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Preface

The Coordination Centre for Effects (CCE) located at MNP, commissioned the Institute of Environmental Sciences, Leiden University (CML) to (a) further harmonize European landcover data from CORINE and the Stockholm Environment Institute for use under the LRTAP Convention and (b) extend the European background database on critical loads of the CCE with empirical critical loads for nitrogen. This information is compared to inputs from National Focal Centres under the International Cooperative Programme on Modelling and Mapping. The aim is to increase the robustness and cross-border consistency of information in the European database on critical loads. Results of this study were presented at this year's CCE-workshop (Sofia, 23-25 April 2007). The research had been carried out by Nancy de Bakker (Chapter 1 and 2) and Maarten van 't Zelfde (Chapter 3 and 4) under supervision of Wil Tamis at CML, and Jaap Slootweg and Jean-Paul Hettelingh at the CCE. Roland Bobbink (University of Utrecht) and Arjan van Hinsberg (MNP) are gratefully acknowledged for the discussions about the necessity and possibility to adapt available empirical critical loads.

Wil Tamis
Leiden, 30 June 2007

Summary

The Coordination Centre for Effects (CCE) developes modelling and mapping methodologies and databases on European critical loads. This includes collaboration with and the use of data from 27 National Focal Centres (NFCs) in Europe on critical loads and related variables (as e.g. ecosystem type). CCE deliverables become available for integrated assessment models that are used for the support of air pollution abatement policies under the LRTAP-Convention and under the European Commission. In order to further harmonize the input of the NFCs European data on critical loads for nitrogen and distribution of ecosystems have been compared with the national input from the NFCs.

This report describes results of work that is conducted to extend the European database on *modelled* critical loads with *empirical* critical loads for nitrogen based on Achermann & Bobbink (2003). Empirical critical loads are based on scientific knowledge on effects of nitrogen enrichment on ecosystems, in contrast to modelled critical loads which are based on soil properties and steady-state mass balances. The list of ecosystem types for which an empirical critical load had been determined by Achermann & Bobbink (2003) was matched with the list of all ecosystem types provided by the NFCs and European land cover information. Empirical critical loads are lacking or not yet available for a large number of ecosystem types. The necessity and possibilities to derive and diversify additional information on empirical critical loads are evaluated and where possible adaptations are presented.

A harmonized European land cover map, based on information of the Stockholm Environment Institute and the CORINE database (SEI-map), was tailored for the production of a European empirical critical load map. A tentative comparison has been made between the distribution of forest ecosystems according to NFC data and the SEI-map. From the comparison of both maps it appeared that for a number of countries there are relatively large differences in the forest surfaces, although the spatial distribution of the forest are similar. A second comparison has been made between the critical loads from the NFCs and the empirical critical loads from the SEI-map. When the modelled critical loads of the NFCs are compared the empirical critical loads from the SEI-map, it appeared that there is a reasonable agreement between the two sources and that differences can be explained by the fact that NFCs generally use *lower* CLs. As expected, there is a good correspondence between the empirical critical loads assigned by the NFCs and the SEI-map.

The results of the comparison of critical loads and ecosystem classes between NFCs and the SEI-map will be communicated by the CCE to the NFCs, which might contribute to further harmonization of the input of the NFCs.

Samenvatting

Het “Coordination Centre for Effects” (CCE) van het MNP ontwikkelt modellen en databases voor de bepaling van kritische waarden voor atmosferische depositie. Voor dit doel werkt het CCE nauw samen met – en verzamelt het gegevens van 27 National Focal Centres (NFCs) in Europa met betrekking tot “critical loads” (CL) en verwante relevante informatie (zoals ecosysteem type). Het CCE voert berekeningen hiermee uit en produceert databases voor geïntegreerde modellen voor de ondersteuning van het luchtbeleid onder de LRTAP-Conventie en onder de Europese Commissie.
Om de levering van de gegevens door de vele verschillende NFCs verder te kunnen harmoniseren zijn nationale gegevens van de NFCs vergeleken met nieuwe Europese gegevens van CL voor stikstof en van voorkomen en verspreiding van ecosystemen.

Dit rapport beschrijft resultaten van werk om de Europese database van berekende critical loads uit te breiden met empirische critical loads (eCL) voor stikstof gebaseerd op Achermann & Bobbink (2003). Emprische CL zijn gebaseerd op wetenschappelijke kennis over effecten van verrijking met stikstof op ecosystemen, in tegenstelling tot berekende CL die afgeleid worden op basis van bodemtypes en “steady- state” massa balansen. De lijst met ecosysteemtypen waarvoor een eCL is bepaald door Achermann c.s. is vergeleken met de lijst met ecosysteemtypen van de NFCs en de nieuwe Europese verspreidingskaart van ecosystemen. Empirische CL ontbreken of zijn nog niet beschikbaar voor een groot aantal ecosysteemtypen. De noodzaak en mogelijkheden voor aanvullende, meer verfijnde informatie van eCLs wordt behandeld en uitgewerkt.

Er is een nieuwe Europese verspreidingskaart van ecosystemen gemaakt, die is gebaseerd op gegevens van het Stockholm Environment Institute (SEI) en informatie van de CORINE database, waarbij gebruik is gemaakt van de EUNIS-ecosysteem classificatie, hierna de SEI-kaart genoemd. De SEI-kaart is gebruikt om een Europese kaart van empirische critical loads te compileren.

Op de eerste plaats is een vergelijking gemaakt tussen de NFCs en de SEI-kaart, wat betreft het voorkomen en verspreiding van ecosystemen. Dit was alleen mogelijk voor het ecosysteem type bossen. Uit de vergelijking van beide kaarten blijkt dat voor een aantal landen relatief grote verschillen zijn in de oppervlakte aan bossen, maar het ruimtelijke patroon van bossen in beiden kaarten overeenkomt. Vervolgens is er een vergelijking gemaakt tussen de CL van de NFCs en de eCl van de SEI-kaart. Als de berekende CL van de NFCs worden vergeleken met de eCL, dan is er voor een deel van de landen een redelijke overeenkomst. Verschillen kunnen worden verklaard door het feit dat sommige NFCs *lagere* CL-s gebruiken. Er is, zoals te verwachten, een goede overeenstemming tussen de eCLs van de NFCs en die van de SEI-kaart.

De resultaten van de verschillende vergelijkingen van (e)CL en type en oppervlakte van ecosystemen zal ondermeer door het CCE worden gecommuniceerd aan NFCs, ter ondersteuning van een verdere harmonisatie van de inbreng van de NFCs.

1 Introduction

1.1 Nitrogen deposition and its effects

Emissions of nitrogen as ammonia and nitrogen oxides have strongly increased in Europe in the second half of the 20^{th} century. While ammonia is mainly emitted by intensive agriculture, nitrogen oxides derive mainly by burning of fossil fuels, traffic and industry. Both by wet and dry deposition these nutrients become available for plants in the direct surroundings or further away from the source all around the world. The effects of nitrogen not only become visible via acidity, an important recognized problem since the early 1980s, but also via enrichment. This may lead among others to eutrophication, increased sensitivity to secondary stresses and increased leaching of nitrate from soils (references in: Bouwman *et al.* 2002). For ecosystems these effects become visible via biomass increases, shifts in species composition, increased sensitivity to parasites, etc. (Achermann & Bobbink, 2003).

1.2 LRTAP Convention

The problems of increased nitrogen emission and deposition do not only act on a national scale alone, but also across national borders. Recognition of the consequences of this transboundary air pollution by the UN Economic Commission for Europe (UNECE) led to the development of the Convention of Long-range Transboundary Air Pollution (LRTAP). The aim is that parties try to limit and, as far as possible, gradually reduce and prevent air pollution (UNECE, 2007). One of the International Cooperative Programmes (ICPs) of LRTAP is on Modelling and Mapping of Critical Levels and Loads and Air Pollution Effects, Risks and Trends (ICP M&M). This ICP provides information on critical loads and levels, development and application of methods for effect-based approaches and on modelling and mapping of present status and trends of impacts of air pollution. The Coordination Centre for Effects (CCE), Bilthoven, The Netherlands is the data centre of this ICP. It collects and collates data of National Focal Centres (NFCs) on critical loads and related variables, applies ICP calculation methods and generates data bases available for integrated assessment models (CCE, 2007).

1.3 Critical loads

Since the attention was drawn on the effects of 'acid rain' on forest die back in the 1980s, atmospheric deposition was an important international scientific topic of interest. An important concept is the critical load of chemical compounds as e.g. sulphur and nitrogen. Critical load is defined a quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to the present knowledge (Nilsson & Grennfelt, 1988). Since then, several methods have been developed to estimate the critical loads per ecosystem (De Vries *et al.,* 2006). In the procedures developed within LRTAP two types of critical loads are being used: 1) critical load (CLs) based on soil properties and steady-state mass balance methods and 2) empirical critical loads (eCLs) based on scientific knowledge on effects of nitrogen enrichment on ecosystems. The critical loads for different ecosystem types are assigned by the national focal centres (NFC). For the habitat descriptions the EUNIS habitat classification (Davies *et al.,* 2004) is used.

However, there are differences between countries in the type of data they provide (e.g. the of EUNIS levels, the amount of habitat types covered, etc.). Also differences may arise when applying mass based critical loads or empirical critical loads.

1.4 Harmonization and validation

The CCE commissioned this study to improve its data verification capabilities and to further enhance cross border consistency of ecosystem specific inputs of NFCs. For this two types of European data are being used. First, a European map of EUNIS-ecosystems produced in collaboration with the Stockholm Environment Institute (SEI), including data from CORINE is used: The SEI-map. Secondly, European empirical critical load data are being applied for a limited number of EUNIS-habitats. The Institute of Environmental Sciences, Leiden University, The Netherlands (CML) was asked to verify the data of the NFCs by comparing the NFC-input with information on European land cover map and with European empirical critical loads assigned to land cover categories.

The general aim of this project is:

To compare the present used EUNIS classifications and critical loads of the National Focal Centres (NFCs) with the European land cover data and empirical critical loads. This may form a basis for a more harmonized data input of future CCE-calls for data on nutrient N from NFCs.

This general aim leads to the following steps:

- Adaptation of the European empirical critical loads to the EUNIS-classes of the SEI-map (Chapter 2);
- Production of SEI-map and conversion to empirical critical load map (Chapter 3);
- Comparison of the EUNIS habitat classes of individual areas on the SEI-map and on the maps of the NFCs (Chapter 4);
- Comparison of the critical loads from the NFCs with the European empirical critical loads derived from the SEI land cover map (Chapter 4).

The comparisons of EUNIS habitat classes and critical loads are reported for those countries that are a member of the LRTAP *and* provided data on critical loads on acidity and eutrophication to the CCE. An overview of those countries is listed in table 1.

Table 1: Overview of European countries which have National Focal Centres that produce datasets on critical loads of acidity and eutrophication *and* are member of LRTAP

Austria	Finland	Poland
Belarus	France	Russia
Belgium	Hungary	Slovakia
Bulgaria	Ireland	Slovenia
Croatia	Italy	Spain
Cyprus	Latvia	Sweden
Czech Republic	Lithuania	Switzerland
Denmark	Moldova	Ukraine
Estonia	the Netherlands	United Kingdom
Germany	Norway	

2 Adaptation of European empirical critical loads for EUNIS habitat classes of the SEI land cover map

2.1 Existing and European empirical critical loads

Until 2006 the NFCs have calculated critical loads for acidity and eutrophication, based on soil properties and steady-state mass balance methods (Posch *et al.,* 2005). In the CCE-call of voluntary data of 2006 NFCs have also been asked for the first time to deliver empirical critical loads for nitrogen. These empirical critical loads (eCls) are based on Achermann & Bobbink (2003) and were derived from scientific studies or expert knowledge on the effects of long term (at least 2-3 years) increased nitrogen deposition on the structure and function of natural and semi-natural ecosystems. For the descriptions of ecosystems the EUNIS habitat classification (Davies *et al*., 2004) was used. The empirical critical loads are presented as ranges (in kg N/ha.yr).

Not for all EUNIS habitat types eCLs are available, since no or not yet enough published scientific studies exist from which eCLs could be derived (Bobbink, personal comment 2007). No additional literature studies were conducted to fill gaps in missing eCl values for other EUNIS codes. For forest systems Dorland & Bobbink (2005) prepared eCL data, however these have to be approved yet in an expert workshop. During this project Dr. R. Bobbink was consulted to discuss possibilities for the application and differentiation of empirical critical load ranges.

2.2 Adaptation of eCls for EUNIS-classes on the SEI land cover map

To convert the European empirical critical load data to the land cover codes distinguished on the SEI-map (see Chapter 3), four steps are recognized:

1. check consistency of used EUNIS codes on SEI-map;
2. check necessity and availability of empirical Critical Loads (eCLs) for EUNIS classes distinguished on SEI-map;
3. analyse and study application of differentiation of the eCL ranges according the general relationships mentioned in Achermann & Bobbink (2003);
4. analyse possibilities to adopt eCLs for present SEI-EUNIS codes without eCLs.

2.3 Check the consistency of applied EUNIS codes on SEI land cover map

In this first step the EUNIS codes and descriptions from the SEI-map (see for full details of production of this map Chapter 3) were compared with the EUNIS classification by Davies *et al.* (2004). On this SEI-map EUNIS-codes were applied, except for forests and agricultural lands. In most cases second level EUNIS-codes or combinations of these codes were used, while for grasslands EUNIS-classes E1 and E2 combinations of third level codes were used. All coastal habitats are grouped to the first EUNIS class (B). Forest were coded on the SEI-map according SEI codes from a former EUNIS version (1000 till 1072, 2000 till 2270 and 3000 till 3177), though those had already been preliminary grouped in second level EUNIS classes G1, G3 and G4 according to the most recent EUNIS classification. Agricultural land, other than grassland, was coded I1 by SEI with numbers 1-1031, of which the numbers refer to the dominant crop that was cultivated on the agricultural land. These agricultural codes were grouped for this project in EUNIS class I1 (Arable land and market gardens).

In this project two numeric classifications have been used to describe all present EUNIS codes on second and on third level in the SEI-map and in the data delivered by the NFCs (see Annex 2). These classifications have to be created because the SEI-map contains also codes which are combinations of EUNIS classes, like ‘A3 or A4’. The classification on the second level makes it possible to compare the EUNIS-codes of the SEI-map with the EUNIS-codes in the NFC-dataset. The classification on the third level will be used for the assignment of empirical critical loads. Annex 2 contains the overview of the classes in the second level and third level numeric EUNIS-classification present on the SEI-map.

2.4 Check of necessity and availability of eCLs for EUNIS-classes on SEI-map

To check the necessity and availability of eCLs for the EUNIS classes on the SEI land cover map the following sources were used:

- the overview of the EUNIS codes on the SEI-map (the result from Step 1);
- the report with the descriptions of the EUNIS classes by Davies *et al.* (2004);
- the overview with available eCLs per EUNIS class by Achermann & Bobbink (2003).

The EUNIS classes distinguished on the SEI land cover map are presented with the short habitat description in Table 2. For each of these EUNIS code the necessity for considering this habitat in CL analysis was evaluated by assessing the descriptions of the EUNIS class (Davies *et al.* (2004). E.g. the A3/A4 EUNIS class in the SEI land cover map is described as Infra- and Circalittoral rock and other hard substrata. These habitats are variable saline, dominated by kelp, seaweed or animals and variable influenced by wind, tidal streams and wave action. We considered that probably little effect of nitrogen enrichment via nitrogen deposition will occur in these habitat types. All Coastal habitats on the SEI land cover map are grouped in EUNIS class B. This class on the SEI map therefore combines among others the unvegetated coastal dunes and sandy shores, with coastal dune heaths and dune slacks, coastal shingles, soft and rock cliffs. For most classes, though not all (e.g. B1.1 and B3.2), CL analysis is recommended. However, this distinction is not possible on the SEI land cover map. EUNIS class C3 refers to littoral zones of inland surface water bodies. Nitrogen enrichment may also affect these habitats.
In Table 2 the necessity for CL analysis of each EUNIS habitat from the SEI map is represented; ‘-’ refers to the habitats for which CL analysis is not necessary (e.g. A3/A4); ‘+/-’ refers to habitat class for which part of the habitats are sensitive to nitrogen enrichment and should be considered in CL analysis (e.g. B); ‘+’ refers to habitats that are probably nitrogen sensitive and CL analysis are recommended (e.g. C3).

In addition, the availability of empirical Critical Loads (eCLs) for the present EUNIS codes[1] on the SEI land cover map was examined. The empirical Critical Loads from Achermann & Bobbink (2003) were used (Annex 1). In Table 4 the availability of any eCL information for this EUNIS habitat is represented by ‘+’ (= available), ‘-’ (= not available) or ‘+/-’; which refers to available eCL information for part of the on the SEI map used EUNIS codes. When eCLs information is available for a EUNIS class that is identical to the EUNIS class distinguished on the SEI land cover map, the eCL ranges are

[1] Please note that the EUNIS table was revised and the version of 21-07-2005 was used in this report. The code A2.6 from Achermann & Bobbink (2003) coincides with A2.5 in the revised report.

applied and reported in bold black figures in Table 2. For other classes eCl information is available for only part of the EUNIS class from the SEI land cover map (e.g. an eCl is known for the third level EUNIS, while second or first level EUNIS is on the SEI map). The eCLs from Achermann & Bobbink (2003) are often set to sensitive ecosystems and these systems are often only a small representative of the whole second or first level EUNIS class. Evaluation of the appropriate eCL range for these EUNIS habitats form the SEI land cover map and adoption of eCL values is discussed in paragraph 2.4. Besides, for some other EUNIS classes no eCLs are available from Achermann & Bobbink (2003).

Table 2. Overview of EUNIS vegetation classes distinguished on the SEI land cover map and information on necessity for CL analysis, availability and ranges of empirical Critical Load. Necessity for CL analysis and availability of eCL is represented by: - = no; + = yes and +/- = for part of the EUNIS class. Bold black eCL ranges are based on identical EUNIS classes reported by Achermann & Bobbink (2003), grey values represent eCL (ranges) adopted from known eCL information based on expert knowledge. In the most right column the source of the eCL range and/or additional comments are represented (B2002: Achermann & Bobbink., (2003) and EUNIS code).

EUNIS CODES SEI MAP	SHORT DESCRIPTION (DAVIES *ET AL.* 2004)	NECESSITY FOR CL ANALYSIS	IS ECL INFORMATION AVAILABLE	ECL RANGE (KG N/HA.YR) MIN	MAX	BASED ON / REMARK:
A1 or A2 without A2.5	Littoral rock/sediment and other hard substrata without A2.5	-	-			
A2.5	Coastal saltmarshes and saline reedbeds	+	+	**30**	**40**	B2002: A2.54; A2.55
A3 or A4	Infra- and Circalittoral rock and other hard substrata	-	-			
A3 or A4 or A5	Infra-, littoral rock, sediments and other hard substrata	-	-			
A5	Sublittoral sediment	-	-			
B	Coastal habitats	+/-	+/-	ND (10)	ND	
C1	Surface standing waters	+	+/-	ND (5)	ND	* eCl class C1.1 (or C1.16) not representative for C1
C2	Surface running waters	+	-	ND	ND	* not enough background information
C1 or C2	Surface standing and running waters	+	+/-	ND (5)	ND	* eCl class C1.1 (or C1.16) not representative for C1/ C2
C3	Littoral zone of inland surface water bodies	+	-	ND	ND	* not enough background information
D1	Raised and blanket bogs	+	+	**5**	**10**	B2002: D1
D2 or D4	Valley mires, poor fens, transition mires or base-rich fens, calcareous spring mires	+	+	**10** **15** **15**	**20** **35** **25**	B2002: D2.2; B2002: D4.1; B2002: D4,2
E1 without E1.2, E1.7,	Dry grasslands without E1.2, E1.7, E1.8, E1.9, E1.A	+	-	15	25	* all base-rich vegetation types;

EUNIS CODES SEI MAP	SHORT DESCRIPTION (DAVIES *ET AL.* 2004)	NECESSITY FOR CL ANALYSIS	IS eCL INFORMATION AVAILABLE	eCL RANGE (KG N/HA.YR) MIN	MAX	BASED ON / REMARK:
E1.8, E1.9, E1.A						therefore eCL adopted from B2002: E1.26
E1.2	Perrenial grasslands and basic steppes	+	+/-	15	25	* variety of wetness in class E1.2; best estimate eCL of subclass B2002: E1.26
E1.7 or E1.9	Non-Mediterranean dry acid and neutral grassland	+	+	**10**	**20**	B2002: E1.7; E1.94; E1.95
E1.8 or E1.A	Mediterranean dry acid and neutral closed/open grassland	+	-	15	20	* value adopted high value range temperate equivalent B2002: E1.7; E1.94; E1.95
E2 without 2.3	Mesic grasslands without E2.3	+	+/-	20	30	* value adopted from E2.2, though different habitats are represented by E2
E2.3	Mountain hay meadows	+	+	**10**	**20**	B2002: E2.3
E3	Seasonally wet and wet grasslands	+	+/-	ND (10)	ND	* trophic gradient in E3; eCl E3.51 and E3.52 not appropriate for whole E3
E4	Alpine and subalpine grasslands	+	-	5	15	B2002: E4.2; E4.3; E4.4
E5	Woodland fringes and clearings and tall forb stands	+	-	ND	ND	* diverse vegetations affected by agriculture or saline influences
F1	Tundra	+	+	**5**	**10**	B2002: F1
F2	Arctic, alpine and subalpine scrub	+	+	**5**	**15**	B2002: F2
F4	Temperate shrub heathland	+	+	**10** **10**	**20 (25)** **20**	B2002: F4.11; B2002: F4.2
F5 or F6	Maquis, arborescent matorral and thermo-Mediterranean brushes or Garrigue	+	-	ND	ND	* not enough background information
F9	Riverine and fen scrubs	-	-			
G2000..2279 (G1)	Broadleaved deciduous woodland	+	+	**10**	**20**	B2002: comb. forest layer, dependent on the process of interest
G1000..1072 (G3)	Coniferous woodland	+	+	**10**	**20**	
G3000..3177 (G4)	Mixed deciduous and coniferous woodland	+	+	**10**	**20**	
H3	Inland cliffs, rock pavements and outcrops	-	-			
H4	Snow or ice-dominated habitats	-	-			
H5	Miscellaneous inland habitats with no or sparse vegetation	-	-			
I1	Arable land and market gardens	-	-			
I2	Cultivated areas: gardens/parks	-	-			
J	Constructed, industrial and other artificial habitats	-	-			

2.5 Analyse and study of differentiation of the range

The third step describes the analysis and the study of the application of differentiation of the eCL ranges according the general relationships, mentioned in Achermann & Bobbink (2003). They described several factors which may lead to differentiation within the eCL ranges for non-wetland systems (EUNIS classes E, F and G; Table 3). There is not a specific order of importance for these factors (Bobbink, personal comment 2007), though the factors act at different scales. For differentiation of the eCL ranges on an European scale not all factors can be used here. Management activities, or P limitation act on smaller, more local scales. For NFCs this specific information is or could be available and can be used by them. Other factors like temperature or base-cation availability are applicable on larger scales and can therefore be used to differentiate the ranges on European scale.

Table 3. Overview factors differentiation eCL range non-wetland systems (Achermann & Bobbink, 2003).

Action	Temperature / frost period	Soil wetness	Base-cation availability	P limitation	Management intensity
Move to lower part	COLD/LONG	DRY	LOW	N-LIMITED	LOW
Use middle part	INTERMED	NORMAL	INTERMED	UNKNOWN	USUAL
Move to higher part	HOT/NONE	WET	HIGH	P-LIMITED	HIGH

Table 4. Overview of differentiation of the available eCL ranges for non-wetland systems cross the biogeographical regions (Cultbase, 2005). * For forests (G) an eCl is available, though the height of the eCl is dependent of the process.

<table>
<tr><th></th><th>Alpine North</th><th>Boreal</th><th>Nemoral</th><th>Alpine South</th><th>Continental</th><th>Pannonic</th><th>Atlantic North</th><th>Atlantic Central</th><th>Mediterranean mountains</th><th>Mediterranean North</th><th>Lusitanian</th><th>Mediterranean South</th></tr>
<tr><td>EUNIS class gr. seas. (days)</td><td>130</td><td>157</td><td>196</td><td>220</td><td>227</td><td>250</td><td>255</td><td>296</td><td>298</td><td>335</td><td>353</td><td>363</td></tr>
<tr><td>D2 or D4</td><td colspan="5">10-15</td><td colspan="7">15-20</td></tr>
<tr><td>E1 without E1.2, E1.7, E1.8, E1.9, E1.A</td><td colspan="5">15-20</td><td colspan="7">20-25</td></tr>
<tr><td>E1.2</td><td colspan="5">15-20</td><td colspan="7">20-25</td></tr>
<tr><td>E1.7 or E1.9</td><td colspan="5">10-15</td><td colspan="7">15-20</td></tr>
<tr><td>E1.8 or E1.A</td><td colspan="12">15-20</td></tr>
<tr><td>E2 without 2.3</td><td colspan="5">20-25</td><td colspan="7">25-30</td></tr>
<tr><td>E2.3</td><td colspan="5">10-15</td><td colspan="7">15-20</td></tr>
<tr><td>E4</td><td colspan="5">5-10</td><td colspan="7">10-15</td></tr>
<tr><td>F1</td><td colspan="12">5-10</td></tr>
<tr><td>F2</td><td colspan="5">5-10</td><td colspan="7">10-15</td></tr>
<tr><td>F4</td><td colspan="5">10-15</td><td colspan="7">15-20</td></tr>
<tr><td>G1 (2000..2279)</td><td colspan="12">ND*</td></tr>
<tr><td>G3 (1000..1072)</td><td colspan="12">ND*</td></tr>
<tr><td>G4 (3000..3177)</td><td colspan="12">ND*</td></tr>
</table>

To differentiate the eCL range for non-wetland habitat across Europe by application of differences in temperature/frost period we propose to use biogeographical regions as a first step. From these biogeographical regions information (Cultbase, 2005) is available, among other on the length of the growing season, as a proxy for long winters and frost periods. Table 4 shows the different biogeographical regions with the average length of the growing season. The empirical critical loads are differentiated linearly in ranges of 5 kg $N \cdot ha^{-1} \cdot yr^{-1}$ over the biogeographical regions according the length of the growing season. In general, this leads to a division of the range in two groups (Figure 1).

The subranges of 5 kg $N \cdot ha^{-1} \cdot yr^{-1}$ were chosen, since no better accuracy can be obtained as several factors affect the eCl for a specific habitat. A more accurate decision for differentiation could be made when several factors are used. On European scale application of base cation availability, in addition to temperature/frost period would enhance the decision for differentiation. For forests the eCLs are not divided in two subgroups, since the eCL range of 10-20 is dependent on the (biological) process one focuses on for nitrogen sensitivity.

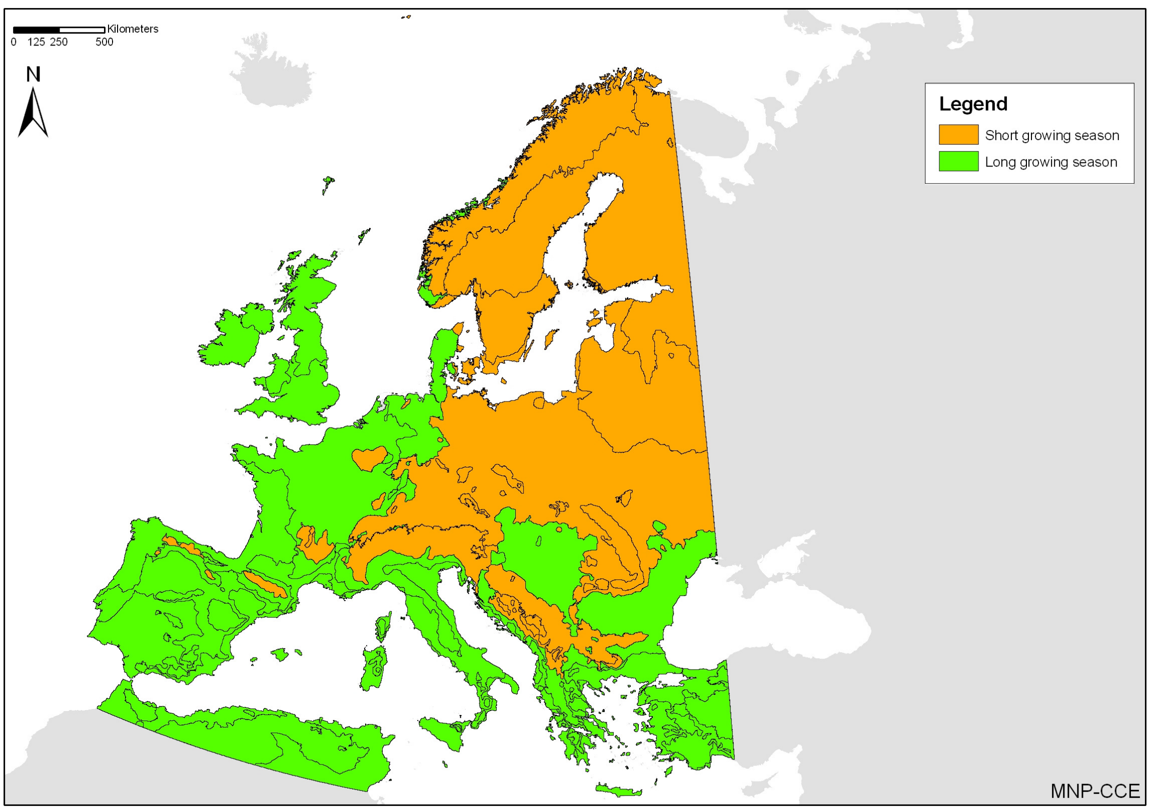

Figure 1. Overview of two groups of biogeographical regions across Europe (Cultbase, 2005).

2.6 Analysis of possibilities to derive missing eCLs

The last step is the analysis of the possibilities for derivation of missing eCLs for a number of SEI-EUNIS codes. From Table 2 it is clear that there exist gaps in the knowledge on the eCLs for almost all EUNIS classes. Achermann & Bobbink (2003) remarked that there is limited knowledge on the effects of enhanced nitrogen enrichment for specific habitat types, especially for steppe grassland, all Mediterranean vegetation types, wet-swamp forests, many types of mires and fens, several coastal habitats and high altitude systems. However, also for other vegetation types additional information is needed to be able to apply eCLs on the SEI-map.

For some EUNIS classes eCL ranges are available, but also complications arise because on the SEI-map some EUNIS classes were grouped with other EUNIS classes for which no eCL is available or necessary. Based on expert knowledge we filled the gaps by adoption of eCLs from comparable systems, or adopting the values from a third level EUNIS group within the EUNIS class. In adopting eCLs we apply the precautionary principle. From an conservation point of view it is recommended to apply the lowest eCL available to protect also the more sensitive habitat types. Therefore, we advise to choose the lowest eCL value. For each adopted value, the motivation is added below and shortly commented in Table 2.

Additional information on the assignation of eCL ranges from Table 2 is given here:

Inland surface waters (EUNIS class C)

- We choose not to set an eCL range for waters of C1. The known eCL (Achermann & Bobbink, 2003) is only assigned to permanent oligotrophic waters (C1.1) and to a subgroup of these waters (C1.16). These water types are only a small representative of the whole C1 level, while other C1-waters have generally a higher nutrient availability. One could choose to set the eCl range based on the most sensitive system (here C1.1), however this is probably a too low estimate for most waters. Setting a higher value for the C1 level would result in an inaccurate value for the waters within the C1 level belonging to C1.1.
- For surface running water and the litoral zone of these water, C2 and C3, respectively, no eCl could be set due high variability of systems within these groups.

Mires, bogs and fen habitats (EUNIS class D)

- On the SEI land cover map the grouped EUNIS classes 'D2 or D4' are distinguished. For both D2 and D4 eCL information is available from scientific research. However, it is impossible to discriminate between D2 (poor fens) or D4 (rich fens) on the SEI-map. Since many of these systems are vulnerable for N-enrichment, we suggest to use the lowest eCL range for the combined group.

Grasslands and tall forb habitats (EUNIS class E)

- On the SEI-map the EUNIS second EUNIS level E1 was split in the following classes: 'E1 without E1.2, E1.7, E1.8, E1.9, E1.A', 'E1.2', 'E1.7 or E1.9' and 'E1.8 or E1.A'. Only for 'E1.7 or E1.9' eCL information is available.
  - The subgroup of dry grasslands, 'E1 without E1.2, E1.7, E1.8, E1.9, E1.A' on the SEI-map consists mainly of base-rich soils. High base cation availability lowers the vulnerability for nitrogen enrichment (table 2). For E1.26, a subgroup of the

base-rich groups within E1, an eCL is known. Therefore, we adopt the eCL of E1.26 for the whole 'E1 without E1.2, E1.7, E1.8, E1.9, E1.A group' on the SEI-map.

  - For E1.2, the eCl from the E1.26 is the best estimate, therefore this eCL was adopted.
  - The systems E1.8 or E1.A are Mediterranean equivalents of E1.7 or E1.9. For the latter systems an eCL was set. In general Mediterranean systems have longer growing seasons and higher temperatures compared to temperate systems. Therefore nutrient turn-over rates are higher. The eCL for the Mediterranean systems E1.8 or E1.A, distinguished on the SEI land cover map, was therefore set on the high end of the range of the eCL for E1.7 or E1.9.
- The mesic grasslands grouped under 'E2 without E2.3' are often cultivated by men. They contain lowland and montane mesotrophic and eutrophic pastures and hay meadows of the boreal, nemoral, warm temperate humid and mediterranean zones, but also sports fields and agricultural improved and reseeded grasslands (Davies *et al.* 2004). The eCL from 'E2.2 low and medium altitude hay meadows', is not the best representative for the whole E2 group. However, no better eCL information is available, therefore this eCL range was adopted for this whole group.
- No eCl was set for E3. Within 'E3: Seasonally wet grasslands' a gradient of nutrient availability exists. E3.51 and E3.52, for which eCLs were set by Achermann & Bobbink, (2003), represent oligotrophic systems and are not representative for whole E3. Other systems in this group are generally more eutrophic or Mediterranean (i.e. potentially higher eCL due to higher nutrient turnover and longer growing seasons).
- In E5 woodland fringes and clearings and tall forb stands many different circumstances (nutrient availability and wetness) are grouped. In addition, no eCl information is available for this class. Therefore no eCl was set.

Heathland, scrub and tundra habitat (EUNIS class F)

- For F4 eCLs are distinguished on the second and third level. F4 represents wet, dry and macaronesian heaths. The macaronesion have probably higher eCl values than wet and dry heaths for which eCls are known. However, across Europe wet and dry heaths are more present. Since no different classes within F4 can be distinguished on the SEI-map, we suggest setting the eCL for this habitat type to the lowest eCL range for the combined group.

In some cases no appropriate eCL range could be adopted. For some EUNIS classes for which CL analysis is sensible, one could, however, choose to add the minimum value of the available eCL information for this class. A maximum eCL can, however, not be set. Absence of any eCLs will result in no evaluation for exceedance of nitrogen deposition of a habitat at all, though it is to some level sensitive to nitrogen deposition (Dr. Hettelingh, personal comment 2007). The minimum eCL-values are added in brackets in Table 2.

2.7 Comparison with methodology of SEBI-project

On 22 November 2006 the methodology of adaptation of the European empirical critical loads to EUNIS classes of the SEI-map and the differentiation of the eCl ranges across Europe was discussed with A. van Hinsberg, RIVM, Bilthoven, the Netherlands. Van

Hinsberg is working at the National Focal Center of the Netherlands and has done a comparable analysis for Dutch habitats as part of the SEBI-project. The approach of applying empirical critical loads to EUNIS classes of the SEI-map and the differentiation of the eCL ranges across Europe was comparable between our and the SEBI-project.

The NFCs have more detailed information available on different habitats than are present on the SEI-map. In addition to the eCls from Achermann & Bobbink (2003), A. van Hinsberg applied also the formulated eCLs from Dorland & Bobbink (2005). To differentiate within the eCl ranges in the Netherlands Van Hinsberg applied a model in which temperature difference, hydrology, soil properties, etc were put. The outcome of this model determined the height within the eCl range. The approach followed in this project is comparable. Application of the forest eCLs from Dorland & Bobbink (2005) in this study would improve the result only slighty, since only limited EUNIS classes are described. However, these eCLs have not yet been set officially. The use of biogeographical regions, as a basis for temperature differences across Europe is a good alternative approach. Adding base-cation availability would enhance the possibility to differentiate the eCl range more accurately. Good maps on temperature/frost period and soil properties are available at CCE. Van Hinsberg also formulated the wish to differentiate eCL ranges in smaller steps, to stimulate the use of empirical critical loads across NFCs in Europe. However, since several factors influence the prevailing eCl for a specific habitat, an exact value for a specific biogeographical region is inappropriate. In addition, these eCLs are based on scientific research that has a certain variation.

3 Production of a European land cover and critical load map

3.1 General

First the existing national ecosystem classification from the NFC is described in section The basic data from SEI for the European land cover map are the subject of section 3. In section 4 the production of the European land cover map is described in detail. In the final section the main subject is the production of a European critical load map based on the European land cover map and empirical critical loads for the ecosystems (Chapter 2).

3.2 Existing NFC-data on ecosystem classification

The NFC data on ecosystem classifications (and critical loads) used for the comparison (in Chapter 4) were available from the data base of the CCE. The data were obtained from different calls. Dependent of the country the NFCs provided data on habitats according to different levels of the EUNIS classification. Not all countries provide data on all habitat types. Often only data on forest vegetation (EUNIS class G and subclasses) was supplied. Some countries only supplied data on the first, other on the second, third level or more detailed EUNIS level. Table 5 represents an overview of the (most recent) EUNIS classes (to the second EUNIS level) that are reported by the countries in 2006.

3.3 Basic data for the European land cover map

The basis for land cover data is the harmonized SEI land cover map (abbreviated to SEI-map), created under the LRTAP-convention. Maps per country, additional data and updates were provided by the Stockholm Environment Institute (SEI) in York. In a forth-coming chapter produced by S. Cinderby c.s. in 'European Critical loads and Dynamic Modelling: CCE Progress Report 2007' (edited by: J. Slootweg, M. Posch, J.-P. Hettelingh), the production of those basic data will be described in detail.

For their map SEI used the land cover codes from the European Nature Information System habitat classification (EUNIS) (Davies *et al.,* 2004). The EUNIS classification is a hierarchical typology of the habitats in Europe and its adjoining seas. The classes on the SEI-map mainly correspond to the second EUNIS level (e.g. D1, F1, etc). However, also vegetation types grouped to the first EUNIS level (e.g. B for all coastal habitats), combination of different EUNIS levels (e.g. A1 or A2 without A2.5), or a classification to the third EUNIS level were used. On the SEI-map forests (EUNIS class G) kept their former code version, but a preliminary classification to a second level EUNIS classes was in addition provided by S. Cinderby of SEI. Table 6 gives an overview of the EUNIS habitat classes distinguished on the SEI-map. See also § 2.3.

Table 5. Overview of first en second level EUNIS classes distinguished by the different NFCs. Countries with (*) distinguished (some) EUNIS classes to a lower level.

EUNIS CODE		AT - Austria (*)	BE - Belgium	BG - Bulgaria	BY - (Belarus*)	CH - Switzerland (*)	CY - Cyprus (*)	CZ - Czech republic	DE - Germany (*)	DK - Denmark	EE - Estonia	ES - Spain	FI - Finland	FR - France (*)	GB - United Kingdom	HR - Kroatia	HU - Hungary	IE - Ireland	IT - Italy (*)	LV - Latvia	MD - Moldova	NL- the Netherlands (*)	NO - Norway	PL - Poland	RU - Russia	SE - Sweden	SK - Slovak Republic
A	2						+		+													+					
	4																		+								
B	1								+					+	+				+			+					
	3																		+								
C	1					+							+		+				+			+	+			+	
	2														+												
	3								+										+								
D	D				+						+																
	1					+								+	+							+					
	2					+			+					+								+					
	4					+			+					+								+					
	5								+																		
	6								+																		
E	E		+		+																+						
	1					+	+		+						+				+			+					
	2								+										+			+					
	3					+			+						+			+	+			+					
	4					+			+					+	+				+								
F	F		+																								
	2					+			+										+								
																			+								
	4								+						+			+				+					
	5						+												+								
	7						+												+								
	9								+																		
G	G		+		+	+										+							+				
	1	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+		+	+	+	+		+		+	+
	2						+							+					+								
	3	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+		+	+	+	+
	4	+	+		+	+		+	+		+	+		+	+			+	+	+					+	+	

Table 6. Overview of the EUNIS classes distinguished in the SEI-map.

EUNIS CODES	EUNIS description
A1 or A2 without A2.5	Littoral rock and other hard substrata or Littoral sediment without Coastal saltmarshes and saline reed beds
A2.5	Coastal salt marshes and saline reed beds
A3 or A4	Infralittoral rock and other hard substrata or Circalittoral rock and other hard substrata
A5	Sublittoral sediment
A3 or A4 or A5	Infralittoral rock and other hard substrata or Circalittoral rock and other hard substrata or Sublittoral rock
B1, B2 or B3	Coastal habitats
C1	Surface standing waters
C2	Surface running waters
C3	Littoral zone of inland surface water bodies
C1 or C2	Surface standing waters and surface running waters
D1	Raised and blanket bogs
D2 or D4	Valley mires, poor fens and transition mires or Base-rich fens and calcareous spring mires
E1 without E1.2, E1.7, E1.8, E1.9, E1.A	Dry grasslands without perennial grasslands and basic steppes or Non-Mediterranean dry acid and neutral closed grassland or Non-Mediterranean dry acid and neutral closed grassland or Mediterranean dry acid and neutral open or closed grasslands
E1.2	Perennial grasslands and basic steppes
E1.7 or E1.9	Non-Mediterranean dry acid and neutral closed grassland or Non-Mediterranean dry acid and neutral closed grassland
E1.8 or E1.A	Mediterranean dry acid and neutral closed grassland or Mediterranean dry acid and neutral open grassland
E2 without 2.3	Mesic grasslands without Mountain hay meadows
E2.3	Mountain hay meadows
E3	Seasonally wet and wet grasslands
E4	Alpine and subalpine grasslands
E5	Woodland fringes and clearings and tall forb stands
F1	Tundra
F2	Arctic, alpine and subalpine scrub
F4	Temperate shrub heathland
F5 or F6	Maquis, arborescent matorral and thermo-Mediterranean brushes or Garrigue
F9	Riverine and fen scrubs
G3	Coniferous woodland
G1	Broadleaved deciduous woodland
G4	Mixed deciduous and coniferous woodland
H3	Inland cliffs, rock pavements and outcrops
H4	Snow or ice-dominated habitats
H5	Miscellaneous inland habitats with very sparse or no vegetation
I1	Arable land and market gardens
I2	Cultivated areas of gardens and parks
J	Constructed, industrial and other artificial habitats

3.4 Production of the European land cover map

The basic data of SEI, viz the individual land cover maps, was first converted to the special numeric EUNIS classification on second level (see Annex 2). Bigger countries were delivered in parts. An automated procedure has been developed to convert the delivered shape files to ArcGrid raster files with 100 meter resolution in EMEP-projection. This procedure uses special software JP-Solution written by Jaap Slootweg (Visual Basic) which can run scripts in loop-mode by country or by part of a country. These scripts create PYTHON scripts which can perform several ARC-GIS 9.1 methods and functions. The scripts are described in Annex 3 (in Dutch).

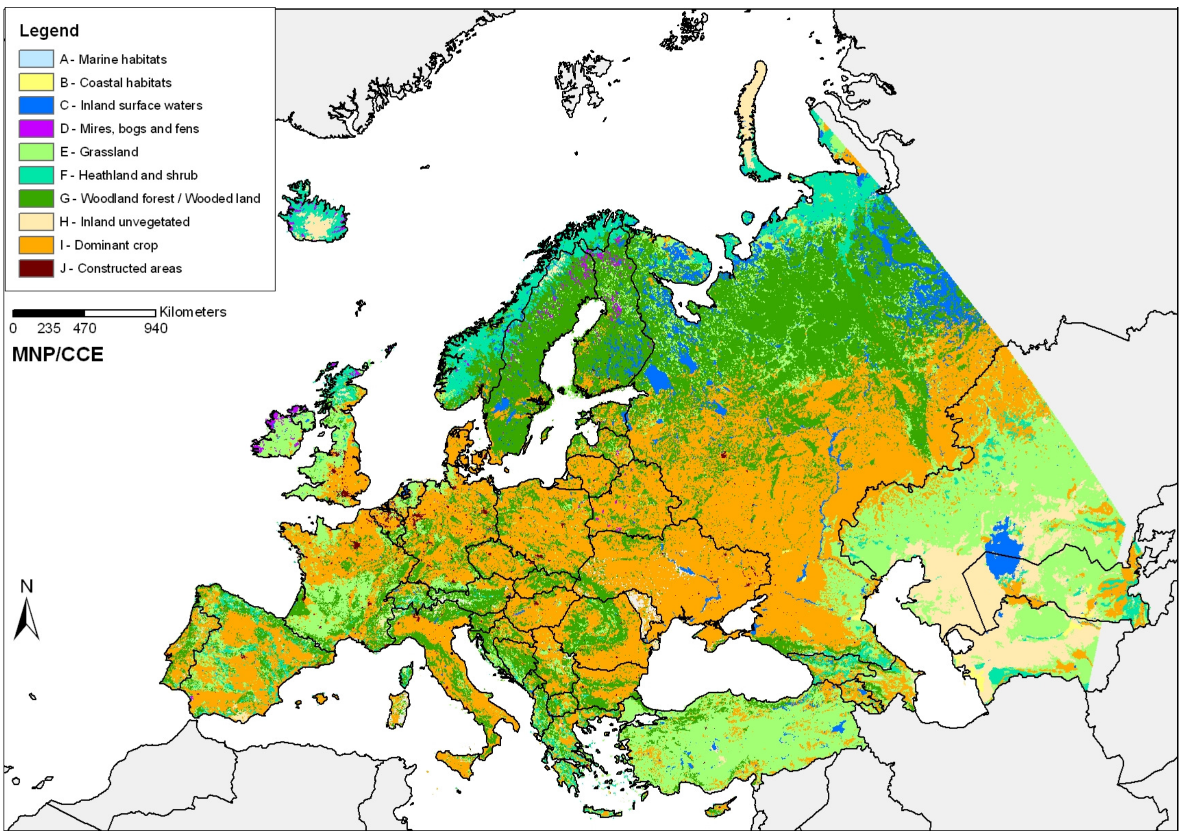

Figure 2. The final SEI-map with EUNIS-classes (first level) for Europe.

The main steps of the automated procedure are:

- reclassification codes of SEI-maps to numerical EUNIS-codes on second level;
- conversion to EMEP projection;
- conversion of vector polygons to 100 meter raster grid;
- clipping to countries borders;
- in case of big countries, merging the parts.

The outcome of this procedure is a 100 meter grid map by country on second EUNIS-level. Annex 4 gives the description of the distinguished numeric EUNIS codes on the second level. In a final step the separate countries are merged to a European land cover map, the SEI-map (Fig. 2). On this map the EUNIS classes on second level have been aggregated to the first EUNIS level.

3.5 Assigning eCLs to the SEI-map

For the assignment of eCLs to the EUNIS-classes of the SEI- map, the available eCLs-class derived in Chapter 2 (Table 2) have been used. This information has been used in an automated procedure to produce a European empirical critical load map. The outcome of this procedure are 1) 100 meter grid minimum and maximum eCLs maps by country, and 2) CCE compatible tables of sites with eCLs per country in EMEP50 grid and EMEP50 eCLs maps. The scripts for this procedure are described (in Dutch) in Annex 3.

The basic steps of this automated procedure are:

- creating a ftable by extending eCLs to the EUNIS-classes on the third level;
- overlay of polygons of SEI-map (in personal geodatabase) with biogeographical regions;
- determination of minimum, average and maximum eCLs for each overlaid polygon: the eCL-polygons.

Further steps for the production of the 100 meter grid eCLs maps are:

- conversion of eCL-polygons to 100 meter raster grid;
- clipping raster files to countries border;
- in case of big countries merging the parts.

These maps will be further used in the harmonization of the input of the NFCs.

Further steps for the production of the EMEP50 eCLs maps are:

- overlay of the eCLs polygons with EMEP50 grid;
- combining eCL-polygons with same EUNIS class, biogeographical area and EMEP50 grid;
- clipping of the polygons to countries border;
- exporting of the eCLs per EMEP50 grid per country in CCE CL load database format;
- in case of big countries merging the parts.

This EMEP50 information on eCLs will be used for the CCE background database and for the comparison of CL between the SEI-map and the NFCs. A final step is the creation of a European EMEP50 eCLs map. Figure 3 shows the maps with the minimum and maximum eCLs for the 5th percentile for the EMEP-grid. For this maps EUNIS-classes B and C were not included, since for these classes no maximum had been determined (see Table 2, Chapter 2). The lowest eCLs are found in the mountainous areas, in Scandinavia and western Ireland. For further interpretation of these maps, we refer to the forthcoming CCE-progress report.

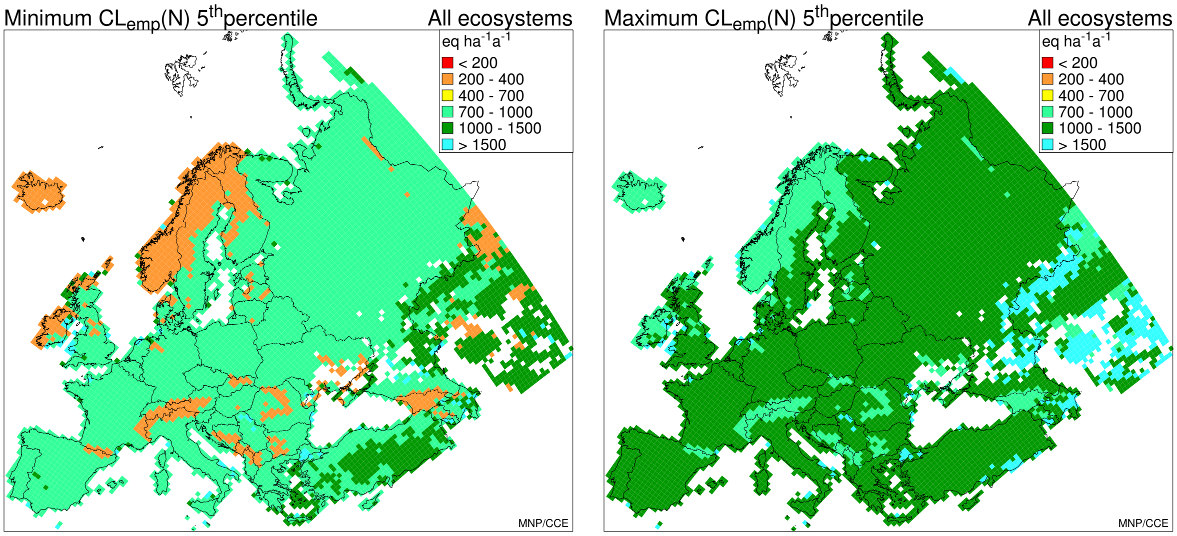

Figure 3. Minimum (left) and maximum (right) eCL-map (EMEP-grid, 5th percentile).

4 Comparison of the EUNIS-classes and (empirical) critical loads for nitrogen between the SEI-map and the NFC data

4.1 Comparison of the EUNIS-classes

The comparison between the EUNIS-classes of the SEI-map (see paragraph 3.1) and the ones provided NFC-s have been carried out in two ways. Firstly, the point information of the NFCs have been compared with the polygon information from the SEI-map. Secondly, the composition of EUNIS-classes of EMEP50-grid cells have been compared between the NFCs and the SEI-map.

4.1.1 Comparison between NFC-point and SEI-polygons

Until now most NFCs only produce critical loads for forest sites (EUNIS-code G). To make a meaningful comparison for most of the countries, we only considered the NFC forest sites. We analyzed for these NFC forest points, which EUNIS-classes are found on the SEI-map. We expected of course that the NFC forest points correspond to EUNIS-class G (forest) on the SEI-map. For this comparison we made a point in polygon overlay. For this we used the latitude and longitude information of the NFC forest sites. The EUNIS-codes of the SEI-map were aggregated to the first level. Figure 4 shows that there is in general a large discrepancy between the NFC information and the SEI-map information. For some countries like Chechnya (CZ) the accordance is good (>90%), but for other countries like Great Britain (GB) it is bad (<20%).

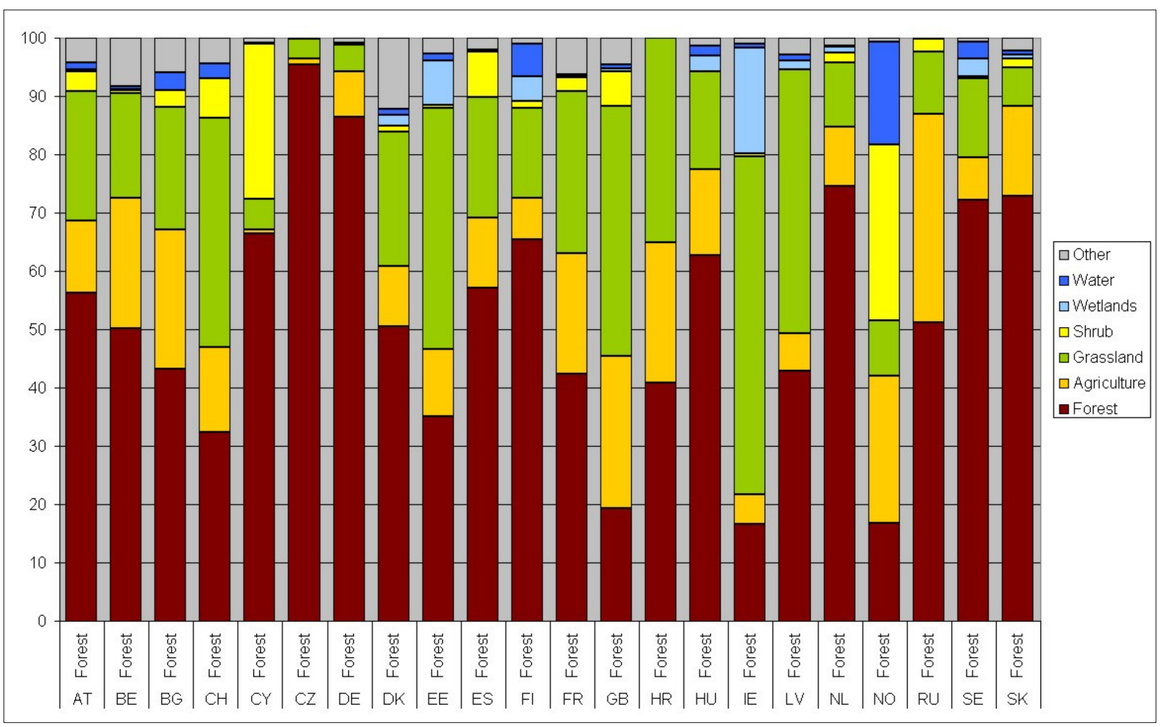

Figure 4. Composition of EUNIS-classes of SEI-map for NFC-forest points per country.

Possible reasons for the lack of agreement between the NFC forest site point information and EUNIS-classes from the SEI-map are:
- NFC point co-ordinates are not always precise (10 km difference);
- the NFC point is sometimes a centroid of a polygon. Then it is more coincidence if the EUNIS-class of a certain polygon are similar;
- EUNIS-classes are fuzzy, for example the classes shrub (F) and forest (G) may overlap.

4.1.2 Comparison of composition of EMEP50-grid

A comparison of the composition of EUNIS-classes of larger areas between NFCs and the SEI-map does not have the abovementioned drawbacks. Therefore, we compared the areas of different EUNIS-classes by EMEP50-grid cell. As already mentioned in the former section, most NFCs only produce critical loads for forest sites. To make a meaningful comparison for most of the countries, we compared the area of forests by EMEP50 grid cell between NFCs and the SEI-map. We used the most *recent* NFC-information (partly 2007). We used the Kappa-Histo-statistic as measure for correspondence. A high Kappa-statistic means a high similarity area of the EMEP50-grid cell between NFCs and the SEI-map and vice versa. In Figure 5 the result of this comparison is depicted.

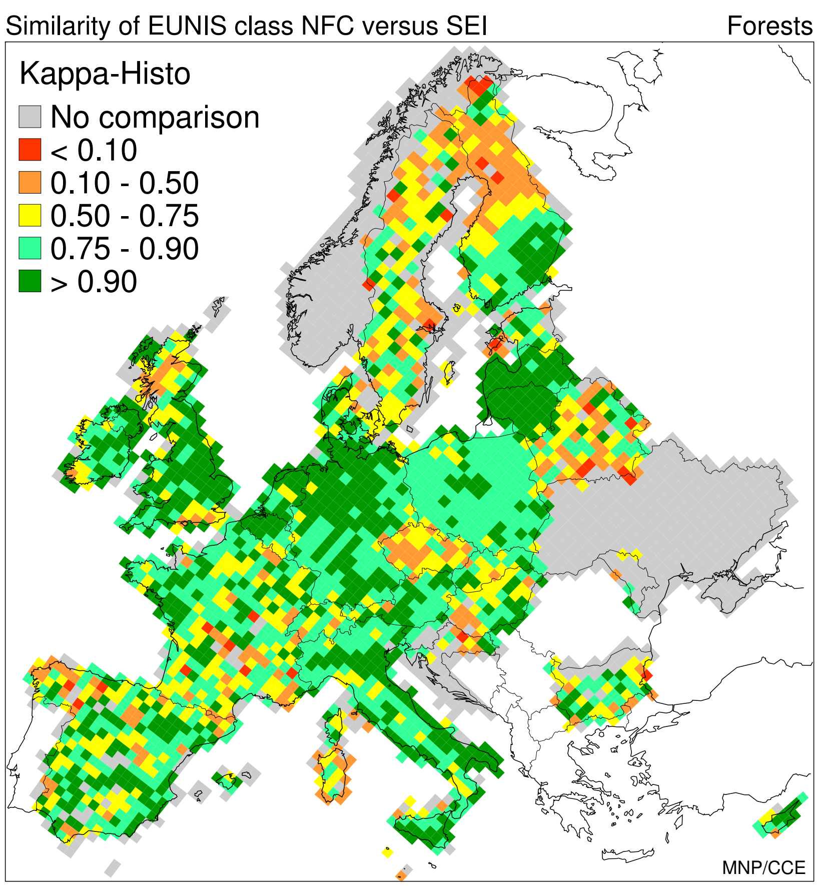

Figure 5. Correspondence (Kappa-Histo statistic) in area forest per EMEP50-grid cells between NFCs and the SEI-map.

This map shows that for most countries the correspondence in area of forest is quite high, with exception of some areas like Scandinavia and the Czech Republic. Possible reasons for the low correspondence in these latter areas were investigated by studying both source maps for forest (Fig. 6). From Figure 6 it is clear that the magnitude of the forest area differ but that the forest patterns look similar. In general the area of forests in the NFC-map seems to be higher then in the SEI-map. A possible explanation for this may be that EUNIS-classes like shrubs (F) are included in the NFC-information. For further discussion see the forthcoming CCE-progress report.

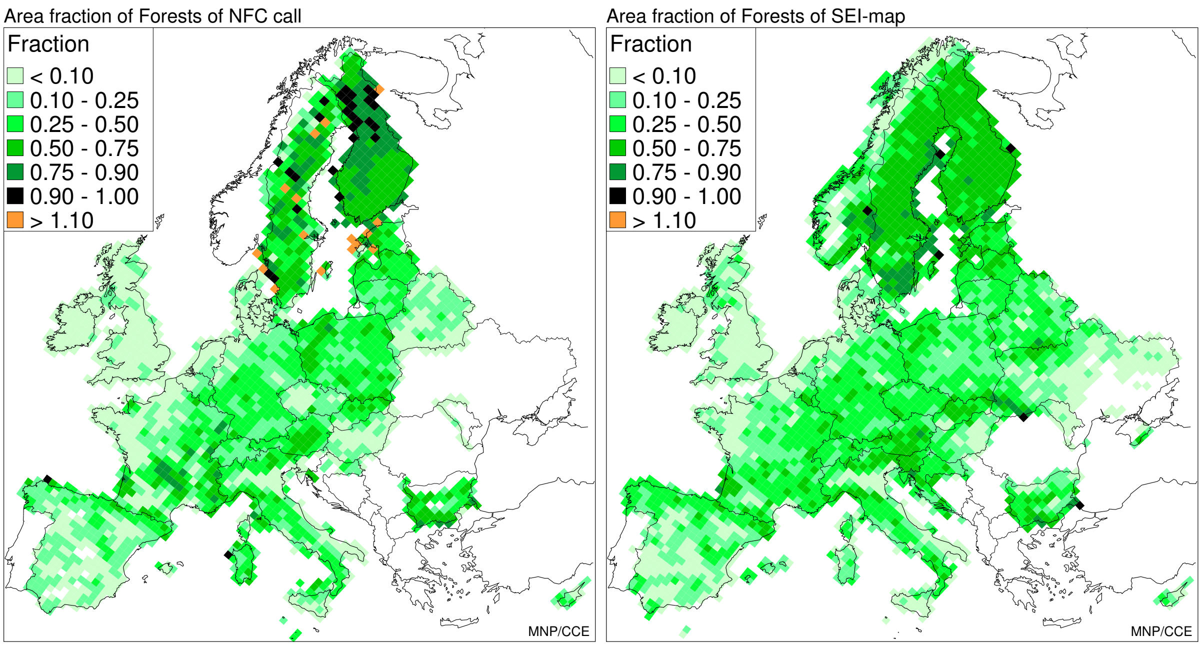

Figure 6. Distribution of forest by EMEP50 grid cell, left: source NFCs, right: source SEI-map.

4.2 Comparison of the critical loads

4.2.1 General

We compared the empirical critical loads from the SEI-map (see paragraph 3.2) with the critical loads from the NFCs. Modelled as well as empirical critical loads were available as a result of the CCE call for voluntary data from a 2007 call. So, we compared the eCLs from the SEI-map on the one hand with the CLs and eCLs from the NFCs on the other hand. The comparison was made in two steps. Firstly, we checked whether the CLs and eCLs from the NFCs lie within the *range* of the eCL of the SEI-map. Secondly, we compared the (e)CL-levels for the EMEP50-maps from the different sources.

4.2.2. Check CL of NFCs within range eCL of SEI-map

A first comparison is made between the critical loads of the NFCs and the empirical critical loads from the SEI-map at the level of EMEP50 grid cells. For this comparison we took the lowest and highest eCL per EMEP50 grid cell as range. EUNIS-classes B and C were excluded from this analysis, because for these classes no maximum had been derived (see Tabel 2, Chapter 2). In Figure 7 (left) the percentage of NFC-sites with CLs lying within the range of eCL of the SEI-map are presented. In north-west and central Europe most of the NFC-CLs are lying within the range of the eCLs from the SEI-map, in contrast to the Mediterranean countries, North Sweden, Finland and Russia. Of course this figure does not give information for these latter areas whether the NFC-CLs are lower or higher than the eCLs from the SEI-map. So, we compared in addition the minimum CL from the NFCs with the minimum eCL of the SEI-map Fig. 7 right), since the minimum critical loads are the most important protection levels to be taken into account.

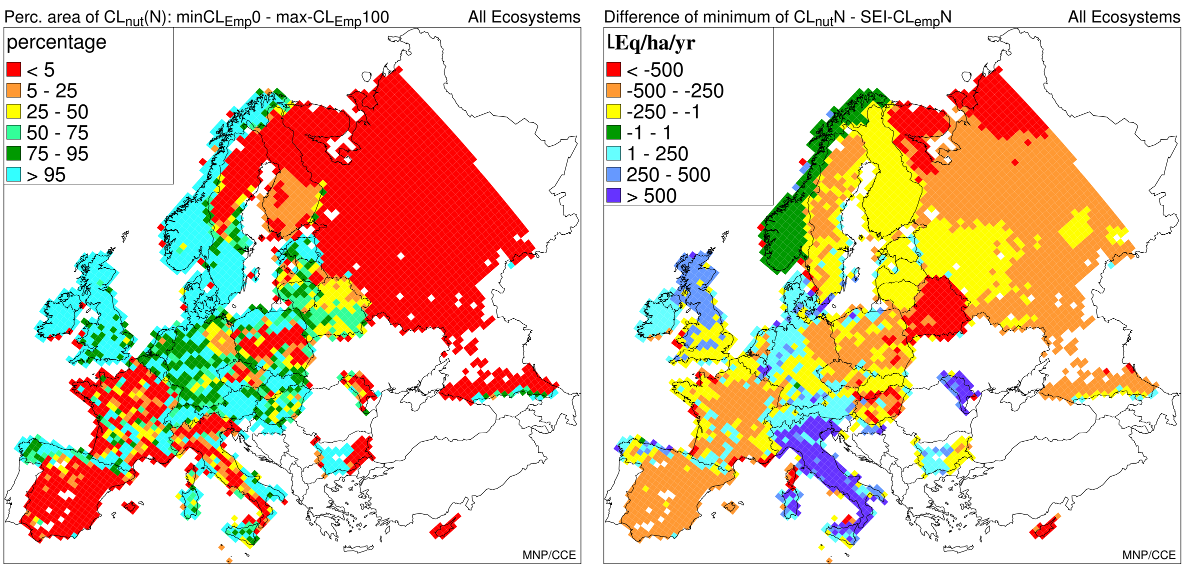

Figure 7 Left: Percentage of NFC-sites of which the CLs lie within the range of eCLs of the SEI-map; Right: Difference of minimum critical load (eq ha^{-1} a^{-1}) between the NFC-CLs and the eCLs of the SEI-map.

From Figure 7 (right) it becomes clear that the deviance in Figure 6 can largely be explained by the lower CLs from the NFCs than the eCLs from the SEI-map. Remark also that in Italy and part of Moldavia the CLs from the NFCs are higher than the eCLs from the SEI-map.

4.2.3 Check eCL of NFCs within range eCL of SEI-map

In the same way a second comparison is made between the *empirical* critical loads of the NFCs and the empirical critical loads from the SEI-map at the level of EMEP50 grid cells (Figure 8 left). In Figure 8 (left) we see that the eCLs from the NFCs are generally lying within the range of eCLs from the SEI-map. This could be expected because all eCLs were derived from the same scientific source, using the same guidelines. We did an additional analysis by comparing the minimum eCLs from the NFCs and the SEI-map (Figure 8 right). From Figure 8 (right) it is clear that the eCLs from the NFCs are generally higher than the eCLs from the SEI-map, probably because most NFCs do not use a minimum but an average eCL.

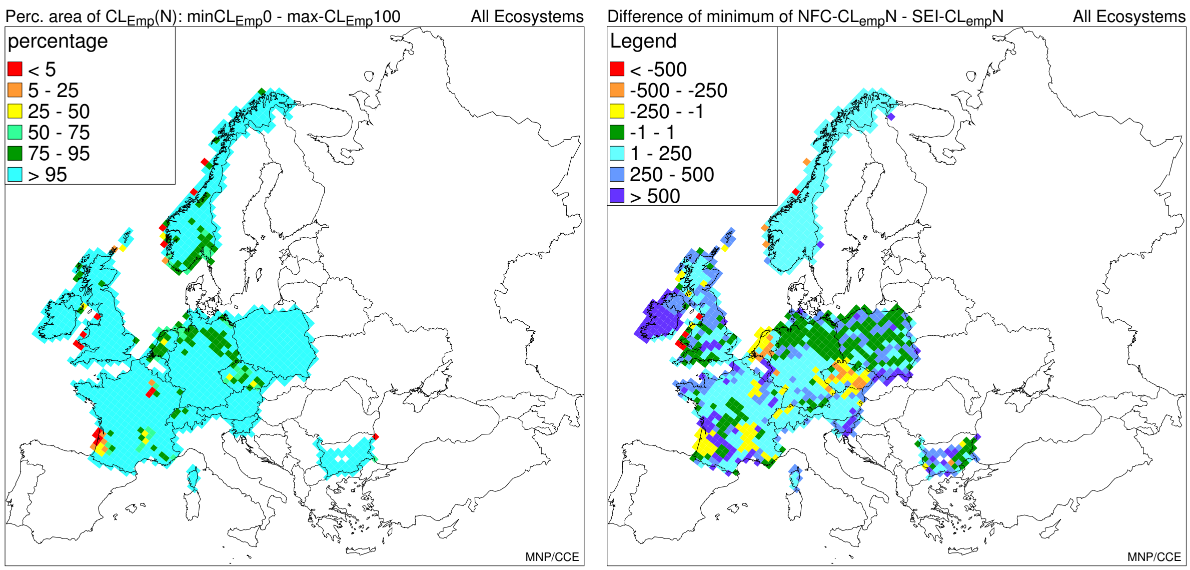

Figure 8 Left: Percentage of NFC-sites of which the eCLs lie within the range of eCLs of the SEI- map; Right: Difference of minimum critical load (eq ha^{-1} a^{-1}) between the NFC-eCLs and the eCLs of the SEI-map

4.3 Comparison of percentile (e)CL-levels of SEI-map and NFCs

For a further analysis of the possible differences of (e)CLs between the SEI-map and the NFCs we produced an additional series of percentile maps for the different sources. Figure 9 shows the lowest (0%), the median (50%) and highest (100%) (e)CL for the minimum and maximum eCl from the SEI-map (upper and second row) and the (e)Cls from the NFCs (third and bottom row). In the eCLmaps derived from the SEI-map the eCL changes at the border between Finland and Russia. This seems to be an artifact of different sources for Finland (CORINE land cover map) and for Russia (former version of the SEI-map). The CL-maps from the NFCs (bottom row) differ much more from the eCL-map from the SEI-map then the eCL-map from the NFC-s. The patterns of eCLs in the SEI maps and the NFC maps look similar, e.g. lower critical loads are found in Scandinavia, Ireland and the Alps in both maps. The empirical critical loads in the NFC maps fall within the minimum and maximum of the eCL-map of the SEI-map. This is according to the observation that the NFCs have generally used the average eCLs. In general the CLs of the NFC seems to be lower than their eCLs.

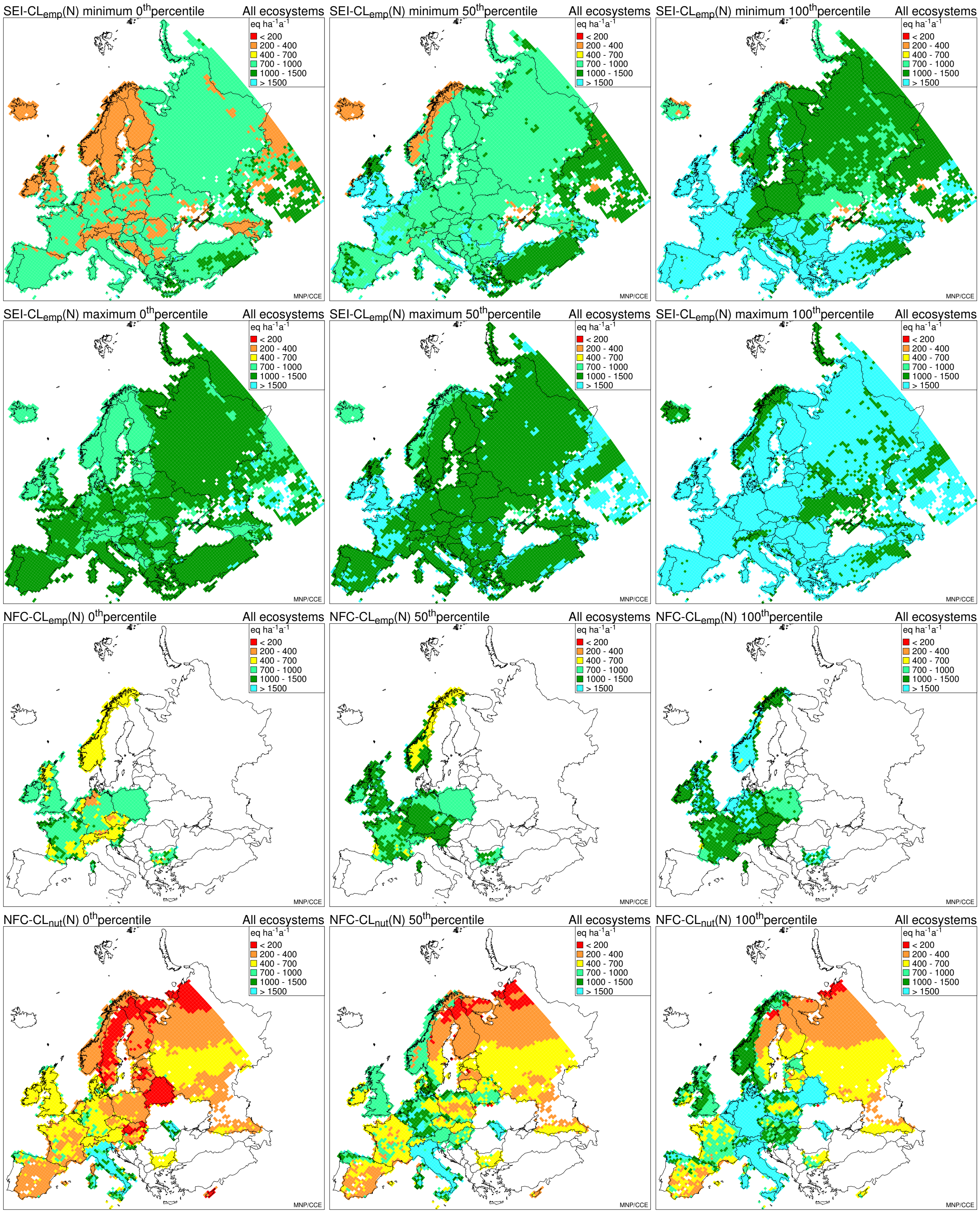

Figure 9. Percentile maps (0, 50, 100%) for the eCL of the SEI-map (minimum: upper row, maximum: second row), the eCL of NFCs (third row), and the CLs of the NFCs (bottom row).

5 Conclusions and recommendations

5.1 Conclusions

For the harmonization of the input of the NFCs, European data on critical loads for nitrogen and distribution of ecosystems have been compared with the national input from the NFCs. Empirical critical loads for nitrogen from Achermann & Bobbink c.s. are lacking for a number of ecosystem types for critical load analysis. The necessity and possibilities to derive and diversify empirical critical loads are evaluated and where possible applied. Based on information of SEI, a new 100 m grid European land cover map have been produced. This SEI-map presents information on the distribution of ecosystems according to the second and third level of the EUNIS-classification An European critical load map based on the empirical critical loads and on the SEI-map is presented. The difference in the distribution of ecosystems between the NFC- and the SEI-map could only be evaluated for forest ecosystems. It appeared then that for a number of countries the NFC-map have higher values for forest areas. However the spatial distribution of the forest in both maps are quite similar. From a second comparison between the critical loads from the NFCs and the empirical critical loads from the SEI-map, it appeared that there is a reasonable agreement between the two sources and those differences can be explained by the fact that NFCs generally use *lower* CLs. As expected, there is a good correspondence between the empirical critical loads assigned by the NFCs and the SEI-map.

5.2 Recommendations

The first group of recommendations focuses on the availability of information and use of empirical critical loads:

- A large number of empirical critical loads is missing or not yet available (forests). The research and derivation of eCLs for the missing ecosystem types should be continued.
- For the differentiation of eCls across Europe, additional information should be used, especially the 'base cation availability' and 'temperature/frost period'. The NFCs should use additional information (e.g. P-limitation) to diversify their eCLs.
- The eCL map is now produced on basis of all ecosystem types, from (semi)natural to agricultural systems (EUNIS class I and E2.6). We recommend that only the eCLs for semi-natural and natural ecosystems should be applied.

A second group of recommendations focus on the production and use of the European land cover map, the SEI-map:

- From the SEI-map no distinction can be made between agricultural and (semi)natural grasslands, which is very relevant from the point of view of CL-calculations. We therefore recommend that at least this distinction could be made in future maps.
- Empirical critical loads are often on the third level (or even lower) of EUNIS-classification and the ecosystem information on the SEI-map is on the second level. For a better fit of eCLs and map information we recommend that where possible a third level classification of ecosystems is used on the future maps.

- We recommend to investigate in depth differences in the assignment of ecosystem types and areas and in CLs between NFCs and the SEI-map and how these differences optimal can be analysed, to support the harmonization-process.

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ANNEX 1:

The available empirical critical loads (eCLs) from Achermann & Bobbink 2003

Table 1. Overview of empirical critical loads for nitrogen deposition (kg N ha^{-1} yr^{-1}) to natural and semi-natural ecosystems. Classification of habitats according to EUNIS (except for forests). **## reliable; # quite reliable and (#) expert judgement.**

Ecosystem type	EUNIS-code	kg N $ha^{-1}yr^{-1}$	Reliability	Indication of exceedance
Forest habitats (G)				
Soil processes				
Deciduous and coniferous	-	10-15	#	Increased N mineralization, nitrification
Coniferous forests	-	10-15	##	Increased nitrate leaching
Deciduous forests	-	10-15	(#)	Increased nitrate leaching
Trees				
Deciduous and coniferous	-	15-20	#	Changed N/macro nutrients ratios, decreased P, K, Mg and increased N concentrations in foliar tissue
Temperate forests	-	15-20	(#)	Increased susceptibility to pathogens and pests, change in fungistatic phenolics
Mycorrhiza				
Temperate and boreal forests	-	10-20	(#)	Reduced sporocarp production, changed/reduced below-ground species composition
Ground vegetation				
Temperate and boreal forests	-	10-15	#	Changed species composition, increase of nitrophilous species, increased susceptibility to parasites
Lichens and algae				
Temperate and boreal forests	-	10-15	(#)	Increase of algae, decrease of lichens
Overall				
Temperate forests	-	10-20	#	Changes in soil processes, ground vegetation, mycorrhiza, increased risk of nutrient imbalances and susceptibility to parasites
Boreal forests	-	10-20	#	Changes in soil processes, ground vegetation, mycorrhiza, increased risk of nutrient imbalances and susceptibility to parasites
Heathland, scrub and tundra habitats (F)				
Tundra	F1	5-10[a]	#	Changes in biomass, physiological effects, changes in species composition in moss layer, decrease in lichens
Arctic, alpine and subalpine scrub habitats	F2	5-15[a]	(#)	Decline in lichens, mosses and evergreen shrubs
Northern wet heath	F4.11			
• 'U' *Calluna*-dominated wet heath (upland moorland)	F4.11	10-20[a]	(#)	Decreased heather dominance, decline in lichens and mosses
• 'L' *Erica tetralix* dominated wet heath	F4.11	10-25[a,b]	(#)	Transition heather to grass
Dry heaths	F4.2	10-20[a,b]	##	Transition heather to grass, decline in lichens

Grasslands and tall forb habitats (E)				
Sub-atlantic semi-dry calcareous grassland	E1.26	15-25	##	Increase tall grasses, decline in diversity, increased mineralization, N leaching
Non-mediterranean dry acid and neutral closed grassland	E1.7	10-20	#	Increase in graminoids, decline typical species
Inland dune pioneer grasslands	E1.94	10-20	(#)	Decrease in lichens, increase biomass
Inland dune siliceous grasslands	E1.95	10-20	(#)	Decrease in lichens, increase biomass, increased succession
Low and medium altitude hay meadows	E2.2	20-30	(#)	Increase in tall grasses, decrease in diversity
Mountain hay meadows	E2.3	10-20	(#)	Increase in nitrophilous graminoids, changes in diversity
Moist and wet oligotrophic grasslands	E3.5			
• *Molinia caerulea* meadows	E3.51	15-25	(#)	Increase in tall graminoids, decreased diversity, decrease of bryophytes
• Heath (*Juncus*) meadows and humid (*Nardus stricta*) swards	E3.52	10-20	#	Increase in tall graminoids, decreased diversity, decrease of bryophytes
Alpine and subalpine grasslands	E4.3 and E4.4	10-15	(#)	Increase in nitrophilous graminoids, biodiversity change
Moss and lichen dominated mountain summits	E4.2	5-10	#	Effects upon bryophytes or lichens
Mire, bog and fen habitats (D)				
Raised and blanket bogs	D1	5-10[a,c]	##	Change in species composition, N saturation of *Sphagnum*
Poor fens	D2.2[d]	10-20	#	Increase sedges and vascular plants, negative effects on peat mosses
Rich fens	D4.1[e]	15-35	(#)	Increase tall graminoids, decrease diversity, decrease of characteristic mosses
Mountain rich fens	D4.2	15-25	(#)	Increase vascular plants, decrease bryophytes
Inland surface water habitats (C)				
Permanent oligotrophic waters	C1.1			
• Softwater lakes	C1.1	5-10	##	Isoetid species negatively affected
• Dune slack pools	C1.16	10-20	(#)	Increased biomass and rate of succession
Coastal habitat (B)				
Shifting coastal dunes	B1.3	10-20	(#)	Biomass increase, increase N leaching
Coastal stable dune grasslands	B1.4	10-20	#	Increase tall grasses, decrease prostrate plants, increased N leaching
Coastal dune heaths	B1.5	10-20	(#)	Increase plant production, increase N leaching, accelerated succession
Moist to wet dune slacks	B1.8	10-25	(#)	Increased biomass tall graminoids
Marine habitats (A)				
Pioneer and low-mid salt marshes	A2.64 and A2.65	30-40	(#)	Increase late-successional species, increase productivity

a) use towards high end of range at phosphorus limitation, and towards lower end if phosphorus is not limiting;
b) use towards high end of range when sod cutting has been practiced, use towards lower end of range with low intensity management;
c) use towards high end of range with high precipitation and towards low end of range with low precipitation;
d) for D2.1 (quaking fens and transition mires): use lower end of range (#) and for D2.3 (valley mires): use higher end of range (#);
e) for high latitude or N-limited systems: use lower end of range.

ANNEX 2:

Overview of the classes in the second level and third level numeric EUNIS-classification

Numeric code (E3)	EUNIS CODE list	EUNIS description	Numeric code`(E2) combi
1000	A	Marine habitats	100
1100	A1	Littoral rock and other hard substrata	112
1102	A1 or A2 without A2.5	Littoral rock and other hard substrata or Littoral sediment without Coastal saltmarshes and saline reedbeds	112
1200	A2	Littoral sediment	112
1250	A2.5	Coastal saltmarshes and saline reedbeds	112
1300	A3	Infralittoral rock and other hard substrata	134
1304	A3 or A4	Infralittoral rock and other hard substrata or Circalittoral rock and other hard substrata	134
1349	A3 or A4 or A5	Infralittoral rock and other hard substrata or Circalittoral rock and other hard substrata or Sublittoral rock	139
1400	A4	Circalittoral rock and other hard substrata	134
1500	A5	Sublittoral sediment	105
1600	A6	Deep-sea bed	106
1700	A7	Pelagic water column	107
1800	A8	Ice-associated marine habitats	108
2000	B	Coastal habitats	200
2100	B1	Coastal dunes and sandy shores	201
2200	B2	Coastal shingle	202
2300	B3	Rock cliffs, ledges and shores, including the supralittoral	203
3000	C	Inland surface waters	300
3100	C1	Surface standing waters	301
3102	C1 or C2	Surface standing waters and surface running waters	312
3200	C2	Surface running waters	302
3300	C3	Littoral zone of inland surface waterbodies	303
4000	D	Mires, bogs and fens	400
4100	D1	Raised and blanket bogs	401
4200	D2	Valley mires, poor fens and transition mires	424
4204	D2 or D4	Valley mires, poor fens and transition mires or Base-rich fens and calcareous spring mires	424

Numeric code (E3)	EUNIS CODE list	EUNIS description	Numeric code`(E2) combi
4300	D3	Aapa, palsa and polygon mires	403
4400	D4	Base-rich fens and calcareous spring mires	424
4500	D5	Sedge and reedbeds, normally without free-standing water	405
4600	D6	Inland saline and brackish marshes and reedbeds	406
5000	E	Grasslands and lands dominated by forbs, mosses and lichens	500
5100	E1	Dry grasslands	501
5109	E1 without E1.2, E1.7, E1.8, E1.9, E1.A	Dry grasslands without Perrenial grasslands and basic steppes or Non-Mediterranean dry acid and neutral closed grassland or Non-Mediterranean dry acid and neutral closed grassland or Mediterranean dry acid and neutral closed grassland or Mediterranean dry acid and neutral open grassland	501
5120	E1.2	Perrenial grasslands and basic steppes	501
5179	E1.7 or E1.9	Non-Mediterranean dry acid and neutral closed grassland or Non-Mediterranean dry acid and neutral closed grassland	501
5189	E1.8 or E1.A	Mediterranean dry acid and neutral closed grassland or Mediterranean dry acid and neutral open grassland	501
5200	E2	Mesic grasslands	502
5209	E2 without 2.3	Mesic grasslands without Mountain hay meadows	502
5230	E2.3	Mountain hay meadows	502
5300	E3	Seasonally wet and wet grasslands	503
5400	E4	Alpine and subalpine grasslands	504
5500	E5	Woodland fringes and clearings and tall forb stands	505
5600	E6	Inland salt steppes	506
5700	E7	Sparsely wooded grasslands	507
6000	F	Heathland, scrub and tundra	600
6001	FA	Hedgerows	610
6002	FB	Shrub plantations	611
6100	F1	Tundra	601
6200	F2	Arctic, alpine and subalpine scrub	602
6300	F3	Temperate and mediterranean-montane scrub	603
6400	F4	Temperate shrub heathland	604
6500	F5	Maquis, arborescent matorral and thermo-Mediterranean brushes	656
6506	F5 or F6	Maquis, arborescent matorral and thermo-Mediterranean brushes or Garrigue	656
6600	F6	Garrigue	656

Numeric code (E3)	EUNIS CODE list	EUNIS description	Numeric code`(E2) combi
6700	F7	Spiny Mediterranean heaths (phrygana, hedgehog-heaths and related coastal cliff	607
6800	F8	Thermo-Atlantic xerophytic scrub	608
6900	F9	Riverine and fen scrubs	609
7000	G	Woodland, forest and other wooded land	700
7100	G1	Broadleaved deciduous woodland	701
7300	G3	Coniferous woodland	703
7400	G4	Mixed deciduous and coniferous woodland	704
7500	G5	Lines of trees, small anthropogenic woodlands, recently felled woodland, woodland and coppice	705
8000	H	Inland vegetated or sparsely vegetated habitats	800
8100	H1	Terrestrial underground caves, cave systems, passages and waterbodies	801
8200	H2	Screes	802
8300	H3	Inland cliffs, rock pavements and outcrops	803
8400	H4	Snow or ice-dominated habitats	804
8500	H5	Miscellaneous inland habitats with very sparse or no vegetation	805
8600	H6	Recent volcanic features	806
9000	I	Regularly or recently cultivated agricultural, horticultural and domestic habitats	900
9100	II	Irrigated arable land	901
9100	I1	Arable land and market gardens	901
9200	IN	Non-irrigated arable land	902
9200	I2	Cultivated areas of gardens and parks	902
10000	J	Constructed, industrial and other artificial habitats	1000
10100	J1	Buildings of cities, towns and villages	1001
10200	J2	Low density buildings	1002
10300	J3	Extractive industrial sites	1003
10400	J4	Transport networks and other constructed hard-surfaced areas	1004
10500	J5	Highly artificial man-made waters and associated structures	1005
10600	J6	Waste deposits	1006
24000	X	Habitat complexes	2400
25000	Y	Unknown	2500

ANNEX 3:

Description of the automated procedure and scripts

A. Aanmaken van de SEI-EUNIS2 kaarten en overlay met EMEP en NFC-punten

Beschrijving van de JSL-scripts

Er zijn landen welke in een deel zijn aangeleverd en landen welke in meerdere delen zijn aangeleverd. Hiervoor zijn aparte scripts gemaakt omdat er in het geval van meerdere delen meer stappen moesten worden uitgevoerd.

1. mshp2rasov3.jsl (per land) voor landen in een deel aangeleverd

- **multishp.py**
  - instellen uitvoer projectie EMEP
  - aanmaken van personal geodatabase voor land(deel).
    uitvoer: ***CC*_ALL_GD.mdb**
  - hernoemen van invoer shape file naar naam met underscores
    uitvoer: ***CC*_ALL.shp**
  - conversie van shape file naar personal geodatabase featurelayer
  - toevoegen van herklassificatie db-files aan personal geodatabase
    (per EUNIS1 code een tabel)
    invoer: **SEIEUN_*.dbf**
  - toevoegen van drie velden aan polygon layer
    velden: **EUNISCLS, VEGTYPE en SEICLS**
  - selecteren van land uit landendatabase: **EUR.mdb**

- **loopcc.jsl**:
  - updaten van variabelen **EUNISCLS, VEGTYPE en SEICLS**

- **loopext:**
  - bepalen van extentie van land in EMEP-projectie

- **shp2ras.py (conversie van polygonen naar raster)**
  - conversie van polygonen bestand naar rasterkaart 100 meter
    uitvoer: ***CC*_T_EMEP_EUN**
  - clippen van rasterkaart voor land(deel) naar landsgrenzen
    (excl zee, buitenland)
    uitvoer: ***CC*_T_EMEP_EU2**

- **overlay.py (overlay van SEI_EUNIS kaart met NFC-punten 2006)**
  - toevoegen van NFC-punten-set aan personal geodatabase

invoer: **N_*CC*_Eunis** tabel uit **call06.mdb (NFC06SN)**
uitvoer: **SIT_EUNIS** layer in Personal geodatabase
- conversie van puntenset naar punten-coverage
  uitvoer: **SIT_EUN_ptcv** coverage
- reprojecteren van punten coverage set naar EMEP-projectie
  uitvoer: **SIT_EUN_ptcv2** coverage
- conversie van SEI-EUNIS 100 meter raster kaart (geclipte) naar polygonen shape file
  uitvoer: ***CC*_RAS_pol.shp**
- conversie van polygonen shape file naar polygonen-coverage
  uitvoer: ***CC*_ALL_POLCV**
- Punt in vlakoverlay voor NFC punten in SEI-polygonen
  uitvoer: ***CC*s_eun_sei.shp**
- Exporteren van attribuuttabel naar overzichtsdatabase
  database: **SEI_EUNIS_NFC_EMEP.mdb**

- **combine_emep.py**
  - overlay van SEI-EUNIS 100 meter raster kaart met EMEP50 grid
    uitvoer: ***CC*_CM_EMEP_EU**
  - handmatig moet hierna attribuuttabel worden toegevoegd aan database: **SEI_ECL_EMEP.mdb**

2. mshp2rasov3_big2.jsl (per land) voor landen in meerdere delen aangeleverd

Draai per land en per deel
- **multishp.py** (zie mshp2rasov2.jsl)
  personal geodatabase: ***CC*_ALL_T T*part*_GD.mdb**
- **loopcc_big.jsl**: (zie mshp2rasov2.jsl – loopcc.jsl)
- **loopext** (zie mshp2rasov2.jsl)
- **shp2ras.py (conversie van polygonen naar raster)**
  - conversie van polygonen bestand naar rasterkaart 100 meter
    uitvoer: ***CC*_T_P*part*_EUN**
  - clippen van rasterkaart voor land(deel) naar landsgrenzen (excl zee, buitenland)
    uitvoer: ***CC*_T_P*part*_EU2**

Vastplakken van delen
- **merge_big.py**
  - Aanmaken van personal geodatabase voor heel land
    uitvoer: ***CC*_ALL_GD.mdb**
  - Mergen van polygonen bestand van delen
  - Mergen van 100 meter raster EUNIS-kaart
    uitvoer: ***CC*_T_EMEP_EUN**

Hierna zelfde als bij mshp2rasov2.jsl

- **overlay.py (overlay van SEI_EUNIS kaart met NFC-punten 2006)**
- **combine_emep.py**

Afwijkende landen:

- Portugal, Spanje en Frankrijk omdat extent kleiner moest worden gemaakt i.v.m overzeese gebieden en eilanden ver van Europa.
  100 meter kaart Portugal kleiner extent: **PT_T_EMEP_EU3**
  100 meter kaart Spanje kleiner extent: **ES_T_EMEP_EU2**
- Rusland in geval van laatste twee stappen omdat deze ook in delen moesten worden uitgevoerd.
- Voor Uzbekistan is de extent file handmatig aangemaakt omdat deze niet juist voorkwam in de **EUR.mdb** database.

B. Aanmaken van kaart met biogeografische regio's

De aangeleverde kaart met biogeografische regio's omvat niet heel Europa en moet daarom worden geëxtrapoleerd naar de grenzen van studiegebied.

De belangrijkste ruimtelijke analyse hier voor is het maken van Thiessen Polygons.

a In ArcGIS 9.1 is deze analyse alleen beschikbaar voor coverages. Bij deze variant van de analyse wordt de outside boundary ingesteld op de extent van de punten met een extra 10%. Dit betekent dat de extrapolatie stappen een aantal malen moet worden herhaald om tot de buitenste extent van ons studiegebied te komen uitgaande van de aangeleverde biogeografische regiokaart.

b In ArcGIS 9.2 is deze analyse ook beschikbaar voor features. Maar alleen in de ARC-INFO variant van ARC-GIS. In deze functie zou het ook mogelijk moeten zijn om een extent mee te geven waarbij de outside boundary wordt gesteld op deze opgegeven extent. Dit zou ook een aantal conversie stappen naar coverages besparen.

Al de stappen zijn uitgevoerd in de EMEP-projectie.

Uitgaande van procedure a zijn de volgende stappen nodig :

1 Verrasteren van de polygonen kaart naar een raster van 5*5 km
FeatureToRaster_conversion() →

Bij de eerste run is de invoerkaart: **EnZv7.shp**
Bij de volgende runs is de invoerkaart: **EnZv7_Merge.shp**
Uitvoer: **EnZv7_5k_ra***

2 Conversie van raster naar Point (centroid)
RasterToPoint_conversion()

Uitvoer: **EnZv7_5k_pn***

3 Conversie van punt naar coverage (alleen Arc Info variant)
FeatureclasstoCoverage_conversion()

Uitvoer: **EnZv7_5k_pc***

4 Aanmaken van Thiessen Polygons (alleen Arc Info)
CreateThiessenPolygons_Analysis
Uitvoer: **EnzZv7_5k_th***

5 Verwijderen van inner-polygon (alleen Arc Info)
Erase_Arc()

Polygon welke moet worden uitgesneden: **Enzv7.shp** (oorspronkelijk bestand)
Uitvoer: **EnZv7_5k_ex*.shp**

6 Samenvoegen van polygonen met zelfde klasse (Dissolve)
Dissolve_Management()

Uitvoer: **EnZv7_5k_edi*.shp**

7 Vastplakken van oorspronkelijke kaart met geëxtrapoleerd gedeelte.
Merge_Management()

Invoer: **EnZv7_5k_edi*.shp**
EnZv7.shp

Uitvoer: **EnZv7_Merge.shp**
(Hiervoor wel oude versie van dit bestand hernoemen)

8 Aanmaken van een nieuwe variabele waarin regiocode wordt opgeslagen en met behulp van een query deze variabele (**Enz_Samen**) vullen vanuit twee variabelen met regiocodes. Hierna andere overbodige variabelen uit attribuuttabel verwijderen.

C. Aanmaken van een CCE-compatible file met ECL-s per EMEP cel per land

Beschrijving van de JSL-scripts

Er zijn landen welke in een deel zijn aangeleverd en landen welke in meerdere delen zijn aangeleverd. Hiervoor zijn aparte scripts gemaakt omdat er in het geval van meerdere delen meer stappen moesten worden uitgevoerd.

1. **sei2eclras2_big.jsl (per land) voor landen in een deel aangeleverd en kleinere landen aangeleverd in meerdere delen. Toevoegen van ECL aan SEI-EUNIS records en aanmaken van ECL-MIN en ECL-MAX kaarten**

- **big_id_conv.py (conversie stap om eilandpolygonen te verwijderen en topology van polygonen kloppend)**
  - uitgaan van ***CC*_ALL** table in ***CC*_ALL_GD** personal geodatabase
  - toevoegen van variabele voor unieke id: **OBJECTCOPY**
  - copieren van unieke id naar deze variabele
  - instellen van extent vanuit ***CC*_SELECT file (EUR.MDB)**
  - verrasteren van polygonen op basis van **OBJECTCOPY** (100 meter)
    uitvoer: ***CC*_ALL_ID**
  - terugconverteren naar polygonen in ***CC*_ALL_ID** in personal geodatabase ***CC*_ALL_GD**.mdb
  - toevoegen van een aantal variabelen aan deze tabel:
    GRIDINT, EUNISCLS, VEGTYPE, SEICLS
  - berekenen van de waarde voor **GRIDINT** (= integer van **GRIDCODE**)
  - hernoemen van tabel ***CC*_ALL** naar ***CC*_ALL_OUD**
  - hernoemen van tabel ***CC*_ALL_ID** naar ***CC*_ALL**
- **loopcc_up_id.jsl**
  - overnemen van de waarden in tabel ***CC*_ALL** voor variabelen
    EUNISCLS, VEGTYPE en **SEICLS** vanuit tabel ***CC*_ALL_OUD**
- a**ddclvalue.py**
  - toevoegen van herklassificatie db-file voor ECL aan personal geodatabase
    invoer: **SEI2ECL.dbf**
  - toevoegen van nieuwe ECL-variabelen: **EUNISCL3, ECLMIN, ECLMAX, BGALMIN, BGALMAX, BGAHMIN, BGAHMAX, ECLMINDF, ECLMAXDF, ECLGEMDF**
- **loopcc_cl.jsl**
  - invullen waarden voor **EUNISCL3, ECLMIN, ECLMAX, BGALMIN, BGALMAX, BGAHMIN, BGAHMAX**
- **bga_cl_ber.py**
  - overlay van ***CC*_ALL** met kaart met biogeografische gebieden: **EnZv7_Merge.shp**
    uitvoer: ***CC*_ALL_EnZ**
  - toevoegen van herklassificatie db-file voor biogeografische gebieden aan personal geodatabase
    invoer: **BIOGECLC.dbf**
- **loopcc_up_ecl.jsl**
  - bepalen van waarden voor: **ECLMINDF, ECLMAXDF en ECLGEMDF** a.h.v. biogeografische regio en EUNIS3 klasse.
- **ecl2ras.py**
  - conversie van polygonen bestand naar rasterkaart 100 meter voor ECLMIN
    uitvoer: ***CC*_ ECL_MIN1**
  - clippen van rasterkaart voor land(deel) naar landsgrenzen

(excl. zee, buitenland)
uitvoer: ***CC*_ECL_MIN2**
- conversie van polygonen bestand naar rasterkaart 100 meter voor ECLMAX
uitvoer: ***CC*_ ECL_MAX1**
- clippen van rasterkaart voor land(deel) naar landsgrenzen (excl zee, buitenland)
uitvoer: ***CC*_ECL_MAX2**

2. sei2eclras_biggest.jsl (per land) voor grotere landen aangeleverd in meerdere delen. Toevoegen van ECL aan SEI-EUNIS records en aanmaken van ECL-MIN en ECL-MAX kaarten

Per deel worden onderstaande stappen doorlopen. Hiernaast worden report files aangemaakt waarheen mogelijke fouten worden gerapporteerd. De namen van de report-files worden dynamisch bepaald in de python-scripts.

Countries: **ES, FI, FR, RU en SE**

- **big_id_conv_part.py** (zie sei2eclras_big.jsl)
  personal geodatabase: ***CC*_ALL_T T*part*_GD.mdb**
  naam van id-polygonen file**: *CC*_P*part*_ID**
- **loopcc_up_id_big.jsl** (zie loopcc_up_id.jsl)
- **addclvalue_big.py** (zie sei2eclras_big.jsl – addclvalue.py)
- **loopcc_cl_big.jsl** (zie loopcc_cl.jsl)
- **bga_cl_ber_big.py** (zie sei2eclras_big.jsl – bga_cl_ber.py)
- **loopcc_up_ecl_big.jsl** (zie loopcc_up_ecl.jsl)
- **ecl2ras_big.py**
  - conversie van polygonen bestand naar rasterkaart 100 meter voor ECLMIN
    uitvoer: ***CC*_P*part*_EMI1**
  - clippen van rasterkaart voor land(deel) naar landsgrenzen (excl zee, buitenland)
    uitvoer: ***CC*_P*part*_EMI2**
  - conversie van polygonen bestand naar rasterkaart 100 meter voor ECLMAX
    uitvoer: ***CC*_P*part*_EMA1**
  - clippen van rasterkaart voor land(deel) naar landsgrenzen (excl zee, buitenland)
    uitvoer: ***CC*_P*part*_EMA2**

3. ecl_emep.jsl (per land) voor landen in een deel aangeleverd en kleinere landen aangeleverd in meerdere delen. Overlay van ECL-polygonen met EMEP50-grid en exporteren

Er worden report files aangemaakt waarheen mogelijke fouten worden gerapporteerd. De namen van de report-files worden dynamisch bepaald in de python-scripts.

Uitzonderingen zijn: **DE, RO en PL** voor welke de CLIP stap handmatig is gedaan.

- **ecl_emep.py**
  - Aanmaken van een nieuwe personal geodatabase.
    uitvoer: ***CC*_ALL_GD_2.MDB**
  - Overlay van ***CC*_ALL_EnZ** met EMEP50 polygonen: **emep50polnew.shp**
    uitvoer**:** ***CC*_ECL_EMEP**
  - dissolven van polygonen op basis van de variabelen: **EUNIS3, Enz_Samen en GRIDCODE_1** (is EMEP-grid)
    uitvoer: ***CC*_ECL_EMEP_D**
  - clippen van polygonen naar landsgrenzen (excl. zee, buitenland)
    uitvoer: ***CC*_ECL_EMEP_C**
  - toevoegen van nieuw veld voor oppervlakte: **AREA_SUM**
  - berekenen van de oppervlakte: **AREA_SUM** in hectares
  - exporteren van de attribuuttabel van ***CC*_ECL_EMEP_C** naar speciale database voor converteren naar Call-formaat.
    database: **SEI_ECL_EMEP.mdb**
  - deleten van tussenproducten: ***CC*_ECL_EMEP** en ***CC*_ECL_EMEP_D**

4. ecl_emep_big.jsl (per land) voor grotere landen aangeleverd in meerdere delen. Overlay van ECL-polygonen met EMEP50-grid en exporteren

Er worden report files aangemaakt waarheen mogelijke fouten worden gerapporteerd. De namen van de report-files worden dynamisch bepaald in de python-scripts.

Countries: **ES, FI, FR, RU en SE**

- **ecl_emep_big.py (zie ook ecl_emep.py)**
  - Aanmaken van een nieuwe personal geodatabase.
    uitvoer: ***CC*_ALL_ T*part*_GD_2.MDB**
  - verder zelfde als bij ecl_emep.py

5. Bewerking van CC_ECL_EMEP_C tabellen in SEI_ECL_EMEP-database

- **MERGE_EMEP_EUNIS**
  - Visual Basic script om de tabellen van de verschillende delen per land afkomstig van **ecl_emep_big.jsl** aan elkaar te plakken. Hiervoor is ***CC*_ECL_EMEP_C** gecopieerd naar ***CC*_ECL_EMEP_C_0** en ***CC*_ECL_EMEP_C** leeggemaakt.
- **CONVERT_CALL_FORMAT**
  - Visual Basic script om de gegevens te copieren naar Empirical Critical Load Call formaat. Aparte tabellen voor ECLMINDF en ECLMAXDF
- **Export_EMP_CL**
  - Visual Basic script om de SEI-empirical critical load files te exporteren als CSV file genaamd: ***CC*e.csv**

D. Aanmaken van een EUNIS3-code kaart op basis van SEI-EUNIS kaart

Beschrijving van de JSL-scripts

Er zijn landen welke in een deel zijn aangeleverd en landen welke in meerdere delen zijn aangeleverd. Hiervoor zijn aparte scripts gemaakt omdat er in het geval van meerdere delen meer stappen moesten worden uitgevoerd.

1. eunis3_2ras2.jsl (per land) voor landen in een deel aangeleverd en kleinere landen aangeleverd in meerdere delen

Er worden report files aangemaakt waarheen mogelijke fouten worden gerapporteerd. De namen van de report-files worden dynamisch bepaald in de python-scripts.

- **loopcc_eun3.jsl**
  - EUNIS3 variabele is Null dan waarden 0 toevoegen
  - invoertabel: ***CC*_ALL_EnZ** in database: ***CC*_ALL_GD.mdb**
- **eunis3_2ras.py**
  - conversie van polygonen bestand naar rasterkaart 100 meter voor **EUNIS3**
    uitvoer: ***CC*_T_EUN3_EMP**
  - clippen van rasterkaart voor land(deel) naar landsgrenzen
    (excl zee, buitenland)
    uitvoer: ***CC*_T_EUN3_EM2**

2. eunis3_2ras_bg2.jsl (per land) voor grotere landen aangeleverd in meerdere delen

Er worden report files aangemaakt waarheen mogelijke fouten worden gerapporteerd. De namen van de report-files worden dynamisch bepaald in de python-scripts.

- **loopcc_eun3_big.jsl**
  - **EUNIS3** variabele is Null dan waarden 0 toevoegen
  - invoertabel: ***CC*_ALL_EnZ** in database: ***CC*_ALL_T*part*_GD.mdb**
- **eunis3_2ras.py (zie eunis3_2ras2.jsl)**
  - conversie van polygonen bestand naar rasterkaart 100 meter voor **EUNIS3**
    uitvoer: ***CC*_P*part*_EMP**
  - clippen van rasterkaart voor land(deel) naar landsgrenzen (excl. zee, buitenland)
    uitvoer: ***CC*_P*part*_EM2**
- **merge_eunis3_big.py**
  - Merge parts ***CC*_P*part*_EM2** to merged file: ***CC*_T_EUN3_EM2**

Afwijkende landen:

- Portugal, Spanje en Frankrijk omdat extent kleiner moest worden gemaakt i.v.m overzeese gebieden en eilanden ver van Europa.
  100 meter kaart Portugal kleiner extent: **PT_T_EUN3_EM3**
  100 meter kaart Spanje kleiner extent: **ES_T_EUN3_EM3**
- Van Uzbekistan is de extent file handmatig aangemaakt omdat deze niet juist voorkwam in de **EUR.mdb** database.

ANNEX 4:

Description of the distinguished numeric EUNIS codes on second level

Numeric code`(E2) combi	EUNIS CODE list	EUNIS description
100	A	Marine habitats
112	A1 or A2	Littoral rock and other hard substrata or Littoral sediment without Coastal saltmarshes and saline reedbeds or Littoral sediment with coastal saltmarches and saline reedbeds
134	A3 or A4	Infralittoral rock and other hard substrata or Circalittoral rock and other hard substrata
139	A3 or A4 or A5	Infralittoral rock and other hard substrata or Circalittoral rock and other hard substrata or Sublittoral rock
105	A5	Sublittoral sediment
106	A6	Deep-sea bed
107	A7	Pelagic water column
108	A8	Ice-associated marine habitats
200	B	Coastal habitats
201	B1	Coastal dunes and sandy shores
202	B2	Coastal shingle
203	B3	Rock cliffs, ledges and shores, including the supralittoral
300	C	Inland surface waters
301	C1	Surface standing waters
302	C2	Surface running waters
312	C1 or C2	Surface standing waters and surface running waters
303	C3	Littoral zone of inland surface waterbodies
400	D	Mires, bogs and fens
401	D1	Raised and blanket bogs
424	D2 or D4	Valley mires, poor fens and transition mires or Base-rich fens and calcareous spring mires
403	D3	Aapa, palsa and polygon mires
405	D5	Sedge and reedbeds, normally without free-standing water
406	D6	Inland saline and brackish marshes and reedbeds
500	E	Grasslands and lands dominated by forbs, mosses and lichens
501	E1	Dry grasslands
502	E2	Mesic grasslands
503	E3	Seasonally wet and wet grasslands
504	E4	Alpine and subalpine grasslands
505	E5	Woodland fringes and clearings and tall forb stands
506	E6	Inland salt steppes
507	E7	Sparsely wooded grasslands
600	F	Heathland, scrub and tundra
601	F1	Tundra
602	F2	Arctic, alpine and subalpine scrub
603	F3	Temperate and mediterranean-montane scrub
604	F4	Temperate shrub heathland
656	F5 or F6	Maquis, arborescent matorral and thermo-Mediterranean brushes or Garrigue
607	F7	Spiny Mediterranean heaths (phrygana, hedgehog-heaths and related coastal cliff
608	F8	Thermo-Atlantic xerophytic scrub
609	F9	Riverine and fen scrubs
610	FA	Hedgerows
611	FB	Shrub plantations

Numeric code`(E2) combi	EUNIS CODE list	EUNIS description
700	G	Woodland, forest and other wooded land
701	G1	Broadleaved deciduous woodland
702	G2	Broadleaved evergreen woodland
703	G3	Coniferous woodland
704	G4	Mixed deciduous and coniferous woodland
705	G5	Lines of trees, small anthropogenic woodlands, recently felled woodland, woodland and coppice
800	H	Inland vegetated or sparsely vegetated habitats
801	H1	Terrestrial underground caves, cave systems, passages and waterbodies
802	H2	Screes
803	H3	Inland cliffs, rock pavements and outcrops
804	H4	Snow or ice-dominated habitats
805	H5	Miscellaneous inland habitats with very sparse or no vegetation
806	H6	Recent volcanic features
900	I	Regularly or recently cultivated agricultural, horticultural and domestic habitats
901	I1	Arable land and market gardens
902	I2	Cultivated areas of gardens and parks
1000	J	Constructed, industrial and other artificial habitats
1001	J1	Buildings of cities, towns and villages
1002	J2	Low density buildings
1003	J3	Extractive industrial sites
1004	J4	Transport networks and other constructed hard-surfaced areas
1005	J5	Highly artificial man-made waters and associated structures
1006	J6	Waste deposits
2400	X	Habitat complexes
2500	Y	Unknown