FUTMON
forest monitoring for the future

Impact of deposition and climate change on forest soils and floristic biodiversity

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OEKO-DATA Strausberg, Germany

a Life+ co-financed project for the "Further Development and Implementation of an EU-level Forest Monitoring System".

The project coordination centre is situated at the Institute for World Forestry, Hamburg, Germany.

Effects have concerned the public and they have driven policy makers and scientists for over 30 years since the acidification of Scandinavian lakes were demonstrated and the German word “Waldsterben” (forest decline) became international.

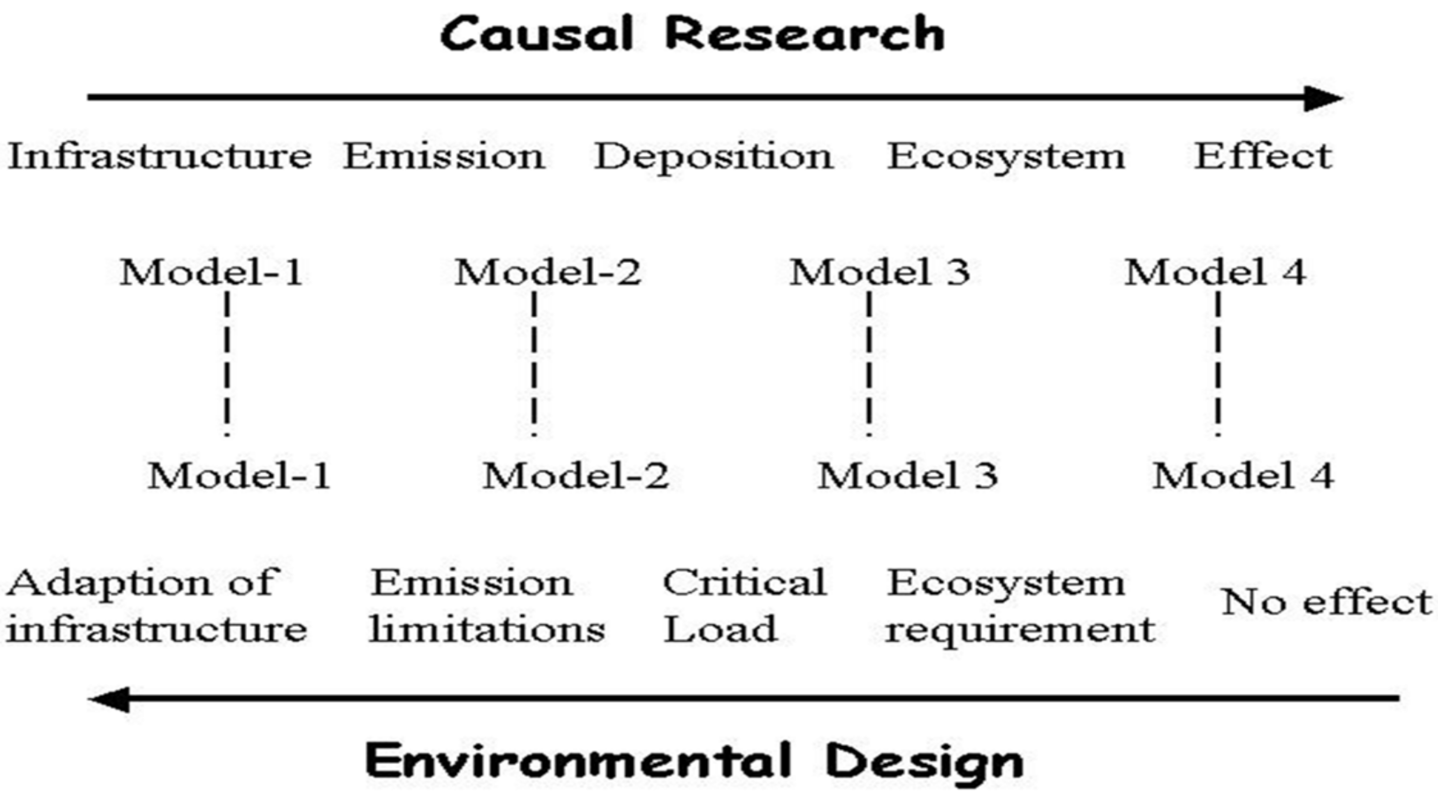
Long-term environmental monitoring and the integration of its results for negotiation and setting of **pollution thresholds** were the key to an effective air pollution policy. Thus, as emissions now decrease, the question is:
Are there trends or changes in ecosystem quality in response to these decreasing emissions in the European region and are the reduction measurements sufficient?

Pollution thresholds - the Critical Load Concept

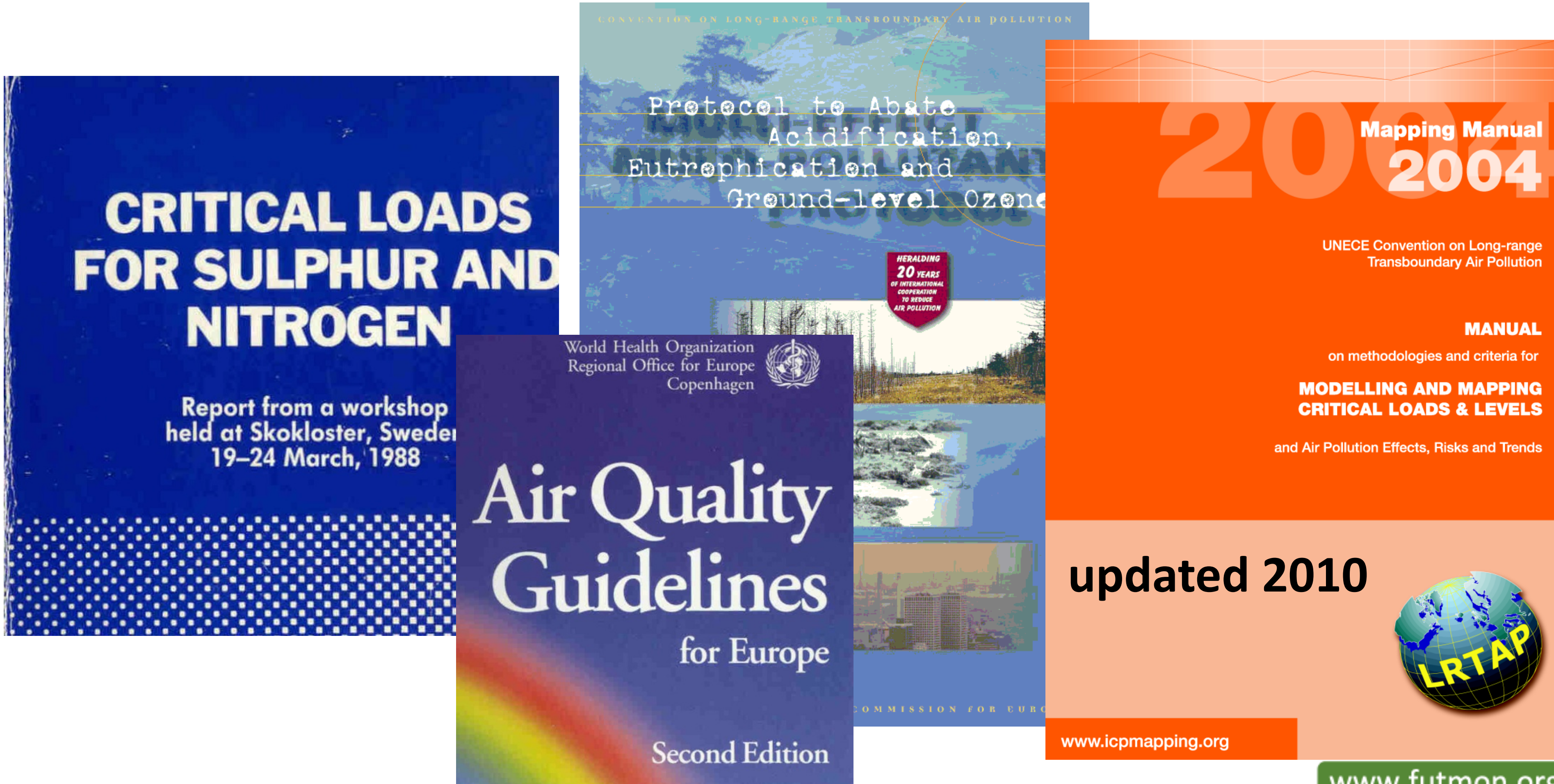
For the protection of the environment and human health, in the interest of precaution, abatement, or the mitigation of environmental impacts, environmental policy has to define specific targets.

Threshold values for the effects of air pollutants have attained much importance in the derivation of environmental goals as they are most convincing criteria for tolerable intensities of anthropogenic interference with ecosystems or their sensitive components.

Critical loads are such threshold values. By definition they are **quantitative estimates of an exposure to a deposition** of one or more pollutants **below which significant harmful effects** on specified sensitive elements of the environment **do not occur** according to present knowledge.

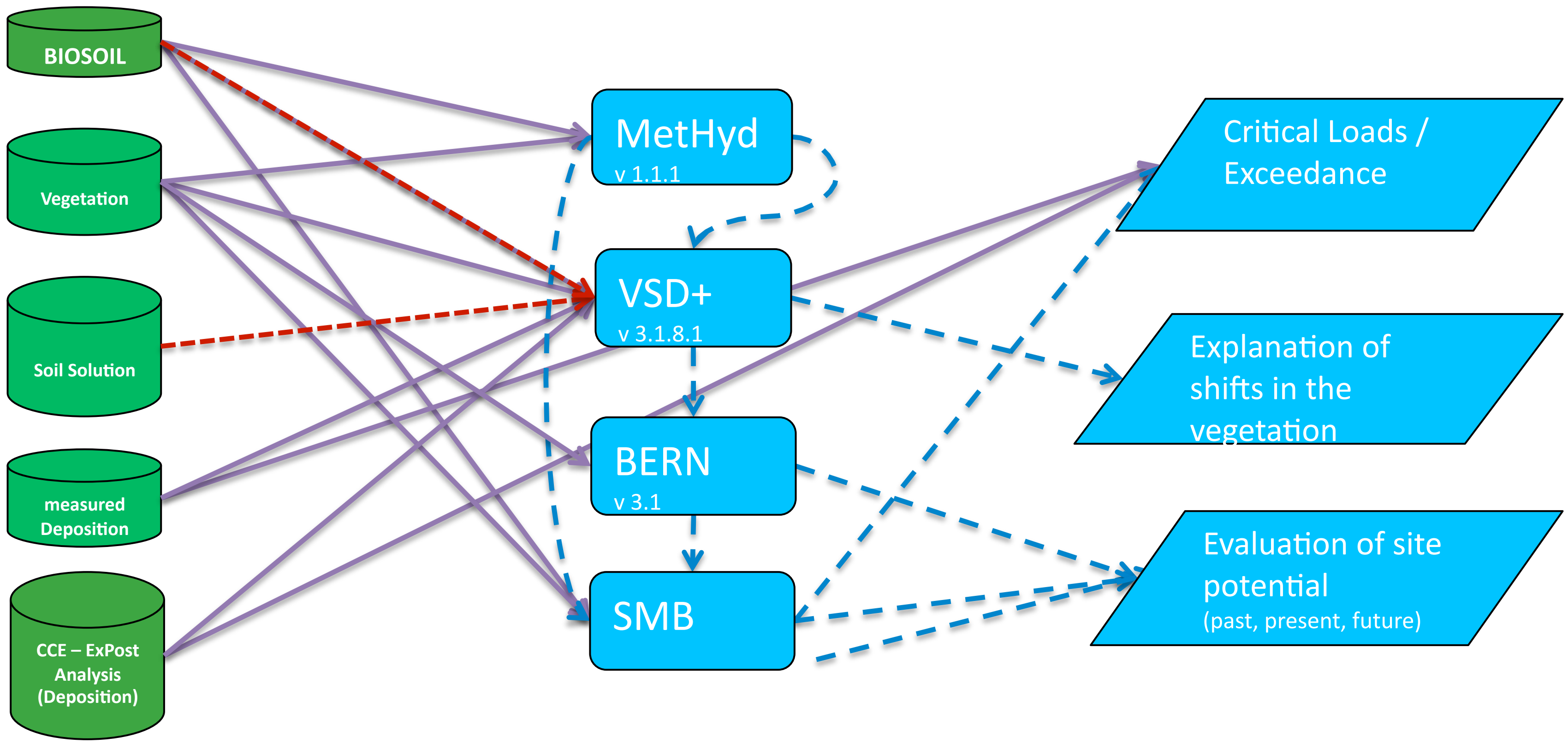

Causal Research
Infrastructure
Emission
Deposition
Ecosystem
Effect
Model-1
Model-2
Model 3
Model 4
Model-1
Model-2
Model 3
Model 4
Adaption of infrastructure
Emission limitations
Critical Load
Ecosystem requirement
No effect
Environmental Design

Critical Loads: A successful approach for sustainability and precautionary environmental protection



Project concept: FutMon intensive monitoring database
Single plot analysis
European trends

Data sources: **Methods/Models:** **Results:**



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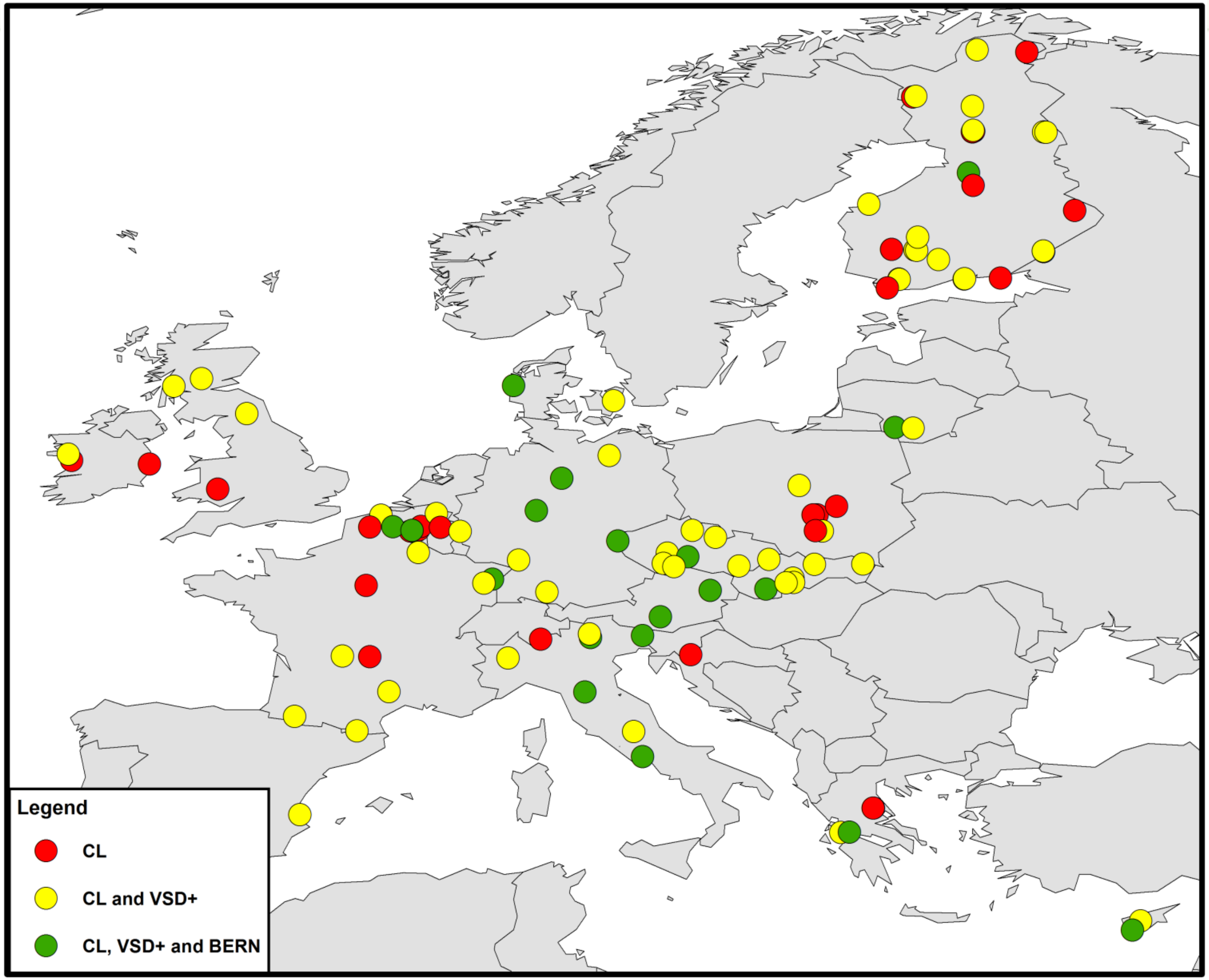
Critical Loads

and their exceedances for acidity and nitrogen

World Forestry



29
57
20

106 intensive monitoring plots in 17 countries

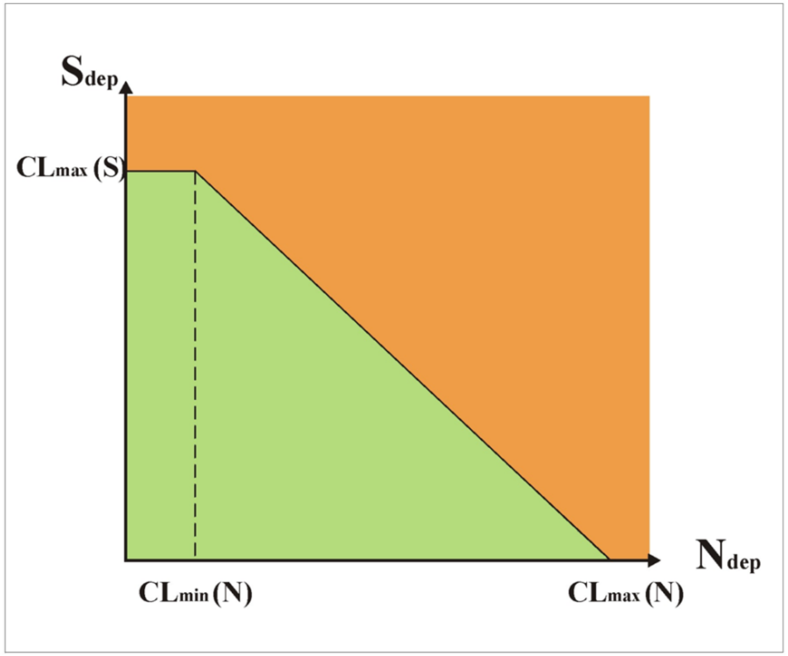
Critical Loads

and their exceedances for acidity and nitrogen

$$CL_{max}(S) = BC^*_{dep} - Cl^*_{dep} + BC_w - BC_u - ANC_{le(crit)}$$

$$CL_{max}(N) = N_u + N_i + \frac{CL_{max}(S)}{(1 - f_{de})}$$

$CL_{max}(S)$	*The critical load for sulphur-based acidity*
$CL_{max}(N)$	*The critical load for nitrogen-based acidity*
BC_w	*Base cations weathering derived from soil type and par material class*
BC^*_{dep}	*Base cations deposition (sea salt corrected)*
Cl^*_{dep}	*Deposition of chloride (sea salt corrected)*
BC_u	*Base cations uptake and removal by biomass under stea conditions*
N_u	*Nitrogen uptake and removal by biomass under steady state conditions*
N_i	*Long-term immobilisation of nitrogen*
f_{de}	*Denitrification factor derived from the soil type, (between 0 and 1, lower and higher denitrification)*
$ANC_{le\ (crit)}$	*Acceptable leaching of acid neutralisation capacity*

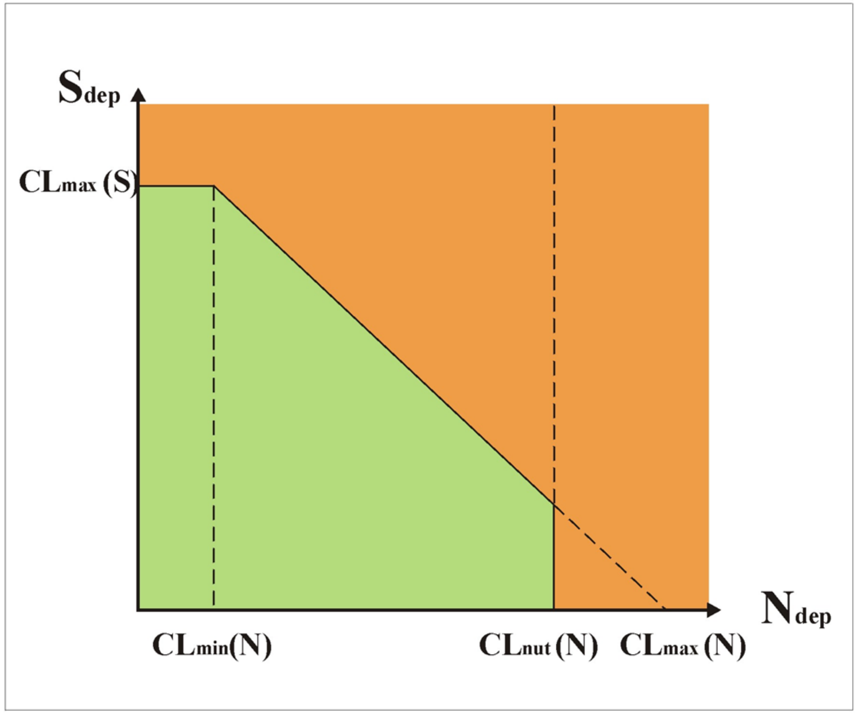


Critical Loads

and their exceedances for acidity and nitrogen

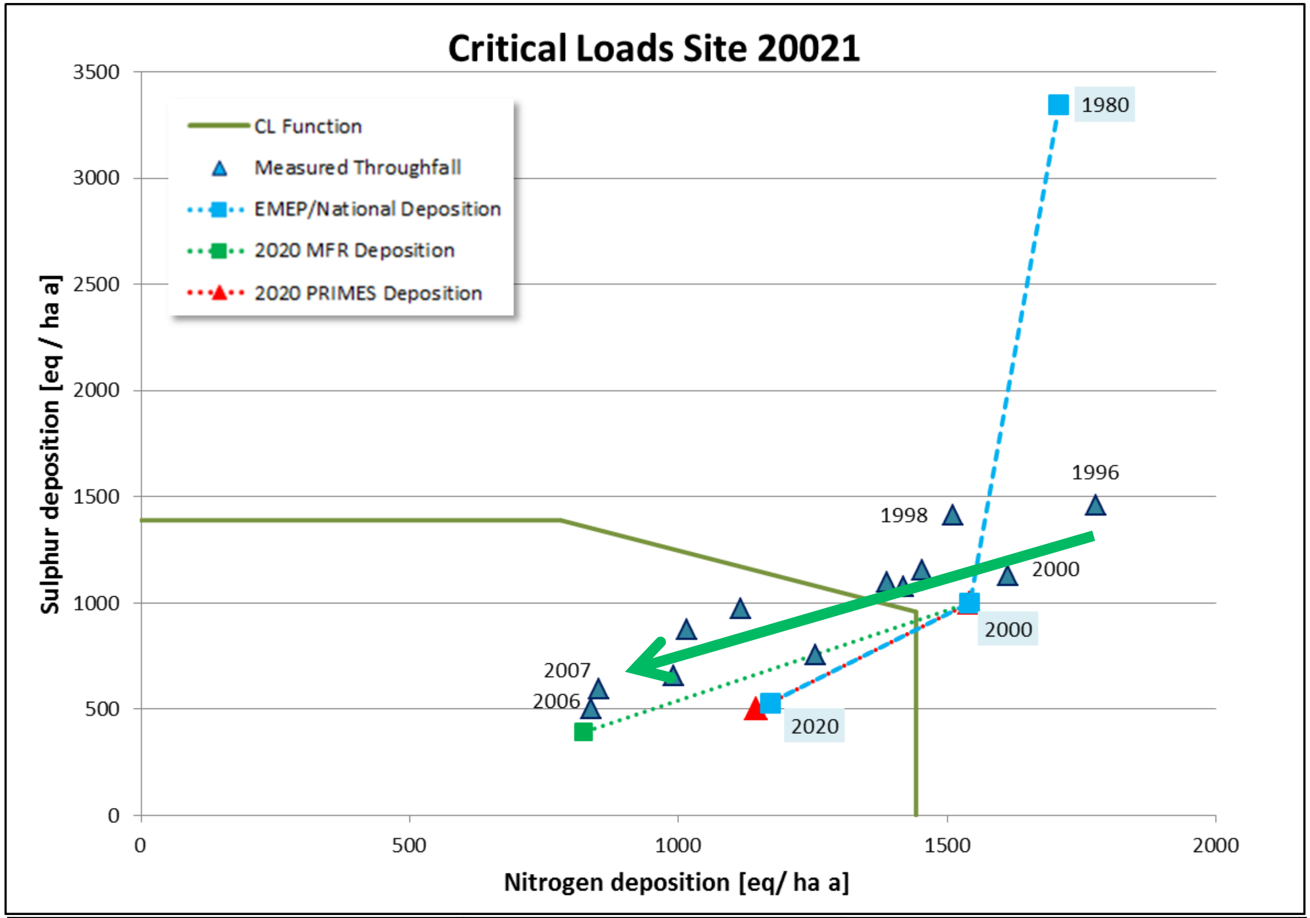
$$CL_{nut}(N) = N_u + N_i + N_{le(acc)} + N_{de}$$

$CL_{nut}(N)$	*The critical load for nutrient nitrogen*
N_u	*Nitrogen uptake and removal by biomass un conditions*
N_i	*Long-term immobilisation of nitrogen*
$N_{le(acc)}$	*Acceptable leaching of nitrogen*
N_{de}	*Denitrification*



Critical Loads

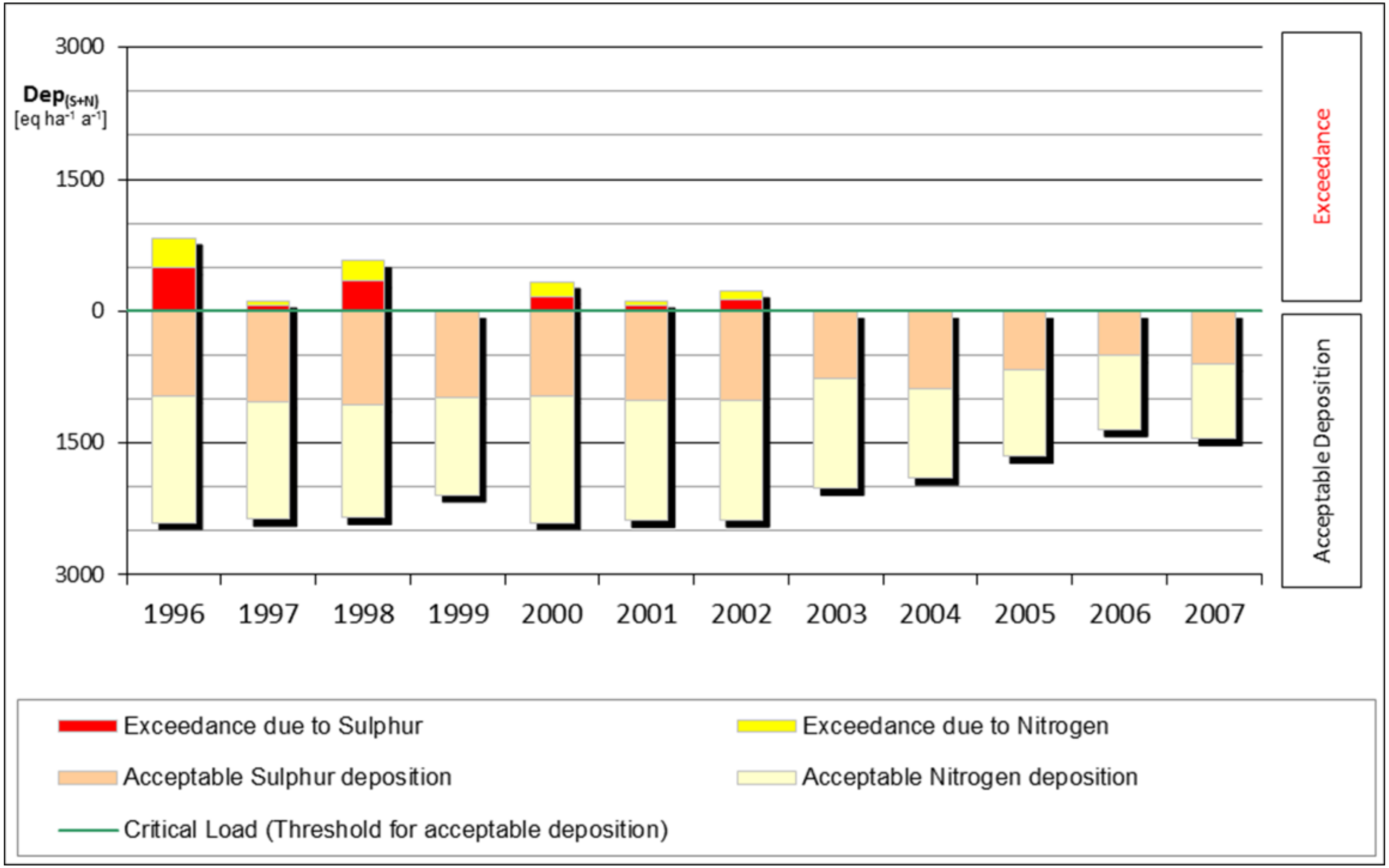
and their exceedances for acidity and nitrogen



FutMon Site:	ID 20021	Country: Belgium
Critical Load calculation:	SMB method	
Deposition modelled:	EMEP 1980, NATIONAL 2000, 2020, PRIMES 2020, MFR 2020	
Deposition measured:	1996 – 2007	

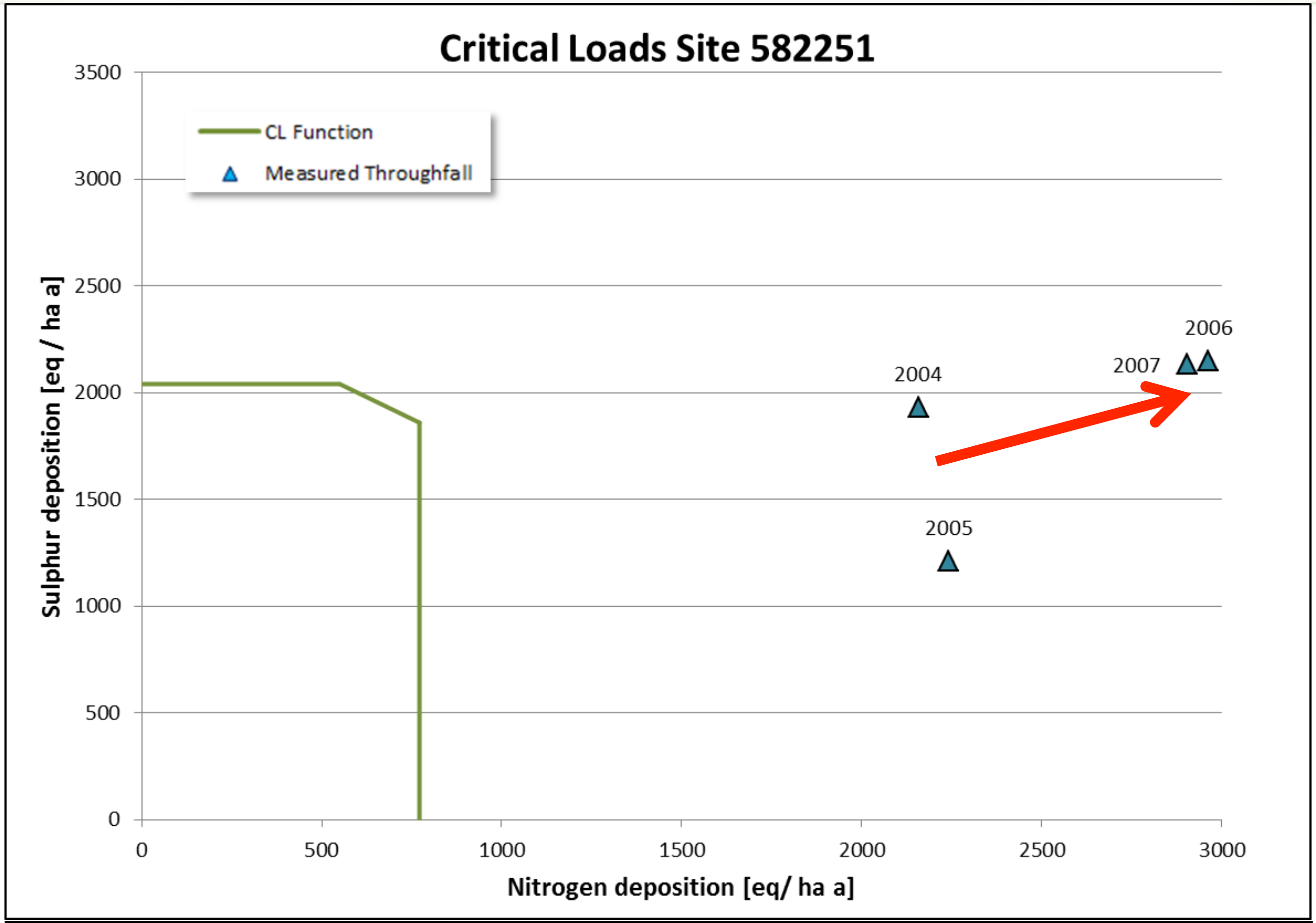
Critical Loads

and their exceedances for acidity and nitrogen



Critical Loads

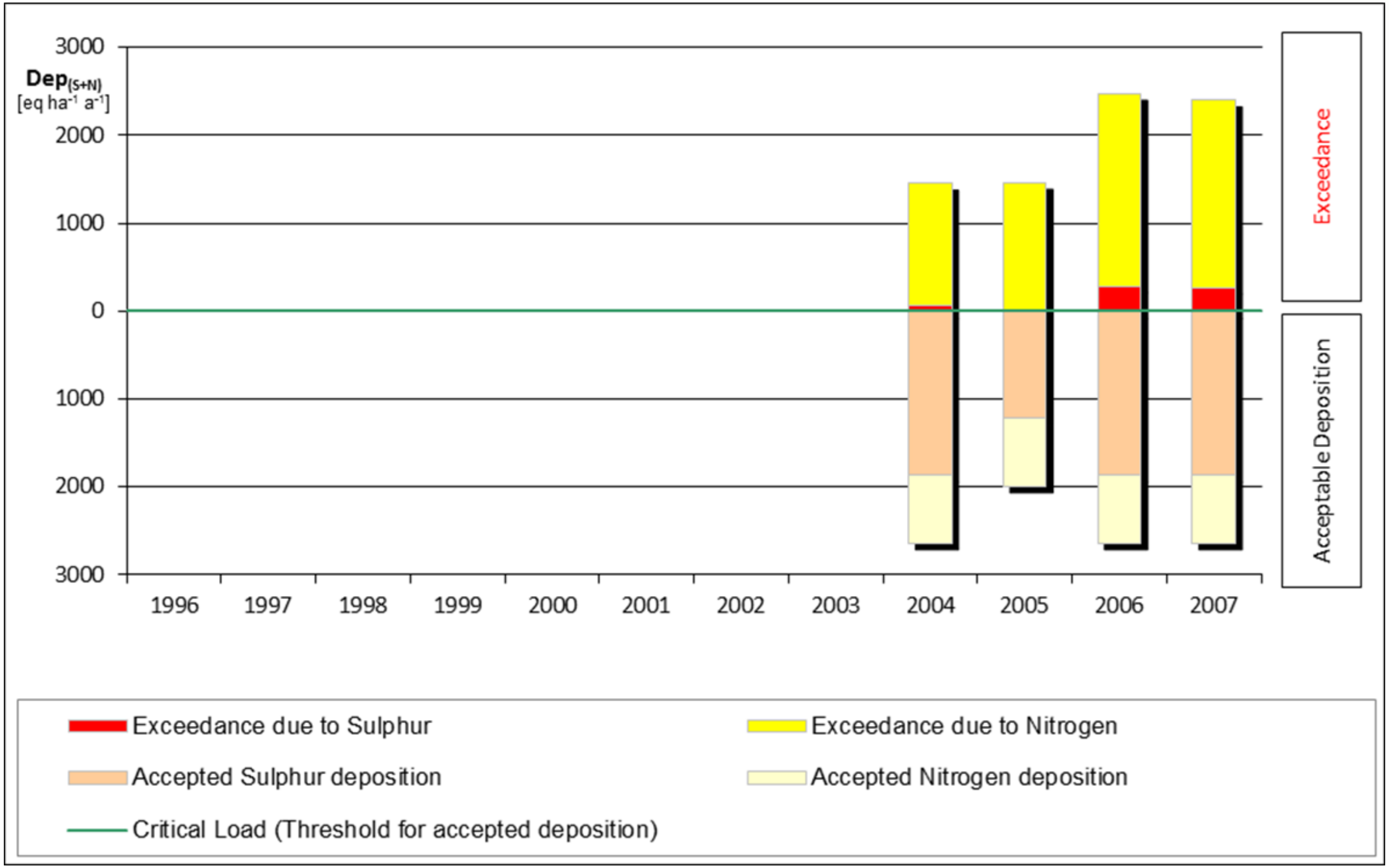
and their exceedances for acidity and nitrogen



FutMon Site:	**ID 582251**	**Country: Czech Republic**
Critical Load calculation:	SMB method	
Deposition modelled:		
Deposition measured:	2004 - 2007	

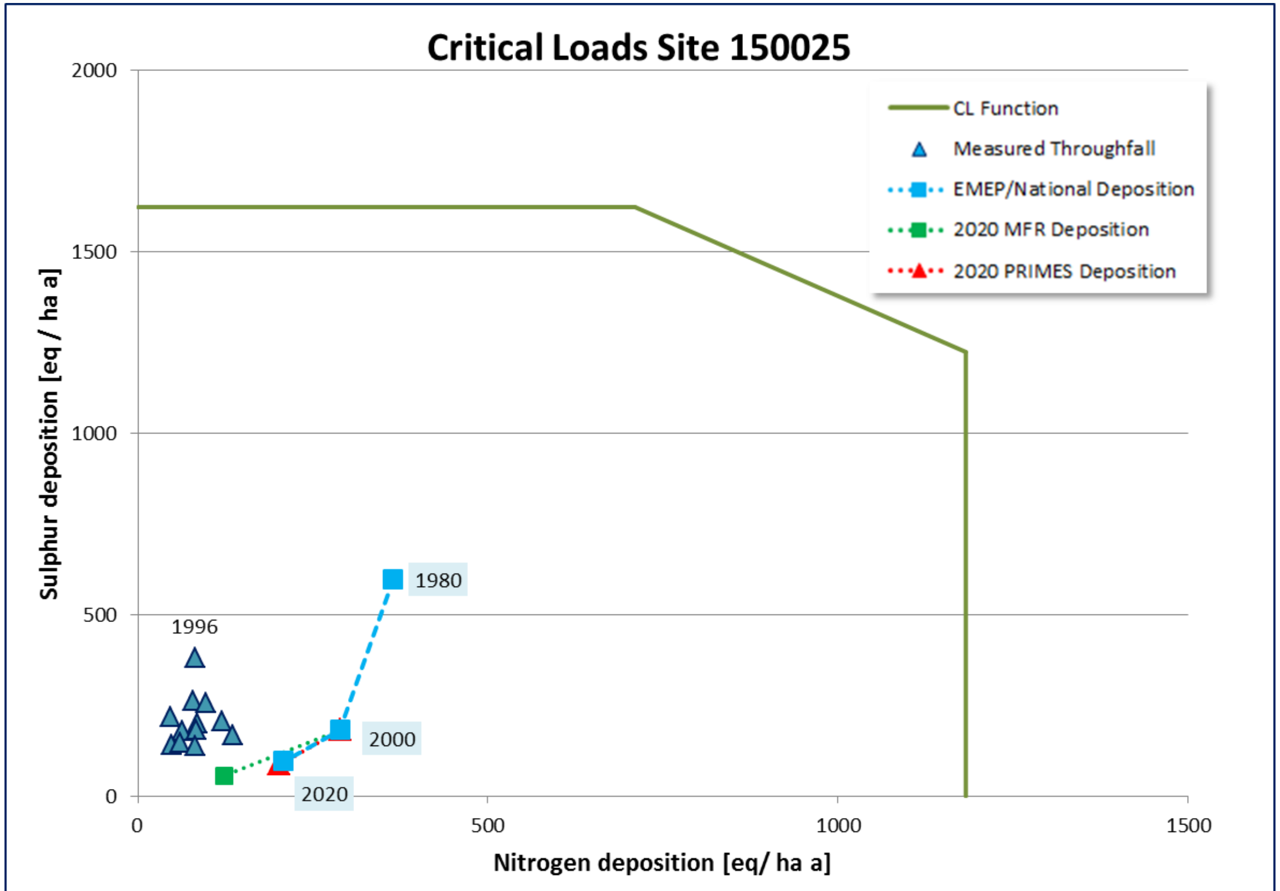
Critical Loads

and their exceedances for acidity and nitrogen

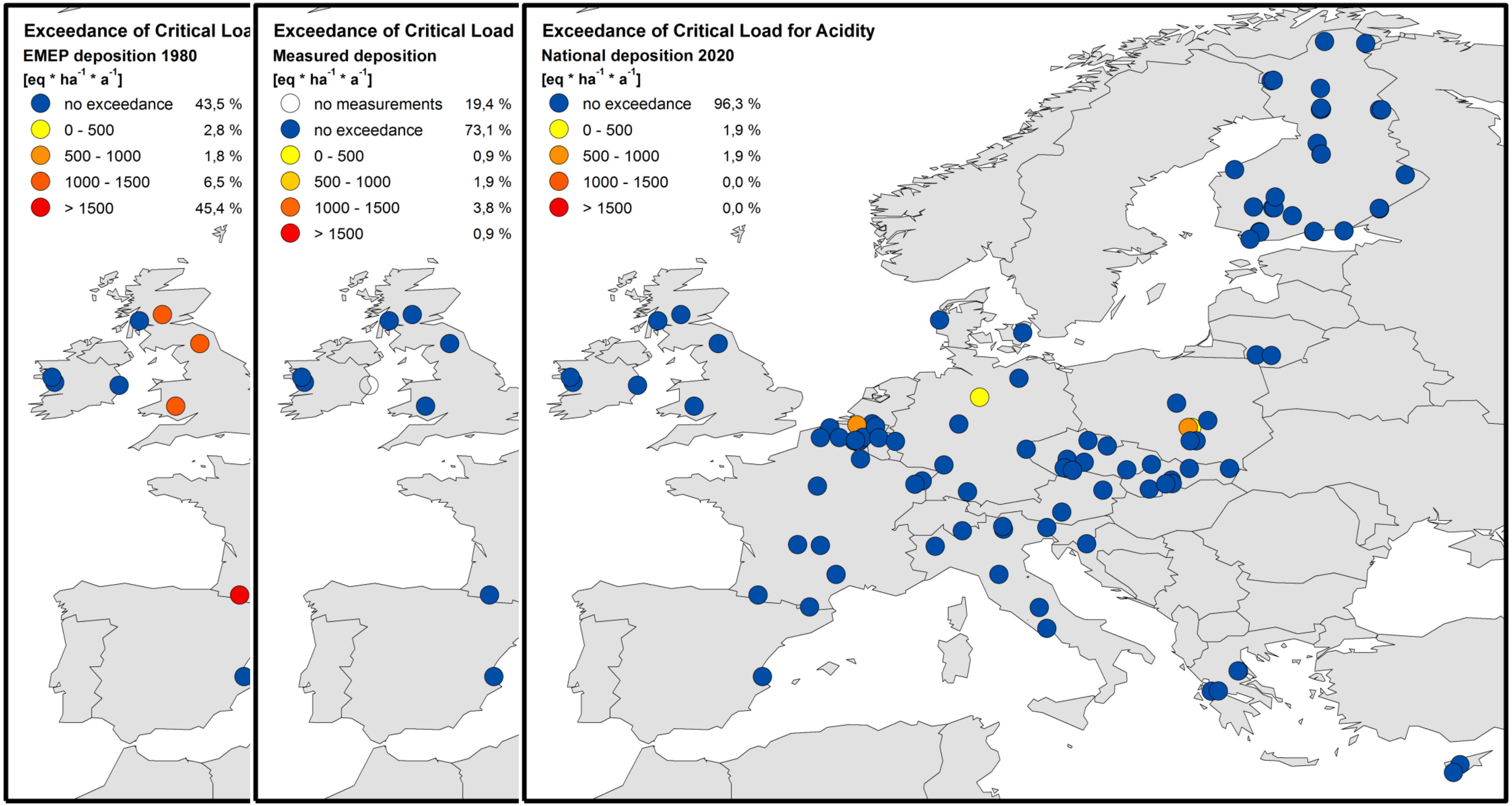


Critical Loads

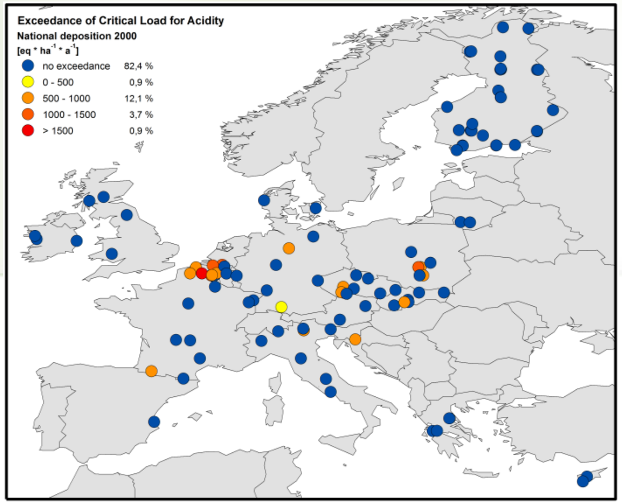
and their exceedances for acidity and nitrogen

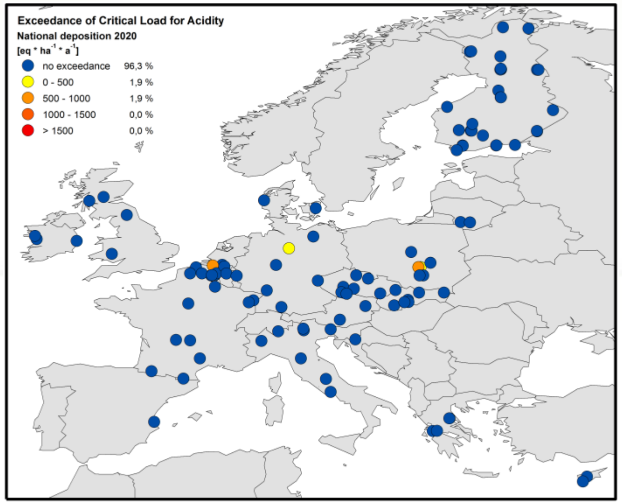


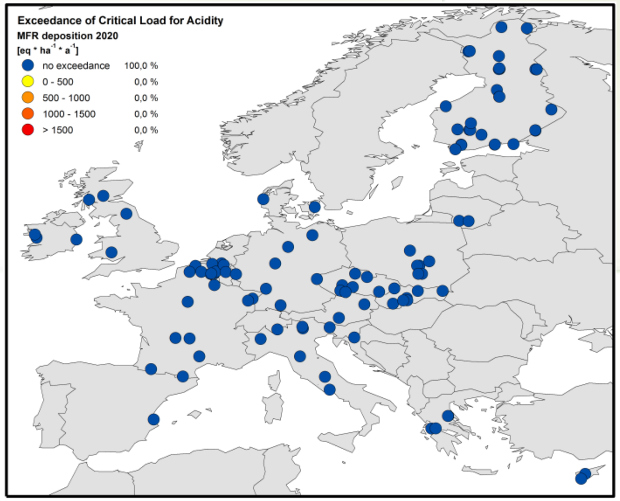
FutMon Site:	ID 150025	Country: Finland
Critical Load calculation:	SMB method	
Deposition modelled:	EMEP 1980, NATIONAL 2000, 2020, PRIMES 2020, MFR 2020	
Deposition measured:	1996 – 2007	



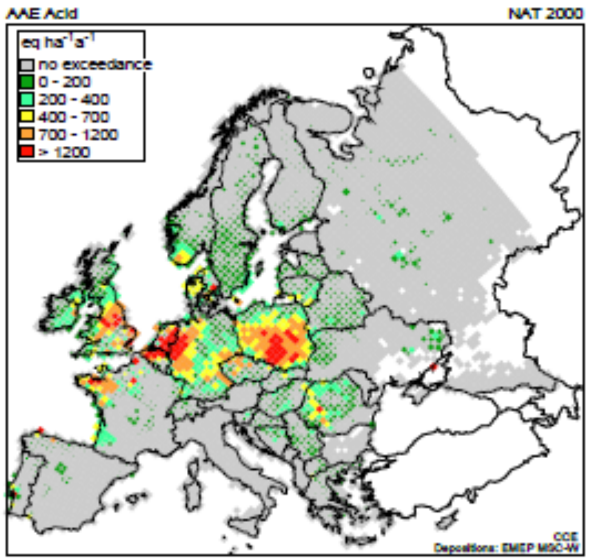
Exceedance of Critical Loads for Acidification

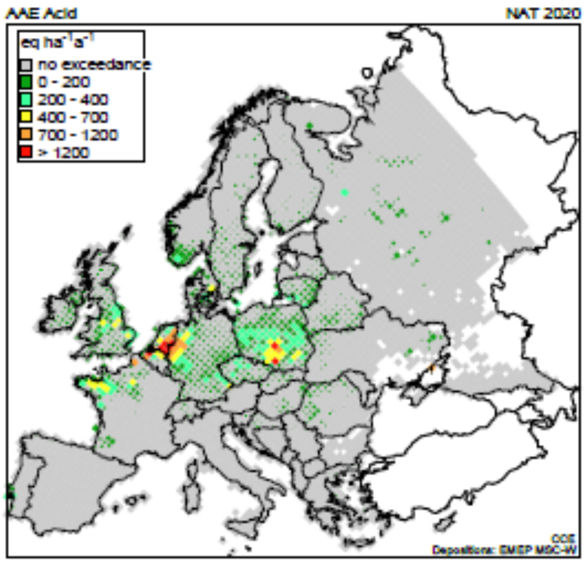


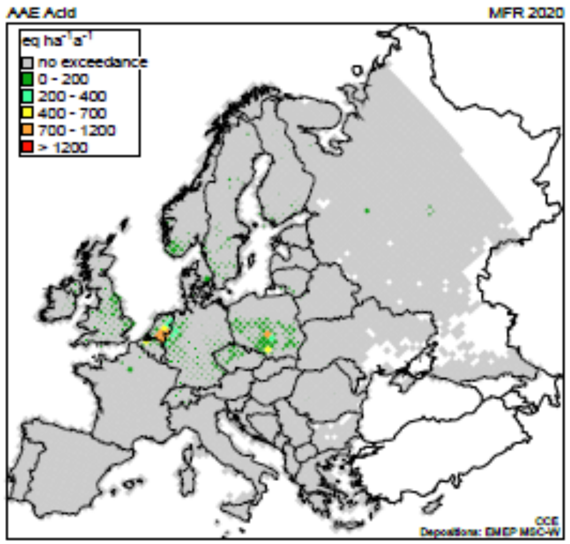




	NAT 2000			NAT 2020			MTFR 2020
FutMon plots	18 %			4 %			0 %
EU 27	19 %			4 %			2 %
All Europe	10 %			4 %			1 %





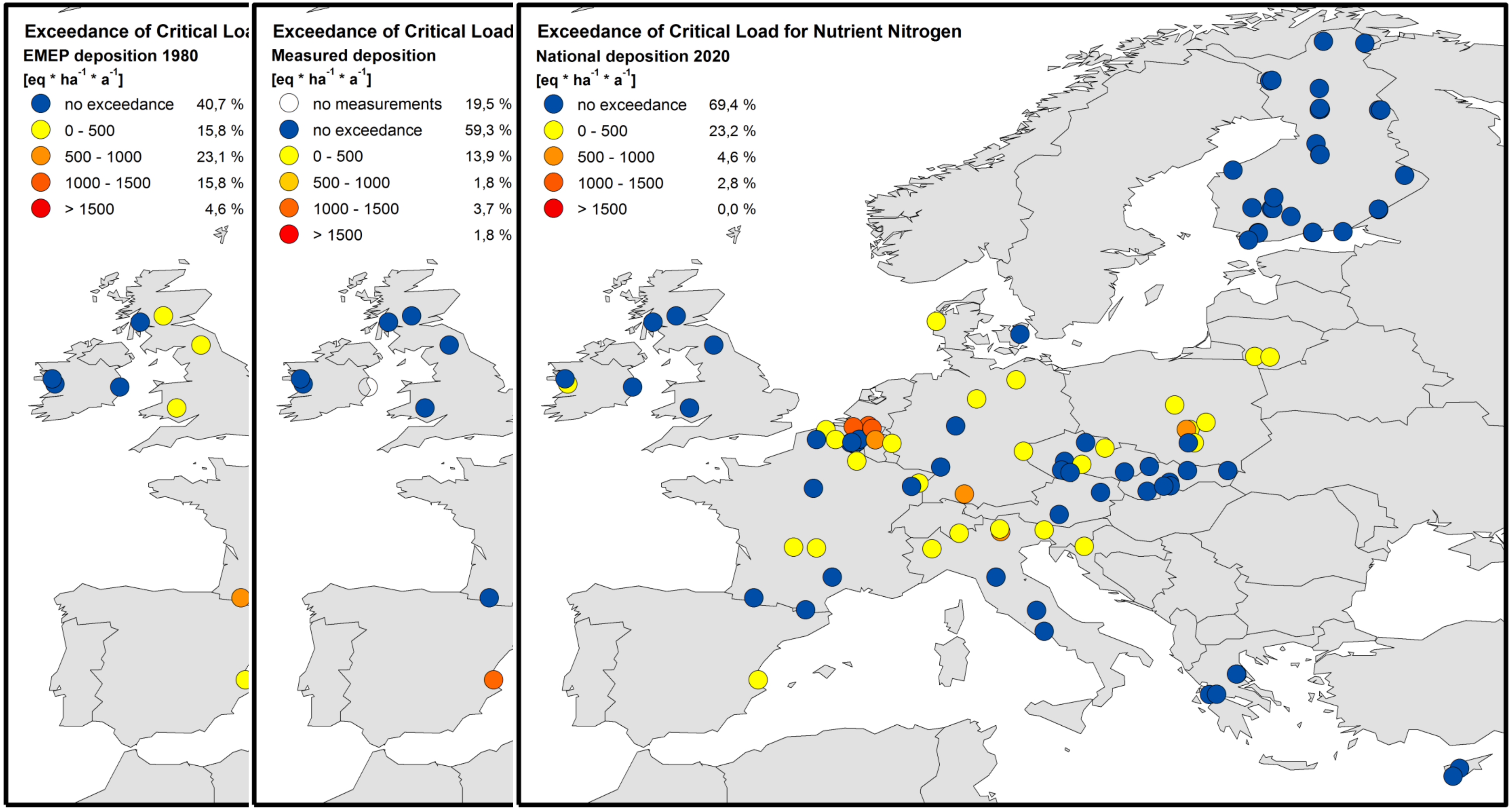


Area at Risk of Acidification

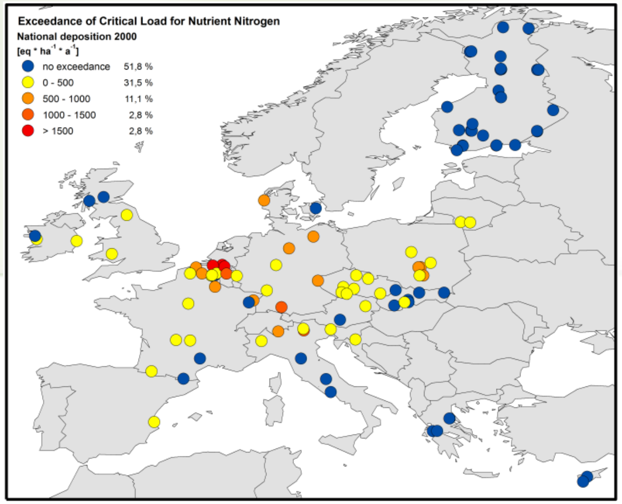
FUTMON

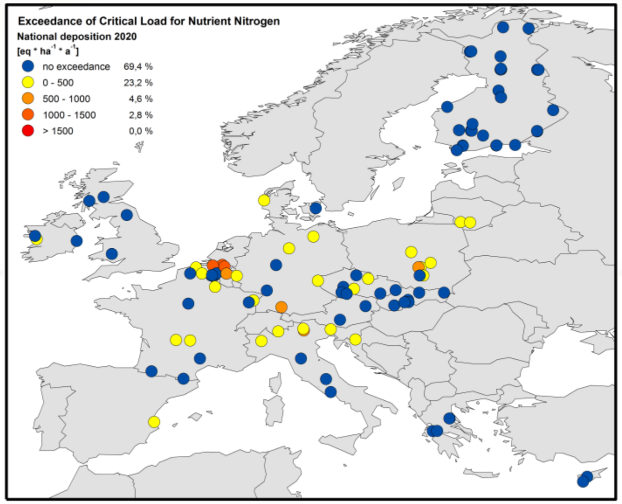
Critical Loads

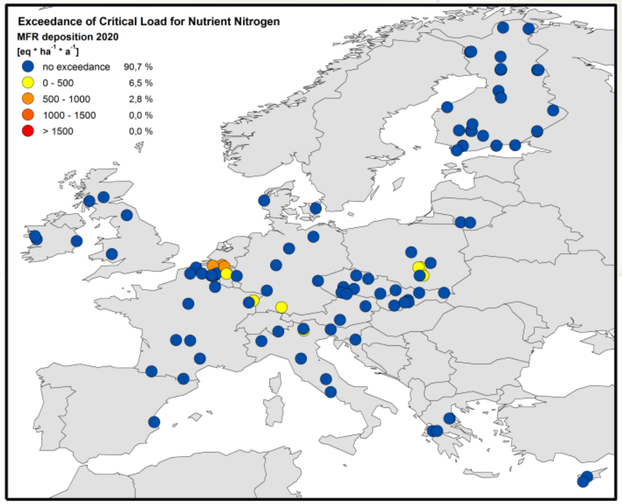
and their exceedances for acidity and nitrogen



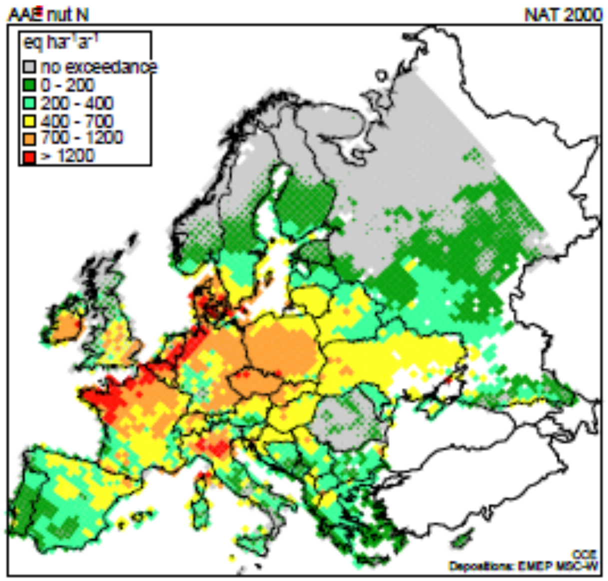
Exceedance of Critical Loads for Nutrient Nitrogen

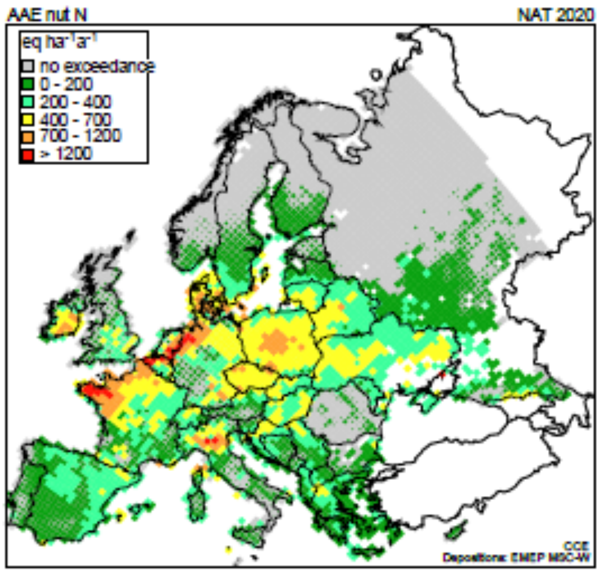


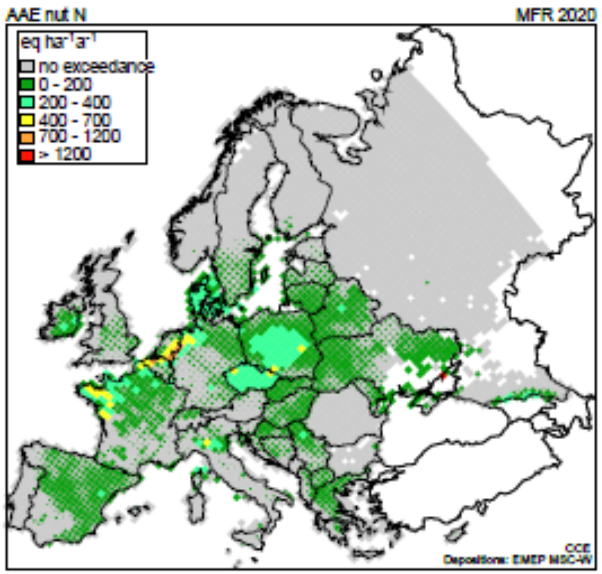




	NAT 2000			NAT 2020			MTFR 2020
FutMon plots	48 %			30 %			10 %
EU 27	74 %			61 %			24 %
All Europe	52 %			38 %			14 %





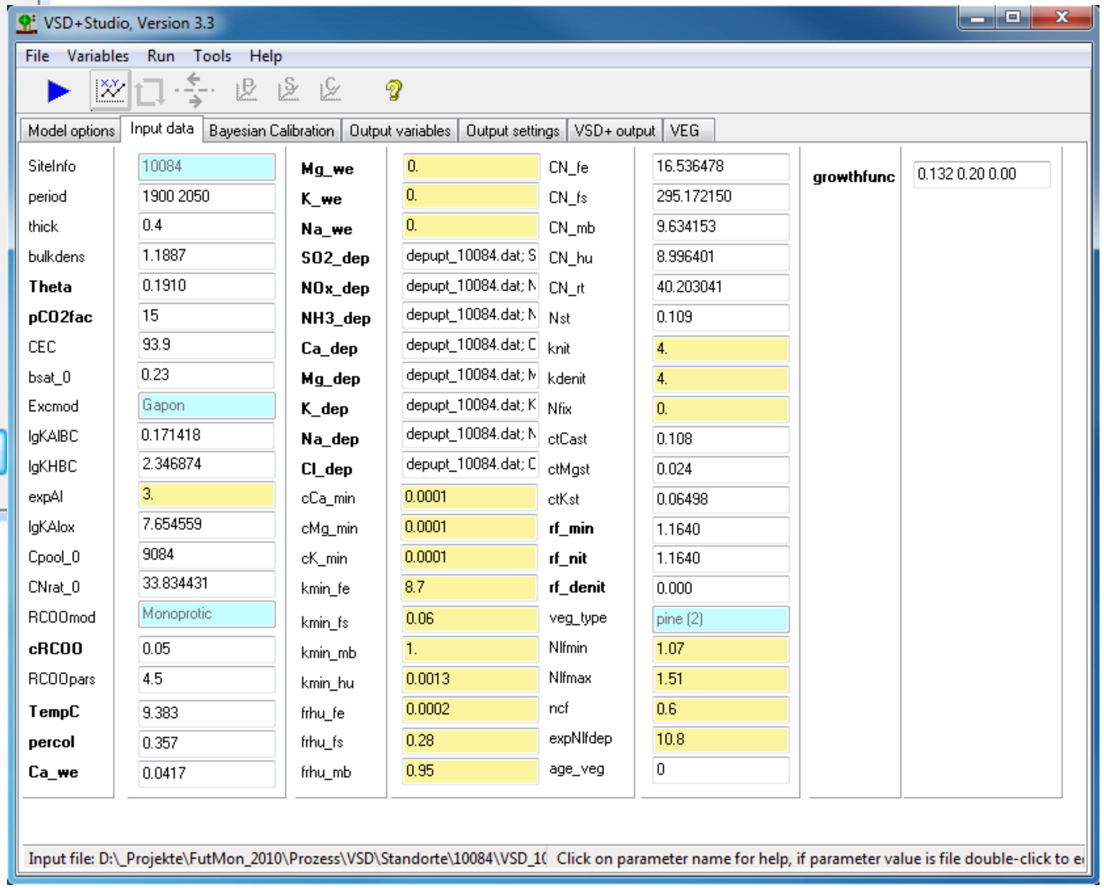


Area at Risk of Eutrophication

Dynamic Modelling

Future development of soil solution chemistry

ICP Modelling & Mapping
Coordination Center for Effects (CCE)
www.rivm.nl/cce

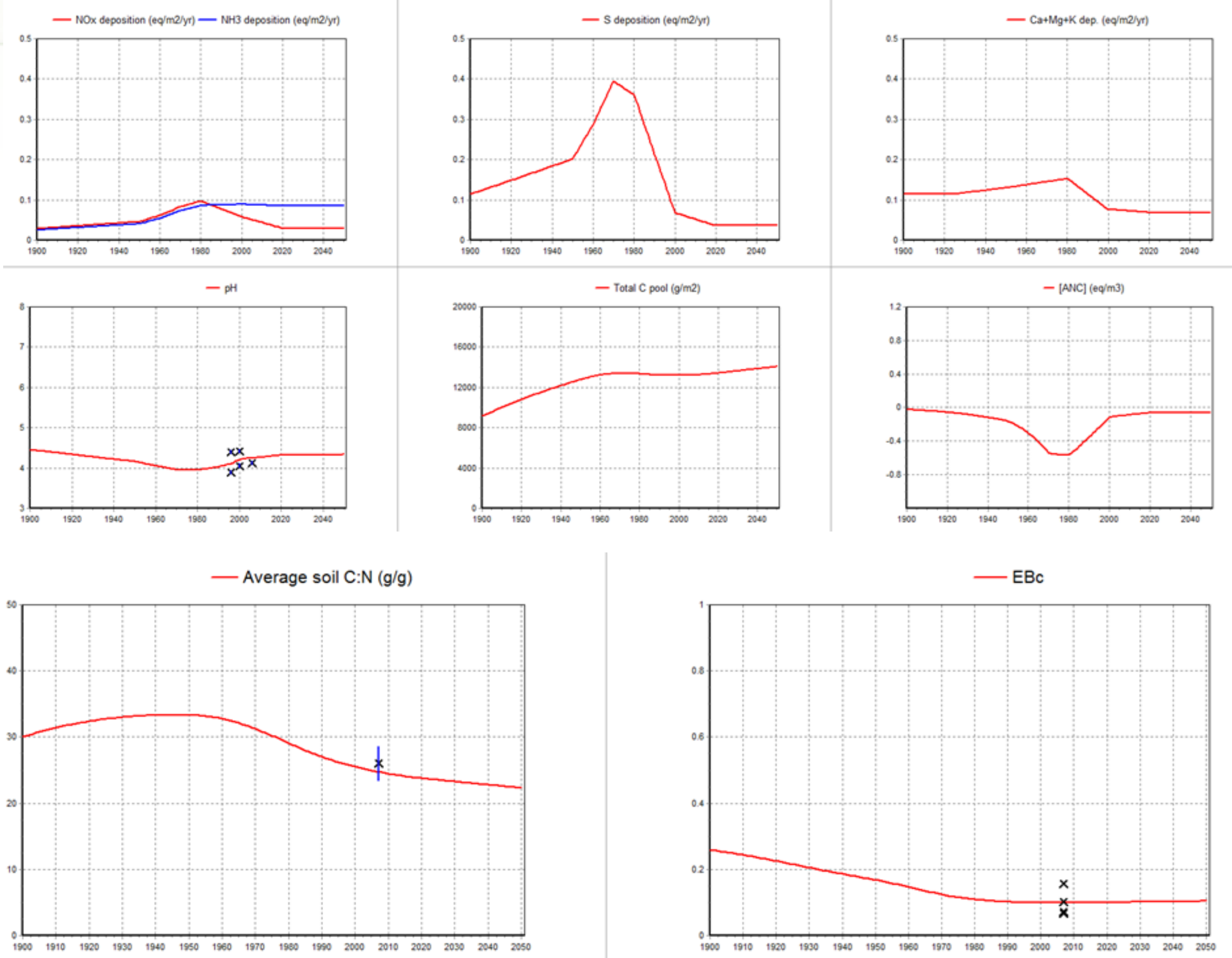


Input data for
the VSD+ model

Dynamic Modelling

Future development of soil solution chemistry

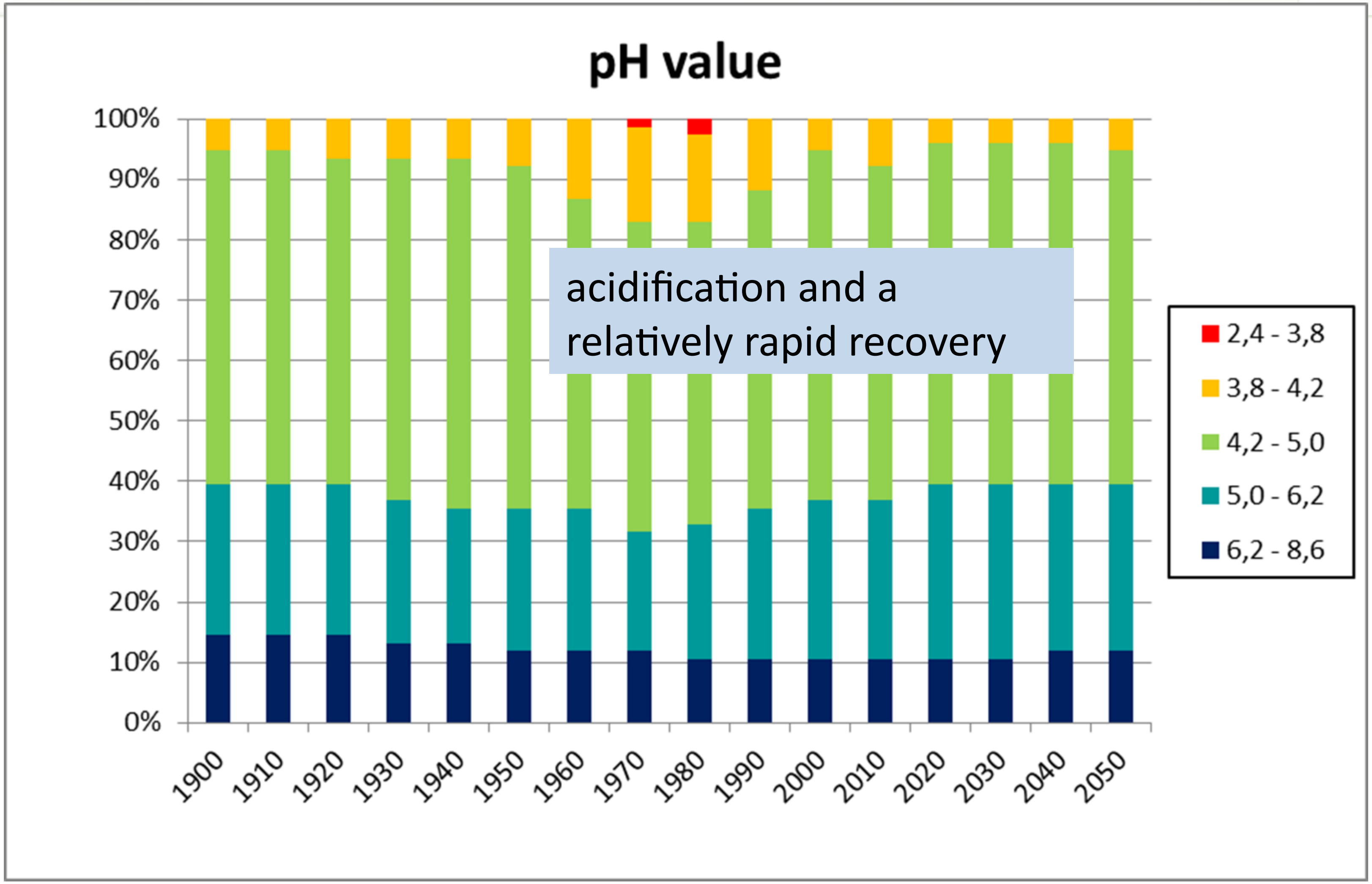
Plot 40301
Germany



Dynamic change of geochemical parameters,
modelled with VSD+ (red/blue lines) and measured / observed values (blue dots)

Dynamic Modelling

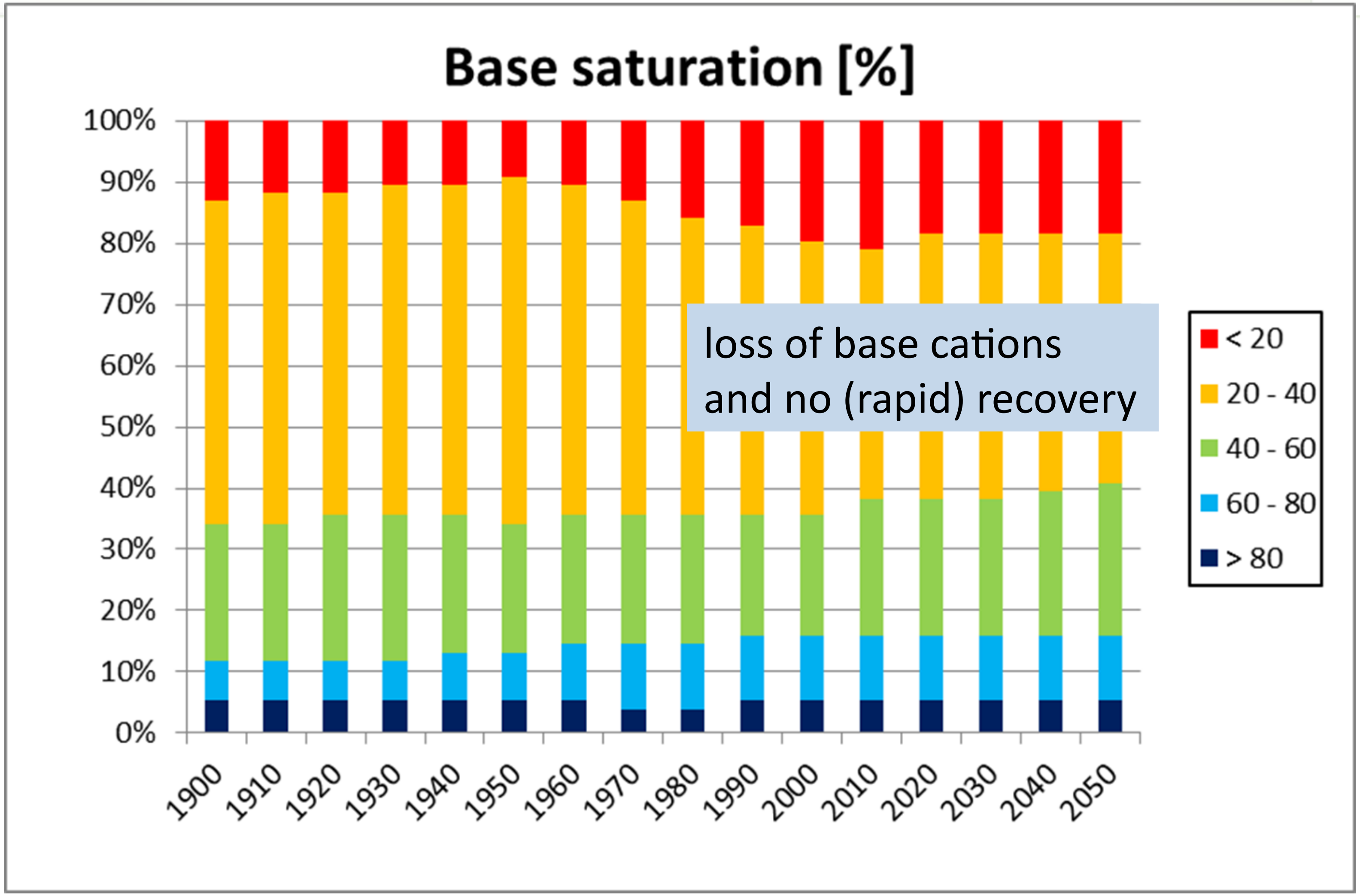
Future development of soil solution chemistry



Overall trend (77 plots) for pH values modelled by VSD+ and classified by buffering classes (ULRICH 1981)

Dynamic Modelling

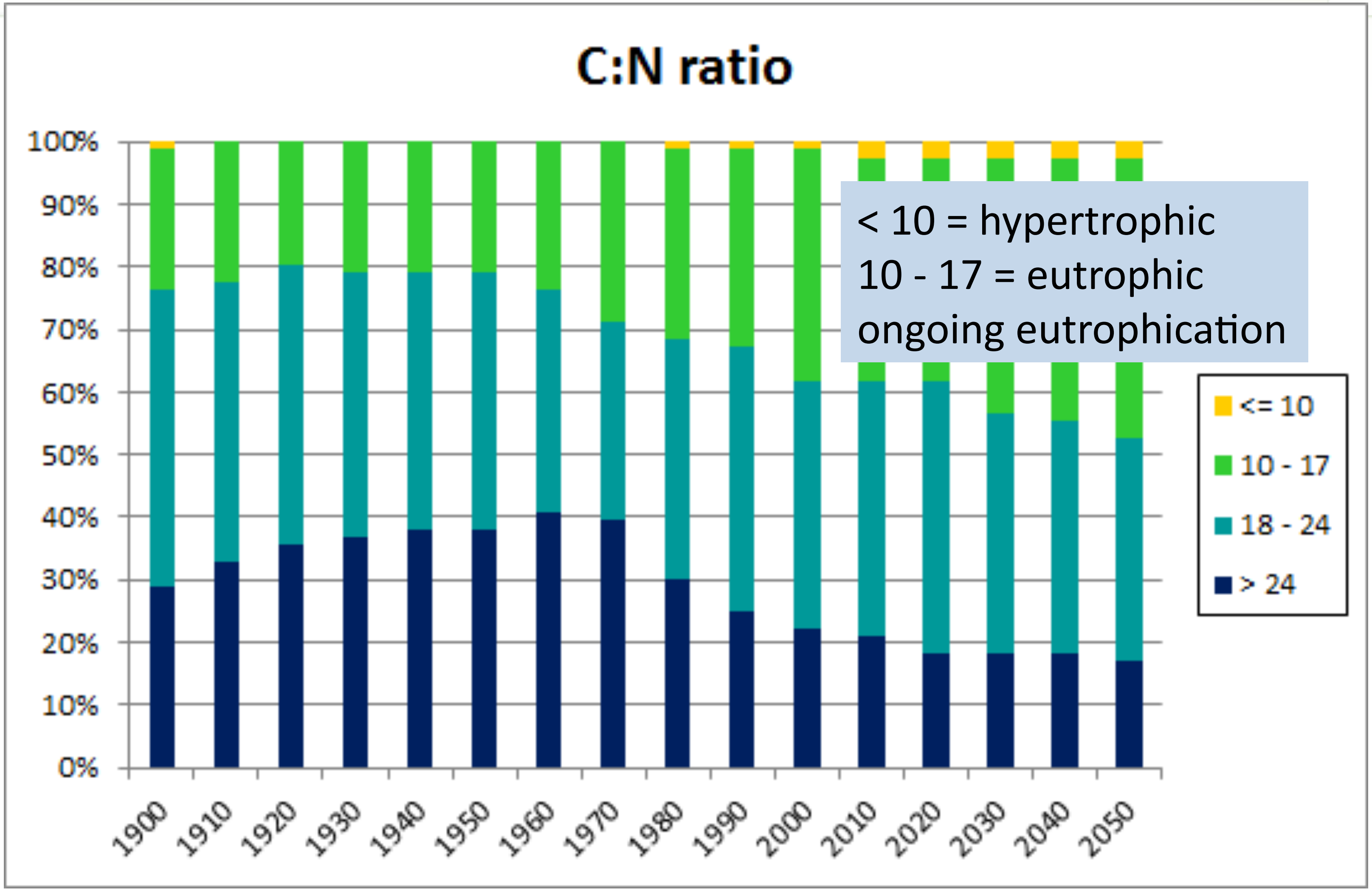
Future development of soil solution chemistry



Overall trend (77 plots) for base saturation classes modelled by VSD+

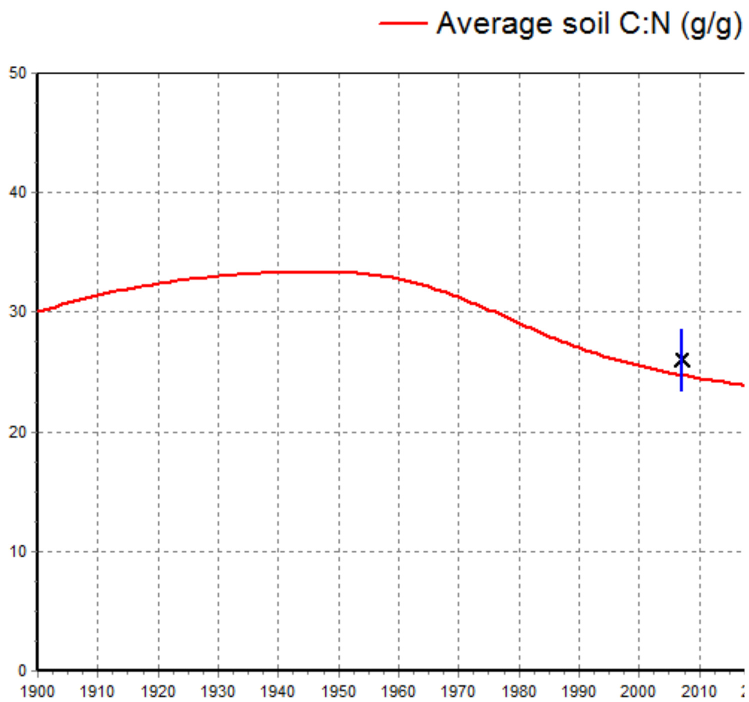
Dynamic Modelling

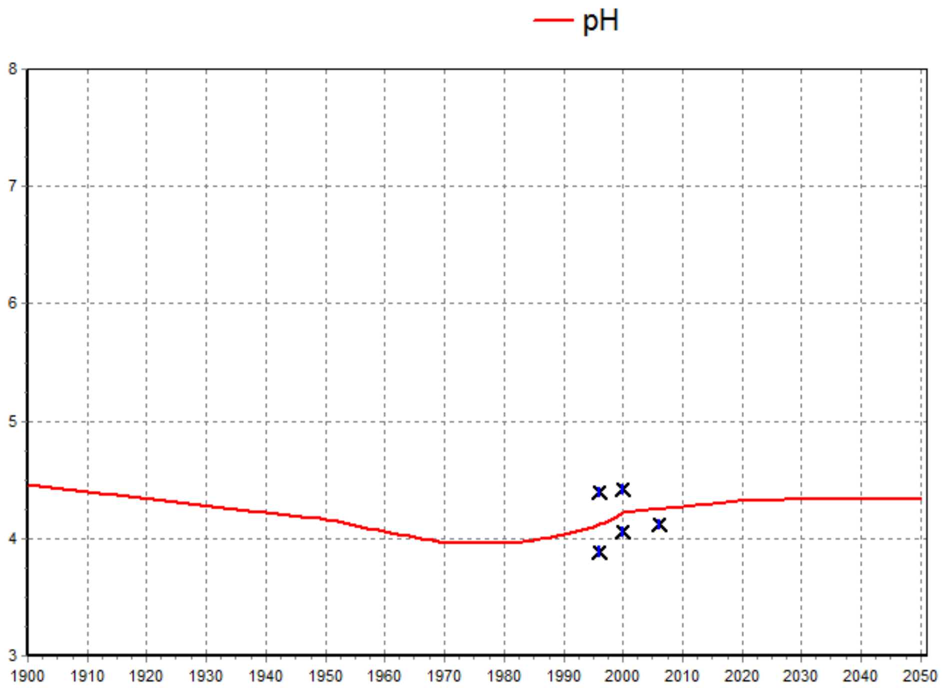
Future development of soil solution chemistry



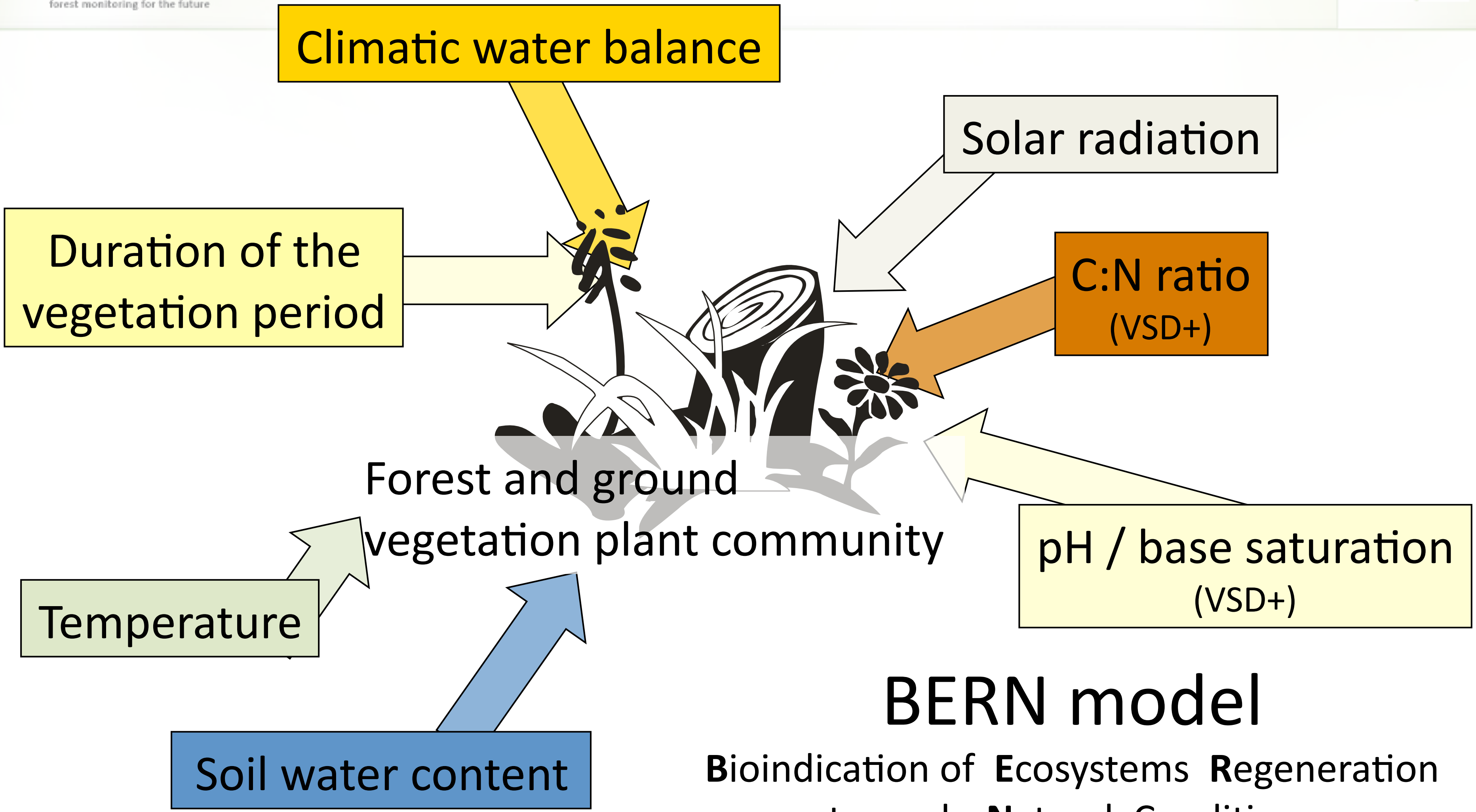
Overall trend (77 plots) for C:N ratio modelled by VSD+ and classified by nutrient levels

Results of VSD+ computation for C:N ratio and pH values used as drivers for the BERN model





This is an important next step, because under the Thematic Strategy on Air Pollution and the Air Pollution Policy Review 2011 -2012 is a demand for knowledge of changes to plant species diversity caused by air pollution under climate change in Europe.



BERN model

Bioindication of **E**cosystems **R**egeneration towards **N**atural Conditions

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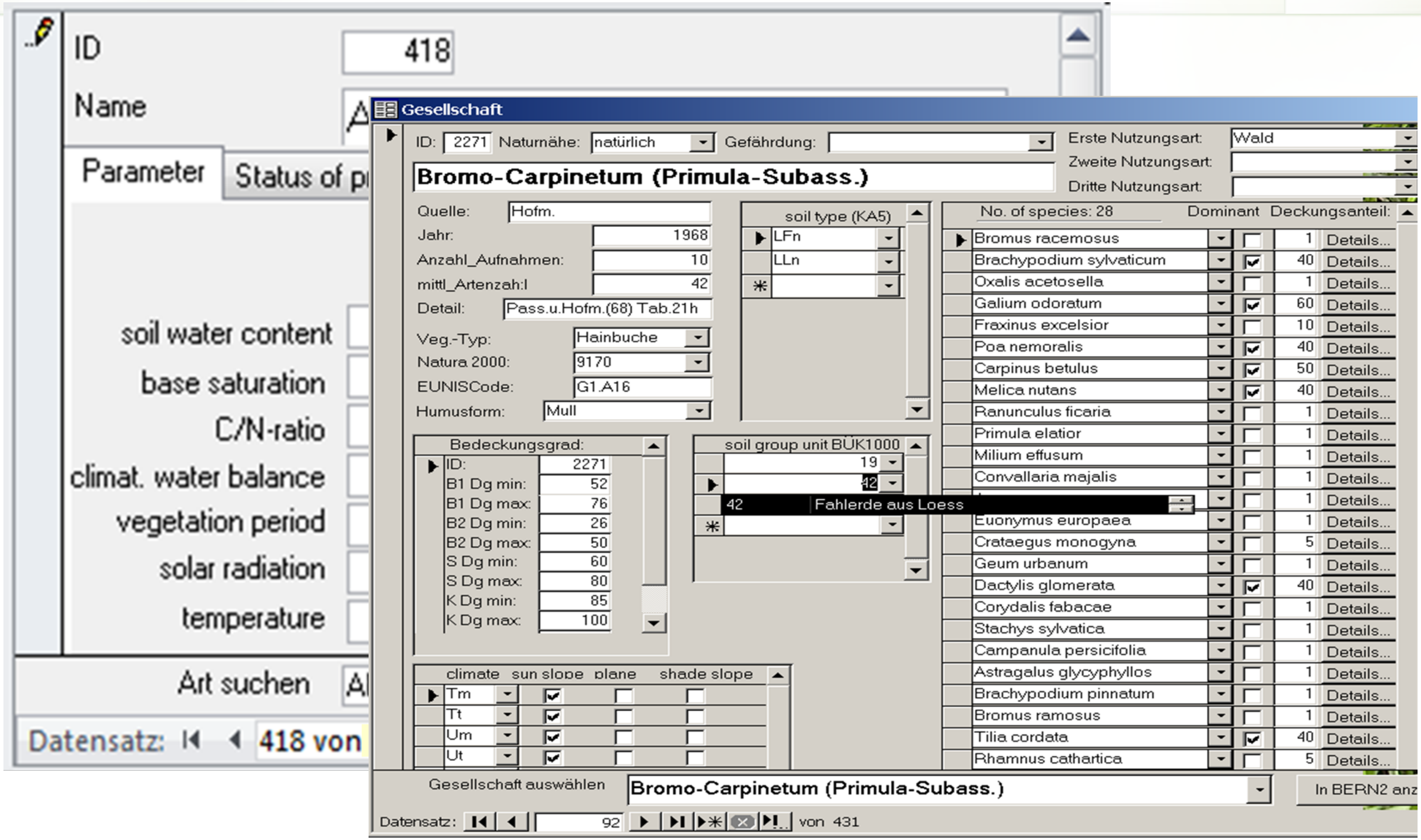
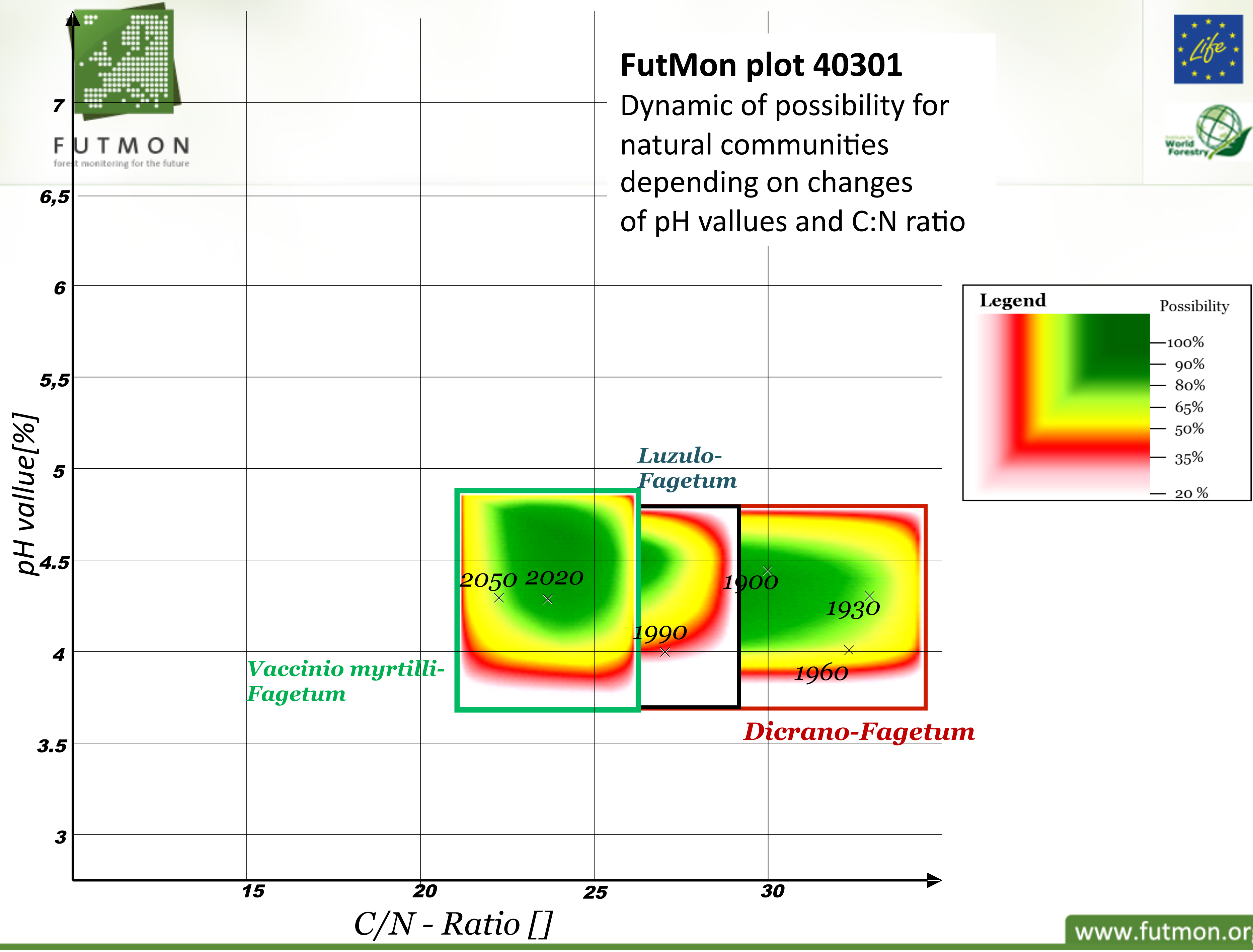
BERN model

Future development of vegetation



FutMon plot 40301

Dynamic of possibility for natural communities depending on changes of pH vallues and C:N ratio



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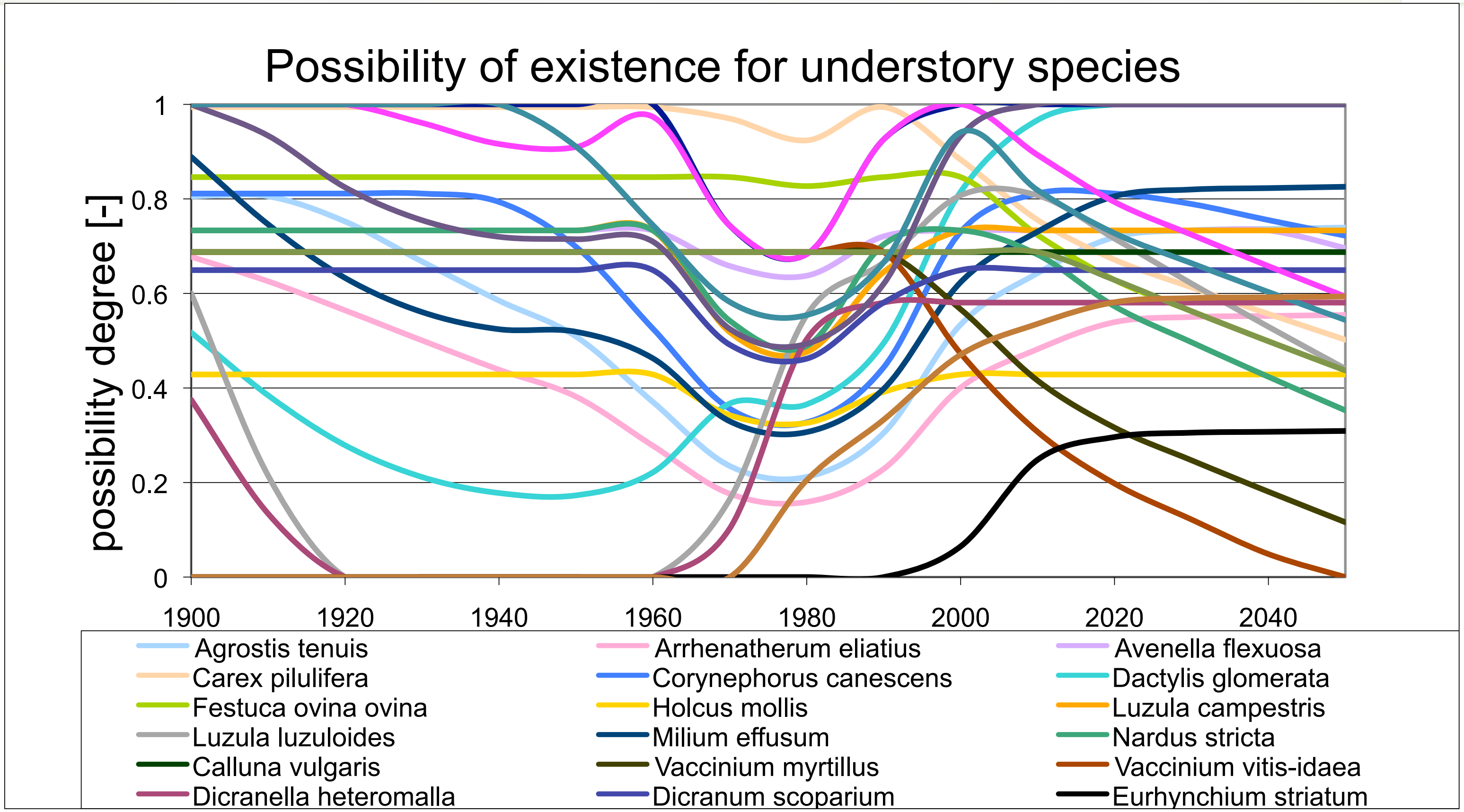
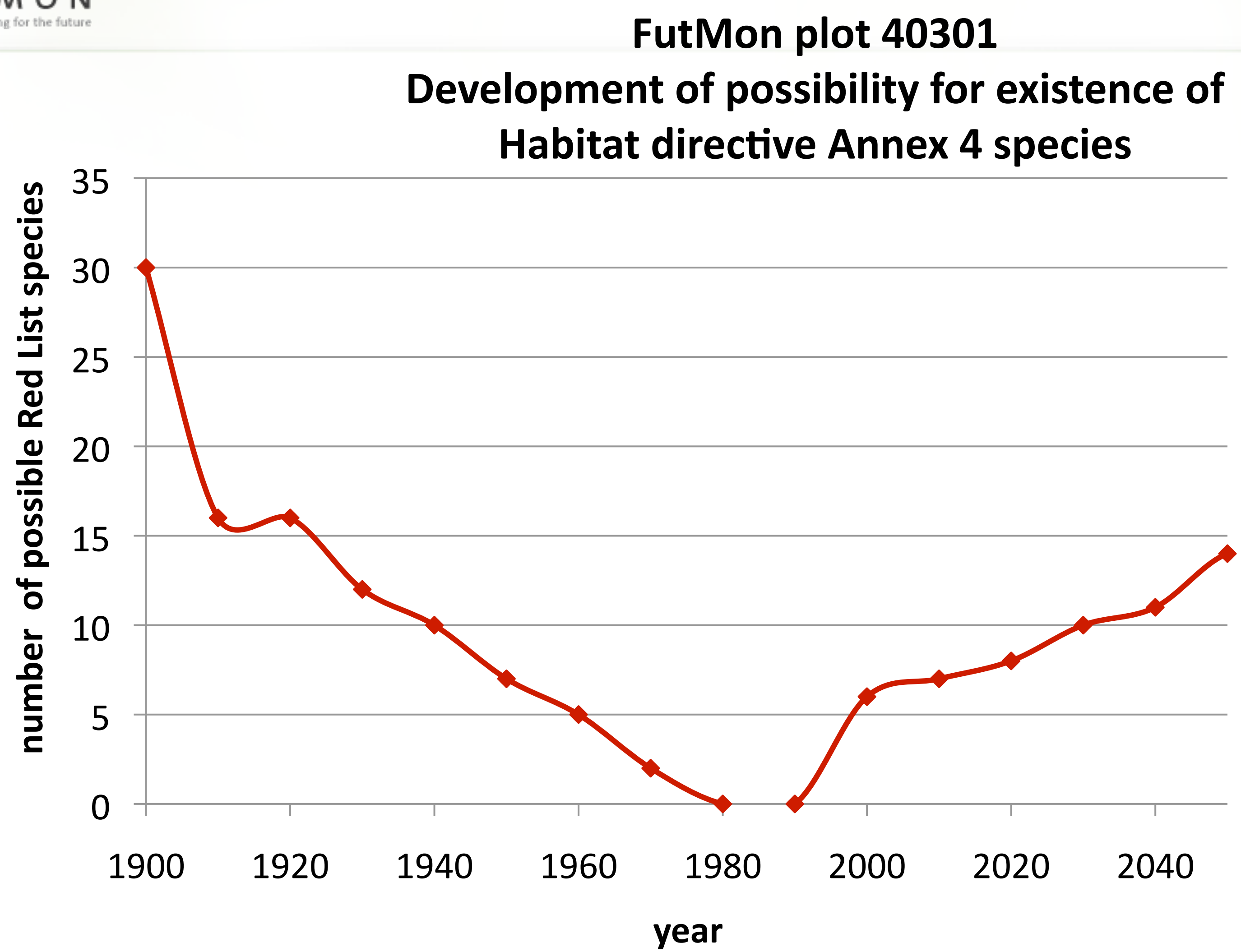
BERN model
Future development of vegetation



FutMon Plot 40301

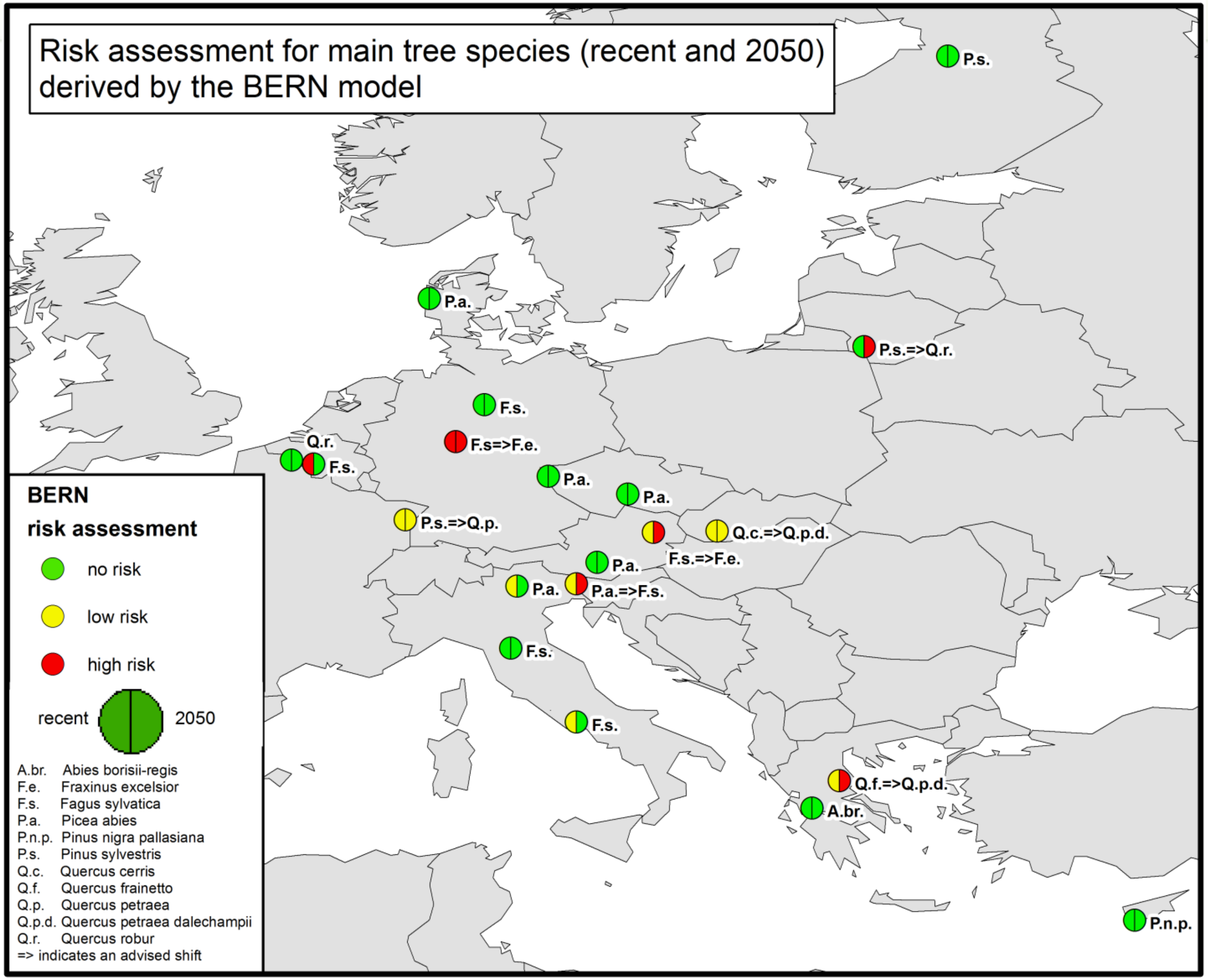
Dynamic of possibility for self regeneration and sustainable existence of site typical plant species depending on changes of site conditions


FutMon plot 40301
Development of possibility for existence of
Habitat directive Annex 4 species
number of possible Red List species
35
30
25
20
15
10
5
0
1900
1920
1940
1960
1980
2000
2020
2040
year

FUTMON
forest monitoring for the future

BERN model

Future development of vegetation



Summery

Critical Loads & exceedances

The reduction of sulphur deposition shows the success of the clean air policies in the EU, over **90 % of the forested sites will be protected from acidifying inputs**.

For nitrogen inputs, however, the model results reveal only minor changes. Assuming full implementation of national legislation (NAT2020), approximately 30 % of the FutMon sites will still receive **eutrophying nitrogen inputs above the critical loads*.**

* in the CCE report with all receptors 60 %

Summery

Dynamic modelling of soil solution

The VSD+ model allows the assessment of soil chemical changes over time taking into account the reaction and development of the system. A summarizing, Europe-wide interpretation for nearly 80 forest sites - each with specific conditions and soil reactions - is hardly possible and not representative. Thus, only basic and general trends can be discussed. An integrated interpretation shows:

- decreasing **C:N ratio** is the dominant trend after about 1970. Such a decrease occurs on half of the plots;
- **pH** changes include an increase in the share of plots with extremely low pH values in the years 1970 and 1980 and a recovery from 1990 onwards to preindustrial conditions (surprisingly);
- model results suggest a generally decreasing **base saturation** in the soils until the present time. It will probably take many decades to build up the base saturation to pre-industrial levels.

Summery

Future development of vegetation (BERN)

The BERN model offers a tool for the estimation of deposition effects and for operational forest management recommendations. Also the influence of climate change can be included in the model. An integrated interpretation shows:

- the 20 selected plots of the pilot study show different degrees of adaptability of the tree species and associated plant communities to the site conditions and modelled future changes;
- on 13 plots tree species correspond to site conditions and will remain adapted in the (modelled) future;
- on 7 plots present site conditions do not match requirements of the presently occurring main tree species, or the present conditions show a worsening in future and tree species changes are recommended.

Summery

Further development and scientific needs

Effect based assessments of forest ecosystems reaction to air pollutants deposition and climate change are necessary instruments for abatement strategies, e.g. a new directive on national emission ceilings.

Long-term intensive forest monitoring at the ecosystem scale is necessary to ensure the effectiveness of pollution control and abatement strategies.

Models rely on measurements, without a proper database for calibration these models are just a complex guess for the future.

The cross-linkage between measurers and modelers is unique (in this project) and sets the basis for an integrated approach to include future trends into current policy processes.

Effects of Nitrogen should be a main task of further work and the recently published "European Nitrogen Assessment " will be a guidance for this.

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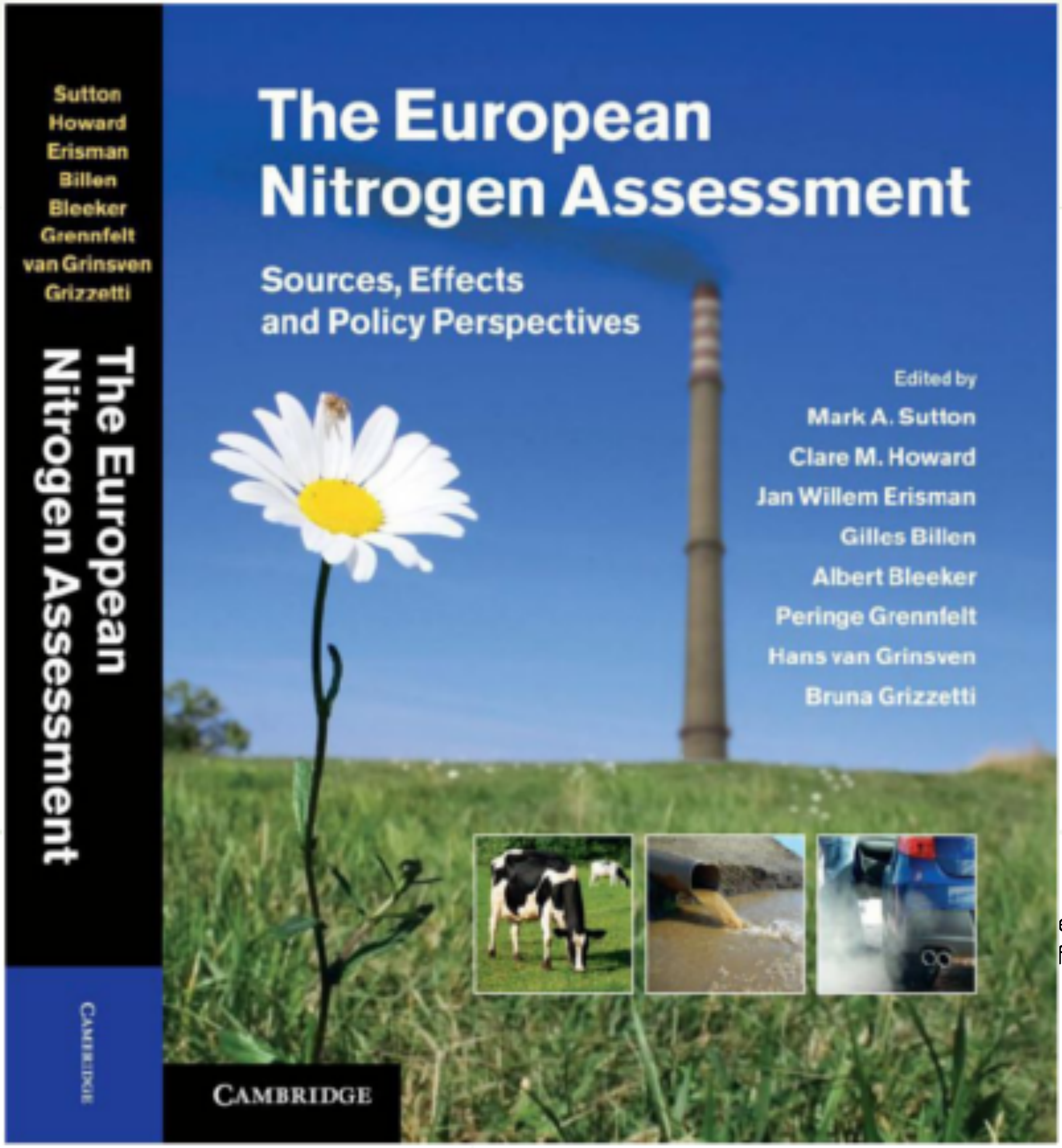

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for