C4: Ecological responses at European scale: progress and highlights

Wim de Vries

Alessandro Cescatti, Gert Jan Reinds, Max Posch, Mark Theobald

ALTERRA
WAGENINGEN UR

éclaire
Effects of climate change on air pollution impacts and response strategies for European ecosystems

Main tasks Component 4

- Further develop and apply dynamic global vegetation models (CLM, LPJ-Guess, Jules, O-CN) and dynamic soil vegetation models (VSD^+-EUgrow-PROPS; MADOC) to predict
  - Carbon sequestration (WP14)
  - Plant species diversity (WP15)

  in response to combined impacts of Climate, CO2, N deposition and ozone exposure in ECLAIRE scenarios.
- Map novel thresholds for N deposition and O_3 exposure and exceedances at European scale (WP16).
- Assess impacts of model resolution on threshold N exceedances at landscape scale (WP17).

ALTERRA WAGENINGEN UR

éclaire
Effects of climate change on air pollution impacts and response strategies for European ecosystems

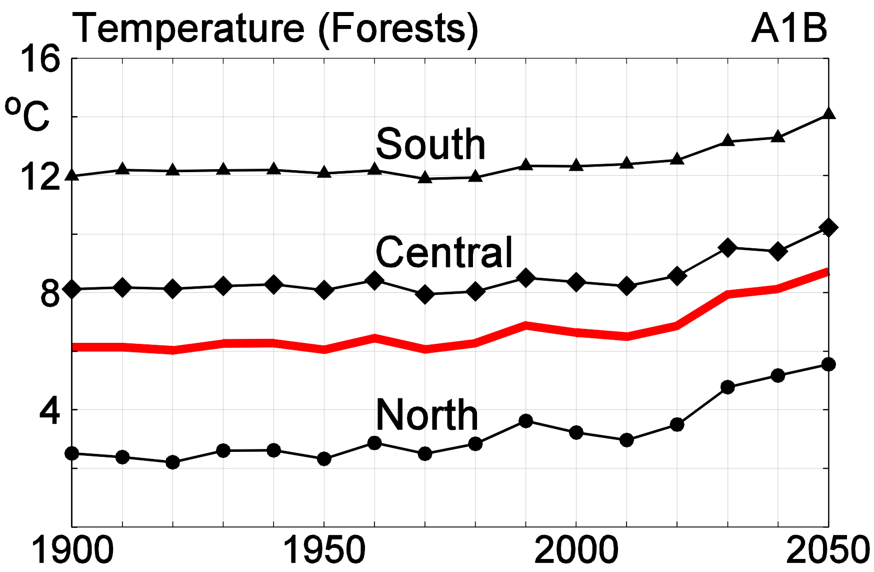
Eclaire scenario model intercomparison: 1900-2050

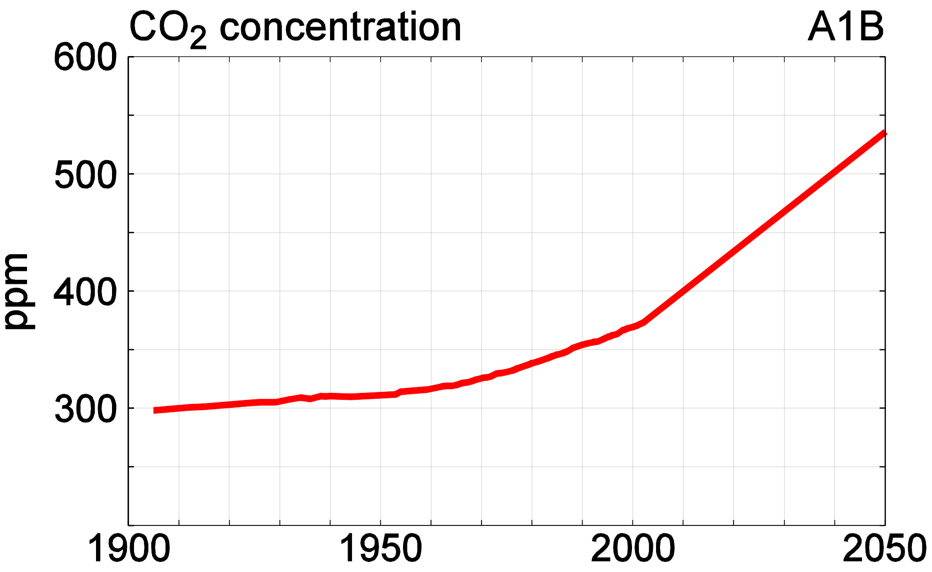
- Climate data (hourly or daily resolution)
  - 1961-2050 ECHAM5 A1B-r3 RCA3 simulation. Includes bias correction for daily temperature and precipitation
  - 1900-1960: random draws out of 1961-1970 ECHAM5 data
- CO_2 concentrations
  - 1900-2005: measured (Antarctic ice and Mauna Loa)
  - 2006-2050: predictions based on IPCC SRES A1B scenario
- N deposition and O_3 exposure (hourly or daily resolution): EMEP model data based on:
  - 1900-2000: Lamarque dataset
  - 2001-2050: New GAINS emission scenarios http://www.iiasa.ac.at/web/home/research/researchPrograms/Overview2.en.html.
- Land-use: fixed cover 2000

ALTERRA WAGENINGEN UR

éclaire Effects of climate change on air pollution impacts and response strategies for European ecosystems

Temporal changes in Temperature and CO2



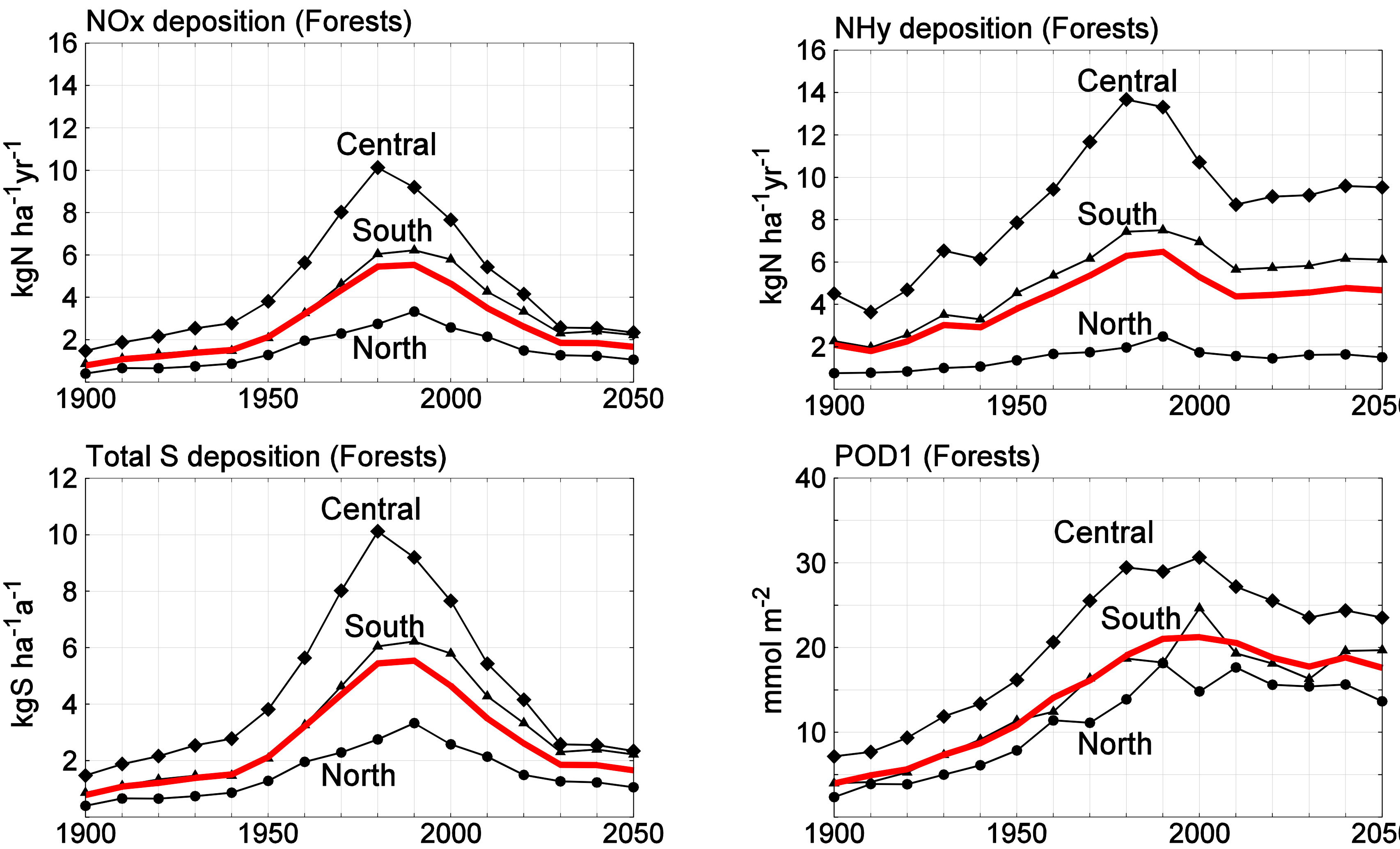


Area-weighted averaged over ca. 800,00 forest sites

ALTERRA WAGENINGEN UR

éclaire
Effects of climate change on air pollution impacts and response strategies for European ecosystems

Temporal changes in N and S deposition and POD1



Area-weighted averaged over ca. 800,00 forest sites

ALTERRA WAGENINGEN UR

éclaire

Effects of climate change on air pollution impacts and response strategies for European ecosystems

WP14: Description of the model runs

MANDATORY

Model experiment	Climate	CO_2	N deposition	O_3
S base	Variable	Constant	Constant	Constant
S10	Variable	Variable	Constant	Constant
S2	Variable	Variable	Constant	Variable
S1	Variable	Variable	Variable	Constant
S0	Variable	Variable	Variable	Variable
S11	Variable	Variable	Variable	Constant
S12	Variable	Constant	Variable	Variable

WP 14: N and O3 modelling scenarios

	O_3	no O_3
N	Scenario 0 CLM OCN	Scenario 1 CLM LPJ OCN
no N	Scenario 2 CLM JULES OCN	Scenario 10 CLM JULES LPJ OCN

3

1

2

1. Effect of N with no O3: 3 models: CLM, LPJ, OCN sym 1 vs. 10
2. Effect of O3 with no N: 3 models: CLM, JULES, OCN sym 2 vs. 10
3. Joint effect of N and O3: 2 models (CLM, OCN) sym 0 vs. 10

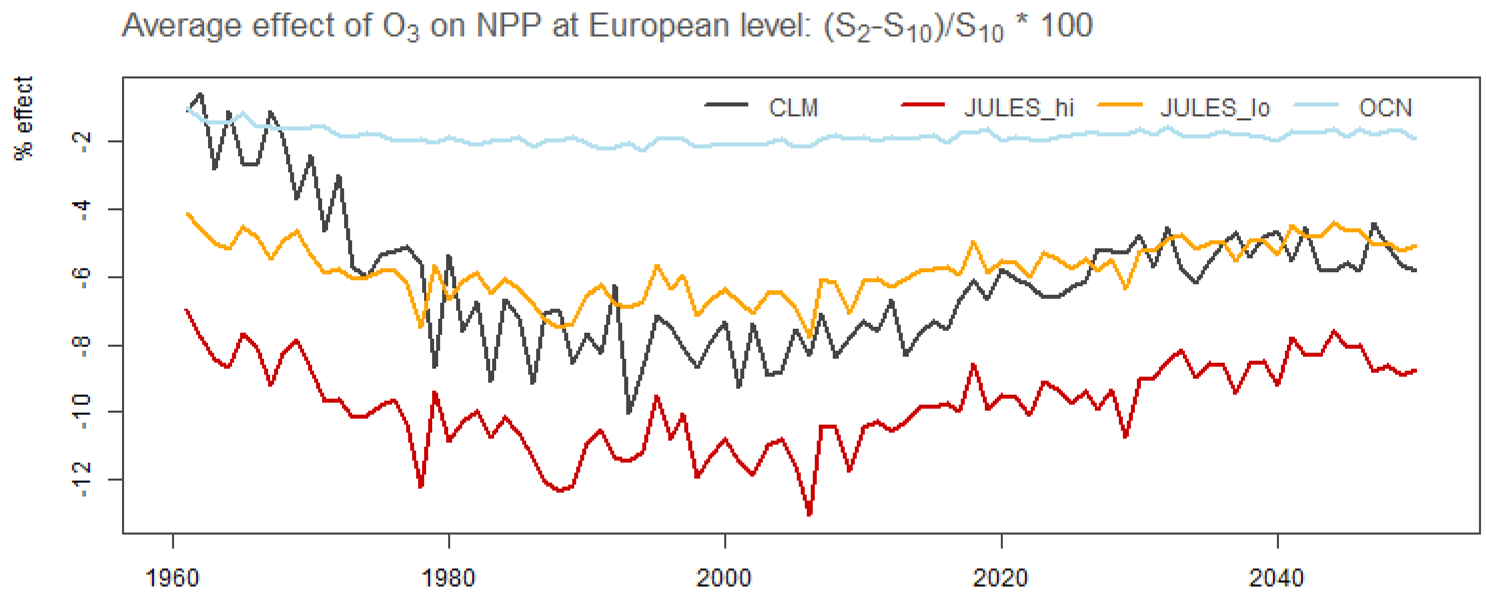
ALTERRA WAGENINGEN UR

éclaire

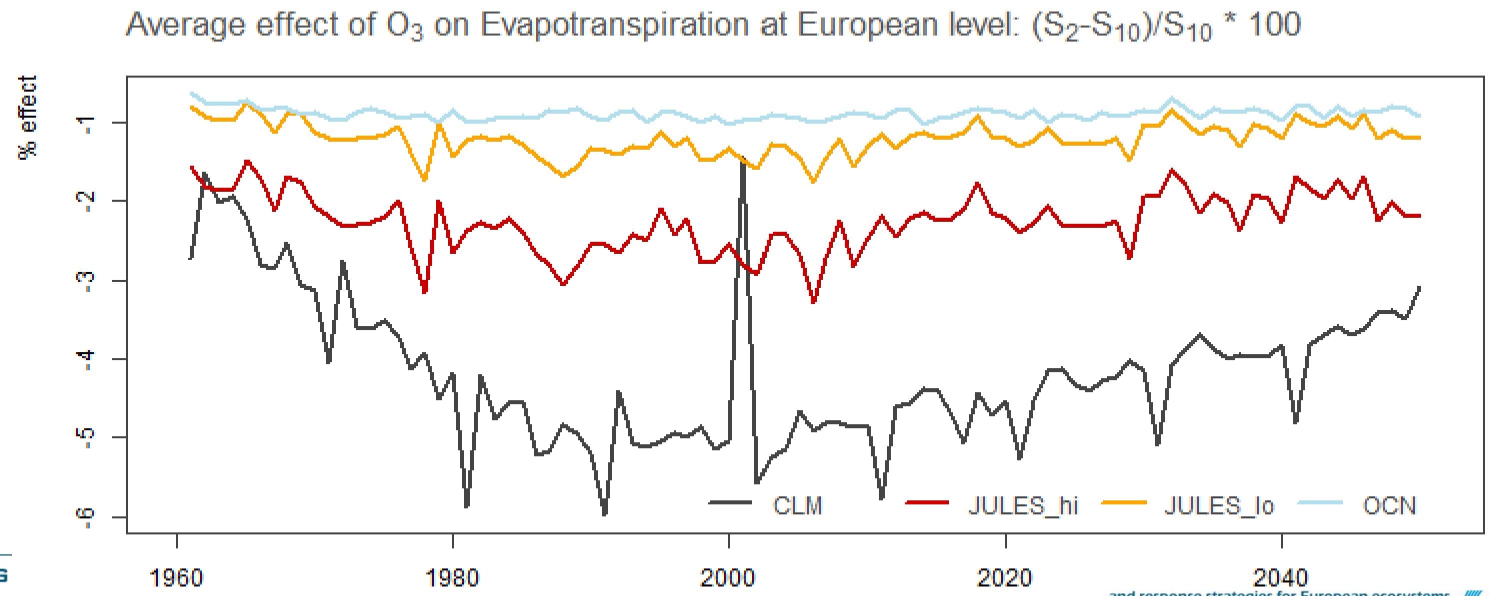
Effects of climate change on air pollution impacts and response strategies for European ecosystems

Ensemble of DGVMs output: effect of O_3

NPP



ETP



ALTERRA WAGENINGEN

and response strategies for European ecosystems

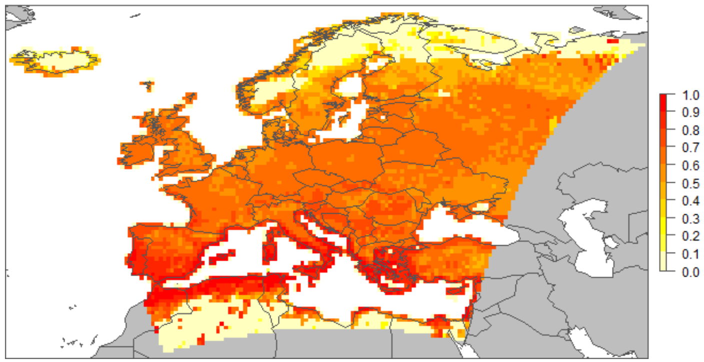
N effect

Frequency of S1 v> 10

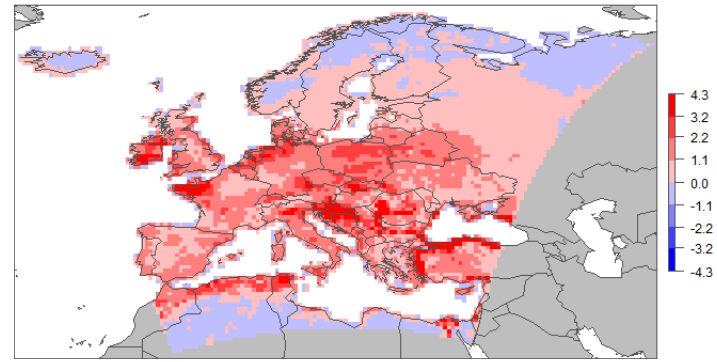
Delta S1-S10

CLM

Frequency CLMsc1 NPP > CLMsc10 NPP 1961-2050

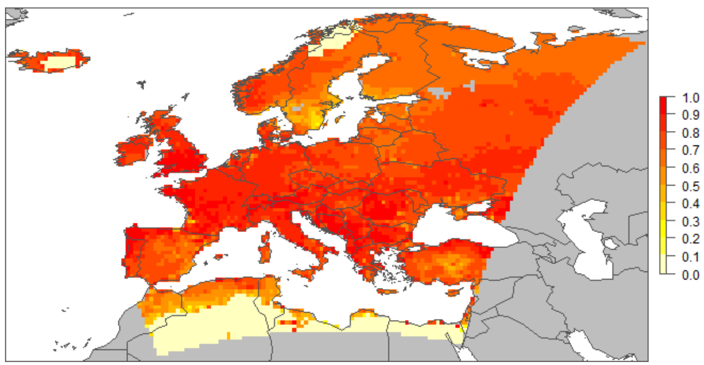


Bias between CLMsc1 and CLMsc10 * 1000 (NPP 1961-2050)

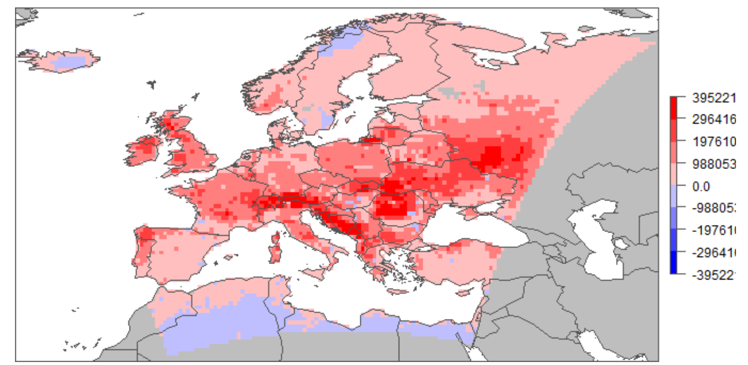


OCN

Frequency OCNsc1 NPP > OCNsc10 NPP 1961-2050

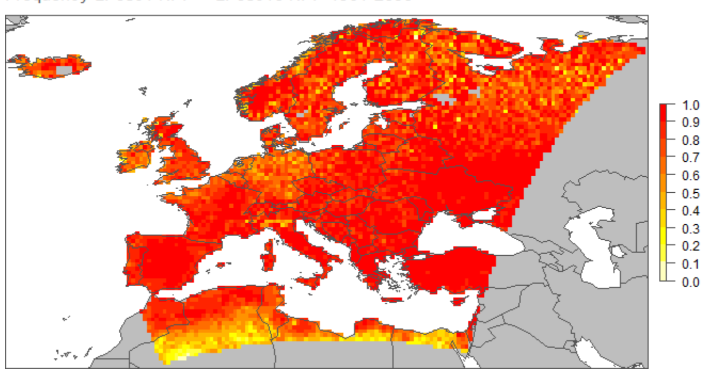


Bias between OCNsc1 vs OCNsc10 * 1000 (NPP 1961-2050)

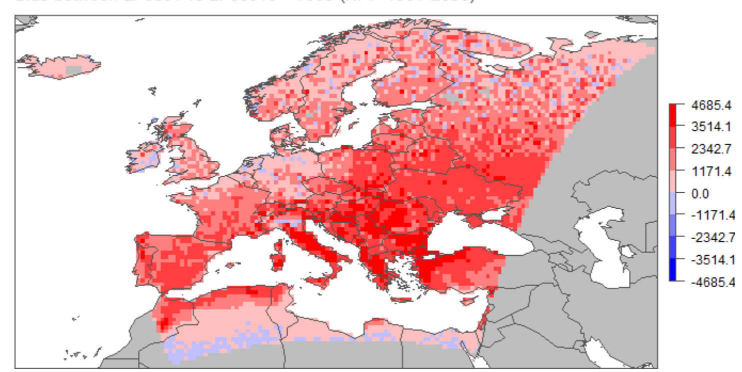


LPJ

Frequency LPJsc1 NPP > LPJsc10 NPP 1961-2050

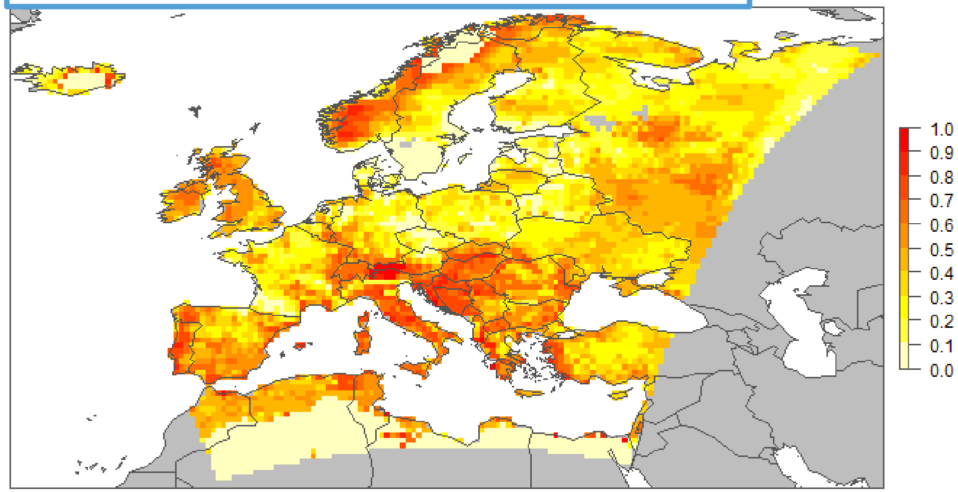


Bias between LPJsc1 vs LPJsc10 * 1000 (NPP 1961-2050)

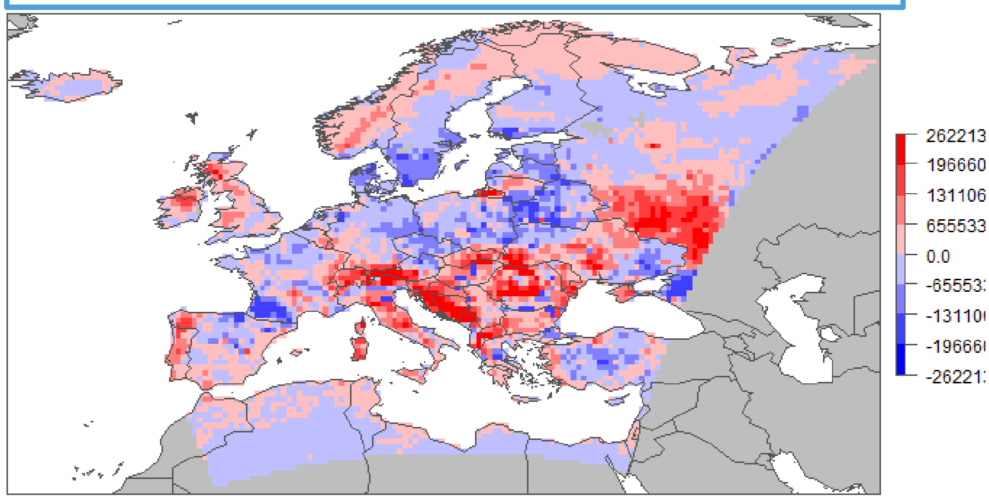


Combined effect of N and O3 on NPP (1961-2050)
Model OCN

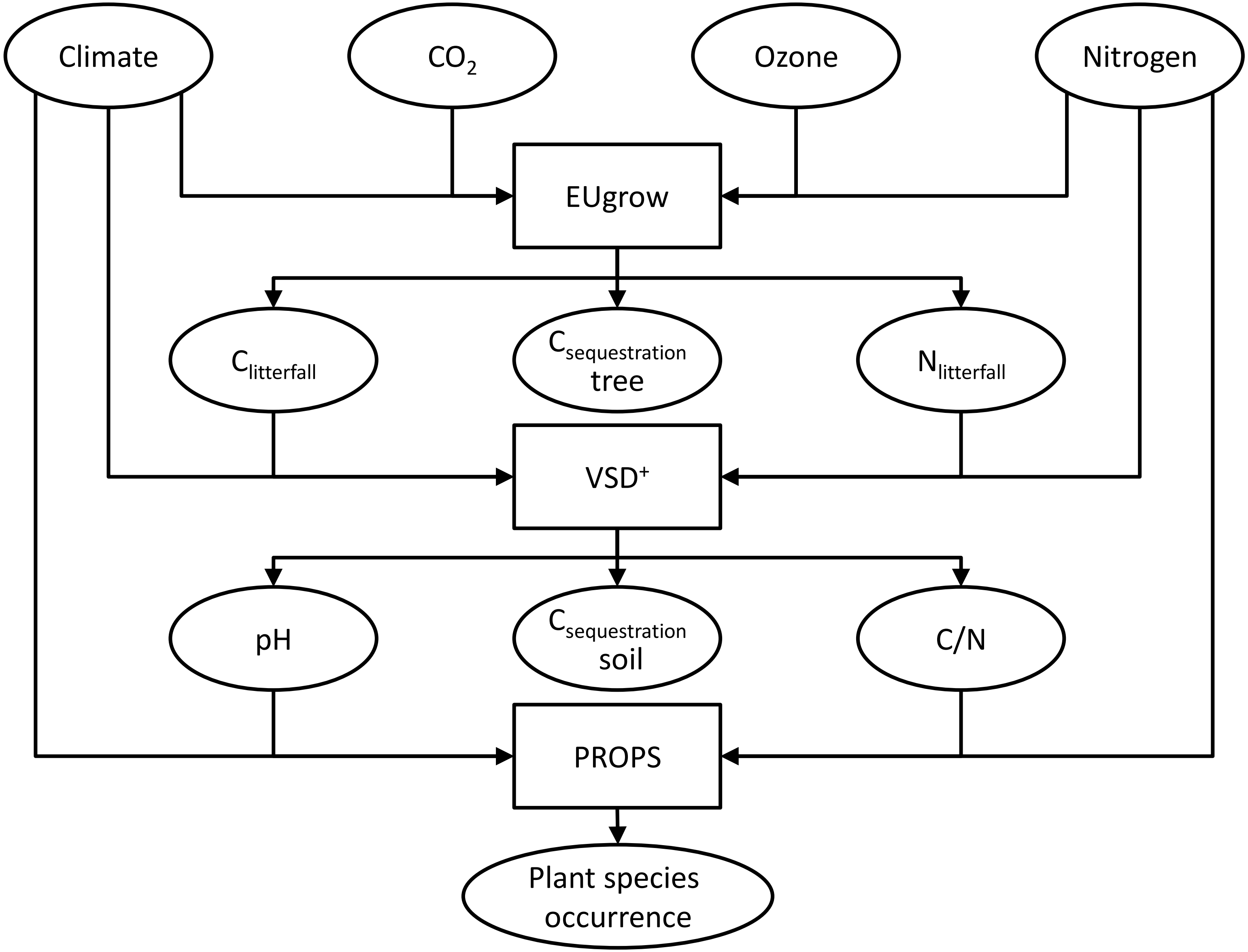
Frequency of s0 > s10



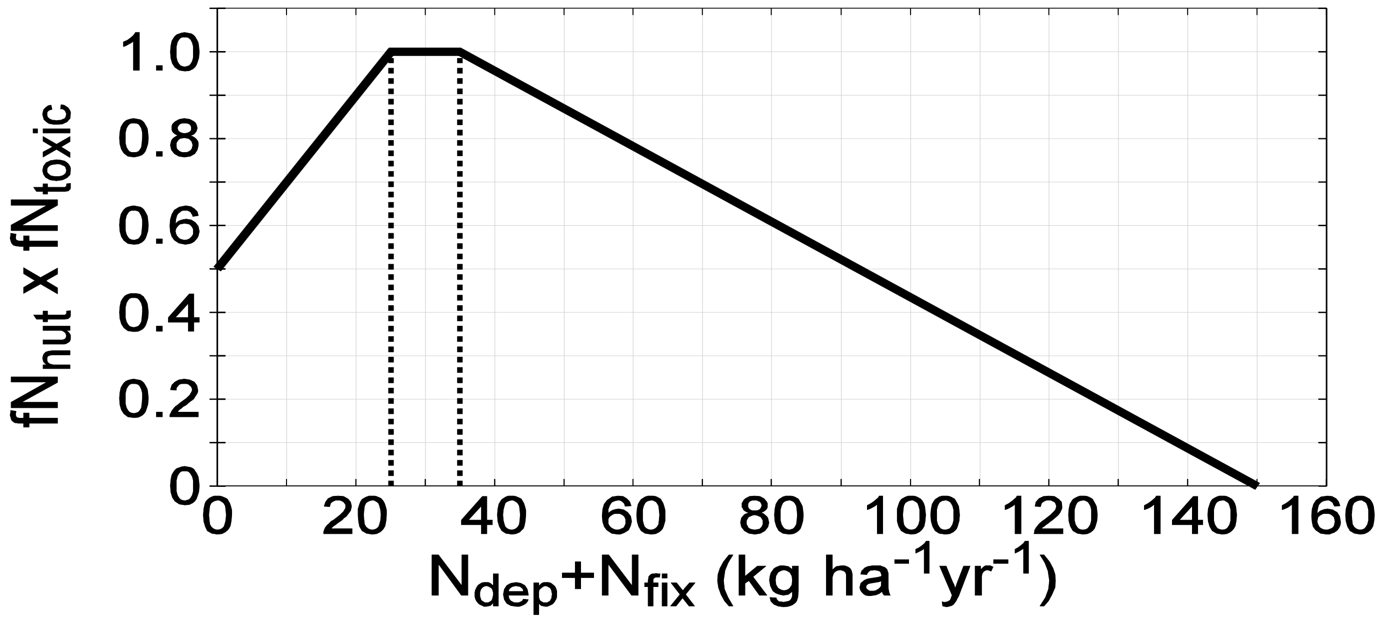
Delta S0 - S10

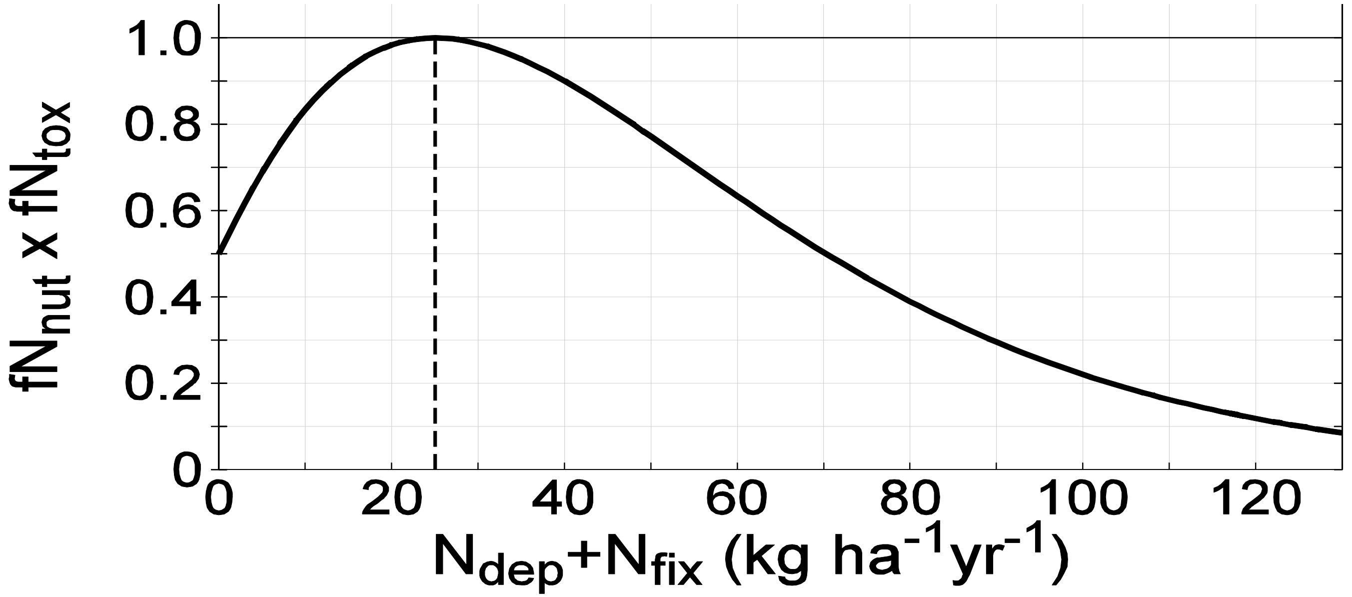


EUgrow/VSD+/PROPS model chain

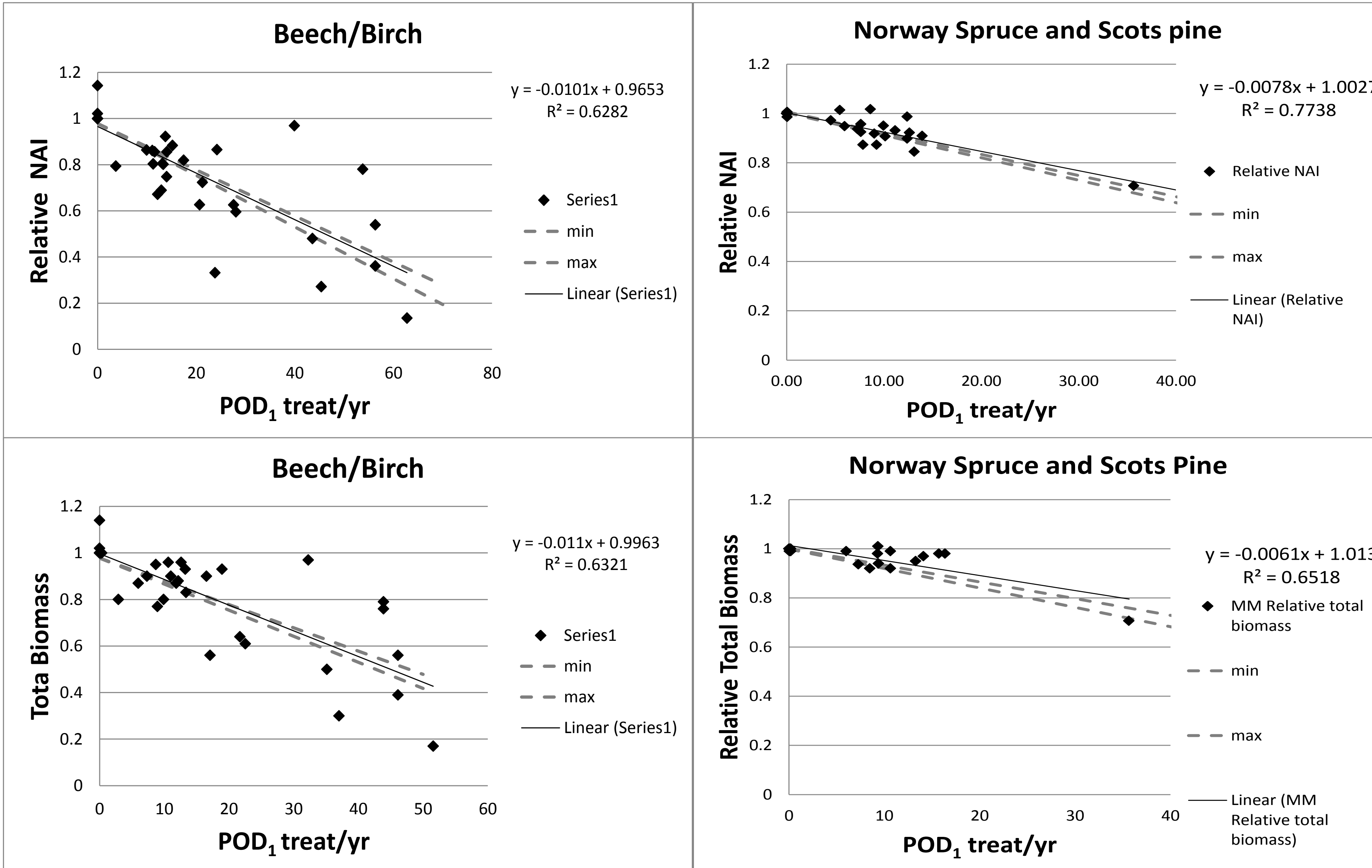


Examples N deposition impacts on growth



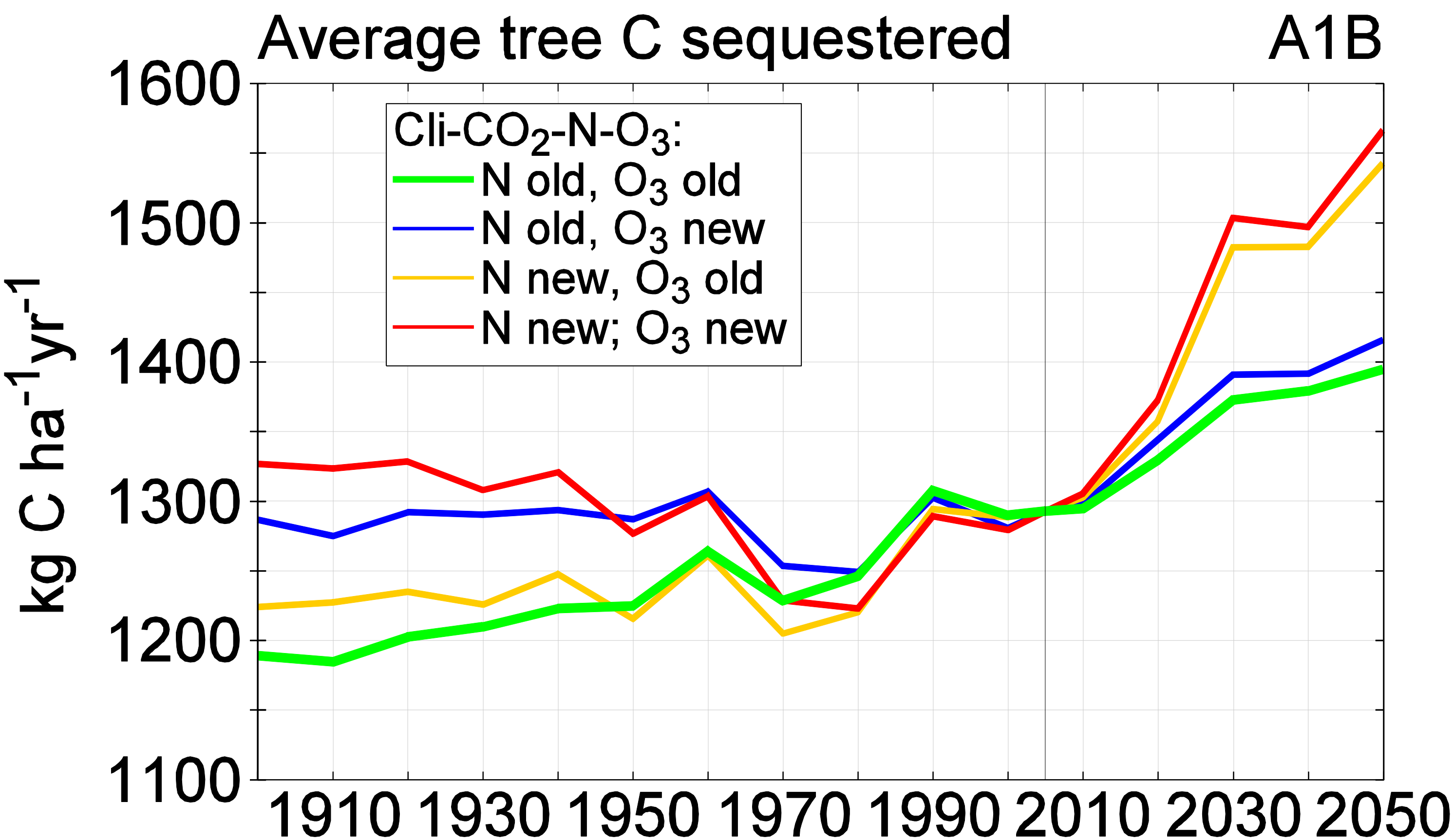


Ozone modifying factors for forest biomass



Source: Emberson et al. (2015)

Impacts of different N and O_3 impact functions on tree C sequestration as calculated by EUgrow



Modeling impacts on plant species diversity

- MADOC- MultiMOVE applied to UK
  - MADOC : predicts soil pH, NO3, DOC and carbon sequestration;
  - MADOC- MultiMOVE: predicts plant species diversity

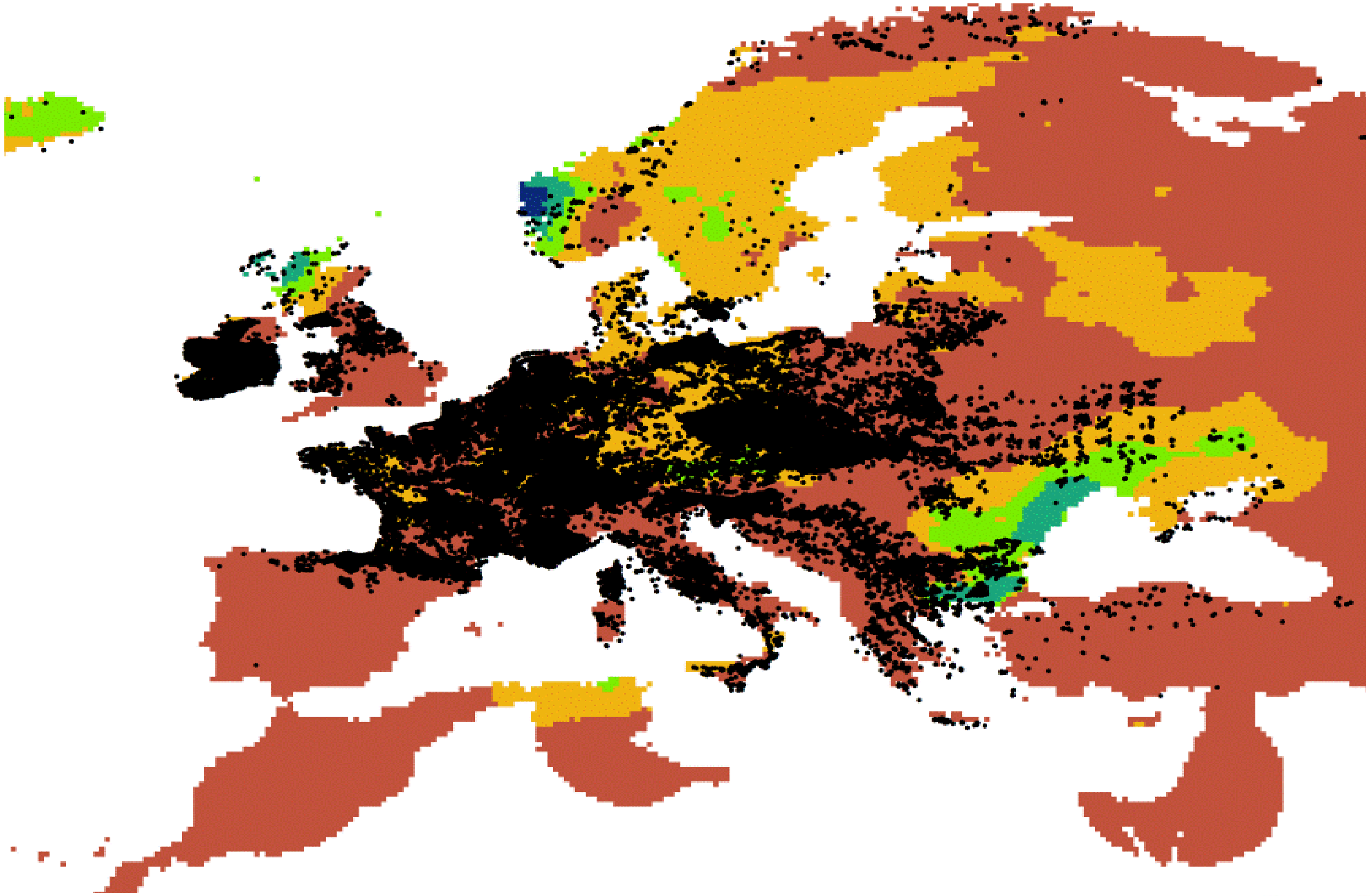
- EUgrow-VSD+-PROPS applied to Europe
  - Linkage EUGrow model to VSD+: assess soil carbon sequestration and predict soil pH and N indicators.
  - Linkage EUGrow-VSD+ to PROPS: predicts plant species diversity in response to climate, pH and N indicators; applied to Europe

Modelling approach PROPS

- Multiple logistic regression model of probabilities of plant species presence based on data at ca. 800,0000 vegetation relevés (Bioscore plots)in Europe versus :
  - Temperature (climate database).
  - Water availability: precipitation (climate database) and ratio actual and potential evapotranspiration (modelled).
  - N deposition (EMEP model)
  - pH and soil C/N ratio (based on indication values related to measurements).

ALTERRA
WAGENINGEN UR

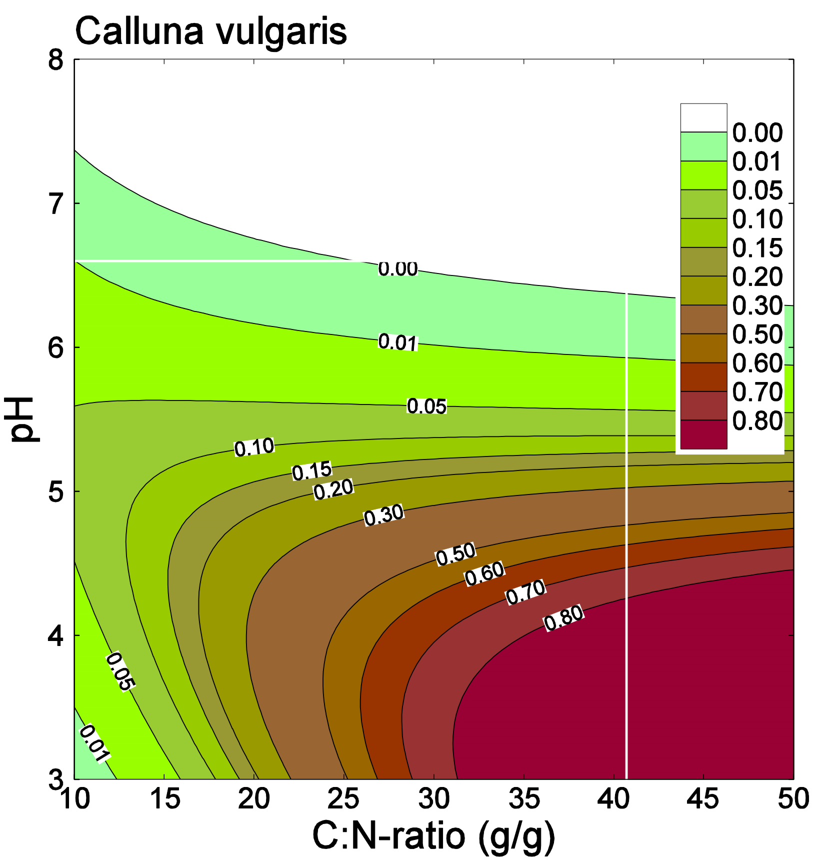
Bioscore plots (black dots) used to derive response functions for vascular plants

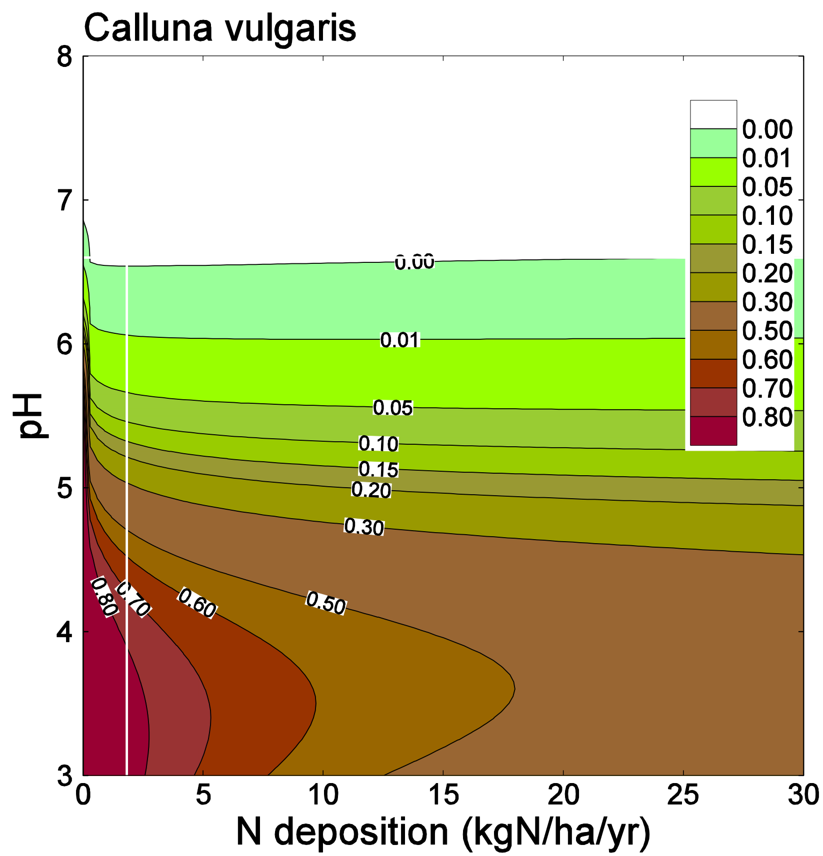


ALTERRA
WAGENINGEN UR

éclaire
Effects of climate change on air pollution impacts and response strategies for European ecosystems

Isolines of occurrence probabilities as function of pH and soil C:N and N deposition for *Calluna vulgaris*



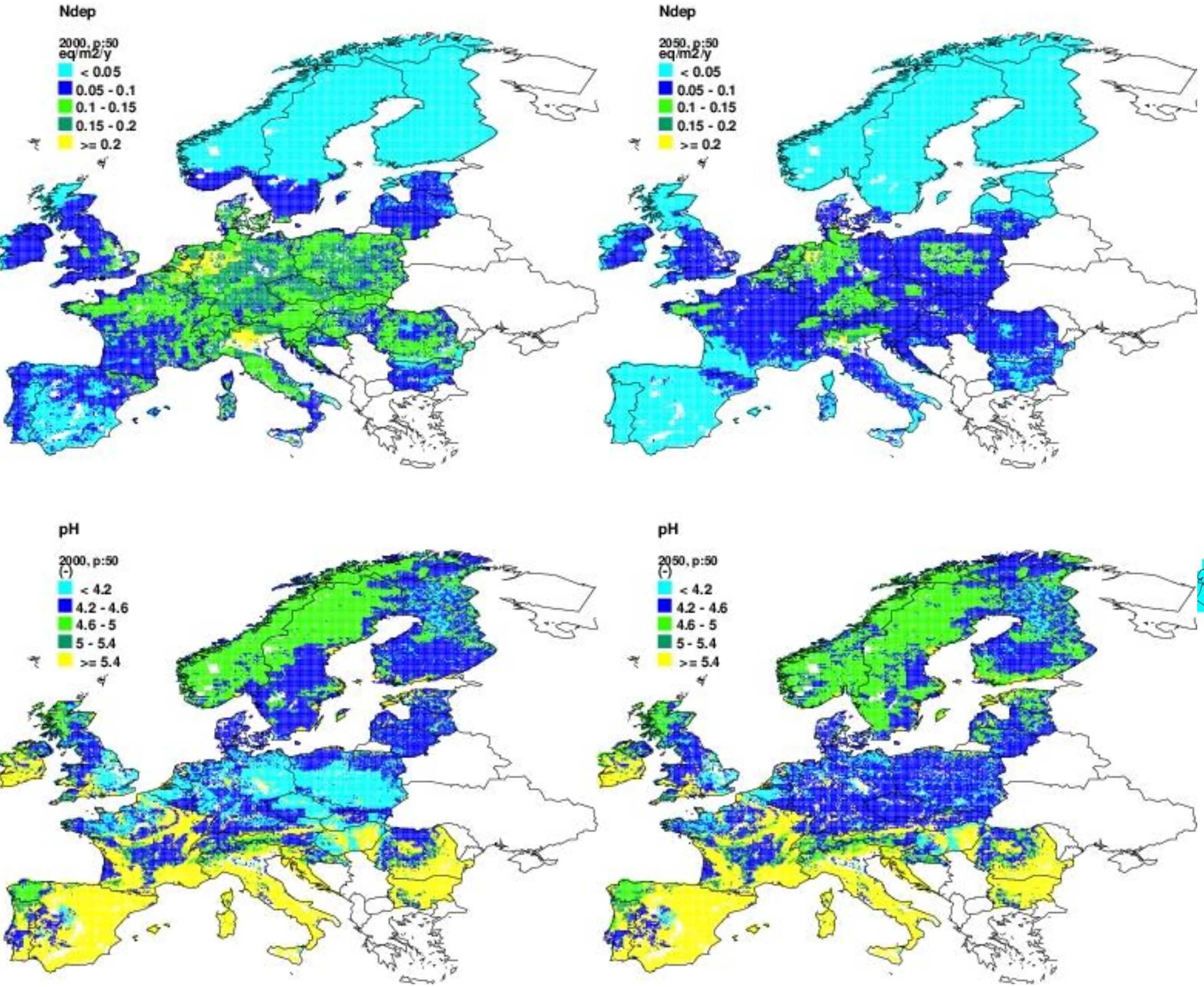


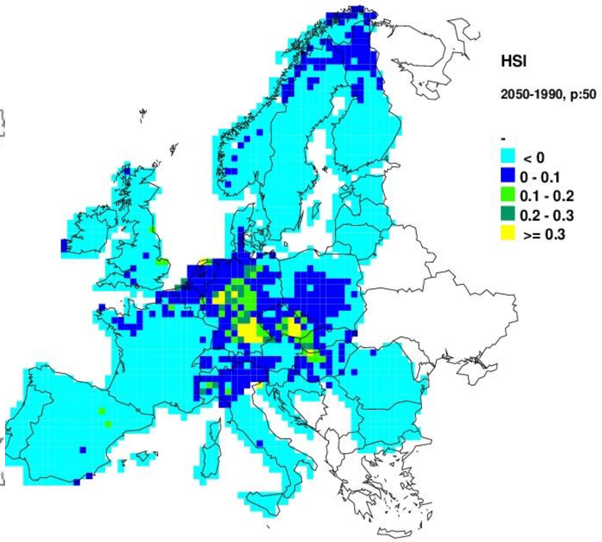
ALTERRA WAGENINGEN UR

éclaire

Effects of climate change on air pollution impacts and response strategies for European ecosystems

Change in Habitat Suitability Index in response to N deposition and pH changes





éclaire
Effects of climate change on air pollution impacts and response strategies for European ecosystems

Mapping novel critical N loads and exceedances

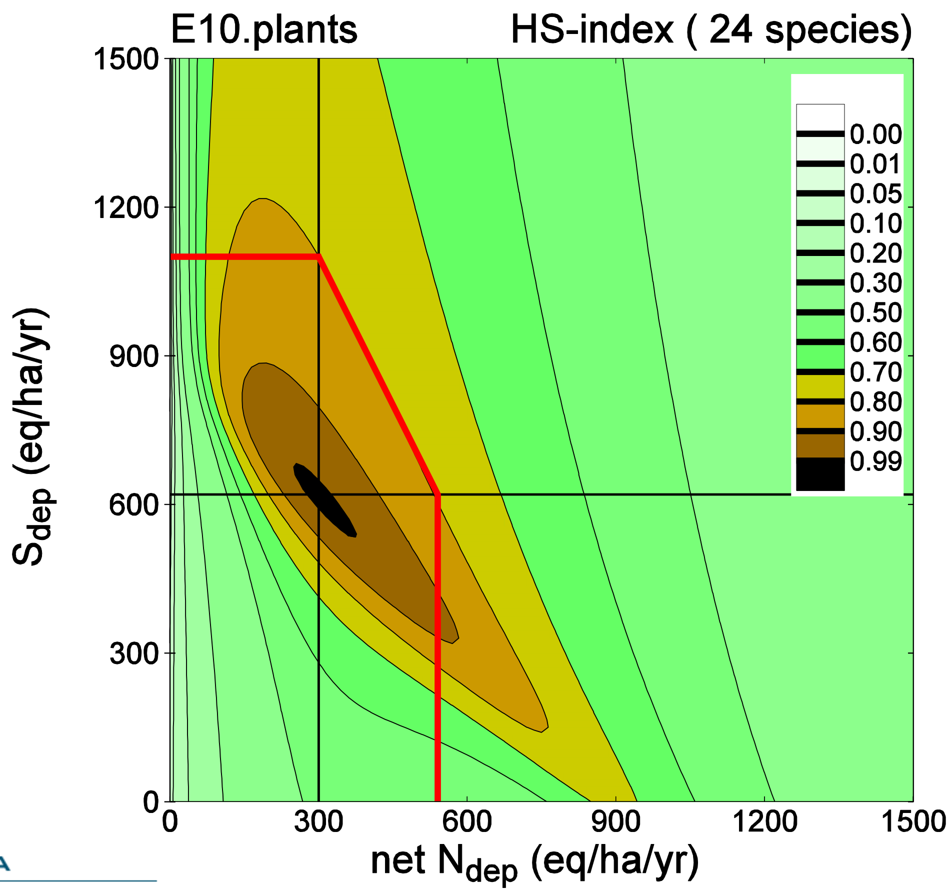
Apply Props in combination with VSD inverse to assess and map

- climate dependent critical N loads
- exceedances of critical N loads

based on assumed critical values for the Habitat Suitability (HS) index

Biodiversity-oriented (nitrogen) critical loads

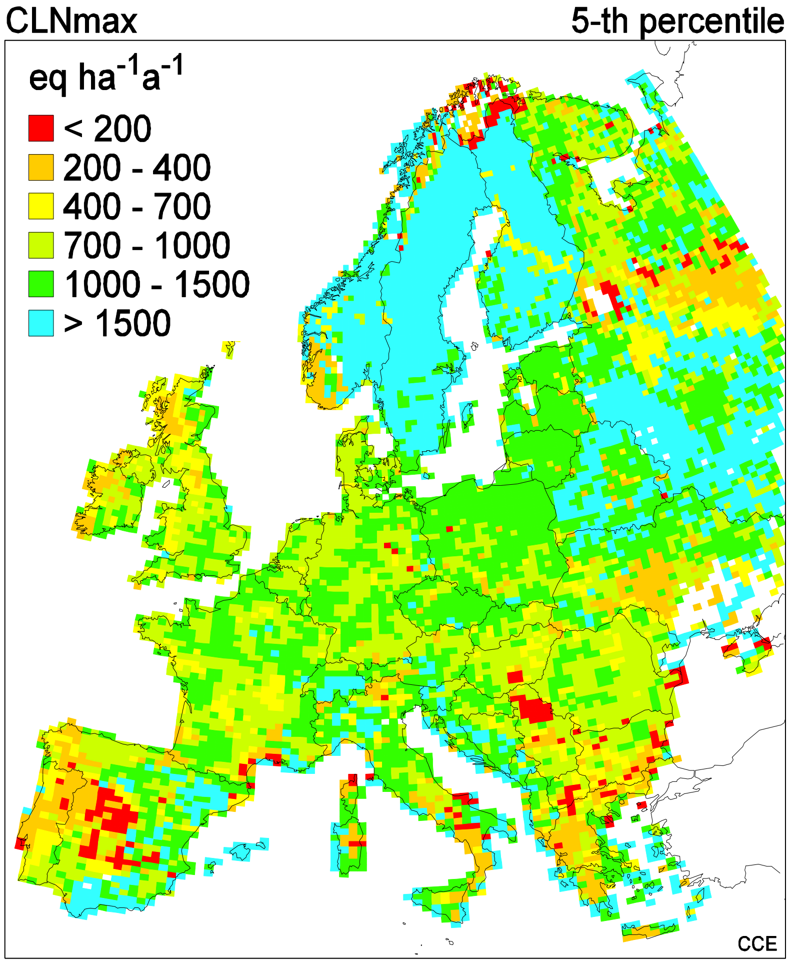
Calculated HS indices for a given habitat with 24 typical species for a range of N and S depositions

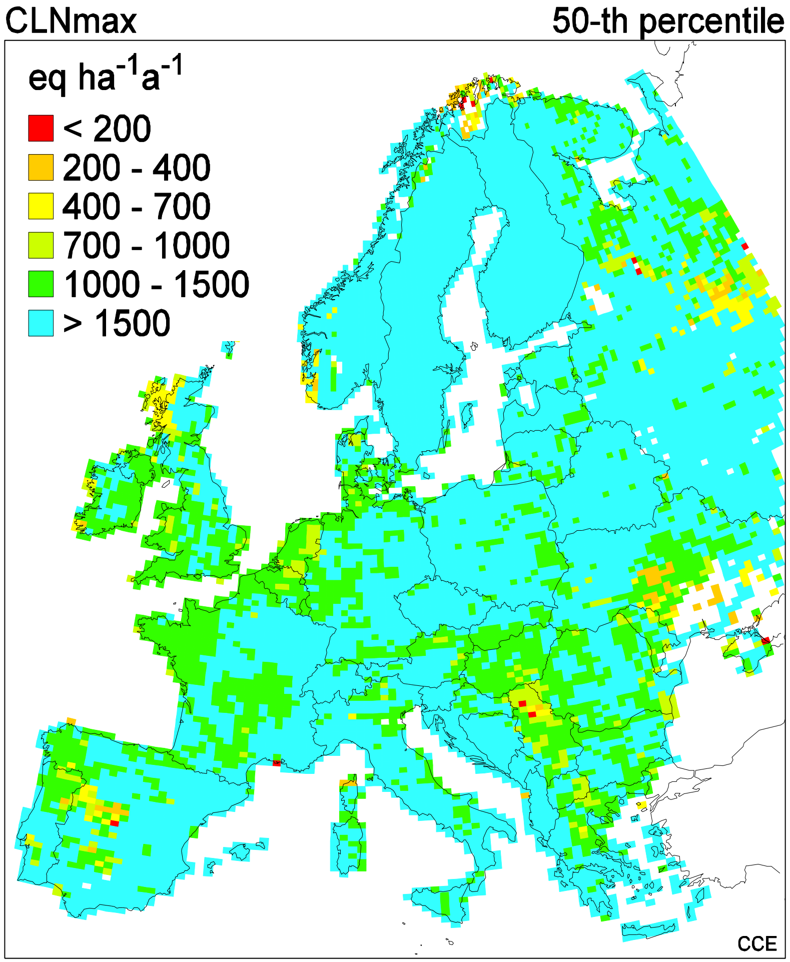


ALTERRA WAGENINGEN UR

éclaire
Effects of climate change on air pollution impacts and response strategies for European ecosystems

Biodiversity-based critical nitrogen loads; CLN

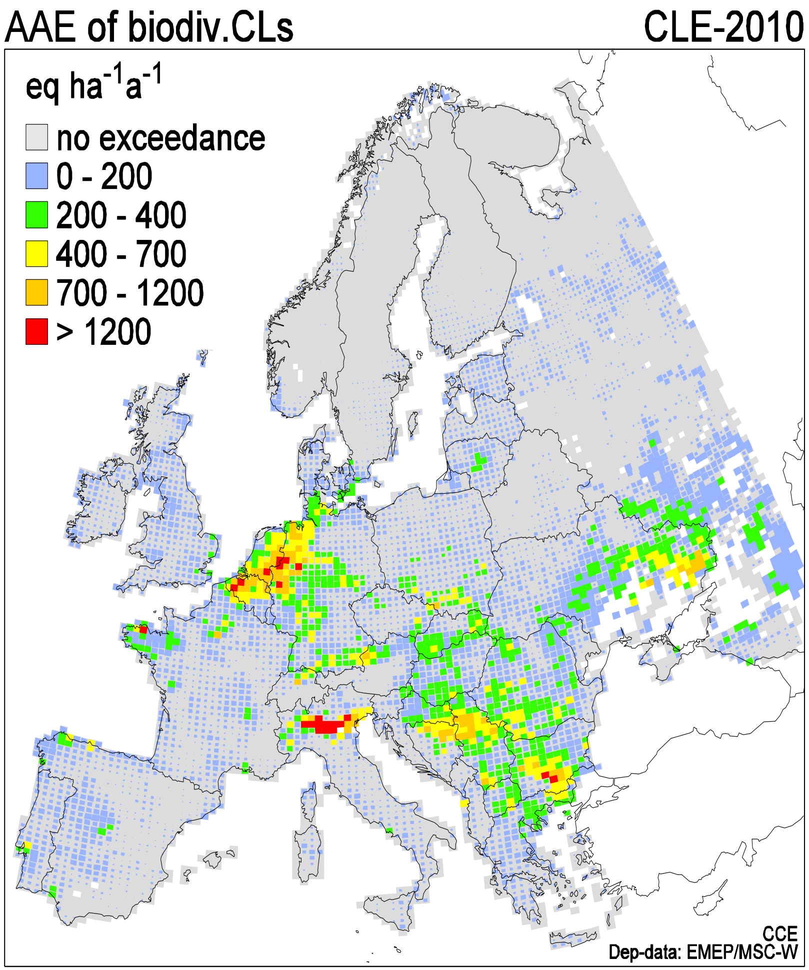


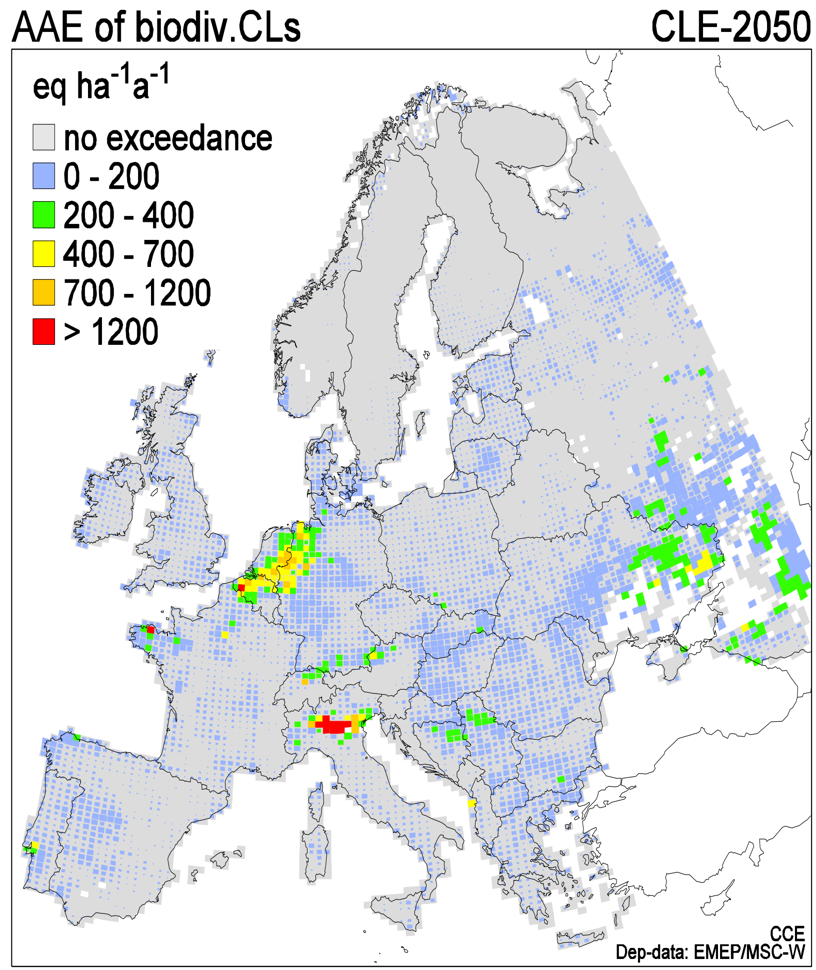


ALTERRA
WAGENINGEN UR

éclaire
Effects of climate change on air pollution impacts and response strategies for European ecosystems

Biodiversity-based CLN exceedances





ALTERRA
WAGENINGEN UR

éclaire
Effects of climate change on air pollution impacts and response strategies for European ecosystems

Mapping novel critical O_3 exposure levels and exceedances

Mapping changes in

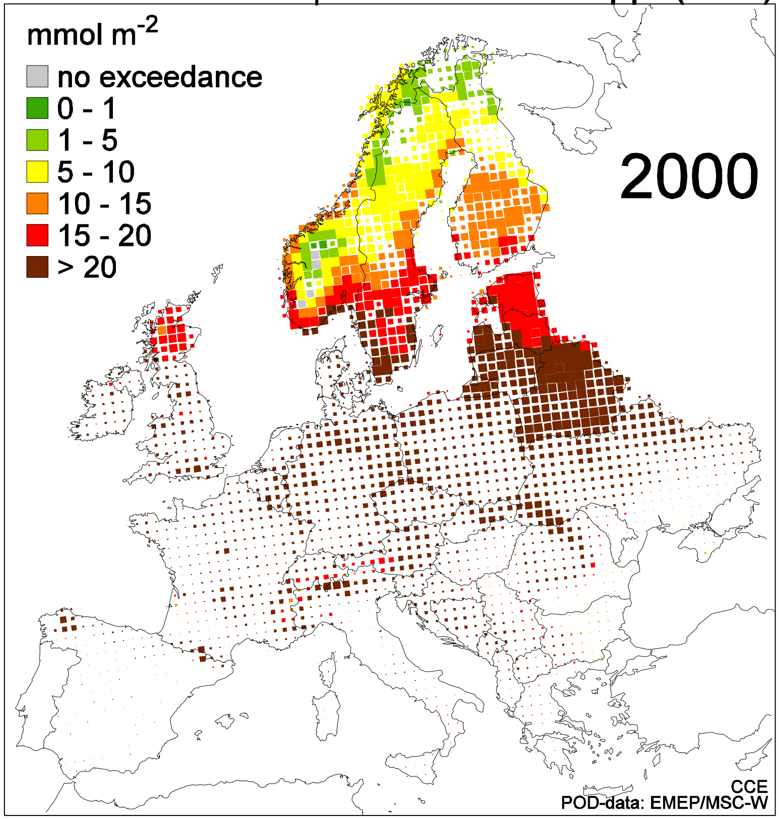
- POD1 threshold exceedances in view of forest growth
- Impacts of POD1 on forest growth (NAI)

Basis

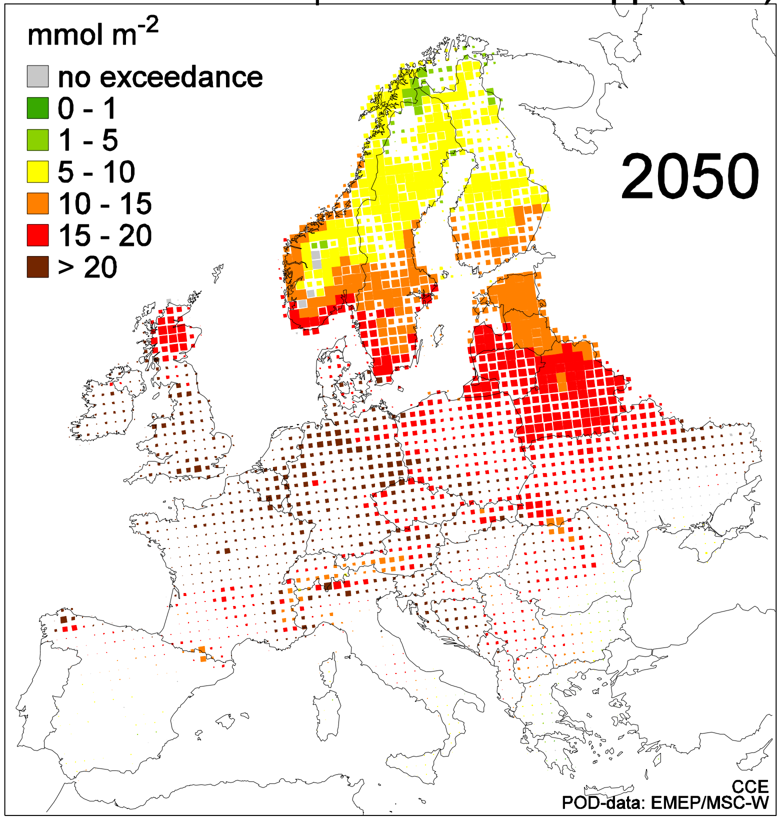
- Current+future POD1 values calculated by EMEP-DO3SE
- Derived relationships NAI and POD1.
- Spatial explicit assessment of tree species at 1 x 1 km

Exceedance POD_1 over time – Birch (*Betula spp.*)

Exceedance POD_1 Betula spp. (>5%)



Exceedance POD_1 Betula spp. (>5%)



Critical POD_1 = 5 mmol/m^2 (based on 5% reduction in net annual increment, NAI; earlier based on total biomass)

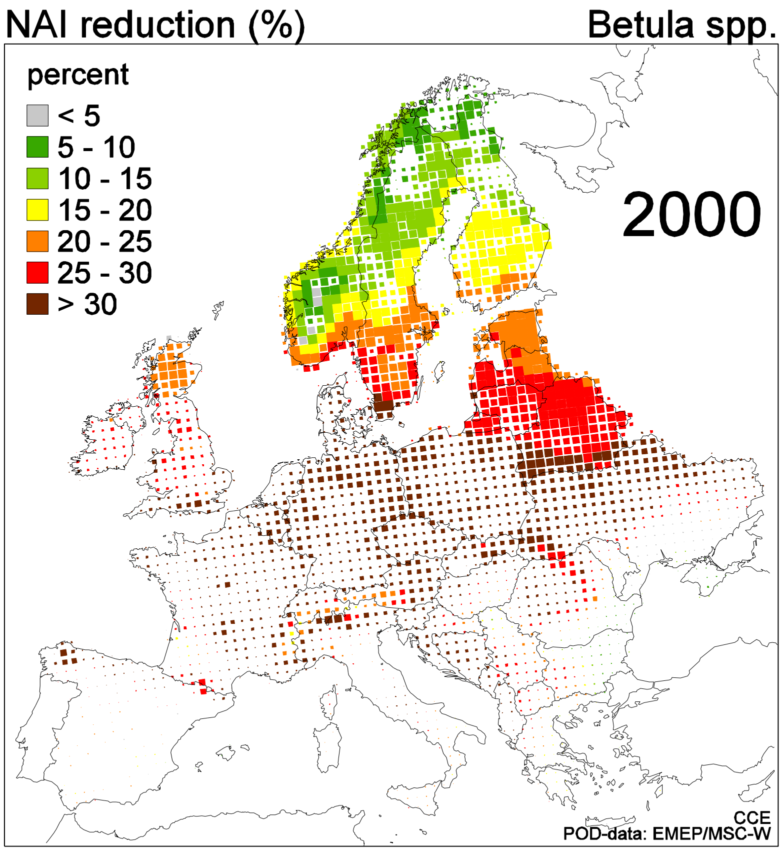
Using data from a database on the coverage of 20 tree species (groups) on a 0.01°×0.01° grid (about 0.5 km×1km) covering Europe grid

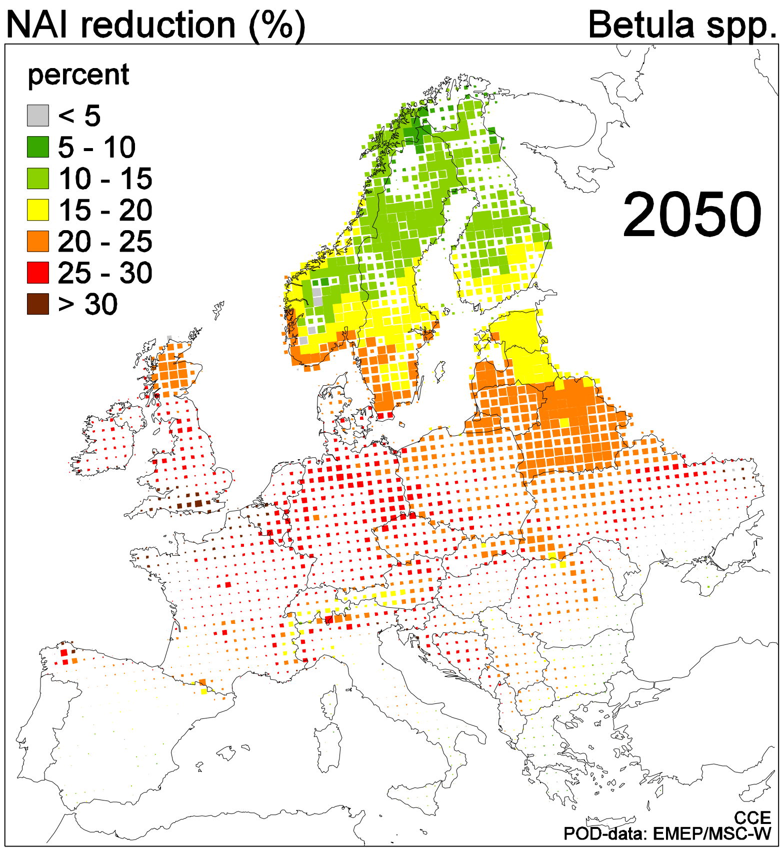
ALTERRA WAGENINGEN UR

éclaire

Effects of climate change on air pollution impacts and response strategies for European ecosystems

Change in NAI reduction over time – Birch (*Betula spp.*)





Reduction in net annual increment, NAI in the year 2000 and in 2050 under the RCA3-ECHAM5_A1B-r3 scenario

ALTERRA
WAGENINGEN UR

Using data from a database on the coverage of 20 tree species (groups) on a 0.01°×0.01° grid (about 0.5 km×1km) covering Europe grid

éclaire
Effects of climate change on air pollution impacts and response strategies for European ecosystems

Local variation in threshold exceedance

- Assessment of critical N thresholds and their exceedances for 2008 in:
  - 2 study regions (central Scotland and the Netherlands)
  - 2 landscapes (Burnsmuir and Noordelijke Friese Wouden)

- at 3 resolutions:
  - Country: 50 km x 50 km, 5 x 5 km and 1 x 1 km
  - Landscape: 5 x 5 km, 1 x 1 km and 50 x 50 m

Domains, grid resolutions and input data sources for zooming.

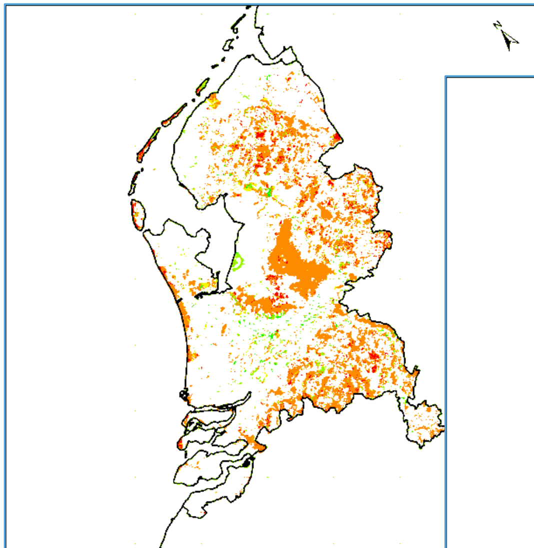
Decreasing domain size, increasing resolution

Domain	Grid resolution	Source of concentration and deposition data
EU27	50 x 50 km	EMEP model
NW Europe (including central Scotland and the Netherlands)	5 x 5 km	EMEP4UK model
Central Scotland and the Netherlands	1 x 1 km	EMEP4UK model
Landscape (Burnsmuir and Noordelijke Friese Wouden)	50 m x 50 m	LADD/ INITIATOR model

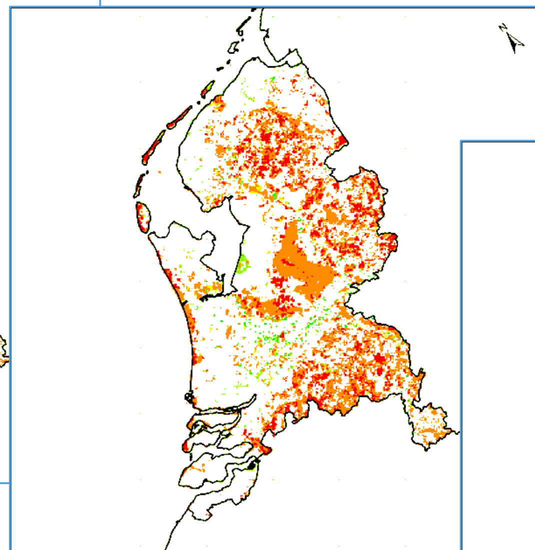
ALTERRA WAGENINGEN UR

éclaire
Effects of climate change on air pollution impacts and response strategies for European ecosystems

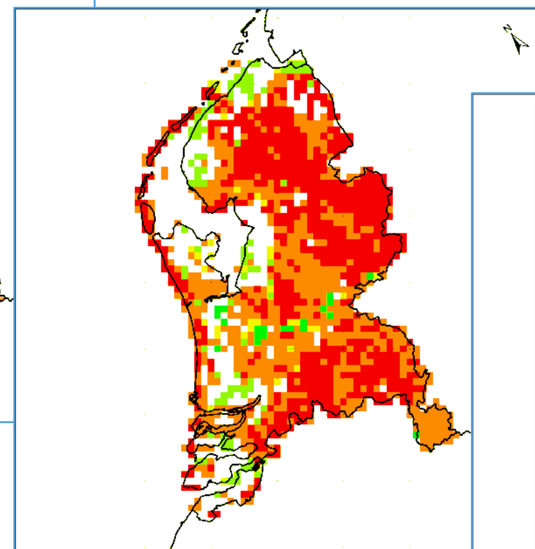
Critical Loads (Netherlands)



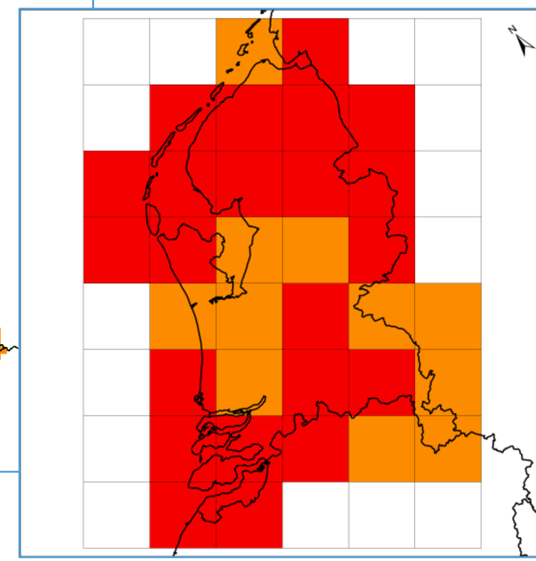
250 x 250 m²



1 x 1 km² (5th percentile)



5 x 5 km² (5th percentile)



50 x 50 km² (5th percentile)

eq ha^{-1} yr^{-1}

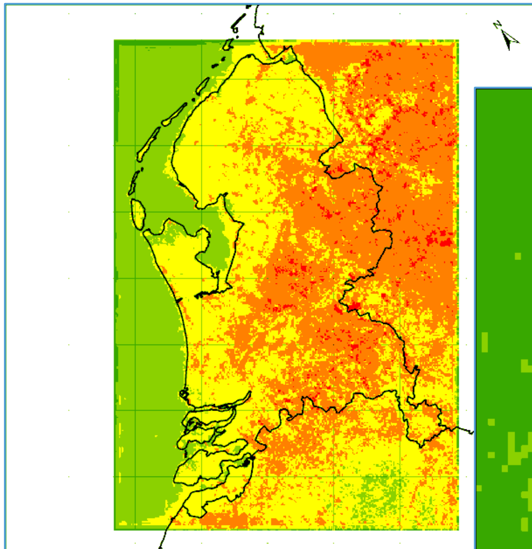
- 0 - 750
- 751 - 1500
- 1501 - 2000
- 2001 - 2500
- 2501 - 6569

ALTERRA WAGENINGEN UR

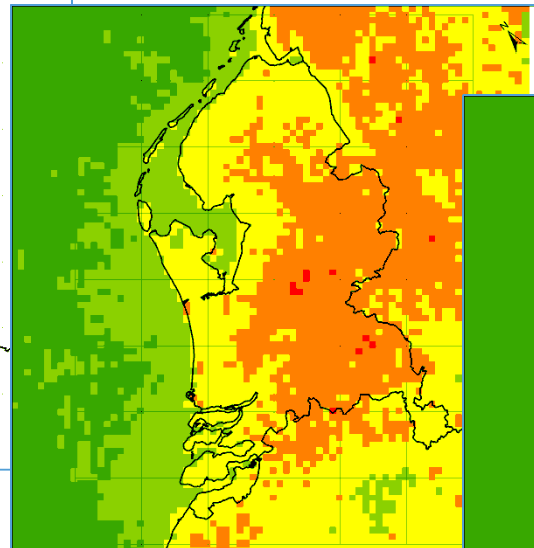
éclaire

Effects of climate change on air pollution impacts and response strategies for European ecosystems

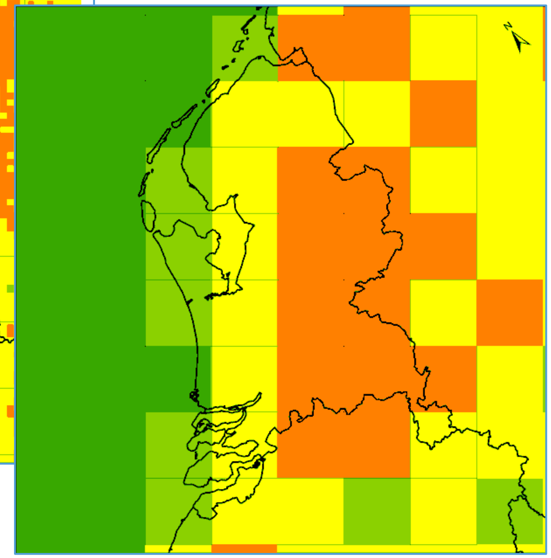
Annual Nitrogen Deposition (WP8, Netherlands, 2008)



1 x 1 km²
(from EMEP4UK)



5 x 5 km²
(from EMEP4UK)



50 x 50 km²
(from EMEP MSC-W)

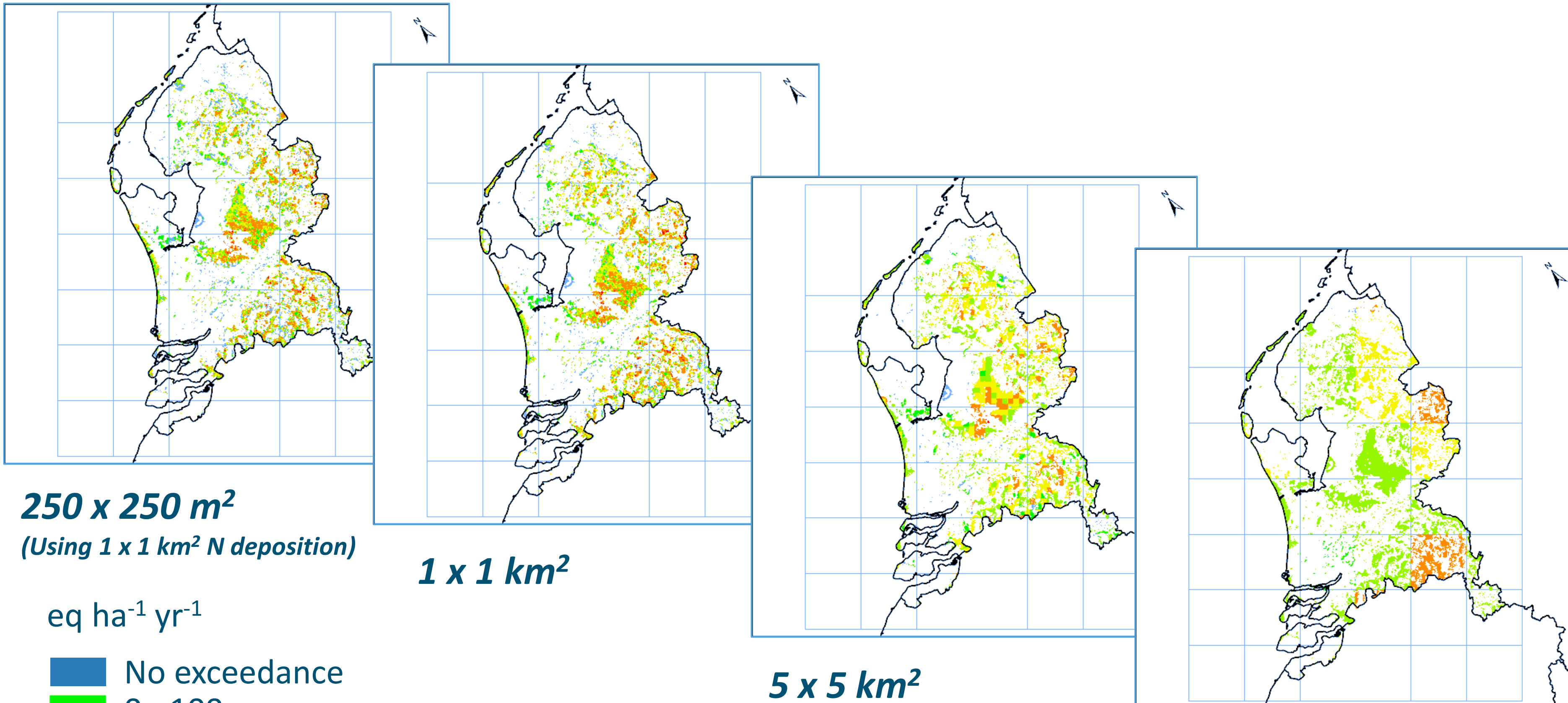
kg N ha^{-1} yr^{-1}

- < 7
- 7 - 10
- 10 - 15
- 15 - 25
- 25 - 35

ALTERRA
WAGENINGEN UR

éclaire
Effects of climate change on air pollution impacts and response strategies for European ecosystems
SEVENTH FRAMEWORK PROGRAMME

Average Accumulated Exceedance (Netherlands, 2008)



250 x 250 m^2

(Using 1 x 1 km^2 N deposition)

1 x 1 km^2

5 x 5 km^2

50 x 50 km^2

eq ha^{-1} yr^{-1}

- No exceedance
- 0 - 100
- 100 - 300
- 300 - 500
- 500 - 1000
- 1000 - 2000

ALTERRA WAGENINGEN UR

éclaire
Effects of climate change on air pollution impacts and response strategies for European ecosystems

Conclusions

- Most deliverables delivered
- Latest insights from other components to be incorporated (e.g. N status dependent O3 effects on growth)
- Models work, principles seem OK but some functions used in modelling (e.g. in PROPS) need review and updating, so results so far are provisional
- Key messages to be defined after that...

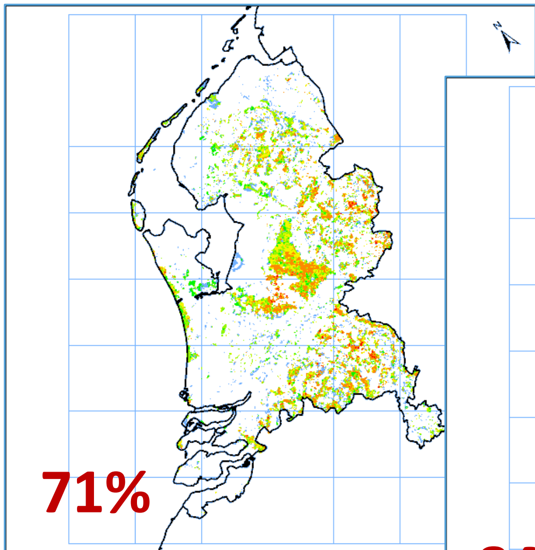
Questions?

ALTERRA
WAGENINGEN UR

éclaire
Effects of climate change on air pollution impacts and response strategies for European ecosystems

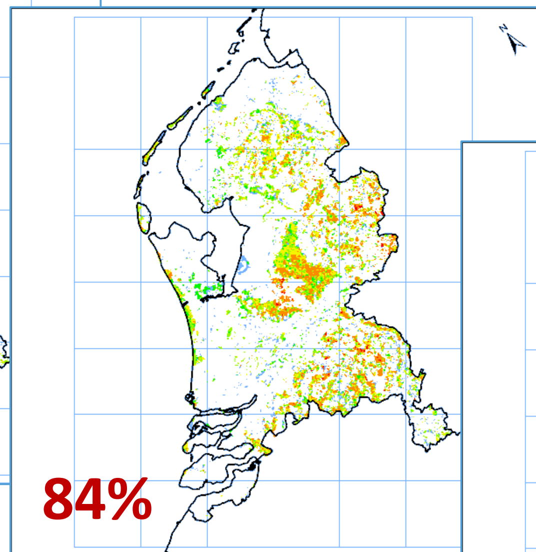
Average Accumulated Exceedance (Netherlands, 2008)

Proportion of nature area exceeded

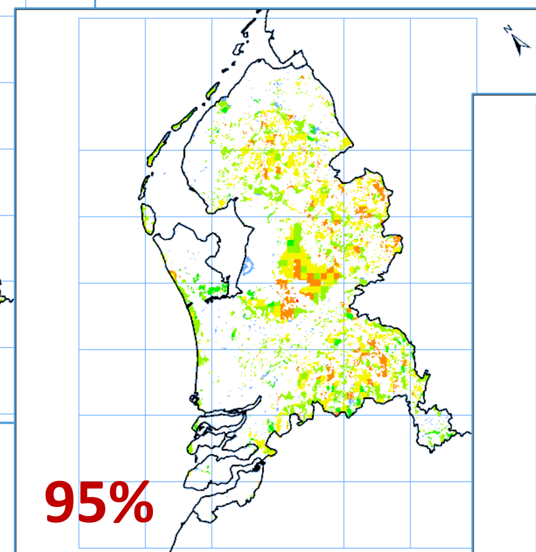


250 x 250 m^2

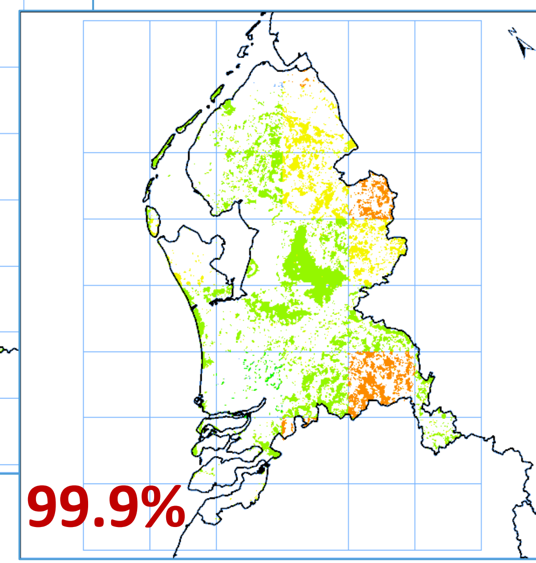
(Using 1 x 1 km^2 N deposition)



1 x 1 km^2



5 x 5 km^2



50 x 50 km^2

eq ha^{-1} yr^{-1}

- No exceedance
- 0 - 100
- 100 - 300
- 300 - 500
- 500 - 1000
- 1000 - 2000

ALTERRA WAGENINGEN UR

éclaire

Effects of climate change on air pollution impacts and response strategies for European ecosystems

SEVENTH FRAMEWORK PROGRAMME

Use of Habitat Suitability Index

For each habitat, the Habitat Suitability Index (HSI), was computed, being the *average normalized species occurrence probability for typical/representative species*:

$$HSI = \frac{1}{n}\sum_{k=1}^{n}\frac{p_k}{p_{k,max}}$$

n is the total number of typical species
p_k is the occurrence probability of typical species k
p_{kmax} *is* the maximum probability of occurrence of species k

The higher the HSI (0-1) the higher the probability that typical plants occur at the site.

ALTERRA WAGENINGEN UR

éclaire Effects of climate change on air pollution impacts and response strategies for European ecosystems

Papers to be expected (in prep)

- DGVM intercomparison on combined impacts of Climate, CO_2, N deposition and ozone exposure by ECLAIRE DGVM models and assessment of plausibility.

- VSD-Eugrow model approach: impacts of alternative empirical relationships on tree and soil C sequestration

- Forward and inverse application of VSD-Props to assess response in HSI to deposition and climate change and a critical load (CL) from a critical HSI

- Impacts of different spatial resolutions on CLN exceedances at country and landscape scale