

Austria

National Focal Centre

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Status

Introduction

In response to the 2015-17 call for data the NFC for Austria provides 1) a report on the status quo regarding biodiversity critical loads, and 2) re-reports the critical load data on acidity (Simple Mass Balance, SMB) and eutrophication (SMB and empirical critical loads) in the new EMEP grid resolution of $0.10^\circ \text{ Lon} \times 0.05^\circ \text{ Lat}$ from the previous call for data. The NFC of Austria is not yet reporting regionalized biodiversity critical loads because of a lack of data and knowledge for many of the existing protected forest and grassland habitats.

Method

For the assessment of biodiversity critical loads we applied dynamic soil-vegetation- modelling and species response function analysis as implemented in PROPS-CLF, recently developed by Posch (2016). The critical load data on acidity and eutrophication were reported without changes to the previous version in the last Annual Report.

For dynamic soil-vegetation modelling we use the dynamic biochemical soil model VSD+ (version 5.4, Bonten et al., 2016) together with the two plant response models PROPS (Reinds et al., 2014) and BERN (Schlutow et al., 2015) (the latter only for validation). The VSD+ model includes cation exchange and organic C and N dynamics according to the RothC-Model (version 26.3, Coleman and Jenkins, 2005). We applied the Habitat Suitability Index (HSI) that describes the degree of suitability of site conditions for a set of typical species to co-occur. The HSI is defined as the arithmetic mean of the normalised probabilities of occurrence of these species (Posch et al., 2014). In our study, we adopted phyto-sociological plant community descriptions approach (European Commission DG Environment, 2013) to define distinctive plant species for each of the sites. Please note that this approach deviates from the species per habitat selection implemented in PROPS-Select (Reinds, 2016) as it is more detailed, resulting in different sets of species within the same EU habitat.

In addition to dynamic soil-vegetation modelling the simple mass balance (SMB) model was used to derive biodiversity critical loads for selected habitat types. We applied the PROPS-CLF model, developed by the Coordination Centre of Effects (Posch, 2016), to the 18 forest sites and also to a number of additional grassland sites (Figure AT-1, Table AT-1). For the purpose of comparison with empirical CLs (Bobbink &

Hettelingh 2011) and CLs based on soil solution criteria we focussed on CLN_{max} of the N-S critical load function. We used a threshold of 0.8 for the Habitat Suitability Index (HSI) to calculate CLN_{max} .

Data sources

For assessing biodiversity critical loads we used 18 forest sites which are part of ICP Forests and ICP Integrated Monitoring in the framework of effects monitoring within the UNECE Convention on Long-range Transboundary Air Pollution. These sites comprise 5 of totally 8 forest types protected under the European Habitat Directive in Austria (Directive 92/43/EEC, Annex 1 and others). In addition, 11 grassland sites grouped to three habitats protected under the EU Directive were used (Figure AT-1, Table AT-1).

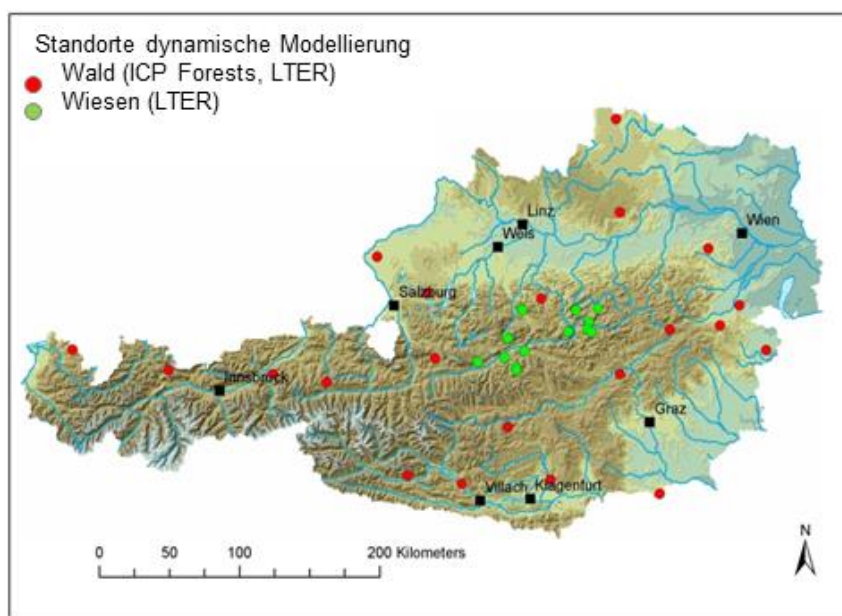


Figure AT-1. Location of forest (red) and grassland (green) sites used for dynamic soil-vegetation modelling.

Discussion regarding biodiversity critical loads

In the course of this and the previous calls for data, dynamic soil-vegetation models were applied to existing long-term forest monitoring sites (ICP Forests, ICP IM) in order to infer biodiversity effects of airborne reactive nitrogen deposition. These activities were supported by an additional research project (CCN-Adapt, Austrian Climate Research Program), which focussed on interacting effects of climate change and air pollution.

Table AT-1. Site characteristics and habitat type according to the European Habitat Directive (Directive 92/43/EEC).

EU Habitat type	Site code	Altitude (m)	Lat	Lon	Plant community
6170: Alpine and subalpine calcareous grasslands	GL_AL40	1487	47.69	14.89	Caricetum ferrugineae LÜDI 1921
	GL_AL55	1676	47.65	14.88	
	GL_AL88	1677	47.63	14.91	
6210: Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia)	GL_HT12	880	47.78	14.24	Onobrychido-Brometum erecti TH. MÜLLER 1966
	GL_HT13	885	47.77	14.26	
	GL_HT38	680	47.52	14.27	
	GL_HT43	810	47.61	14.13	
	GL_HT45	815	47.6	14.1	
6230 *: Species-rich Nardus grasslands, on siliceous substrates in mountain areas	GL_AL29	1585	47.64	14.7	Homogyno alpinae-Nardetum Mráz 1956
	GL_AL30_1	1591	47.64	14.7	
	GL_AL30_2	1070	47.77	14.77	
9110: Luzulo-Fagetum beech forests	IF_AT05	720	46.72	13.68	Luzulo-Abieto-Fagetum (typ. Subass.) HARTM. et JAHN 1967
	IF_AT08	630	48.93	15.19	Calamagrostio villosae-Fagetum sylvatici MIKUSKA 1972
	IF_AT10	960	48.1	12.87	Luzulo-Abieto-Fagetum (typ. Subass.)
	IF_AT13	670	46.63	15.52	HARTM. et JAHN 1967
9130: Asperulo-Fagetum beech forests	IF_AT03	930	46.74	14.50	Asperulo-Fagetum SOUGNEZ et THILL 1959
	IF_AT04	1190	46.77	13.17	
	IF_AT09	510	48.12	16.05	Hordelymo-Fagetum sylvatici TX. 1937 (Dryopteris-Subass.)
	IF_AT11	860	47.88	13.35	Asperulo-Abieti-Fagetum sylvatici (Dryopteris-Subass.) TH. MÜLLER 1966 and Luzulo-Abieto-Fagetum (typ. Subass.) HARTM. et JAHN 1967
	IF_AT15	715	47.63	15.66	Helleboro nigri-Fagetum sylvatici ZUKRIGL 1973
	IM_AT01	900	47.84	14.44	Cardamino trifoliae-Fagetum sensu WILLNER 2002
	IM_AT02	880	47.84	14.44	Adenostylo glabrae-Fagetum sensu WILLNER 2002
9150: Medio-European limestone beech forests of the Cephalanthero-Fagion	IF_AT07	500	47.65	16.13	Cyclamini (purpurascens)-Fagetum sylvatici SOÓ 1962
91G0 *: Pannonic woods with Quercus petraea and Carpinus betulus	IF_AT01	390	47.77	16.32	Carici pilosae-Carpinetum NEUH. & NEUH.-NOV. 1964
	IF_AT02	290	47.49	16.56	Sorbo torminalis-Quercetum (petraea) SVOBODA ex BLAZKOVA 1962 incl. Festuco heterophyllae-Quercetum Neuh. & Neuh.-Nov. 1964
9410: Acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea)	IF_AT12	920	47.49	13.42	Bazzanio-Piceetum (SCHMIDT et GAISBERG 1936) BR.-BL. et SISSINGH in BR.-BL. et al. 1939
	IF_AT14	960	47.37	15.17	Galio rotundifolii-Abietetum WRABER 1959
	IF_AT16	1540	47.06	14.11	Homogyno alpinae-Piceetum (Rhytidiadelphus loreus-Subass.) ZUKRIGL 1973
	IF_AT18	1020	47.39	10.91	Calamagrostio variaae-Piceetum SCHWEINGRUBER 1972

We were able to model the soil chemistry of these sites in a reasonable way using the dynamic soil model VSD+ (Bonten et al., 2016). Yet, management driven changes in the soil solution chemistry and in the HSI could not be modelled appropriately (Figure AT-2A). However, when comparing the results of PROPS with those from a second plant response model (BERN), which is based on an independent empirical data set and which is rather different as to its statistical approach (Schlutow et al.,

2015), they showed a very high relation (Figure AT-2B). We note that BERN generally resulted into higher values because species occurrence calculations are not based on a genuinely probabilistic approach. Hence, the niche functions, which are implemented in PROPS are, in general, reliable for they are statistical representations of observed species occurrence data. However, on a site scale, and particularly when forest management is involved, which is changing the species composition, predictions are inherently difficult and hard to validate.

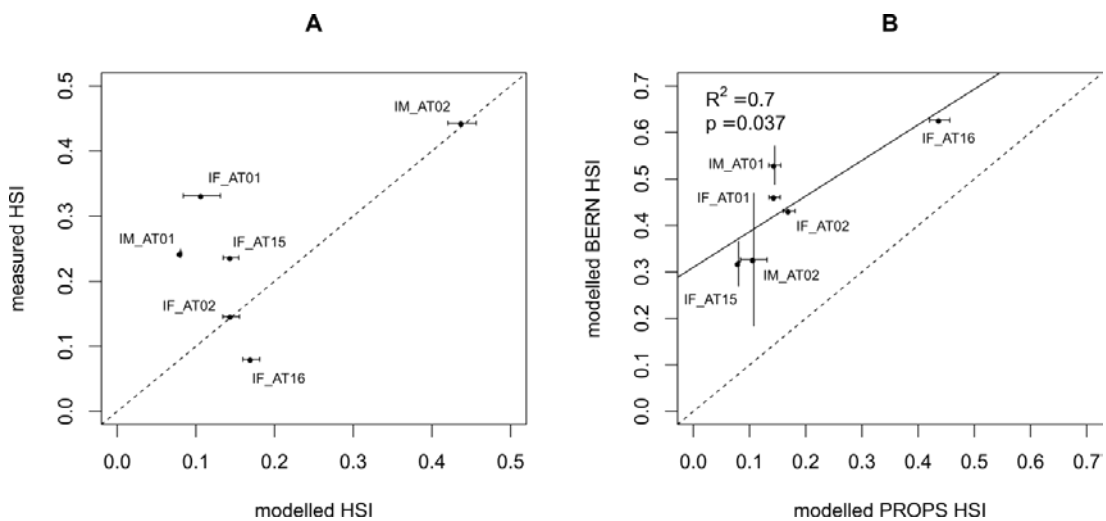


Figure AT-2. Comparison of the modelled Habitat Suitability Index (mean and standard deviation) using PROPS with A) observed data and B) with modelled HSI from BERN (using the same soil and climate data as PROPS). Six sites with vegetation records between 1996 and 2007 were used. The 1:1 line is dashed, the regression line is solid.

When applying climate and deposition scenarios to the calibrated models the HSI was predominantly driven by expected future climate change and only to a low extent by deposition. In line with our expectations, among the distinctive species climate changes increased the occurrence probability of the most thermophilic plant species while the most cold-tolerant species decreased. Also, climate change improved the occurrence probability of the oligotrophic species while species preferring sites with higher nutrient availability declined in response to decreasing soil C:N ratios indicating a tightening of the nutrient cycle. As a consequence, HSI decreased in all habitat types in response to climate change (Figure AT-3A). On the other hand, N deposition increased the occurrence probability of plant species preferring nutrient rich sites. However, the HSI increased to a small extent in all habitat types, meaning that additional N improved habitat suitability at these forest sites (Figure AT-3B). This surprising result is due to the fact that N deposition is rather low in most of the sites but might also be due to the fact that N deficiency is still widespread in Austria because of historic overuse and acidification during the last part of the 20th century (Jandl et al., 2012). As to critical loads, this result means that current and future deposition does not exceed a biodiversity threshold in the majority of the sites.

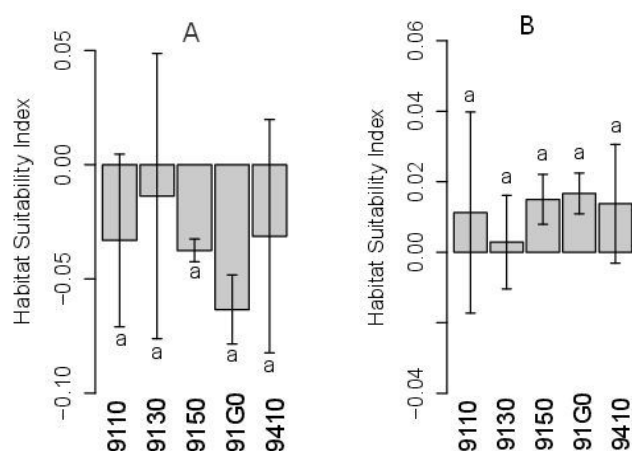


Figure AT-3. Effects of climate change (A) and N deposition (B) on the Habitat Suitability Index (mean and standard deviation of effects in the year 2100 as derived from 5 different climate change scenarios) in different EU habitat directive types. Means with different letters are significant different (Tukey's HSD $p < 0.05$). Effects are given in the form of ANOVA coefficients describing the difference between the mean values of all baseline climate model runs and the respective climate change scenario by the year 2100 and the difference between the mean values of all Maximum Feasible Reduction deposition scenarios and the respective CLE and B10 deposition scenario by the year 2100 at each site. Positive coefficients represent increasing, negative coefficients decreasing effects. Note that MFR scenarios have the lowest N deposition. 9110: *Luzulo-Fagetum* beech forests, 9150: *Medio-European limestone beech forests of the Cephalanthero-Fagion*, 9130: *Asperulo-Fagetum* beech forests, 91G0: *Pannonic woods with Quercus petraea and Carpinus betulus*, 9410: *Acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea)*.

The biodiversity CL (CLN_{max}) calculated with PROPS-CLF for the same forest sites corroborate this finding. CLs were much higher than current deposition. Median CLN_{max} reached a magnitude between 28 and 38 kg N ha⁻¹ y⁻¹ (Figure AT-4). These loads were substantially higher than $CL_{emp}N$ ((5)10-(15)20 kg N ha⁻¹ y⁻¹) and also much higher than the median $CL_{nut}N$ derived from the soil solution criterion SMB approach across Austrian forests (11 kg N ha⁻¹ y⁻¹). The median CLN_{max} for the grassland habitats were between 17 and 21 kg N ha⁻¹ y⁻¹. Similar to forests, $CL_{emp}N$ was substantially lower than CLN_{max} but not so for semi-natural dry grasslands (6210) where $CL_{emp}N$ were in accordance with the calculated biodiversity CLs or even higher (Figure AT-4).

Conclusions regarding biodiversity critical loads

Dynamic modelling suggests that while climate change will clearly lower the species' suitability of Austrian forest habitats which are protected under the European Habitat Directive (Directive 92/43/EEC), N deposition effects will be comparably weak. The reasons are twofold. First, N deposition in these forests will not exceed loads at which major changes in the soil chemistry occur, and, second, climate driven increase in N immobilisation (particularly through tree growth) will offset soil N enrichment (Butler et al., 2012). While climate change is not the focus of this report, it is however important to note that biodiversity CLs, as defined by the Habitat Suitability Index, seem to be higher than

current and future N deposition in the more widespread forest types in Austria.

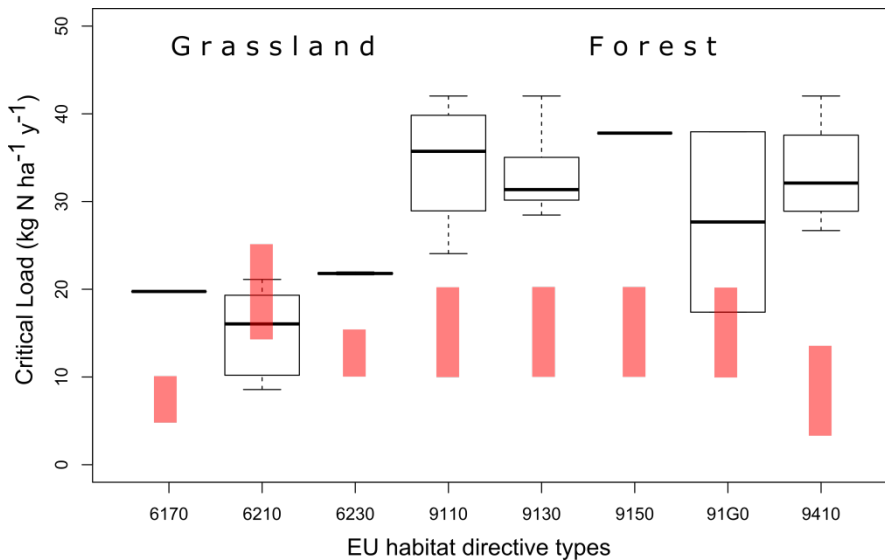


Figure AT-4. Comparison of Biodiversity Critical Loads (CLN_{max} boxplots) and empirical Critical Loads for Nitrogen (red bar with maxima and minima CL_{empN}). 6170: Alpine and subalpine calcareous grasslands, 6210: Semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*), 6230: Species-rich *Nardus* grasslands, on siliceous substrates in mountain areas, 9110: *Luzulo-Fagetum* beech forests, 9150: Medio-European limestone beech forests of the *Cephalanthero-Fagion*, 9130: *Asperulo-Fagetum* beech forests, 91G0: Pannonic woods with *Quercus petraea* and *Carpinus betulus*, 9410: Acidophilous *Picea* forests of the montane to alpine levels (*Vaccinio-Piceetea*).

When using the species response functions of PROPS to derive HSI, the CLs for the different forest habitat types were substantially higher than empirical CLs and mass balance CLs for N. This was also true for two of the three grassland types. Only the CL for semi-natural dry grassland corresponded well with CL_{empN} .

The forest sites used for these analyses are from the Austrian ICP Forests and ICP Integrated Monitoring network. They represent the major forest habitats in Austria with a wide distribution but these networks were not designed to cover rare habitats under conservation protection. Hence, only one of totally 8 Annex I priority habitats could be included due to a lack of data. The knowledge base for grassland is even scarcer. Although we were able to use data for some grassland habitats, which are sensitive to air pollution, only one of totally five Annex I priority habitats could be included. Also many other habitat types protected under the Directive (natural alpine habitats, raised bogs, etc.) could not be included.

Owing to the discrepancy between modelled and empirical CL, which calls for more in-depth analyses, and particularly because of the scarcity of Annex 1 priority habitats in our analysis, we do not yet calculated regionalized biodiversity CLs.

Reported CL data sets

The here reported CL data is the same data as reported in the year 2015:

- Critical loads of acidity: $CL_{\max}S$, $CL_{\min}N$ and $CL_{\max}N$ as computed with the SMB model. Only forest sites with an area $>0.01 \text{ km}^2$ were included;
- Critical loads of nutrient nitrogen ($CL_{\text{nut}}N$): also here the SMB was applied. Only forest sites with an area $>0.01 \text{ km}^2$ were included;
- Empirical critical loads ($CL_{\text{emp}}N$): based on a habitat map and empirical values given in Bobbink and Hettelingh (2011). Only forest sites with an area $>0.01 \text{ km}^2$ were included;
- The two N critical loads are reported in the new database format. For all but forests empirical critical loads for eutrophication effects ($CL_{\text{emp}}N$) were used. For forests, mass balance critical loads ($CL_{\text{nut}}N$) were used because the detail in EUNIS forest types was too coarse to differentiate sufficiently.

Acknowledgements

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