated deposition input or due to sulphate sources in the soil being not considered in the modelling. ForSAFE generally underestimates the concentrations of the tracer ions (primarily as a result of comparably low evapotranspiration) but produces slightly less scatter than the VSD models.
Generally, more disorder is found with the base cation concentration (Figure CH.4D), the simulation of which is complicated by the consideration of additional processes such as cation exchange and nutrient cycling. While VSD results yet scatter along the 1:1-line, VSD+ and ForSAFE tend to underestimate base cation concentrations. Independent of the complexity of N-processes implemented, the correlation of modelled and measured nitrate concentrations still is insufficient (Figure CH.4E). VSD and ForSAFE return nitrate concentrations within a limited range of roughly 1 order of magnitude, while the measured concentrations stretch over 3 orders of magnitude. VSD+, on the other hand, predicts comparably too low nitrate concentrations. Discrepancies in the prediction of relevant soil solution ion concentrations also affect the calculated soil solution pH (as well as mutually dependent Al concentrations and molar base cation to Al (Bc/Al) ratios), which exhibits substantial deviation from measurements Figure CH.4F).

Figure CH.5 illustrates some details of the similarity of modelled and measured soil solution chemistry in terms of classified Cz indices calculated from annualized data of the measurement period. In general, we observe an acceptable agreement of measured and modelled concentrations of chloride, sulphate and sodium, some heterogeneity in the similarity of base cation concentrations and frequently substantial disagreement in modelled and measured concentrations of nitrate, hydrogen ion, Al as well as the Bc/Al ratio. Excluding Al and

Bc/Al due to the intrinsic incompatibility of measured and modelled total Al concentrations, VSD, VSD+ and ForSAFE results produce compared with measurements overall average similarity indices of 0.63, 0.58 and 0.48, respectively. The figure also reveals sites, for which the models reproduce the measured soil solution chemistry fairly well, e.g. site 2078 with an overall Cz index of 0.70, and sites where the models fail to reproduce the observations, e.g. 2216 or 2070 with index values of 0.38 and 0.35.

Forest ground vegetation:
Veg simulates the ground cover of a set of indicator plant species at a certain site and time in response to climatic (soil moisture, light and temperature) and geochemical conditions (N availability, base cation (Bc) availability and soil acidity). The parameterization of the plant specific response to the drivers was revised and amended within the scope of this contribution (see above). For the reconstruction of the ground vegetation composition, we used with all model chains the most actual national variant of the parameter table, version grundvegCH_120319.xls (B. Rihm, pers. comm.).
Given the modelled soil chemistry and the revised parameterization, the three model chains generate consistently very divergent ground vegetation compositions. The median Cz indices are mostly below 0.4 but may also fall to close to 0 (Figure CH.6). In an earlier comparison of ForSAFE-Veg and VSD-Veg vegetation output (Belyazid et al. 2011) it was shown that model-inherent technical differences lead to median Cz indices of roughly 0.8 (same sites, comparable amount of species), if VSD is run with input derived from ForSAFE runs. Any larger dissimilarity in the modelled vegetation (of these sites) is related to discrepancies in the drivers of Veg, which are output from the bio-geochemical models. At the current state we have indications that differences in ground-level PAR and differences in soil solution nitrate concentrations are the primary reasons for the discrepancies in the vegetation simulations.

As an alternative to analyzing (and plotting) the occurrence of every individual species considered in the modelling, we started to explore the potential of classifications regarding a more comprehensible presentation and interpretation of the Veg output. Figure CH.7 displays the pattern of the species occurrence after grouping of the species according to their indicator values for nitrogen and acidity (see above) and averaging of the group occurrences of the 32 sites.
The three models return a regional pattern of the ground vegetation acidity sensitivity being dominated by the group of plants with intermediate sensitivity. In ForSAFE-Veg runs, the share of insensitive plants slightly decreases in the course of time, and the share of very sensitive plants remains constantly low. Both VSD-Veg and VSD+Veg return a steadily increasing share of insensitive plants in the course of the simulation and contradictory trends of the share of sensitive plants. None of the model chains clearly indicates in its ground vegetation composition the peak of acidification in the 1980s, which is unambiguously indicated by the regional trends of the soil solution hydrogen ion concentration.
In the regional nitrogen indicator pattern obtained from ForSAFE-Veg also group 2 plants dominate and the share of group 3 plants increases steadily in the course of time. VSD-Veg and VSD+Veg return noisier N indicator pattern in accordance with strongly varying solution nitrate concentrations. VSD+Veg predicts decreasing shares of plants with high and low sensitivity to available N in favour of group 2 plants. Plants insensitive to available N dominate the VSD-Veg pattern particularly in the early phase of the simulation, although modelled solution nitrate concentrations are very low in this period, at least at 50% of the sites.

This is, however, not inconsistent with the single site behaviour as shown with the sample site 2175 (Figure CH.8). VSD-Veg predicts the dominance of *Alnus glutinosa*, *Robinia pseudoacacia*, *Alnus viridis*, *Vicia sepium* and *Trifolium repens* in phases with low nitrate concentration in the soil solution, and all these species, except *Vicia* (group 2), fall in nitrogen indicator group 3.

In view of the discussed findings, comparing modelled and observed ground vegetation composition still is somewhat provisional. The IAP assessed the ground vegetation composition in the field in the years 2003 to 2005 (S. Braun, pers. comm., Mar 2012) at 28 of the 32 sites. Figure CH.9 displays the scatter of observed and modelled values for all the species observed. For this comparison, we have set observed single species occurrence minima to 10^{-3} and truncated model occurrence at 10^{-5}.

Modelled species coverage often tends to be 1 to 2 orders of magnitude smaller than observed. This systematic bias is related to the number of species modelled, which is on average more than 10 times higher than the number of species observed (Table CH.7). A particular habitat, represented by the observed plant community, simply is populated by a larger number of (potentially occurring) species, which in turn reduces the coverage of each individual. The similarity of observed and modelled ground vegetation composition is also disturbingly low (Figure CH.10). Using the modelled species as population for the Cz index calculation, the resulting indices do hardly exceed 0.3 and fall mostly below 0.2. Considering only the observed species population entails an upward shift of the distribution by a maximum of 0.15 units. Despite that the drivers of Veg differ substantially and partly systematically

Figure CH.7 Trends of the occurrence of groups of modelled species classified according to their indicator values for acidity (left column) and nitrogen (right column). Group 1: high sensitivity; Group 2: medium sensitivity; Group 3: low sensitivity (for details see above).

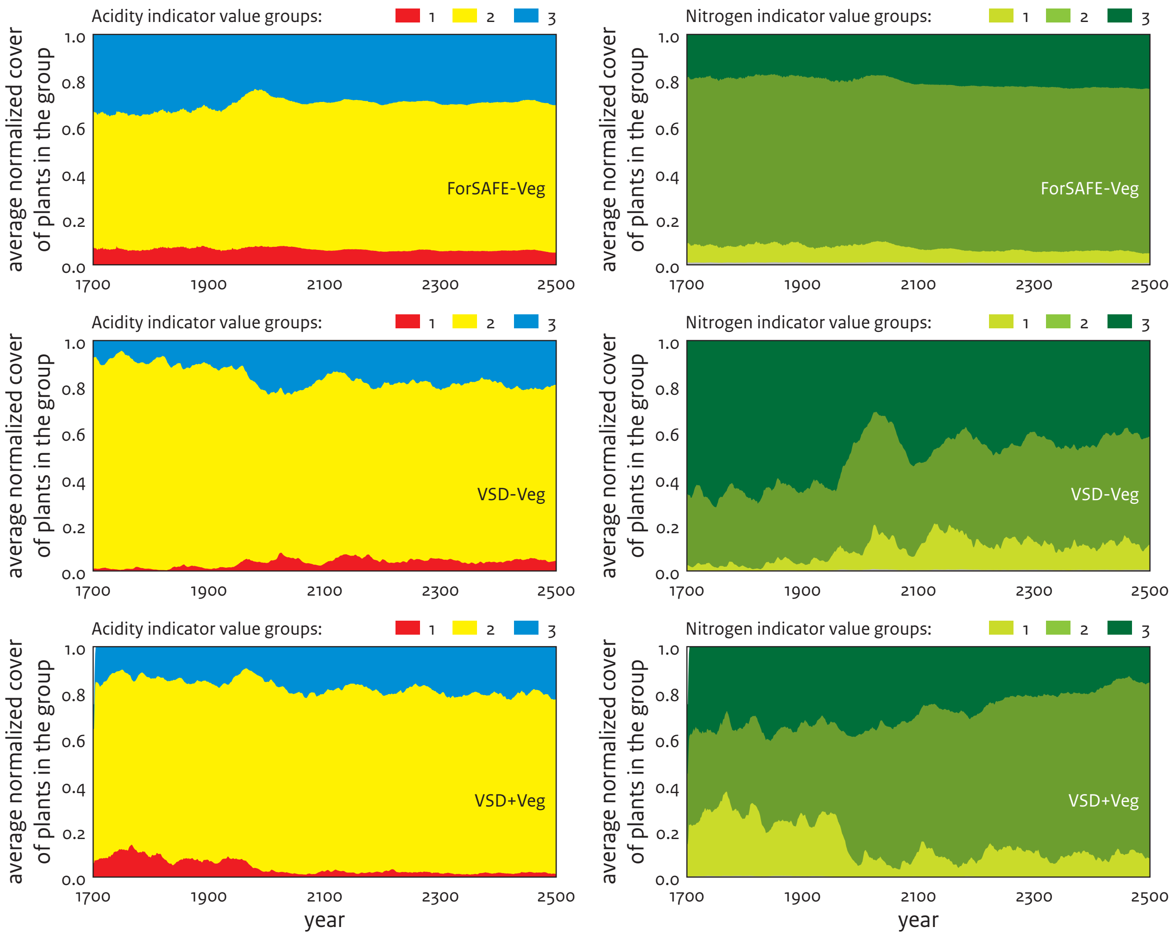


Figure CH.8 Evolution of the vegetation composition over time at site 2175 as simulated by VSD-Veg. Superimposed as white line is the nitrate concentration (mmol$_c$L^{-1}) and as grey line ground-level PAR (µmol m^{-2}s^{-1}).

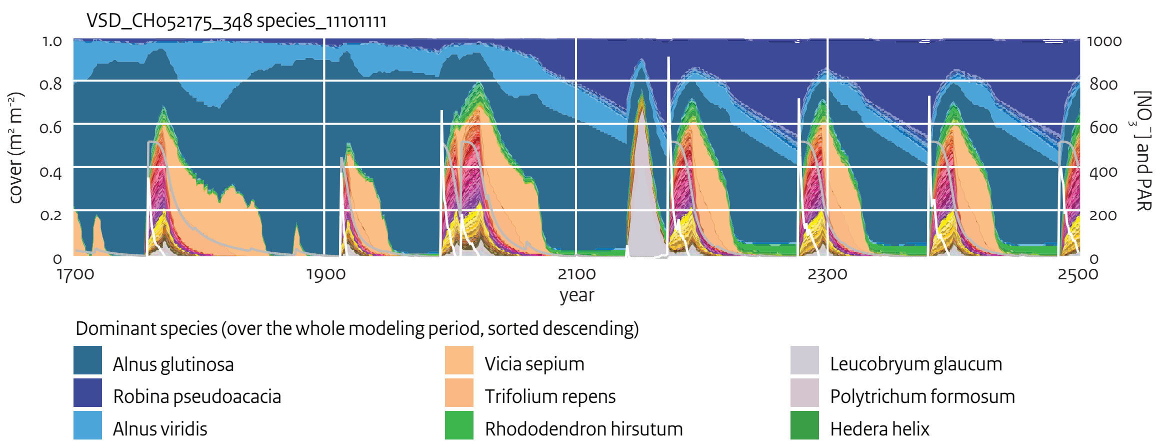


Figure CH.9 Modelled versus observed species occurrence at 28 plots. Every point, representing one observed species and its modelled coverage, obtained from VSD-Veg (VSD; blue), VSD+Veg (VSDP; green) and ForSAFE-Veg (FS; pink).

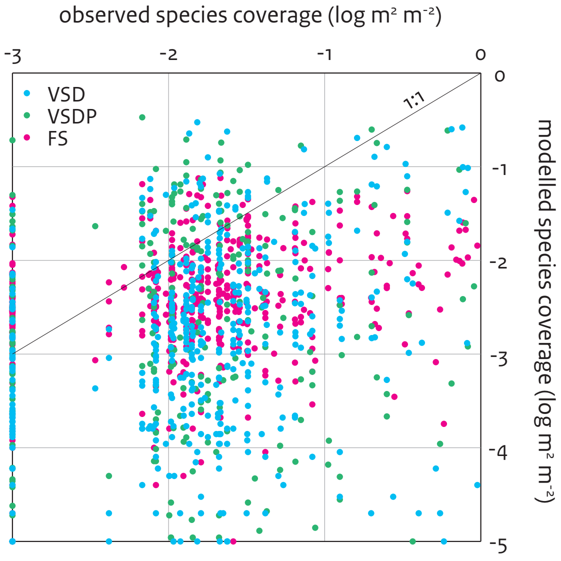


Table CH.7 Number of species observed (obs) and modelled in VSD-Veg, VSD+Veg and ForSAFE-Veg runs.

Site	Year	Species number			
		obs	VSD	VSD+	FS
2027	2005	7	264	121	277
2038	2003	16	337	200	288
2046	2004	28	270	105	282
2068	2003	48	282	118	267
2069	2003	23	306	163	225
2070	2003	21	123	147	272
2078	2003	17	88	105	265
2080	2003	19	190	148	211
2081	2004	11	78	119	263
2082	2004	18	90	147	286
2084	2003	27	119	124	264
2085	2003	16	342	101	244
2092	2003	5	145	137	280
2095	2003	15	131	132	188
2104	2003	18	232	132	239
2105	2003	22	284	146	277
2106	2003	27	288	95	169
2107	2003	18	203	122	285
2117	2004	27	130	117	275
2126	2003	8	99	132	182
2127	2003	12	130	121	264
2138	2003	26	305	160	217
2139	2003	5	133	150	209
2144	2003	9	114	121	185
2174	2004	22	318	222	263
2190	2003	24	171	106	180
2191	2003	27	135	98	265
2216	2005	8	137	143	242

among the three model chains, the divergence of the three distribution functions of the ground vegetation similarity indices is surprisingly small.

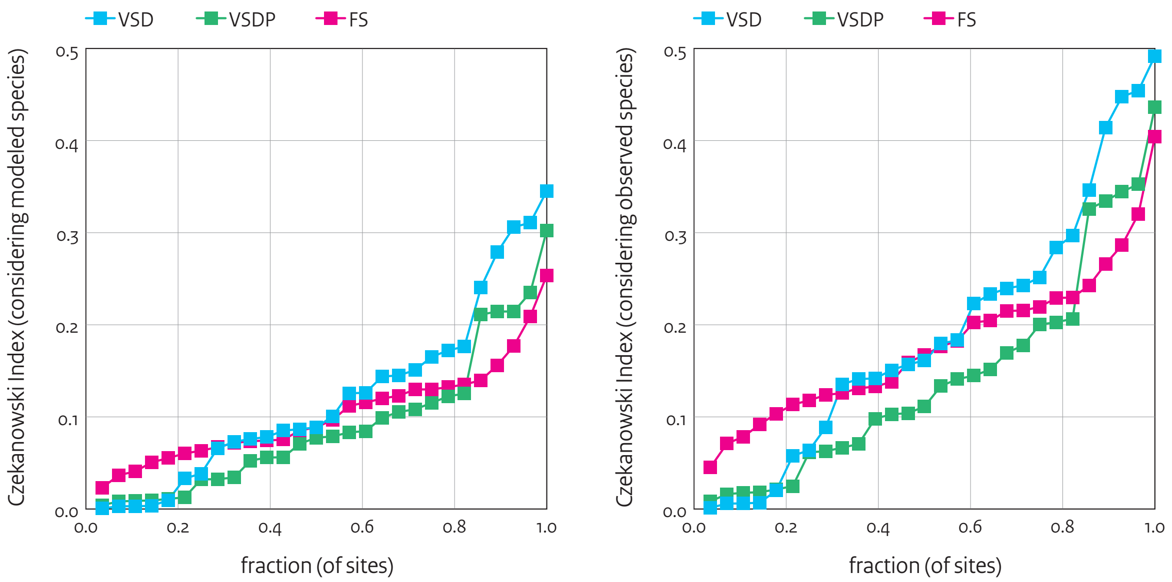
Regionalized soil-vegetation modelling

For the purpose of regionalization in Switzerland, the dynamic models could be run on a larger dataset covering another 250 forest soil profiles. At those sites, there are no measurements or floristic relevés to validate the model results. This means, model runs will only make sense with relatively robust model versions, which produce reliable results.

For assessing the extent of the forest area represented by the modelling sites the Swiss forest area (~12,000 km²) could be stratified according to environmental parameters such as topography, geology, climate, deposition and/or according to ecosystem classes such as EUNIS; the modelling results at the sampling sites would then be projected to the entire forest area by weighting with the size of the respective spatial stratum.

A stratification based only on EUNIS classes of the second level (G1 deciduous, G3 coniferous, G4 mixed forest) does not differentiate sufficiently the existing ranges of environmental parameters in Switzerland. Higher level EUNIS classes for forests (5th and 6th classes) are available in approximately 10 cantons covering less than 25% of the country. Therefore, the EUNIS classification is currently of limited relevance for regionalization at a national level.

Figure CH.10 Distribution of Czekanowski indices of modelled and observed ground vegetation composition at 28 plots using different model variants for the simulation of the ground vegetation composition.



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Appendix A: Instructions for Replying to the Call for Contribution

This appendix is a reprint of the last version of the instructions sent to the National Focal Centres following a letter announcing the 2011/12 Call for Contributions.

1. Introduction

This document contains the instructions for the call for information issued by the CCE as considered by the Working Group on Effects (ECE/EB.AIR/WG.1/2011/2)

The call consists of the following parts:

1. Your NFC report with the **endpoints** of interest of your country that relate to critical loads and a **National Report** of your contribution (for inclusion in the CCE Status Report)
2. Complete sets of input data to the **soil-vegetation** model runs carried out **for your sites**
3. Results of **soil-vegetation** model runs **for ecosystem (EUNIS) types**
4. In case you have updated your critical loads data, you are invited to submit the **updated tables** according the instructions from the 2011 Call for Data

2. Deadline and other general information

- **Deadline** for submissions is 12 March 2012.
- Submissions of **site-specific data** for testing soil-vegetation model runs are welcome as soon as possible, to enable cross-country and/or cross model comparisons.
- For soil-vegetation modelling the deadline is not the finish; you are encouraged to continue testing each others sites and assisting colleagues, culminating in the Training Session at the CCE workshop in Warsaw, 16-19 April.
- Please email your **contribution** to jaap.slootweg@rivm.nl. The data can be attached to the email, but large data files can also be uploaded to ftp://ftp.rivm.nl/cce/incoming/ using ftp. After you have used ftp to submit your data, please don't forget to inform Jaap Slootweg by an email.
- All information is also available on our website www.rivm.nl/cce/ under ***News***. It is suggested to look there occasionally for updates.

3. Endpoints

At its 10th COP meeting (Nagoya, 29 October 2010) the CBD strategic plan for biodiversity 2011-2020, which is the basis for the EU biodiversity strategy to 2020, identified 5 strategic goals for biodiversity (including the so-called "AICHI targets"[1]). For Europe, the EU specified six 2020-biodiversity targets[2].

NFCs are invited to indicate which targets, indicators and indices their application of dynamic models (with respect to the change of plant species diversity) is addressing. Indicators include EU's SEBI2010 indicators as well as indicators and indices as described in chapter 5 of CCE Status Report 2010. NFCs are encouraged to summarize their response in the Excel Table '*Anx1_BiodivTargets_vs_SEBI.xls*' and elaborate on their biodiversity targets, indicators and indices in their National Report.

With the material made available by the CCE you will find the Excel-file called '*Anx1_BiodivTargets_vs_SEBI.xls*' The sheet '*Biod.targets vrs. SEBI2010 ind*' contains the matrix of the biodiversity targets from the EU biodiversity strategy to 2020 (by row) and the SEBI 2010 indicators (by column). Please use the cells in this matrix for referencing to your national activities, e.g., by numbers that are explained further in your National Report, where you can describe the methodology and/or indicator/indices that will or could by applied.

4. Soil-vegetation modelling for sites

At the 2011 CCE workshop there were requests to make progress on several issues:

- Comparison of simulation results for sites of different countries, and using the latest versions of model chains,
- Testing biodiversity indices, and
- Extending species lists involved in the vegetation modelling.

To facilitate such comparisons, and to submit VSD+Veg data of sites you should use the Access Database Application (ADAcc) developed by the CCE. This software has the following features:

- Import a VSD+-file; referenced files with e.g. deposition data series will automatically imported as well.
- Call MetHyd, Bayesian calibration, and VSD+Veg. The results are stored in the database.

The ftp-site *ftp://ftp.rivm.nl/cce/outgoing/NFCsites/* is still valid; it contains the latest version of ADAcc with all available sites incorporated.

NFCs are still encouraged to:

- Apply VSD+Veg and/or any other soil-vegetation model combination and submit the data, including the list of species applied, the reference species composition and the species probability/possibilities. In the case of applying Veg you may have extended and/or altered the **vegetation species list**, including Veg parameters. All versions of the vegetation lists will contribute to the comparisons and eventually to an improved European list.
- Apply VSD+Veg over a simulation period towards a target year for which you have site specific information, in order to compare simulated to monitored species diversity.
- Validation of model combinations (VSD+Veg Studio as provided with this call or your own model for simulating soil-vegetation dynamics) could include the comparison between current and historic species. (Ecological) explanations for the differences and updates/extension of the **European vegetation species list** are valuable contributions.

5. Regionalised soil-vegetation modelling

Let's start testing regionalised application on the basis of the EUNIS classification… This part of the Call is not yet fully prepared. There will be an Access-version of MetHyd/VSD+VEG, with the feature to import complete data sets for a site as described under point 4. This section of the instructions will be extended as soon as the Access version is ready. Meanwhile NFCs are encouraged to develop methods for regionalization and compilation of data for representative sites of the relevant EUNIS classes.

6. Documentation

The main part of the documentation should be on the endpoints (to be) applied in your country. Also provide the CCE with documentation to substantiate and justify sources and methods applied in response to this call for contributions and results of your application of soil-vegetation models.

[1] http://www.cbd.int/sp/targets/

[2] COM(2011) 244 final: http://ec.europa.eu/environment/nature/biodiversity/comm2006/pdf/2020/1_EN_ACT_part1_v7[1].pdf

In case of a critical load update description, and only list the data sources and describe the **deviations** from the Mapping Manual (www.icpmapping.org).

The CCE reporting requirements are currently best served by sending a Word document with a plain single-column layout. Please avoid complicated formatting of your text, tables and figures: E.g., no special fonts; also, figure captions should be plain text and not part of the figure! The final layout will be done by the CCE.

You are encouraged to structure your contribution with respect to a possible update (a section “Methods and Data”), relevant endpoints for you and how they relate to critical loads (“Endpoints”) and testing of soil-vegetation modelling (“Evaluation of modelled vegetation changes”).

M. Posch | J. Slootweg | J.-P. Hettelingh (eds)

Report 680359004

Emission levels of air pollutants in 2020 under the revised Gothenburg protocol will still lead to excessive nitrogen deposition putting more than 40 percent of Europe's nature at risk. This report also describes progress in quantifying net loss of biodiversity.

National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

LRTAP
Long-range Transboundary Air Pollution

éclaire
Effects of climate change on air pollution impacts
and response strategies for European ecosystems

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