

Modelling impacts of changes in nitrogen deposition and climate on ecosystem services in Europe in the period 1900-2050

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Outline presentation

- N deposition impacts on ecosystem services: an overview
- Modelling N deposition and climate impacts on ecosystem services in Europe:
 - *Biodiversity*: Diversity of plant species
 - *Soil quality* regulation: depletion of the pools of BC and Al
 - *Water quality* regulation: dissolved NO_3 and Al in excess of critical limits.
 - *Climate* regulation: Carbon sequestration
- Conclusions

Ecosystems services

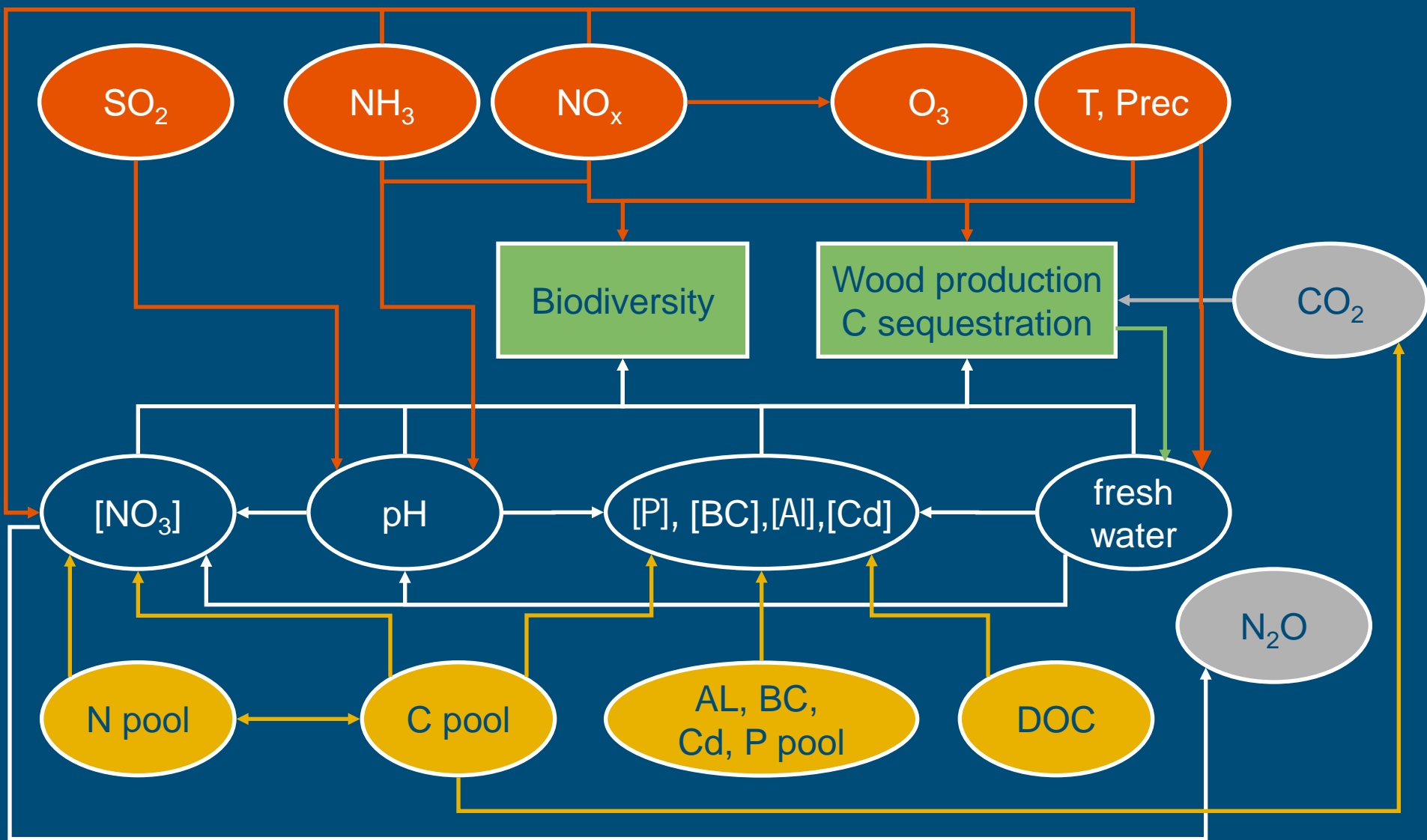
- Ecosystems provide services that are vital to human health and livelihood, including:
 - Provisioning services: e.g. provision of food, **wood**, fresh water, **biodiversity** based products
 - Regulating services: regulation of e.g. **climate**, floods, **water quality** and diseases
 - Supporting services : capacity to regulate essential ecological processes

Link between N deposition and ecosystem services

Ecosystem services	Examples of nitrogen effects
<i>Provisioning services</i>	
Food/fiber, including <ul style="list-style-type: none">- Crops- Wild plants and animal products	Increase in crop production Impacts on biodiversity (based products)
Timber/wood fuel	Increase in wood production
Natural medicines	Impacts on medicinal plants
Fresh water	Impacts on ground water recharge and drainage
<i>Supporting services</i>	
Nutrient cycling and primary production	Increased N litterfall; decrease in soil biodiversity and decomposition

Link between N deposition and ecosystem services

<i>Regulating services</i>	
Air quality regulation	increased concentrations of ammonia (NH ₃), nitrogen oxides (NO _x), ozone (O ₃) and particulate matter (PM10 and PM 2.5)
Climate regulation Green house gas balance	Increased carbon sequestration in forests Increased/decreased carbon sequestration in peat lands
Water quantity regulation	Increased/decreased runoff and ground water recharge Increased drought stress
Water quality regulation (water purification)	NO ₃ , Al concentrations in groundwater and surface water exceeding drinking water quality criteria Fish dieback by algal blooms and anoxic zones (eutrophication) and impacts of Al on fish gills (acidification).
Soil quality regulation	Decrease in acidity buffer; change in soil structure
Pest/disease regulation	Increased human allergic diseases by stimulated greater pollen production



Assessment N impacts on biodiversity

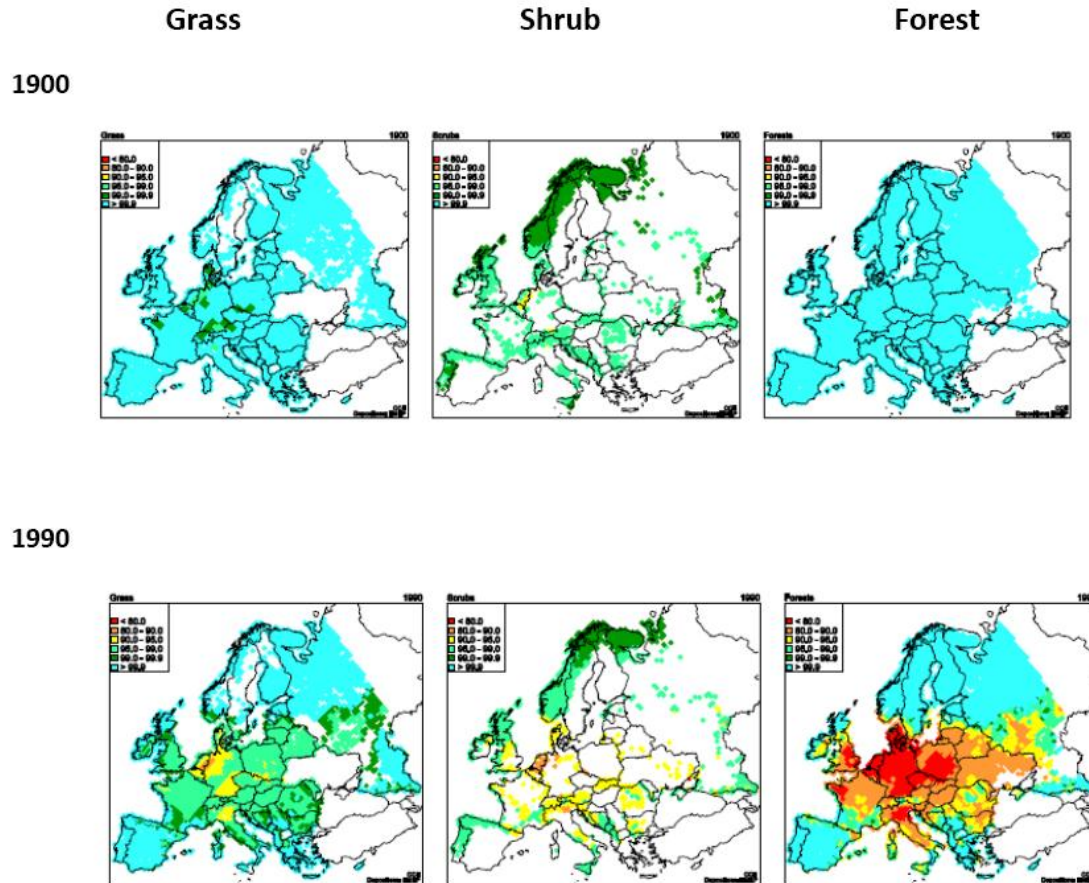
■ Approaches

- Assessment of critical N loads based on empirical data and model approaches
- Assessment of empirical and model based relationships between plant species diversity and N inputs.

■ European applications using N deposition data for the past and future (EMEP model results)

- Critical N load exceedances
- Plant species diversity based on application of empirical relationships and models

Predicted N impacts on biodiversity



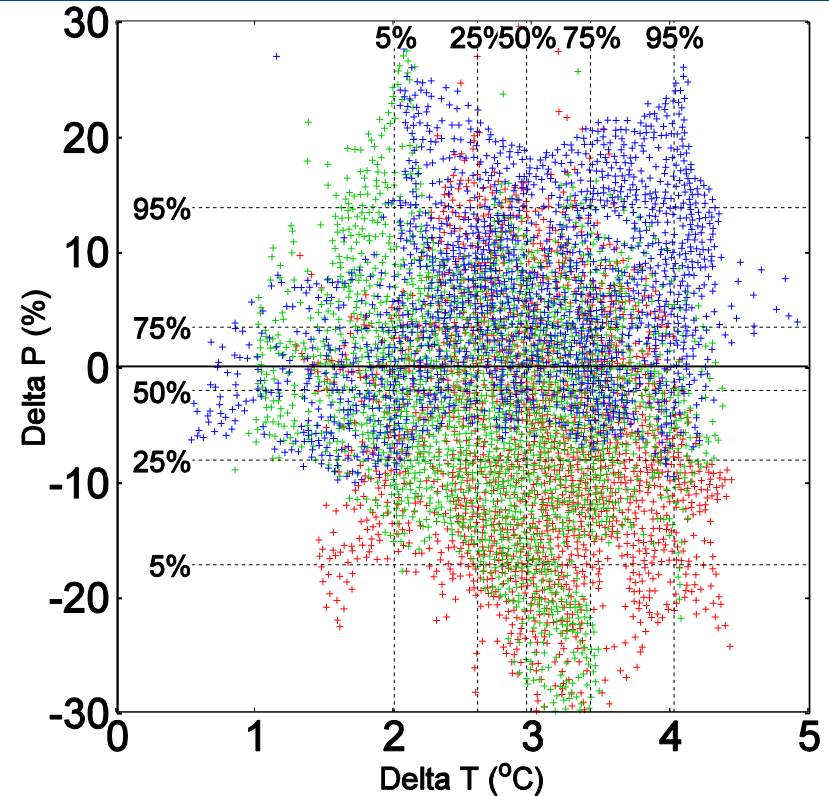
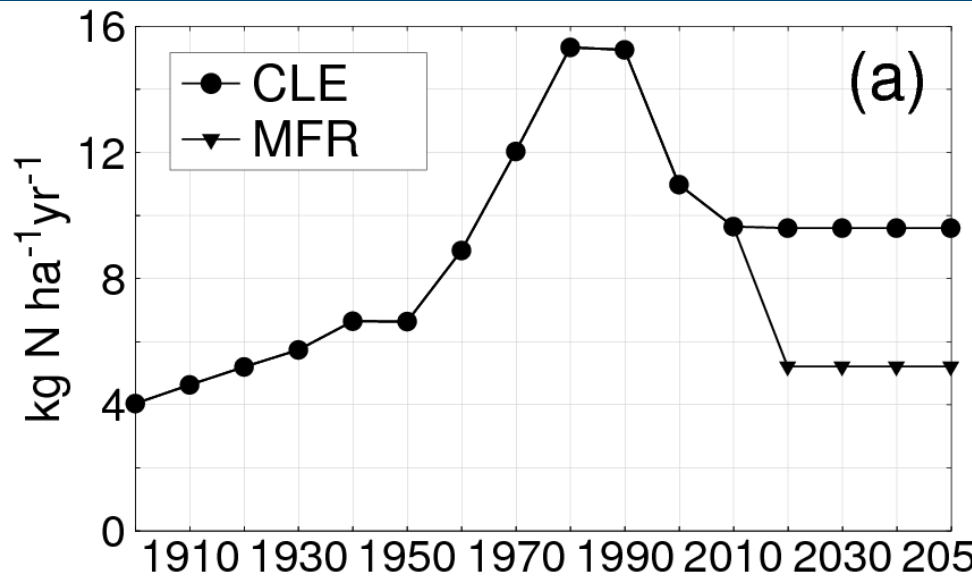
Modeling N impacts on ecosystem services

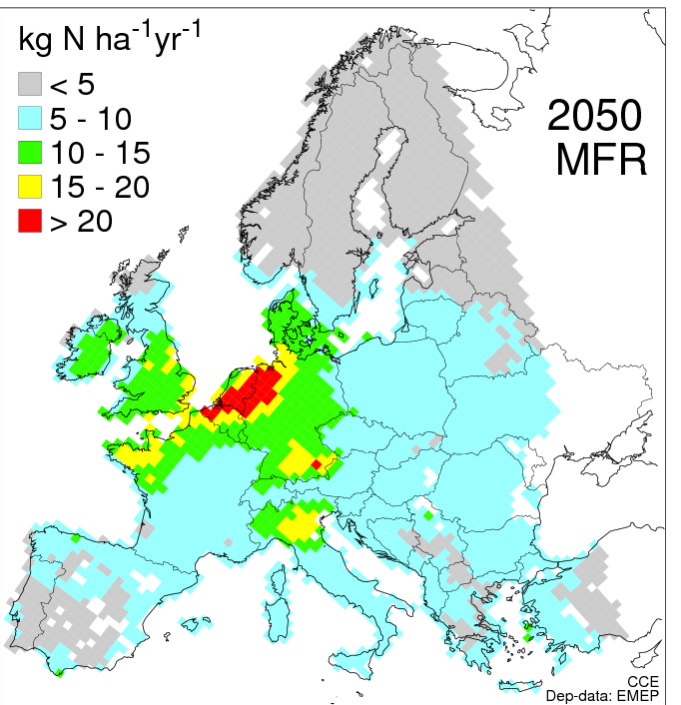
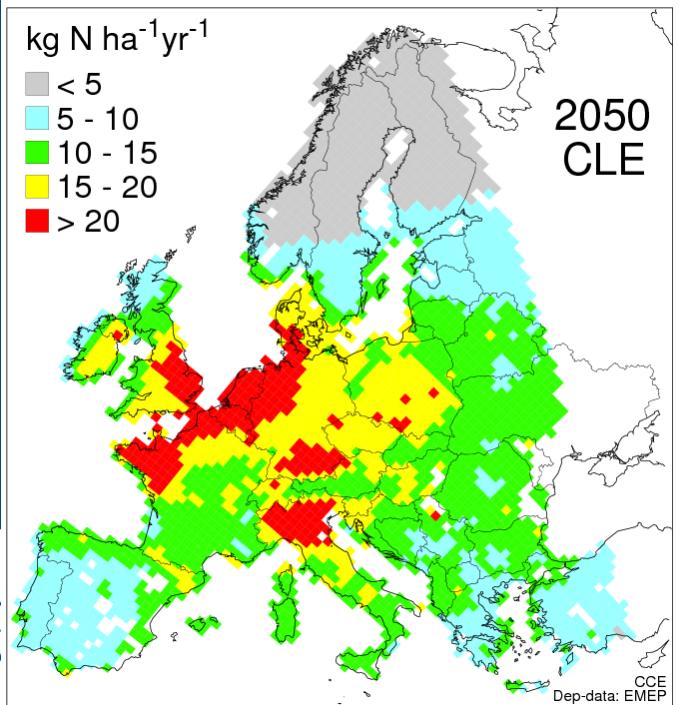
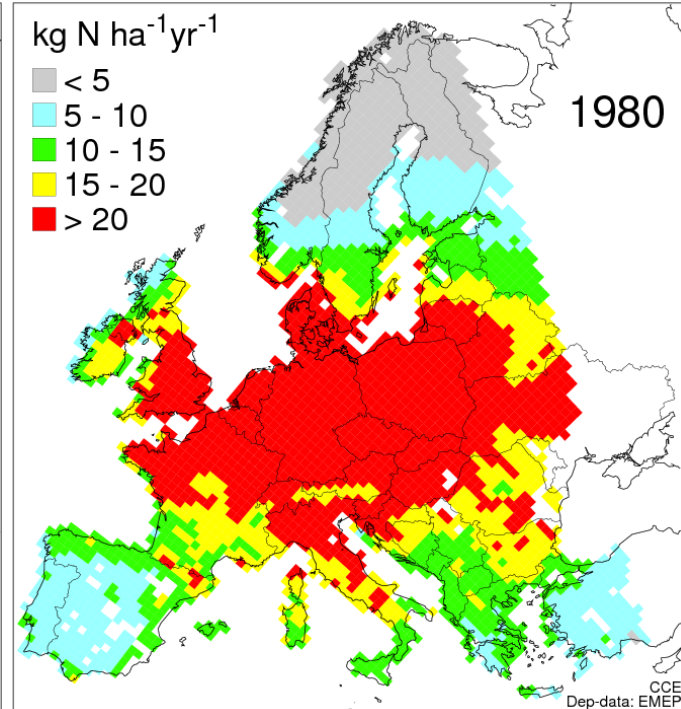
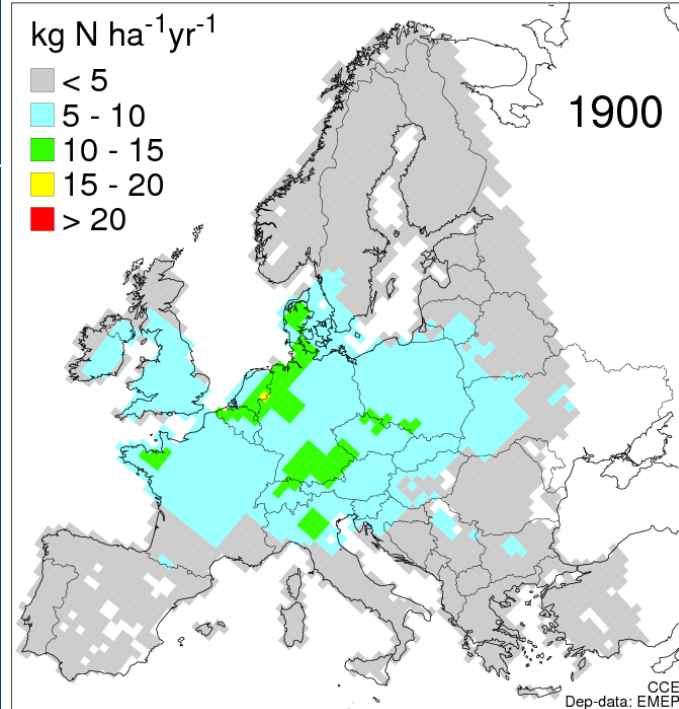
- Use of VSD model to assess the response of forest to climate change and NO_x , NH_3 and SO_2 deposition in the period 1900-2050 on:
 - Soil quality indicators: available Bc and Al pools
 - Water quality indicators: dissolved NO_3 and Al
 - Climate regulating indicator: Tree carbon sequestration

N deposition, climate change and forest growth

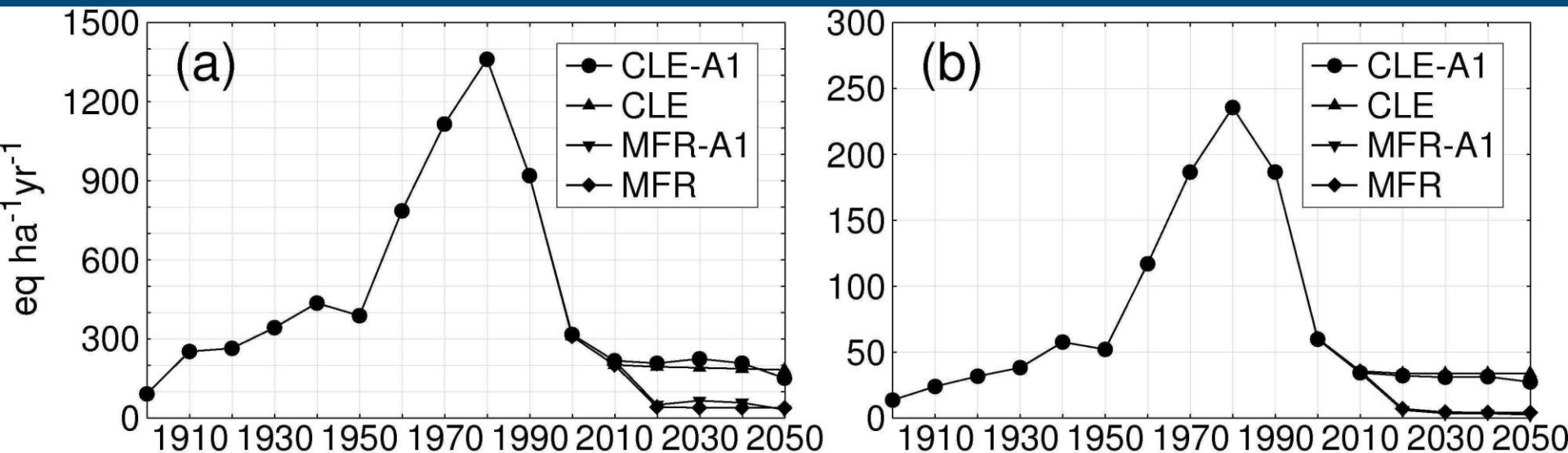
- Environmental effects on tree growth, G , is calculated as a function of the reference growth, G_{ref} , and modifying factors:
- $$G = G_{ref} * f_{climate} * f_{Ndep} * f_{Nutlim}$$
- $$f_{climate} = f_{temperature} \times f_{respiration} \times f_{evapotranspiration}$$
- Modifying factors scaled to a factor 1 in ref year 1980,
- Reference growth assessed with EFISCEN: contains growth data for approximately 20 tree species and 10 age classes in about 250 regions in Europe

Deposition and climate change scenarios



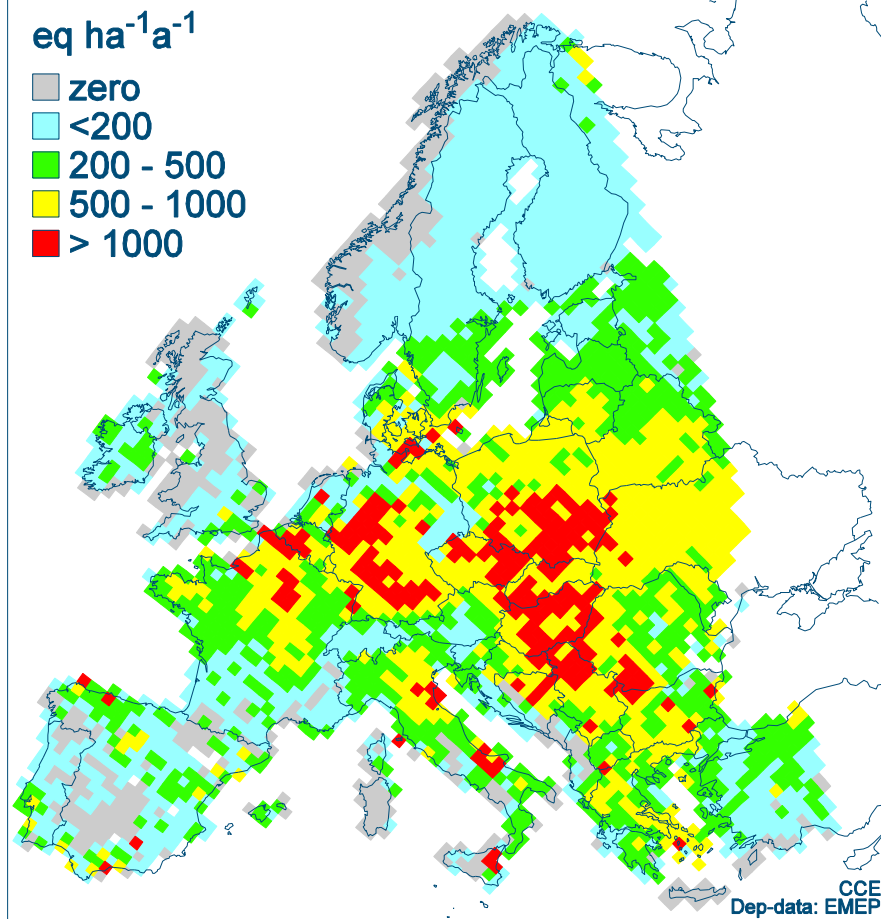


Soil quality regulation: Trends in Bc and Al depletion

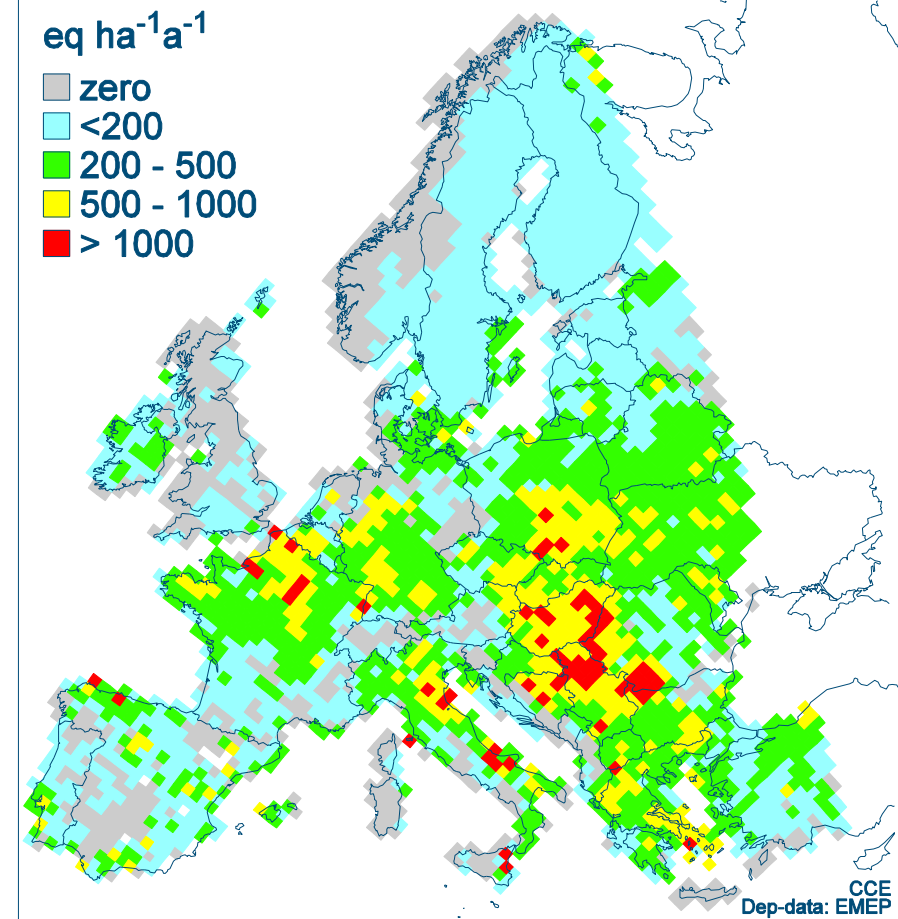


Soil quality regulation: depletion of BC pools

2050: BC depletion (95-th percentile) 1980-N deposition

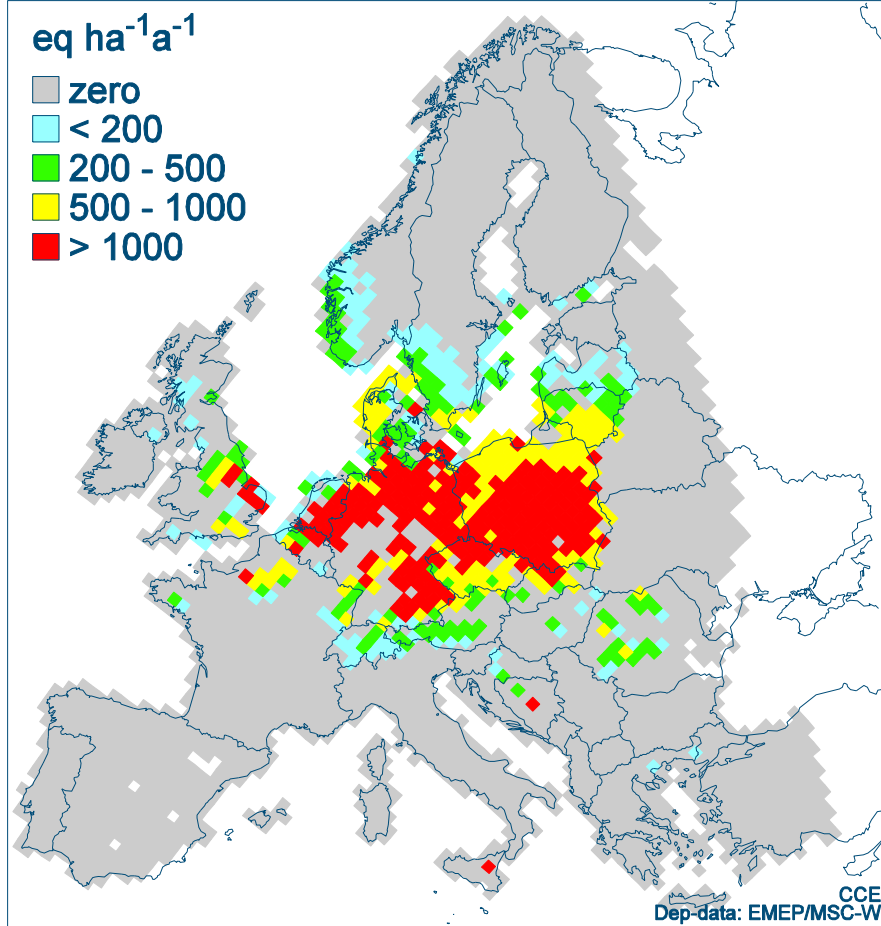


2050: BC depletion (95-th percentile) CLE deposition

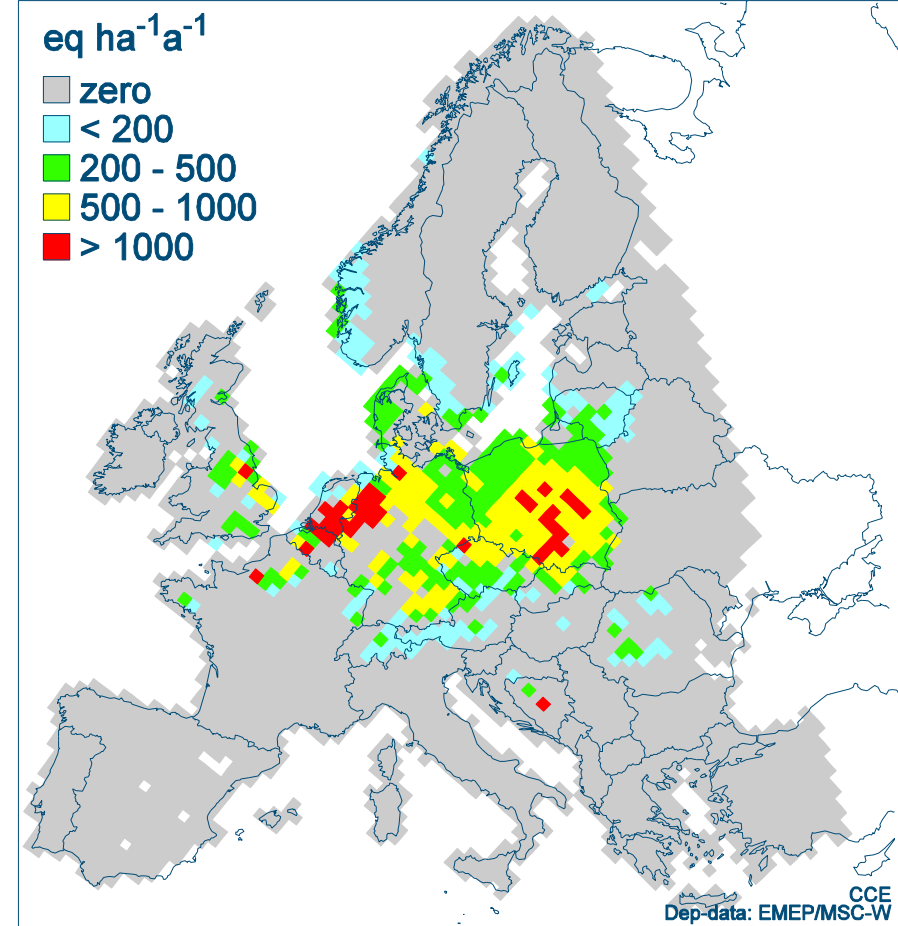


Soil quality regulation: depletion of Al pools

2050: Al depletion (95-th percentile) 1980-N deposition



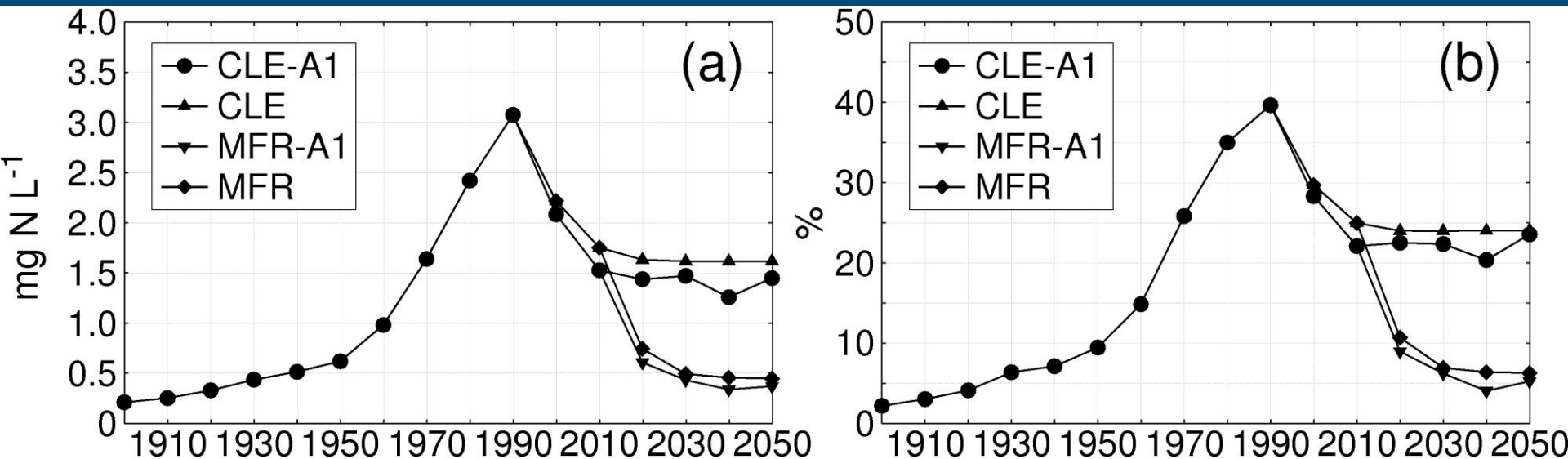
2050: Al depletion (95-th percentile) CLE deposition



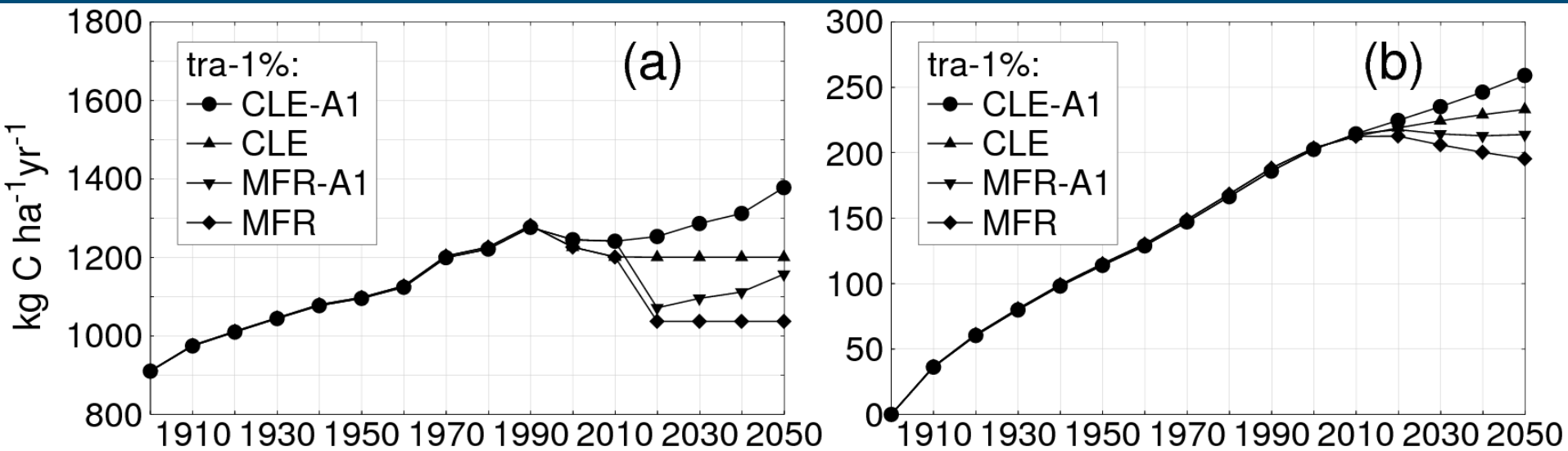
Water quality regulation

- Assess the NO_3 and Al concentration by VSD and compare:
 - NO_3 concentration with limit in ground water in view of possible impacts ($50 \text{ mg NO}_3.\text{l}^{-1}$ is EU quality criterion) and surface water (2.0 mg N.l^{-1} is a criterion mentioned).
 - Al concentration with a limit in ground water of $0,02 \text{ mmol Al.l}^{-1}$ (60 ueq Al.l^{-1}) in view of possible Alzheimer disease.

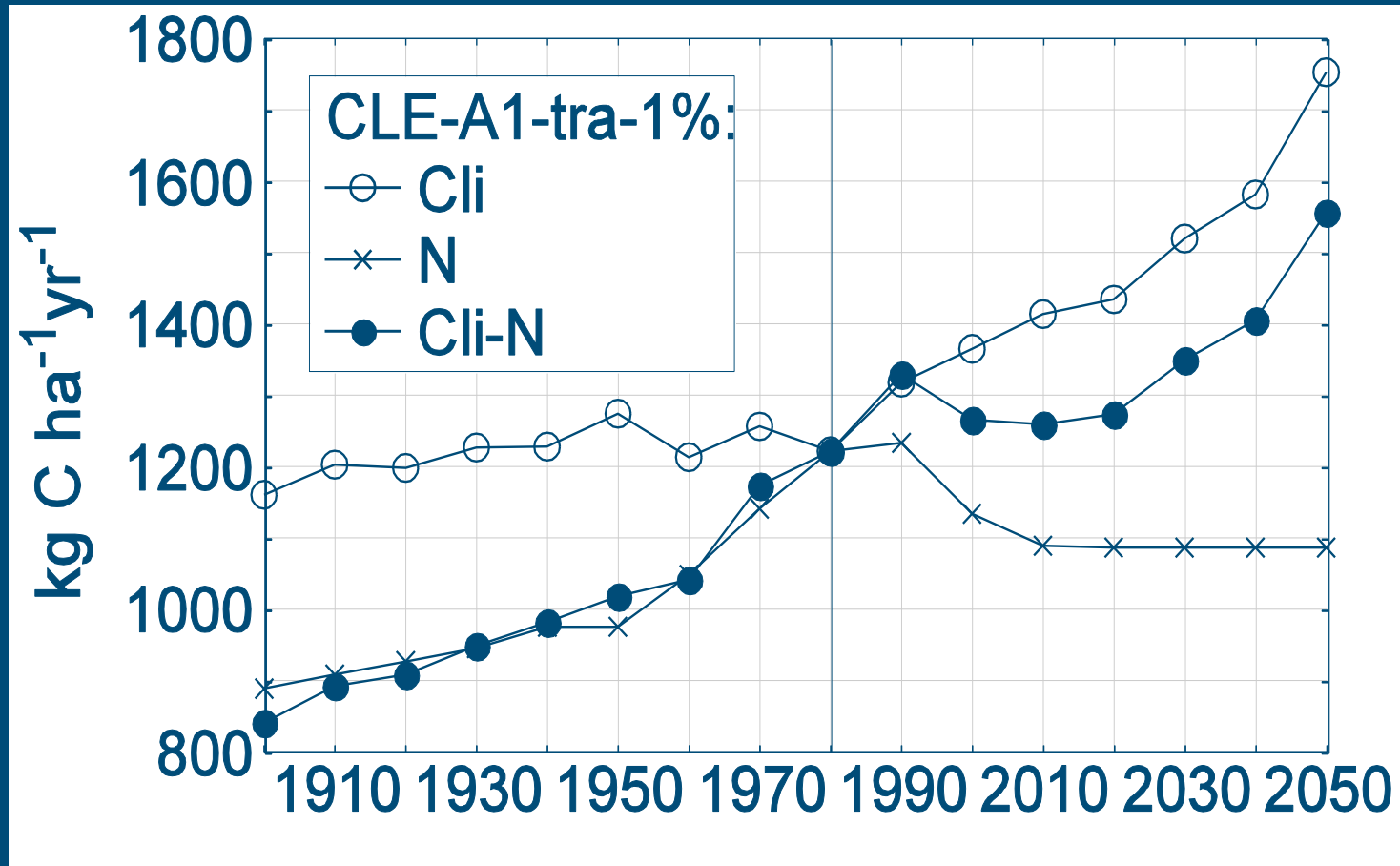
Water quality: Trends in N concentration and in area exceeding a critical N concentration of 2 mg N L⁻¹

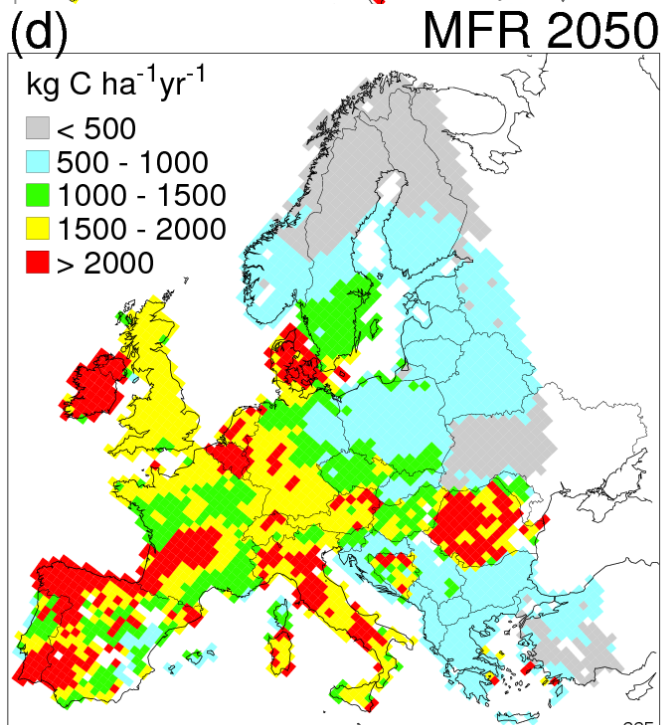
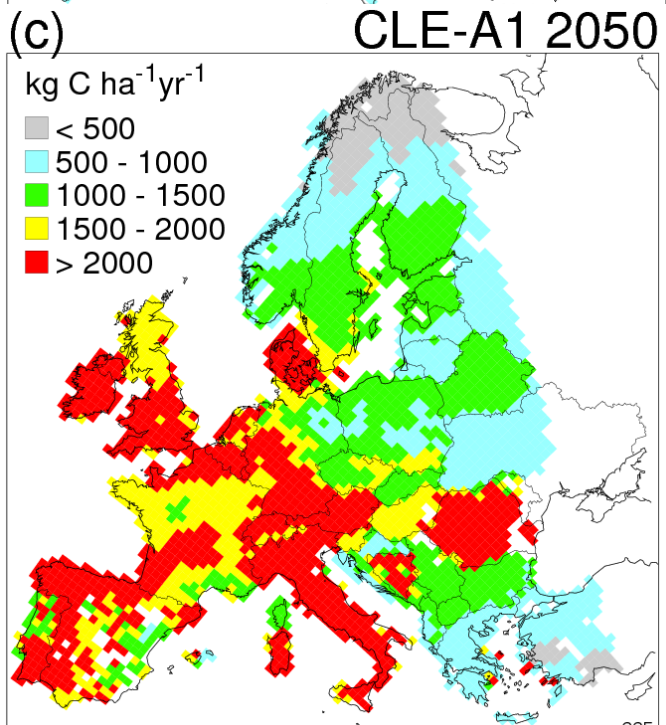
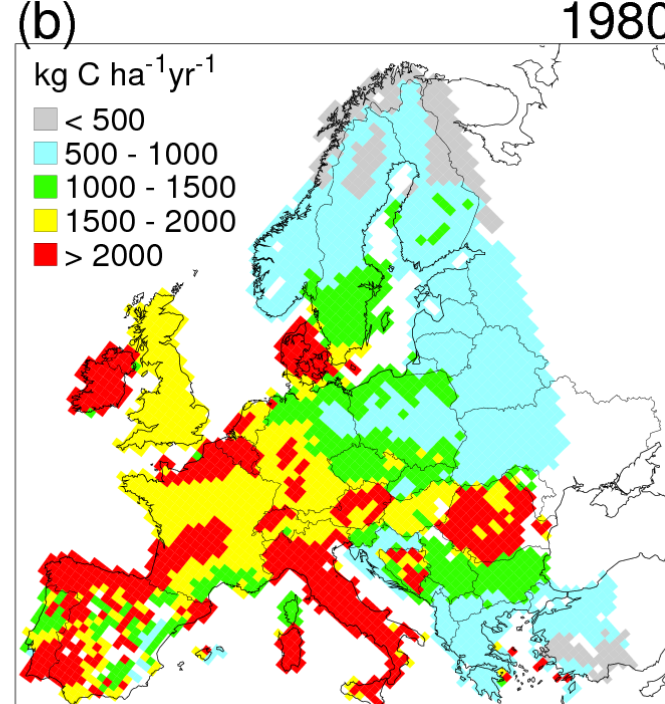
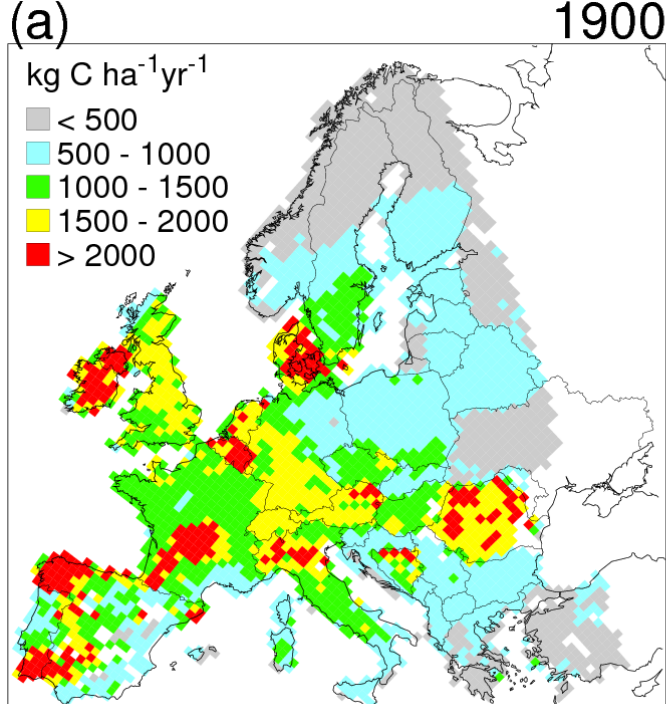


Tree carbon sequestered as a function of climate and N deposition scenarios including nutrient limitation



N and climate interactions on tree carbon sequestration





Conclusions

- Biodiversity has significantly been affected in the last century, specifically in Central and Western Europe.
- Impact of N and S emission (reductions) on soil and water quality parameters are larger than climate change (but climate change impacts are underestimated in VSD!!!).
- N deposition drove tree C sequestration in the past, climate will do it in the future