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Introduction

The German NFC responds to the Call for Data 2012–14 (CCE 2012) and submits effect indicator-values with the aim to assess 'no net loss of biodiversity'. Suitable biodiversity endpoints were tested to compile output variables of soil-vegetation models for different EUNIS classes. The calculation of biodiversity indicators for scenario assessment of changes in biodiversity was done by building a model chain of MetHyd, VSD+ and BERN.
Table DE.1 shows the different sites of the model chain application and the *historic* (1880), *highest* (1980) and *future* (2020) deposition derived by the CCE. The future deposition is based on the revised Gothenburg Protocol. The table shows that most of the plots are clearly in the lower region of the min-max range with respect to historic, highest and future deposition of sulphur and ammonia. The oxidized nitrogen on all plots is clearly above the average of 876 eq ha^{-1} yr^{-1} in the deposition year 1980.

Table DE.1 Selected sites and their past and future deposition in eq ha^{-1} yr^{-1}.

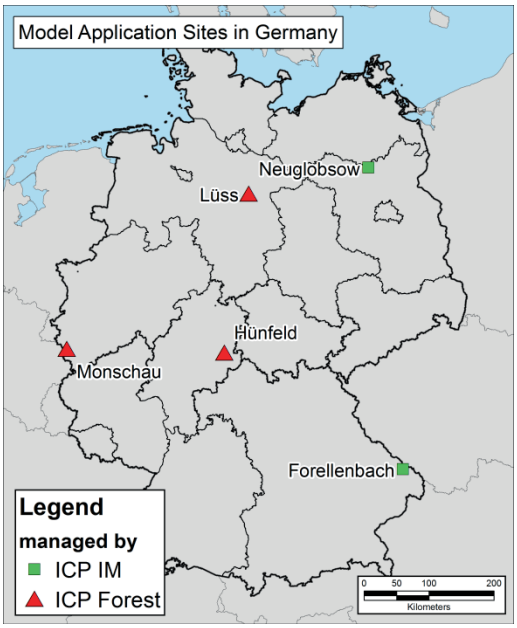
		SOx			NOx			NHy		
	EUNIS class	Historic (1880)	Highest (1980)	Future (2020)	Historic (1880)	Highest (1980)	Future (2020)	Historic (1880)	Highest (1980)	Future (2020)
Min-Max		113-912	1142-10396	126-1451	31-71	355-1396	185-1123	129-756	340-3455	381-2408
Forellenbach	G1.61	251	4363	203	57	1147	262	578	1094	967
Neuglobsow	G1.63	449	3253	232	54	943	269	361	887	677
Lüss	G1.63	341	3876	351	58	1060	501	446	1092	814
Monschau	G3.1D2	376	4535	296	69	1216	269	403	1237	677
Hünfeld	G1.61	384	4574	398	61	1179	419	423	1040	768

Site-specific soil and vegetation model runs at selected plots

Description of selected sites in Germany

For the assessment of biodiversity effects the German NFC applied the latest versions of the MetHyd (v1.5.1) and VSD+ (v5.0.1) model provided by the CCE. Some resulting parameters of the VSD+ model describe indicators of soil eutrophication (C:N ratio) and acidification (pH of soil solution). These parameters were used as input for the recent version of the ecological response model BERN (v3.3). This model is designed and developed by OEKO-DATA. The model chain MetHyd - VSD+ - BERN was applied to five selected sites in Germany with two different deposition scenarios. Two plots are sites of the ICP Integrated Monitoring and three are part of the ICP Forests Level II network. The chosen sites represent different EUNIS-classes and vegetation types. They are also located in quite different landscapes and climate regions (see Figure DE.1). The German sites for the application of the model combination represent not only different ecosystems but also different environmental and soil chemical conditions. The selected plots are also located in regions with different air pollution history and future perspective (see Table DE.1).

Figure DE.1 Selected sites for the application of the model combination in Germany.



Input parameters

Most input data for the VSD+ model were derived by the extended description and characterization of the sites by the different survey projects. The data set for base cations and chloride deposition was derived from the MAPESI project (MAPESI 2011). For this study the average of three years (2005, 2006 and 2007) was chosen as input for landuse specific base cation and chloride deposition. The data set for nitrogen and sulphur deposition was provided by the CCE. This data set includes historic deposition which starts in the year 1880 and ends in the year 2008. The data set also includes the predicted deposition of sulphur and nitrogen in the year 2020 assuming the full application of the revised Gothenburg Protocol (rGP). Another part of this database contains information about assumed non anthropogenic background deposition. This dataset was neglected in this study since it has large gaps (or zero values) for most areas in central Germany. No deposition of nitrogen might influence the soil chemical model too strongly. Therefore the deposition of the year 1880 was used as pre-industrial background deposition (BKG).
The uptake parameter was estimated assuming extensive land use. The values for litterfall (dry mass, carbon and nitrogen content) were derived from measurements on the plots. The input time series

was adapted to reflect a lower litterfall flux during the forest maturing period (first 40 years). The water content of the soil, the percolation and reduction factors of the nitrification, denitrification and mineralization was derived, applying the 'MetHyd' (v1.5.1) tool provided by the CCE.

Application of the soil chemical and vegetation response models

The focuses in this study was the modelling of the soil chemistry (using VSD+) and link the results to a vegetation response model (BERN). The model output of VSD+ for pH and the C:N ratio was chosen to model trends of possibility for plant species and/or plant communities site potential. Figure DE.2 shows the results for pH and C:N ratio for the ICP IM plot "Forellenbach". This plot has measured pH values (soil solution in different soil depths) for more than two decades (blue X with standard deviation bars) and various measurements of soil carbon and nitrogen (in the year 1990 and 2010). These measured values are needed for the calibration and affect the model results directly (see the increasing oscillation in years of pH measurements).

The BERN model calculates the possibilities of plant species and communities by using fuzzy functions for 7 different site factors (soil water content, base saturation or pH, C:N ratio, climatic water balance, vegetation period, solar radiation and temperature). These functions represent the realized ecological niche under pristine or semi-natural conditions. Within this study the dynamic trends of parameters (pH and C:N ratio) and fixed parameters (all others) were used. The inclusion of the dynamic trends shall reflect the reaction of the vegetation to changes in the soil chemistry given by the VSD+ model. The fixed parameters were calibrated to the optimum of the recently found plant community. Figure DE.3 shows the pure number of species with different possibility thresholds in time. A possibility below 0.1 (vitality 10%) marks a high level of plant physiological stress and great risk of damage to the plant or dysfunctions for a plant community. Values above 0.5 (vitality 50%) indicate moderate and values above 0.8 (vitality 80%) full regeneration capabilities for plant species or plant communities. The decreasing trend in the 'rGP' scenario of pH (4.8 to 4.3) and C:N ratio (25 to 22) till 1990 is reflected by a decreasing number of species with moderate (0.5) possibility (140 to 126). The VSD+ modelled pH values react quite strong in the years between 1990 and 2010 while the C:N ratio shows only little fluctuation. The modelled possibility of plant species reacts to this alteration (the plants with low possibilities stronger than the plants with higher values). Figure DE.3 also illustrates the reaction of the biota to lower deposition of sulphur and nitrogen (background deposition). Generally the total number of possible species doesn't vary a lot between these scenarios of deposition. But the reaction of the plant species to the high deposition values in the 1980s is easily traceable in the 'rGP', while staying relatively stable in the 'BKG' scenario. Due to the N limitation less plant species are expected with background deposition. In addition to the analysis of the development of pure species numbers different sets of plant species and plant communities were analysed regarding their site potential. The set of plant species arises from the identification of the current plant community on the site. On the two sites of the ICP Integrated Modelling ('Forellenbach' and 'Neuglobsow') a plant survey and ecologic classification was done by the German NFC

Figure DE.2 pH value in soil solution (left) and C:N ratio in soil (right) modelled with the VSD+ model at the ICP IM plot "Forellenbach" based on the "rGP" scenario.

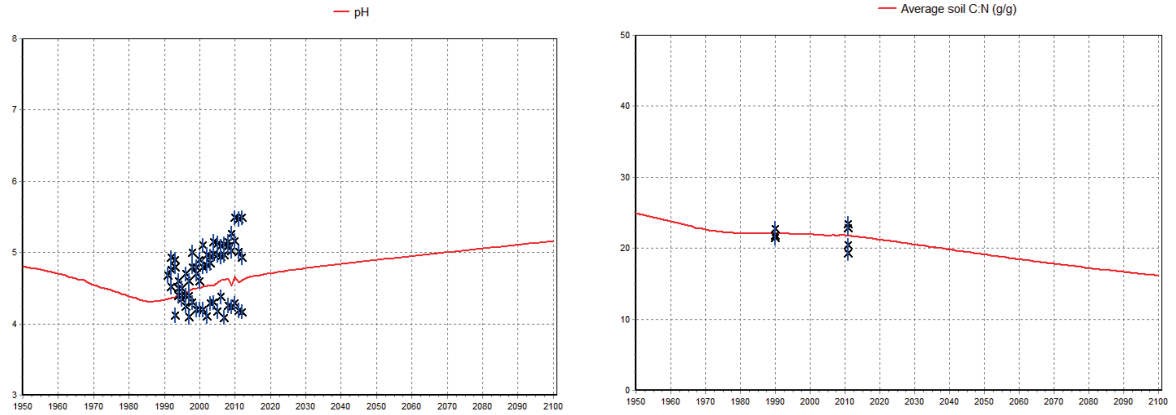
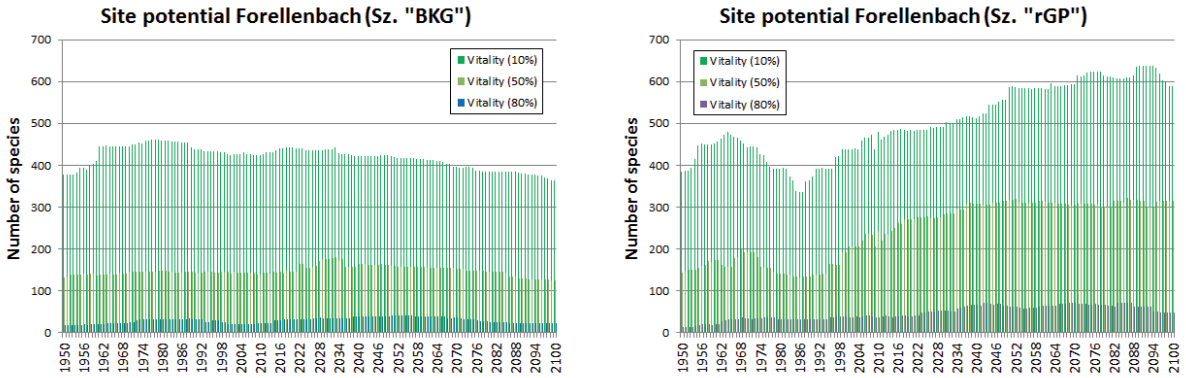


Figure DE.3 Number of plant species with possibility of 0.1, 0.5 and 0.8 at the ICP IM plot 'Forellenbach' for different deposition scenarios (BKG = background and rGP = revised Gothenburg Protocol).



for ICP Modelling & Mapping itself. On the ICP Forest plots the current (last available survey) plant composition and degree of coverage was derived from the database of the ICP Forest. Which plant species are expected to be constant members of a natural plant community is documented in the BERN model. Figure DE.4 shows the results for the ICP IM site 'Forellenbach' assuming *Luzulo-Abieto-Fagetum sylvatici (Vaccinio myrtillus-Subass.)* as current natural plant community. All the expected constant species of this plant community were analysed regarding their dynamic site potential. In addition, the Sørensen index as described in CCE Status Report, Annex 4A p.53 (CCE 2011) was calculated. The reference condition of the plant species was set to 1 in order to represent the best ecological condition. The Sørensen index can be used to indicate the general reaction of all plant species in one graph. Examining the reaction of the plant species indicates that the background (BKG) scenario is characterized by generally higher possibilities compared with the 'rGP' scenario and has no decrease in the 1990s. Also the outlook (2030–2100) seems to be better in the background scenario. Figure DE.5 shows the Sørensen index for the different deposition scenarios on the left side. The graph on the right side displays the site potential of the plot described by the number of species with three different levels of possibilities. By including the possibility of the plant species, the Sørensen index is altered not only by the presence and absence, but also by the vitality of the occurring species.

Figure DE.4 Possibility of plant species and Sørensen Index for VSD+ results on basis of background (left) and revised Gothenburg Protocol deposition (right).

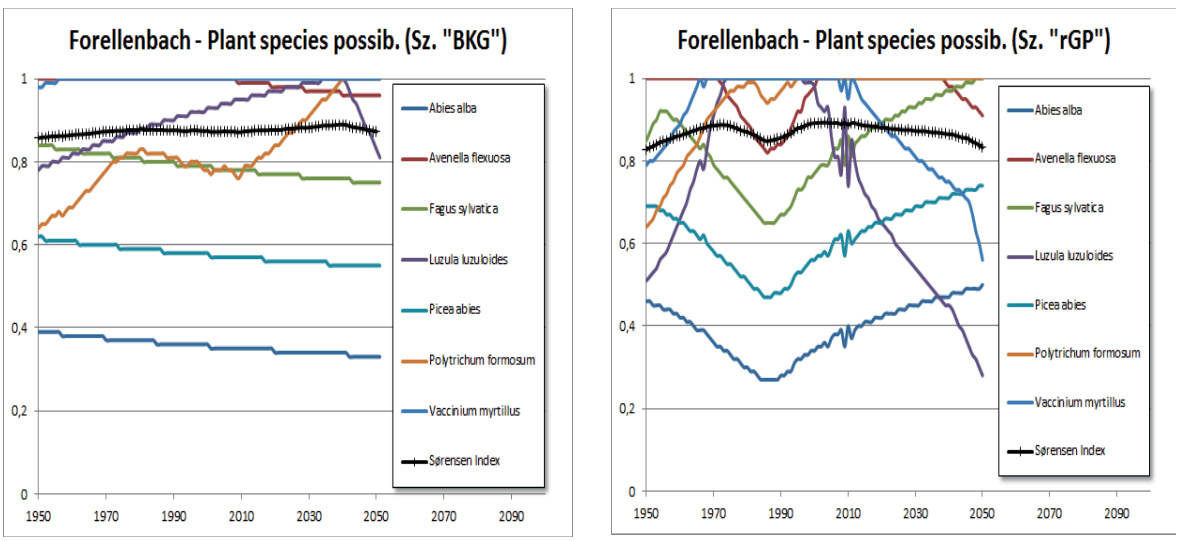
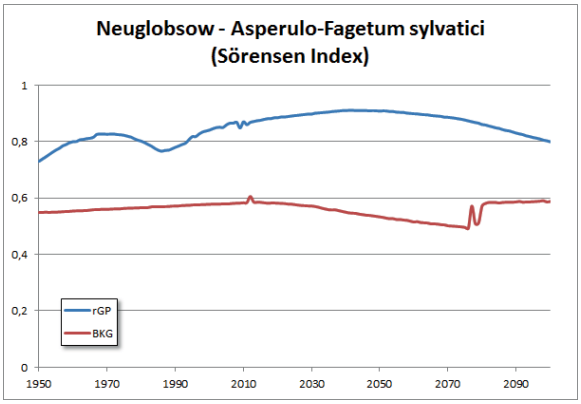
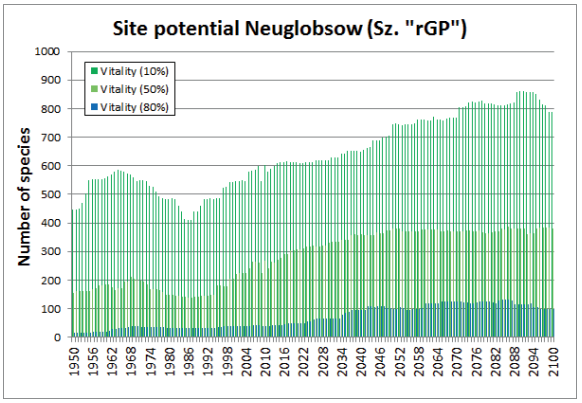
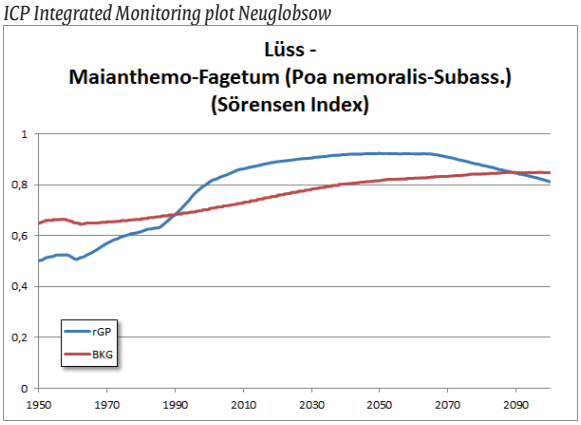


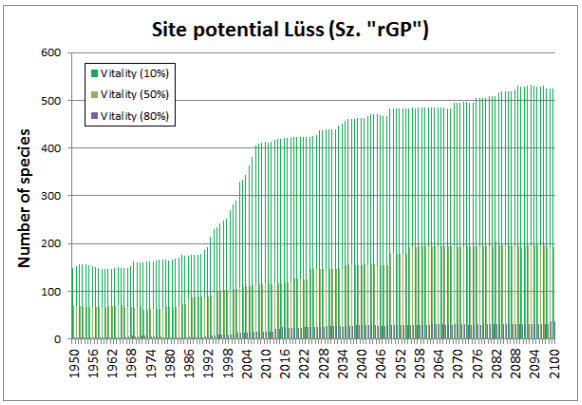
Figure DE.5 Similarity Index (left) and number of possible species (right) for Neuglobsow, Lüss, Monschau and Hünfeld.



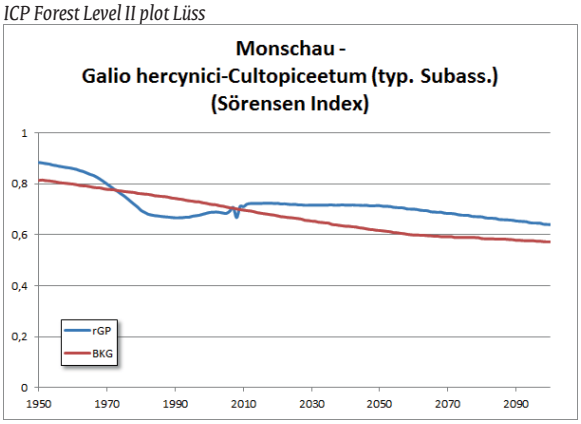


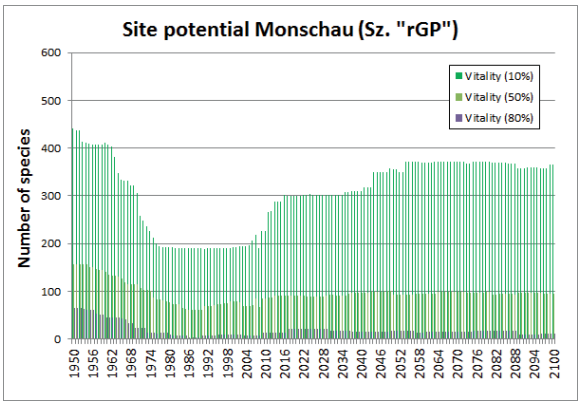
ICP Integrated Monitoring plot Neuglobsow



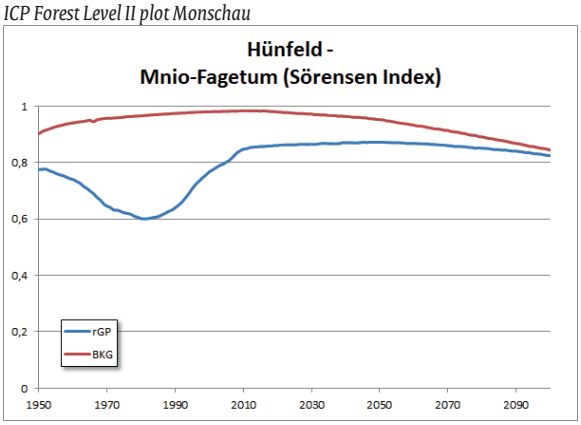


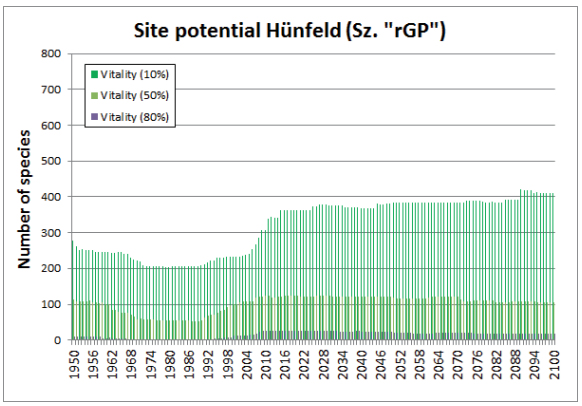
ICP Forest Level II plot Lüss





ICP Forest Level II plot Monschau





ICP Forest Level II plot Hünfeld

Discussion of modelling results

The comparison of the potential number of species (e.g. ICP IM site 'Forellenbach', see Figure DE.3) offers rough estimates of the site potential under different deposition scenarios. On the one hand the site potential in the background deposition run is rather stagnating and has no decrease in the 1980-1990ties. On the other hand the results on basis of higher deposition ('rGP' scenario) predict an increased site potential indicated by higher number of possible plant species on various health levels over large time spans.
From an ecological perspective the number of species alone cannot serve as protection objective to avoid loss of biodiversity. If a nutrient poor site, for example, will be changed to eutrophic conditions the number of species will increase, but rare species may be displaced. This shows that the analysis of the (potential) number of species might not be satisfying for the purpose. Therefore in addition the similarity analysis with the Sørensen index was done.

Two aspects of the similarity analysis determine the interpretation of the results for the Sørensen index crucially. The first aspect is the choice of the reference. The reference plant species composition may vary with different protection goals. For this study the currently existing plant relevés was analyzed regarding the plant species. This set of species was compared with the database of the BERN model and the constant members of the best fitting natural plant community were chosen as reference composition. Therefore the protection target can be described as the good ecological condition. The second aspect of the similarity analysis is the reaction of the single plant species to the predicted changes of soil chemistry. The aggregation of the possibilities of the single plant species might serve as indicator for future ecological developments on the site.
Looking at the results for the ICP IM plot 'Forellenbach' it seems that a few members of the desired plant community will not perform well in the future under the 'rGP' scenario. The results for the 'BKG' scenario show a more constant performance of the single plant species (see Figure DE.4).
The analyses of the potential number of species on all plots are shown in Figure DE.5 (right graphs). Comparing the numbers for the decade 1980-1990 it seems that the number of species will rise in future on all plots. The behaviors of the curves before the decade 1980–90 differ a bit. At the plots 'Neuglobsow' and 'Monschau' the numbers decrease while the plots 'Lüss' and 'Hünfeld' show generally low numbers especially for plant species with moderate and high potential. This analysis might be useful to get a first impression of the plot potential. It doesn't say anything about positive or negative trends in terms of sustainable ecological development or changes in biodiversity. The Sørensen index (see Figure DE.5, left graphs) taking into account the information about constant members of a natural plant community offers more information. Looking at the results for the 'rGP' scenario all figures have in common that the chosen similarity index decreases more or less beginning in the 2040s, but this is not true for the background scenario. Keeping in mind that our latest prediction of the deposition is made for the year 2020 the results far behind this year might be handled with great caution.

A comparison of the Sørensen indices for all plots and both deposition scenarios shows a different pattern. At the plots 'Forellenbach' and 'Monschau' the differences for the pre-industrial 'BKG' and the current 'rGP' scenario are quite minimal. The sites 'Lüss' and 'Hünfeld' show a better performance of the background deposition scenario, and the plot 'Neuglobsow' the opposite. The results at the site 'Neuglobsow' are interesting because it indicates that the current plant community is already adapted to the acidifying and/or eutrophying effects of the air borne deposition. On all plots (except 'Lüss') the difference between 'BKG' and 'rGP' decreases in the far future. This indicates that ecosystems will recover from acidifying and eutrophying effects of the deposition in the past if ambitious emission reduction policies are in force.

Acknowledgement

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