# C4: Ecological responses at European scale: progress and highlights


Wim de Vries

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# Main tasks Component 4

- Further develop and apply verified (in WP13) dynamic global vegetation models (DGVMs) and dynamic soil vegetation growth models (DSVMs) 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.

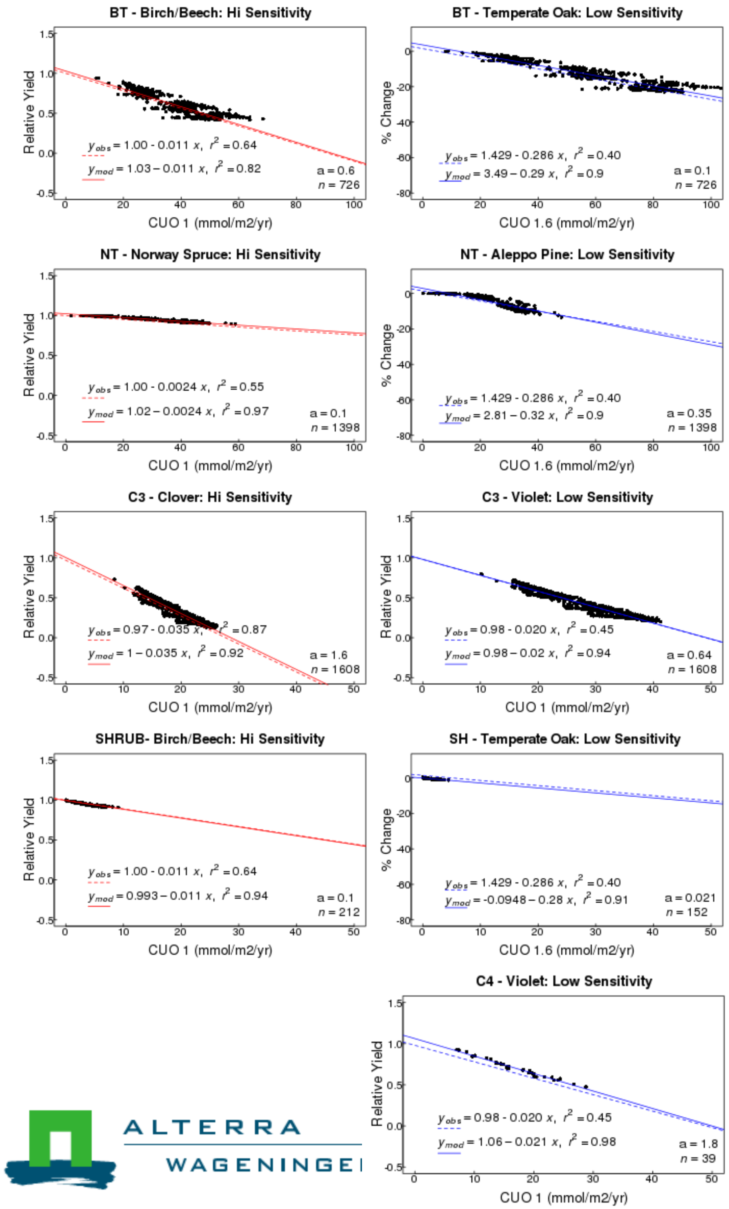
- Map novel thresholds for N deposition and $O_3$ exposure and exceedances at European scale (WP16).
- Assess impacts of model resolution on threshold N exceedances at landscape scale (WP17).

# WP 14 Carbon sequestration: Model development

- DGVMs: CLM, LPJ Guess, Jules, O-CN
- DSVMs: role in ICP-M and M/critical loads community
  - VSD$^+$: soil chemistry model at European scale

  Linked to:
  - FORSPACE: detailed growth model at site scale
  - Eugrow: empirical tree growth model at European scale
- All worked on inclusion impact $O_3$ exposure and/or N deposition on GPP/NPP and other C response parameters

# Re-calibration of JULES for response of vegetation productivity to ozone deposition:




- $O_3$ modelled using flux-gradient approach of Sitch *et al*., (2007)
- Modified stomatal closure using Medlyn *et al*., (2011), parameterised for European PFTs with leaf-level data
- Using observed dose-response relationships (CLRTAP Mapping Manual (2004), Karlsson *et al*., (2007))
- 5 PFTs in JULES (broadleaf tree, needle-leaf tree, $C_3$ grass, $C_4$ grass, shrub)
- High and low ozone sensitive PFTs


Sitch *et al*., (2007). Nature, 791-795
Medlyn *et al*., (2011). GCB, 2134 – 2144
Karlsson *et al*., (2007). Environmental Pollution, 608 – 616
CLRTAP Mapping Manual (2004)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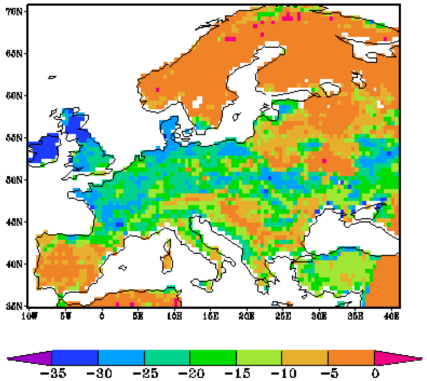
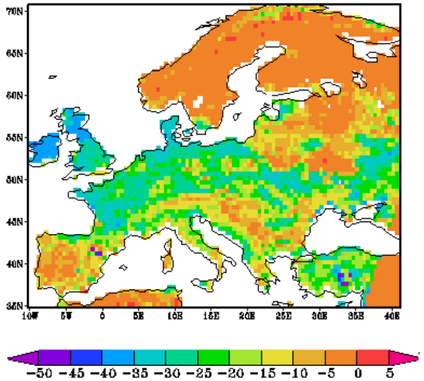
# Impact of ozone on vegetation GPP, NPP and transpiration across Europe (high and low sensitivity):

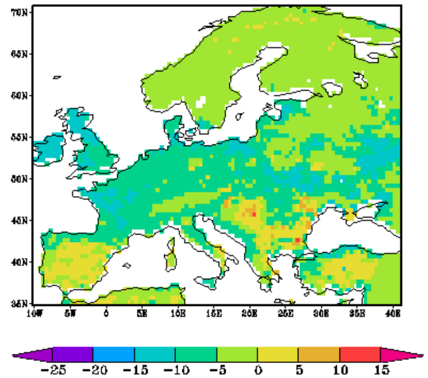
Change in **GPP** with O3 (%) Low



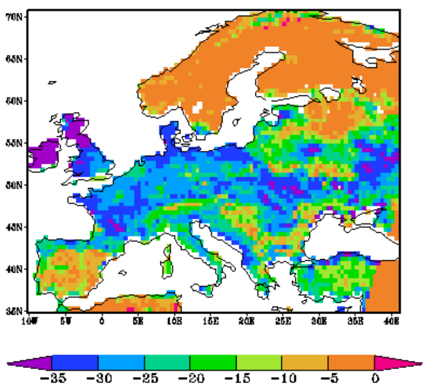

Change in **NPP** with O3 (%) Low



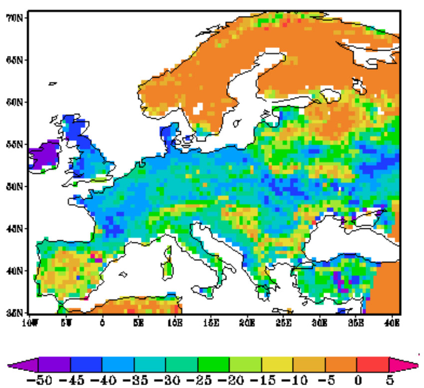

Change in **transpiration** with O3 (%) Low



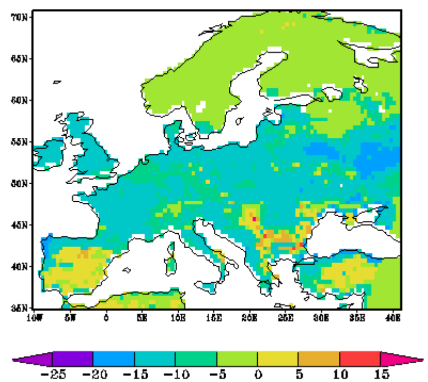

Change in **GPP** with O3 (%) Hi




Change in **NPP** with O3 (%) Hi




Change in **transpiration** with O3 (%) Hi




Large decreases in GPP/NPP with ozone: trees in line with Wittig *et al.*, (2009) meta-analysis, grasses more sensitive.

Transpiration decreases as stomata close with O3, in dry places transpiration increased as soil moisture stress is relieved.

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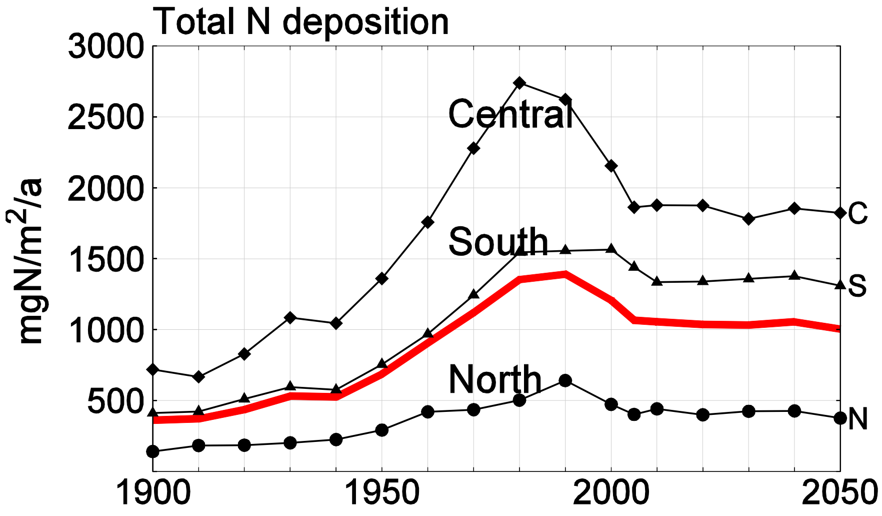
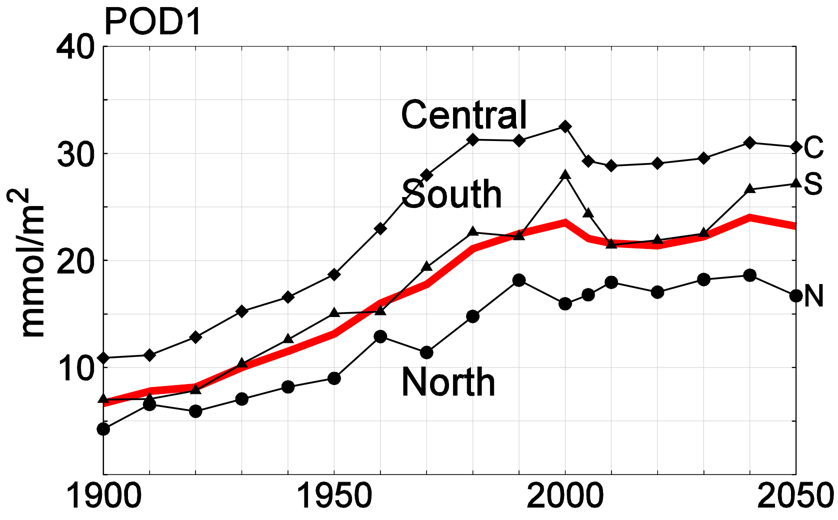
# Model intercomparison: forcing data for 1900-2050

- Climate data (hourly or daily resolution)
  - 1960-2050 ECHAM5 A1B-r3 RCA3 simulation. Includes bias correction for daily temperature and precipitation
  - 1901- 1960: random draws out of 1961-1970 ECHAM5 data
- $CO_2$ concentrations
  - 1900-2005: measured (Antarctic ice and Mount Loa)
  - 2005-2050: predictions based on IPCC SRES A1B scenario
- Land-use: fixed cover 2000
- EMEP model N deposition and $O_3$ exposure (hourly or daily resolution):
  - 1900-2000: Lamarque dataset
  - 2000-2050L new GAINS emission scenarios http://www.iiasa.ac.at/web/home/research/researchPrograms/Overview2.en.html.

# Temporal changes in total N deposition and POD1




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

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# Model experiments

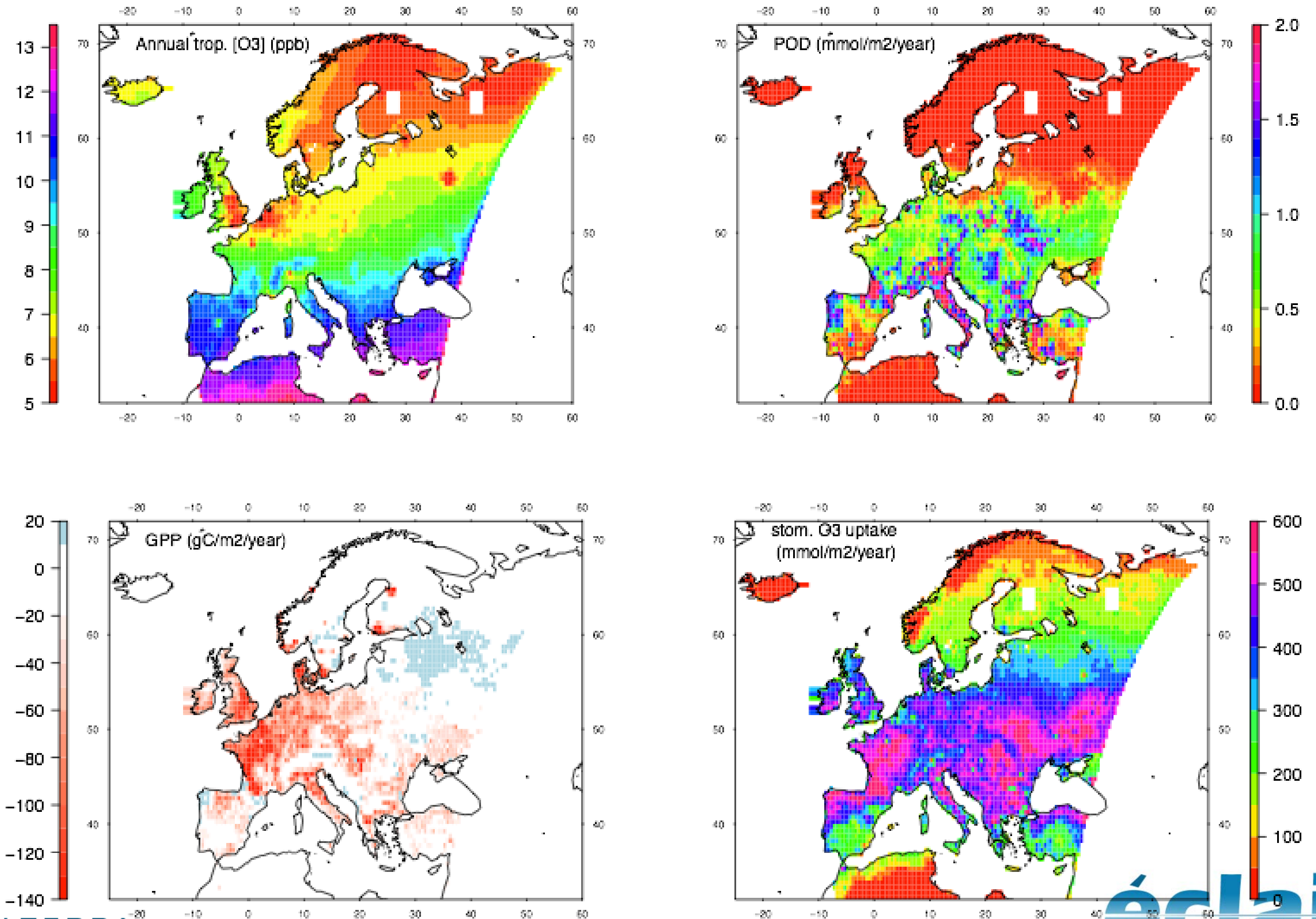
| Name | Climate | $CO_2$ | N deposition | $O_3$ |
|---|---|---|---|---|
| S1 | 1961-2050 | 1961-2050 | 1961 | 1961 |
| S2 | 1961-2050 | 1961-2050 | 1961-2050 | 1961 |
| S3 | 1961-2050 | 1961-2050 | 1961 | 1961-2050 |
| **S4** | 1961-2050 | 1961-2050 | 1961-2050 | 1961-2050 |

# Model intercomparison: response parameters

A selection of on indicators used for model intercomparison at pan European scale for period 1900-2050

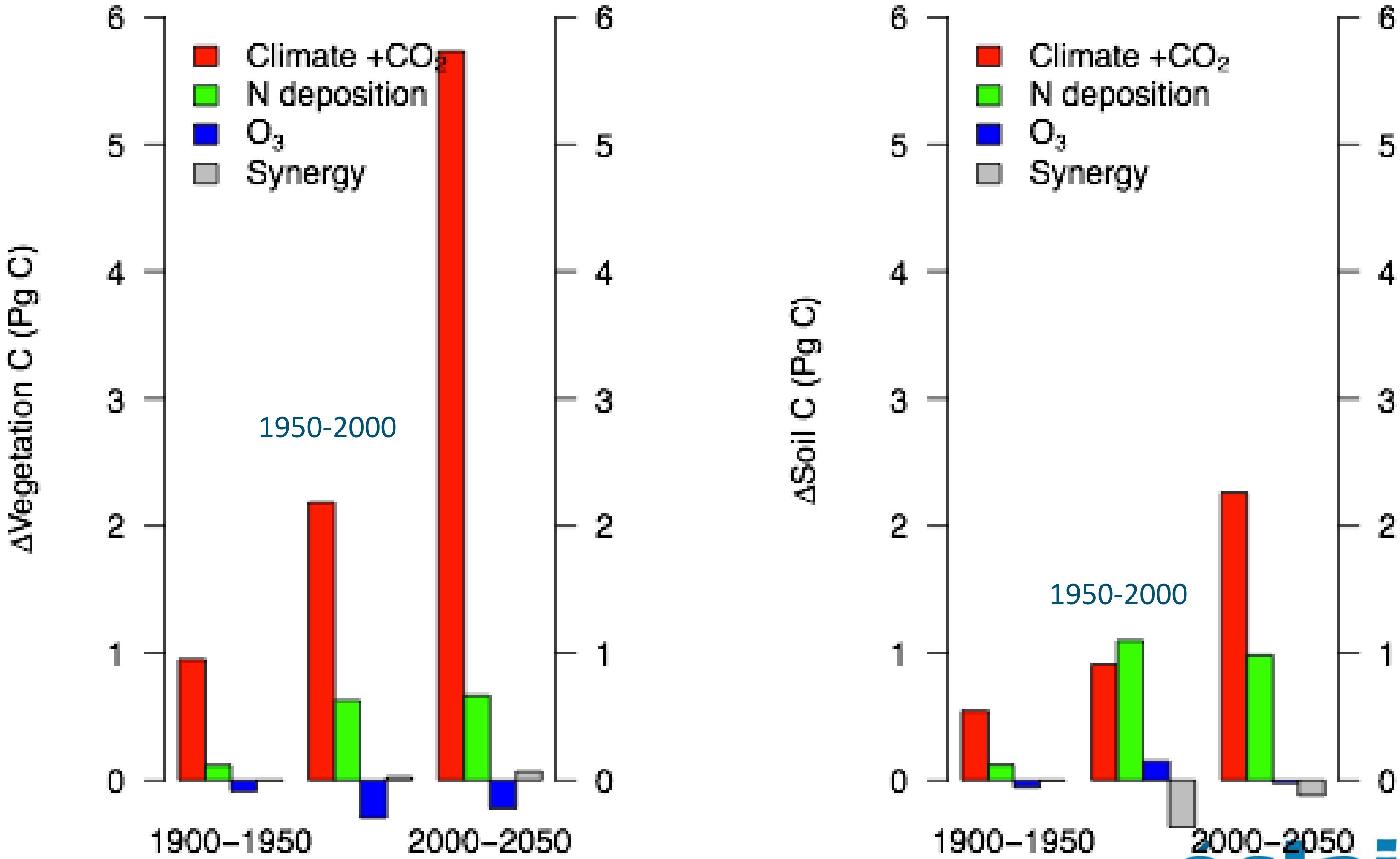
| Term | Land C fluxes | Unit |
|---|---|---|
| Gpp | gross primary production | g C m-2 month$^{-1}$ |
| Npp | net primary production | g C m-2 month$^{-1}$ |
| | Land Pools | |
| **cVeg** | **carbon in vegetation** | **kg C m$^{-2}$** |
| cLitter | carbon in litter pool | kg C m$^{-2}$ |
| cSoil | carbon in soil organic pools | kg C m$^{-2}$ |
| nVeg | nitrogen in vegetation | kg N m$^{-2}$ |
| nLitter | nitrogen in litter pool | kg N m$^{-2}$ |
| nSoil | nitrogen in soil organic pools | kg N m$^{-2}$ |

# O-CN results: $O_3$ effects in the years 2041-2050

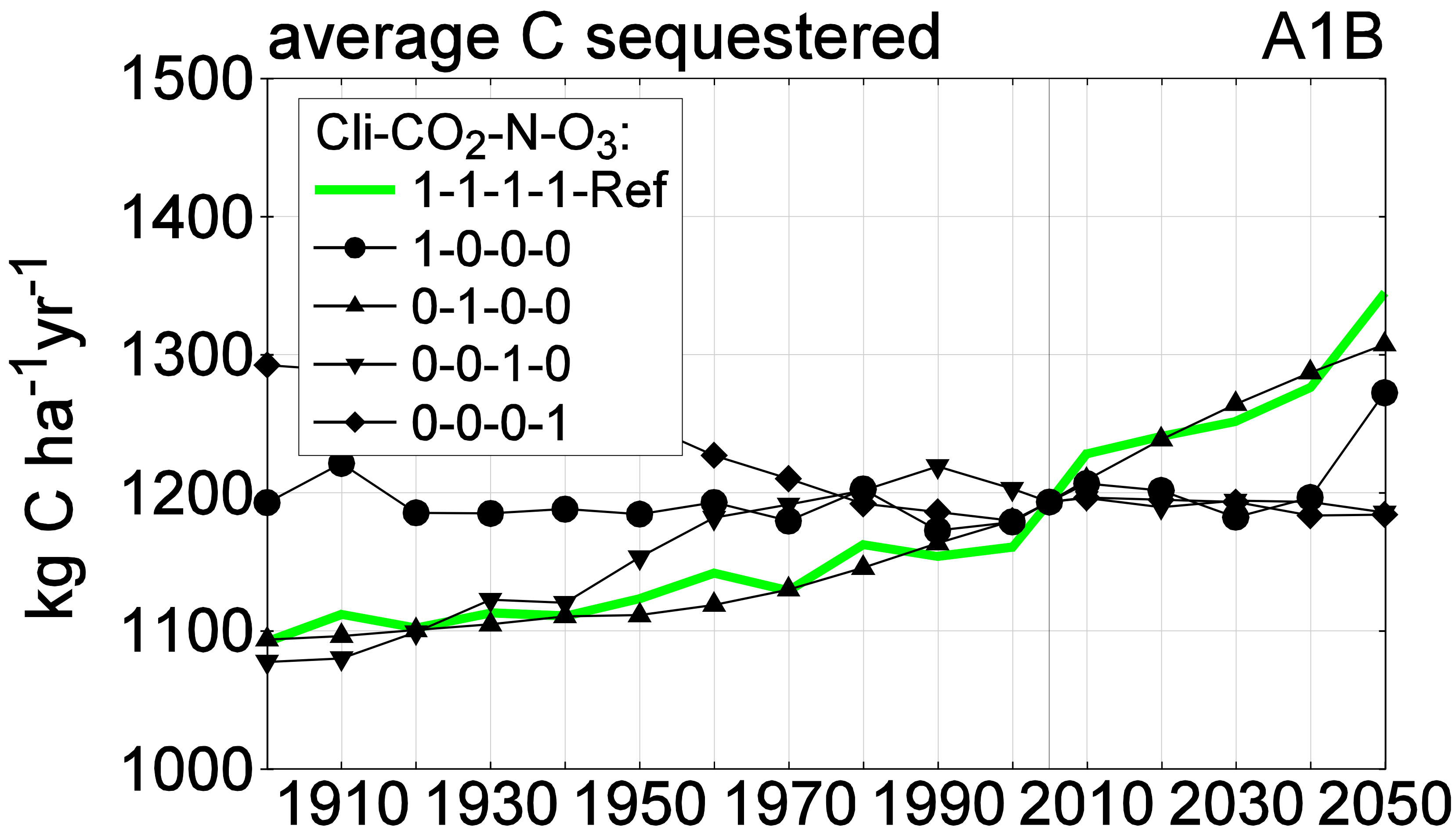



sorry, done in haste, the units of trop O3 and POD are most certainly wrong -> patterns robust

# O-CN results: Projections of European Terrestrial C storage



# EU grow results: Impacts of individual drivers on tree C sequestration

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# WP 15 Plant species diversity :Model development:

- MADOC- MultiMOVE
  - MADOC further developed: predicts soil pH, NO3, DOC and carbon sequestration; applied to UK
  - Linkage MADOC- MultiMOVE

- EUGrow-VSD+-Props
  - Linkage EUGrow model to VSD+: assess soil carbon sequestration and predict soil pH and N indicators.
  - Development of Props (formerly EUMOVE): predicts plant species diversity in response to climate, pH and N indicators; applied to Europe

# MADOC – MultiMOVE

**Drivers:**
- Total N deposition
- Ozone
- Temperature

→ MADOC →

**Indicators**
- Carbon stock and change
- Water quality (pH, nitrates, DOC)

**Drivers for other models:**
- Ellenberg score for N (fertility)
- Ellenberg score for R (acidity)
- Grime score for canopy-height

↓

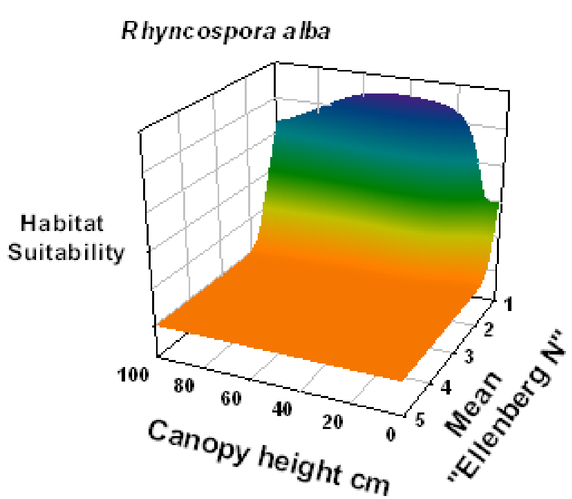
Multi-MOVE

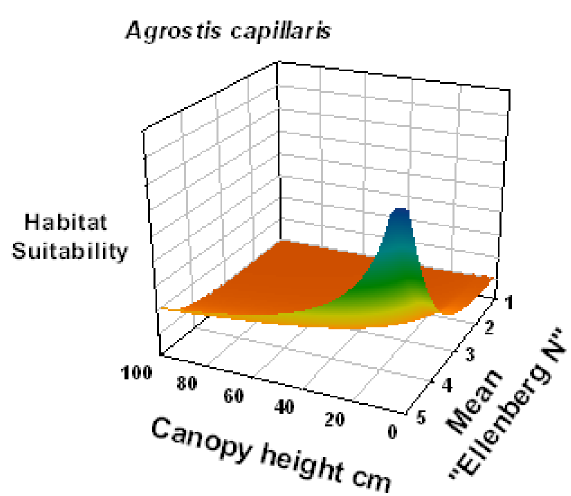
↓

Habitat suitability for target species

↓

Biodiversity




Smart et al. 2010 J Veg Sci 21: 644-656
Henrys et al. *in prep* Methods Ecol Evol

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# MADOC – results

## Journal article published (Rowe et al (2013) :

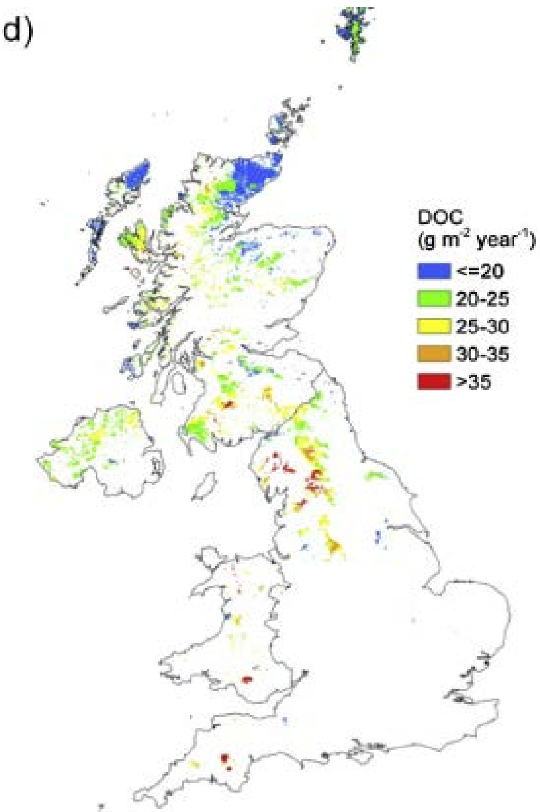
- Prediction of DOC in response to S and N deposition
- Calibration using acid/alkali addition experiment
- Testing against Acid Waters Monitoring Network data

## Implementation

- Fortran
- Flat-format .csv inputs

```fortran
!**************************************************************************
! DYNAMIC
! Call the N14C, DyDOC and VSD subroutines for each Year of the simulation
    InitialDynamicTerminal = 2 ! Set flag to 2 = Dynamic phase
    do Year = StartYear,EndYear,dt
```

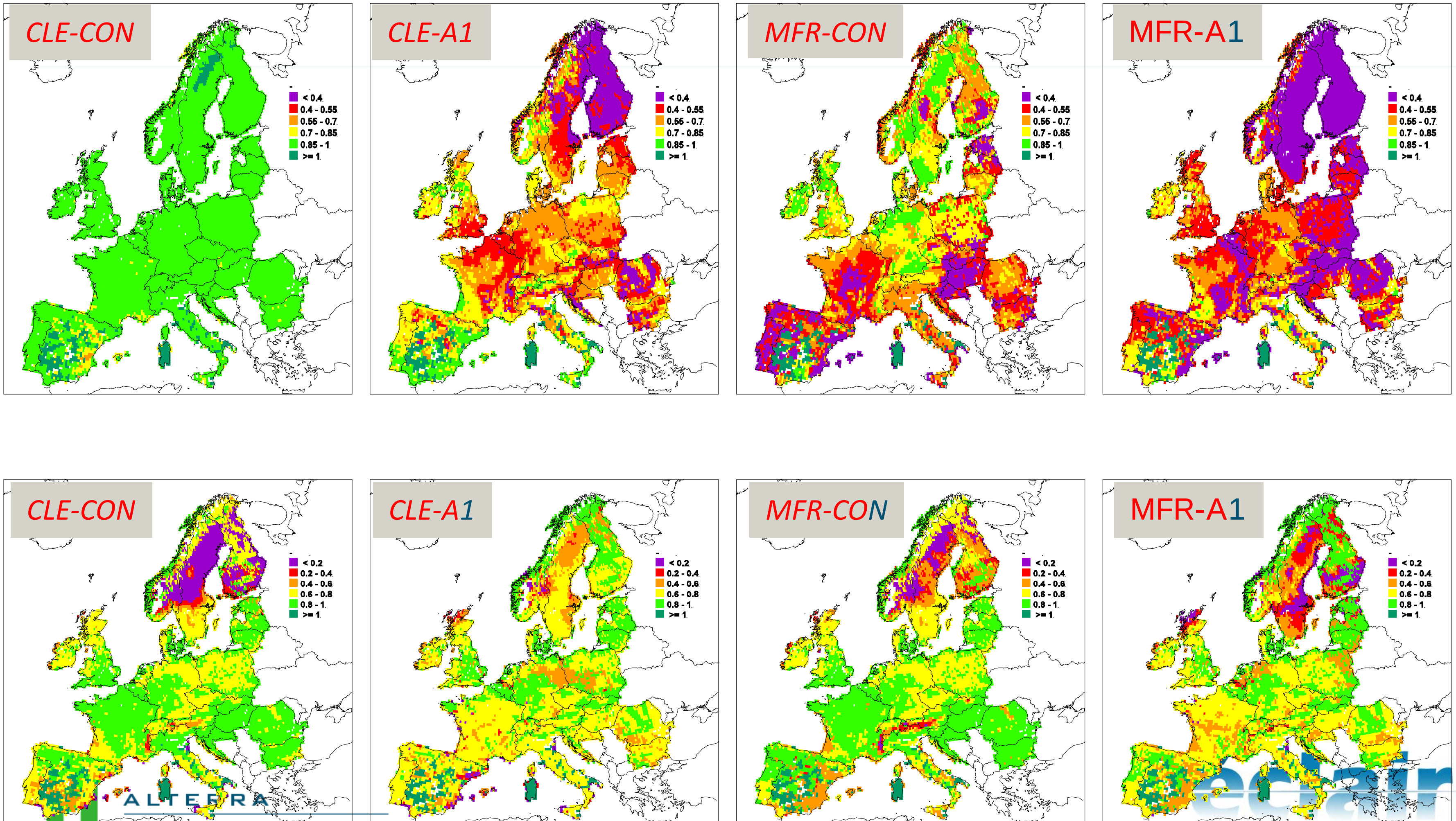
d)



# Modelling approach Props (formerly EUMOVE)

- Multiple logistic regression of measurements of species presence at ca. 800.0000 vegetation relevés in Europe versus :
  - Temperature (climate database).
  - Water availability: precipitation (climate database) and ratio actual and potential evapotranspiration (modelled).
  - pH (based on indication value related to measurements).
  - Nitrogen availability: N deposition (EMEP model) and $NO_3$ concentration (indication value related to measurements)

# Predicted median Bray-Curtis and Simpson plant species index in 2050 for forests by Growup-VSD$^+$-Props

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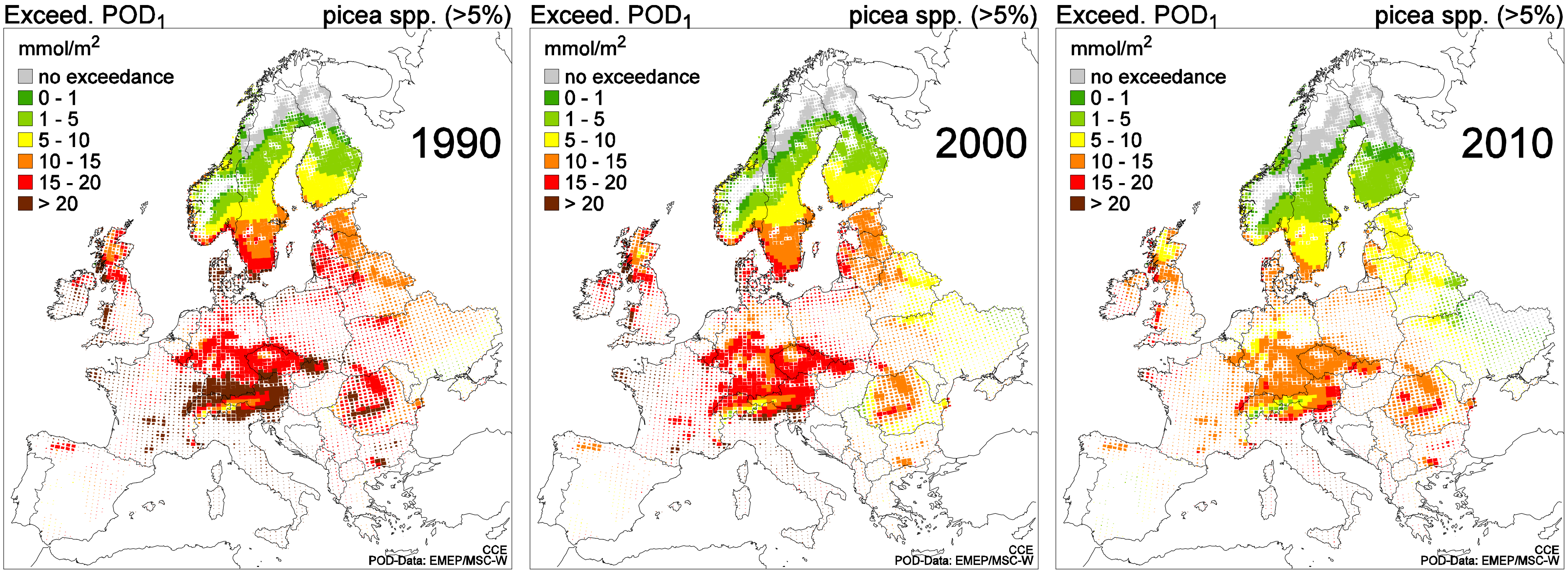
# Mapping novel critical loads and exceedances

- Ozone
  - Mapping POD thresholds, based on spatial explicit assessment of tree species at 1 km x 1km.
  - Mapping exceedances of POD thresholds based on current and future POD by EMEP-$DO_3SE$

- Nitrogen
  - Apply $VSD^+$-Props in an inverse way, to assess climate dependent critical N loads and map exceedances (also applied in WP 17 zooming).

# Exceedance $POD_1$ over time – Spruce (*picea spp.*)




critical limit = 20.8 mmol/m$^2$ (5% yield reduction)
(Official limit = 8 mmol/m$^2$ (2% yield reduction))

Spruce cover-scaled grid cells; 0.50º × 0.25º grid

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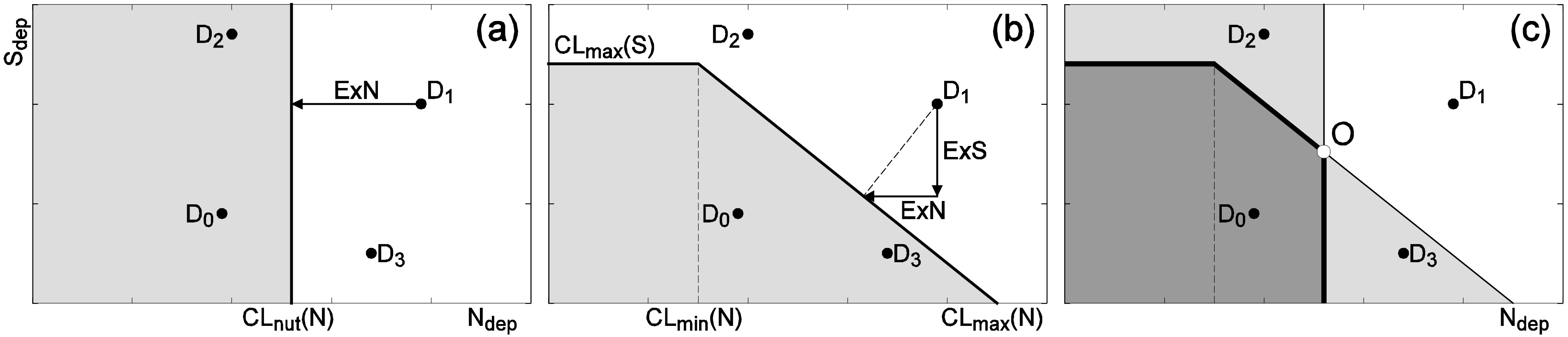
# Biodiversity-oriented (nitrogen) critical loads

**Nitrogen:** critical acceptable concentration (or leaching)
➔ $CL_{nut}(N)$

**Acidity:** E.g., critical pH ➔ Critical Load Function




**Below / above good – Above / below bad …**

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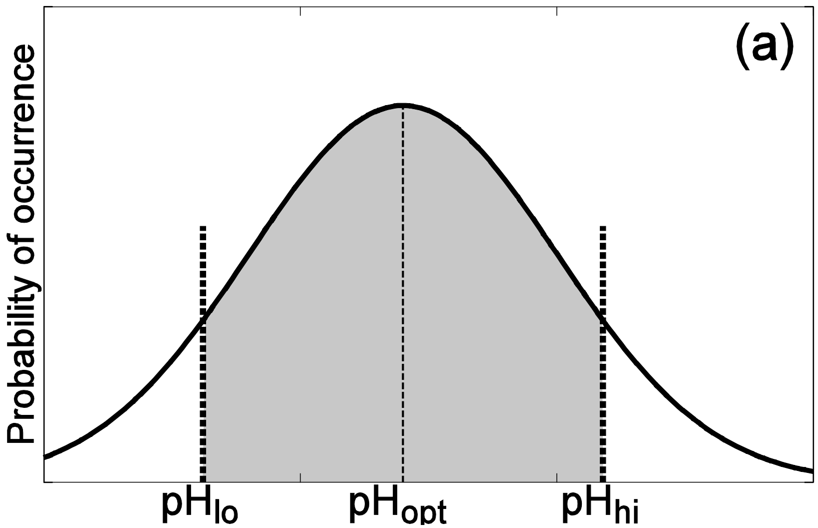
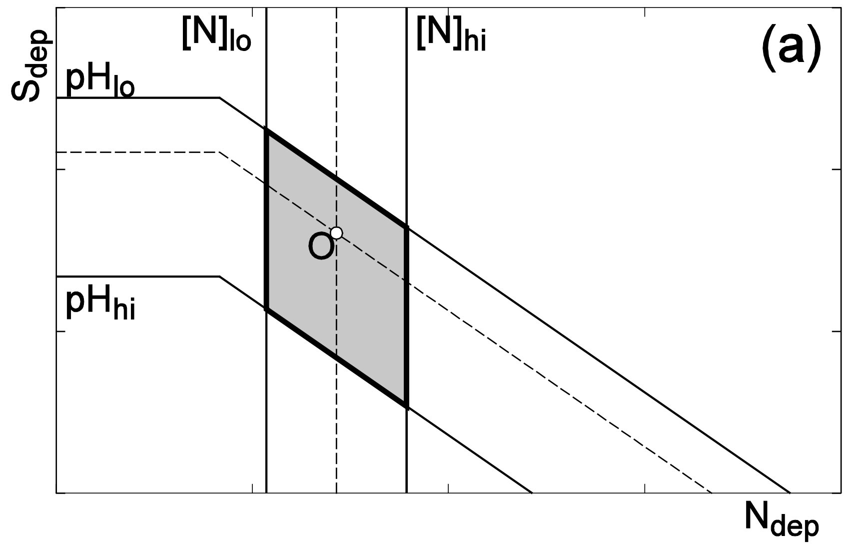
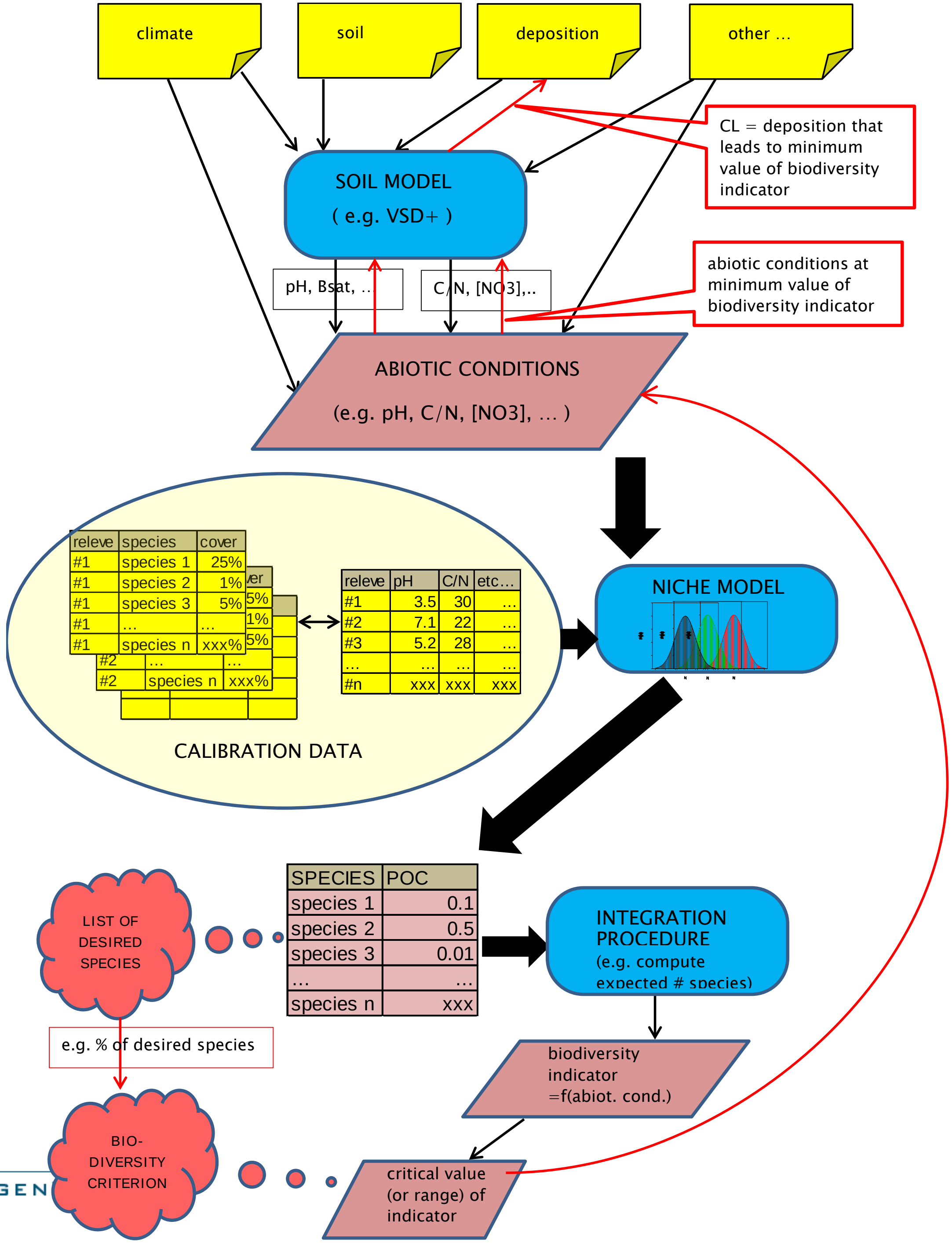
# Biodiversity-oriented (nitrogen) critical loads

From relevees: vegetation ←→ abiotic variable(s) (e.g.[N], pH) with upper and lower bound for Occurrence/abundance etc.

- Variables uncorrelated (see below)
- Variables correlated (hear Max Posch)



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# WP17 Local variation in threshold exceedance

- Assessment of critical N thresholds (VSD+ Props inverse) 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.

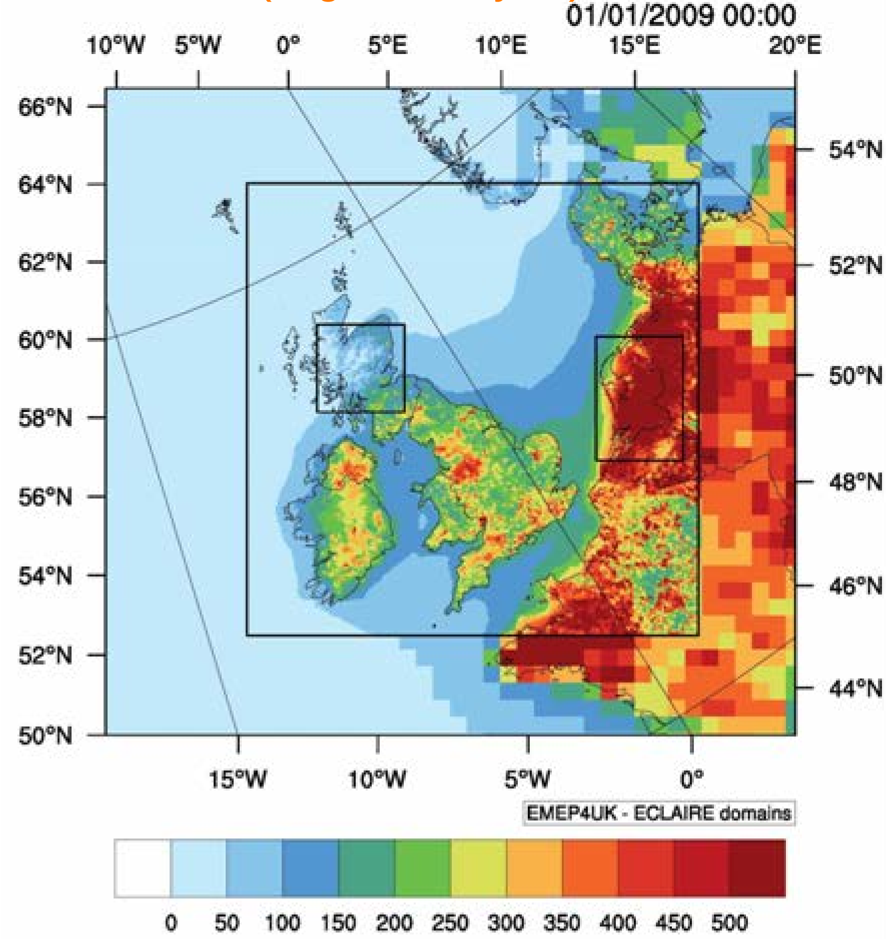
Decreasing domain size, increasing resolution

| 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 | NitroScape/ INITIATOR model |

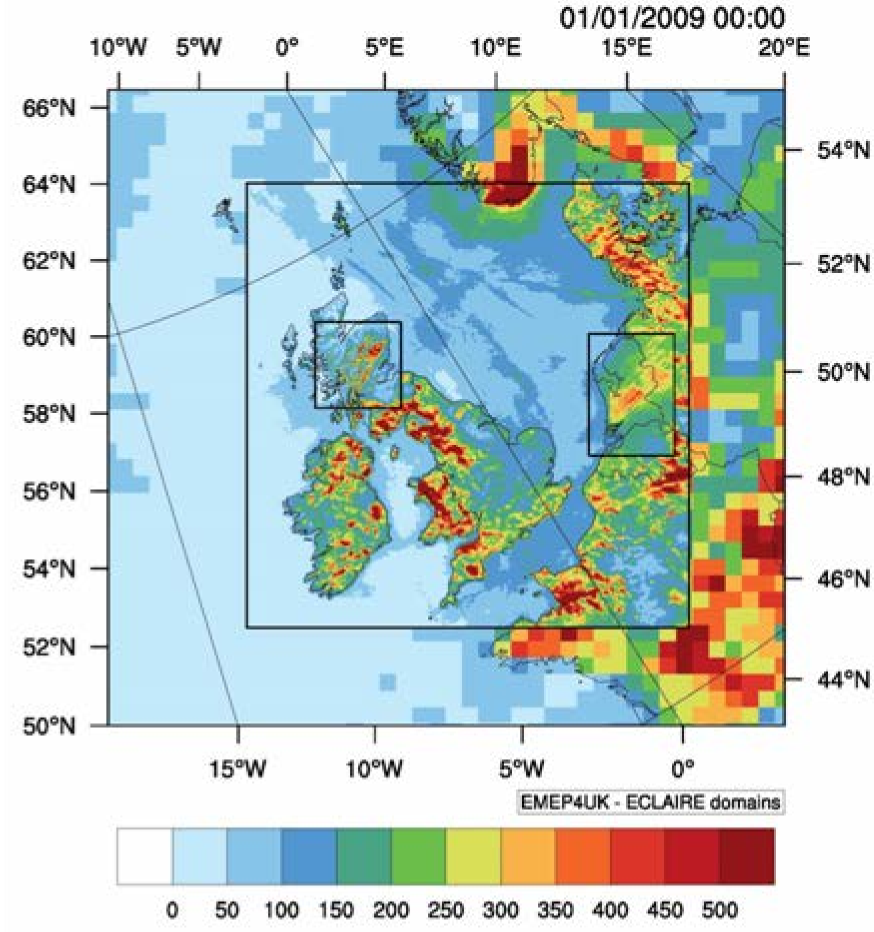
# WP 8: Assessing local and regional variation

## EMEP4UK Simulations at 5 x 5 km and 1 x 1 km resolutions (2008)

Dry Deposition Reduced N
(mg N m$^{-2}$ yr$^{-1}$)



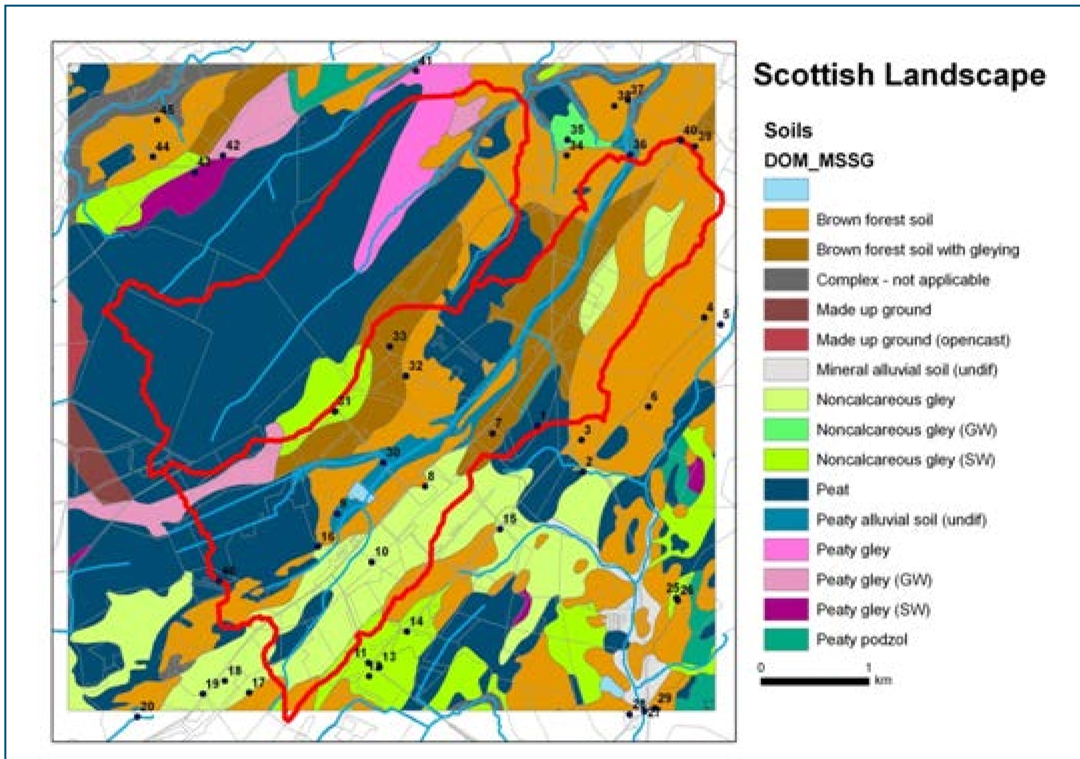

Wet Deposition Reduced N
(mg N m$^{-2}$ yr$^{-1}$ )



# WP 17: Local variation threshold exceedance

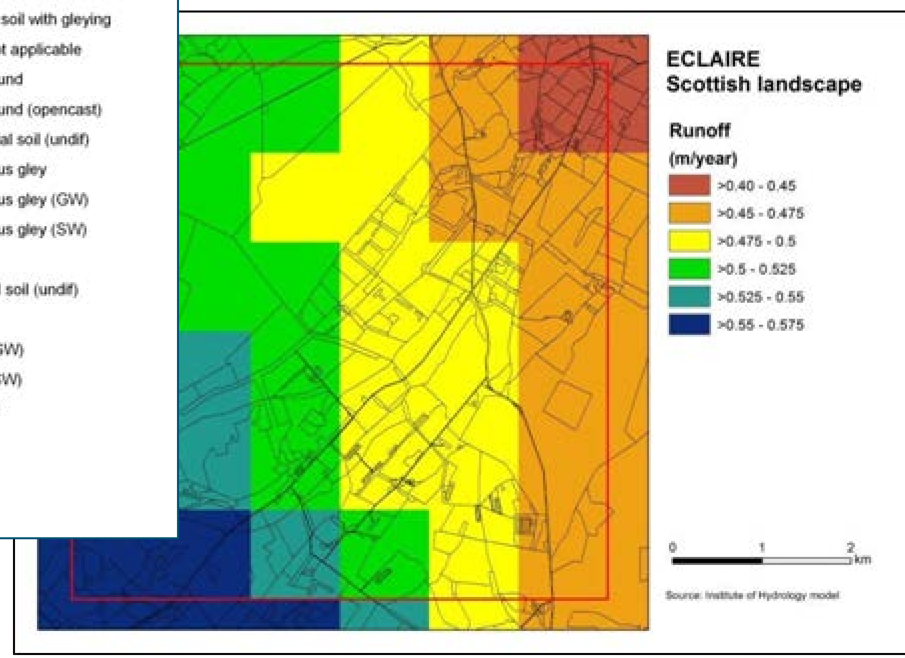
## Application of VSD+ Props at UK landscape (soil data)

*Input data:*



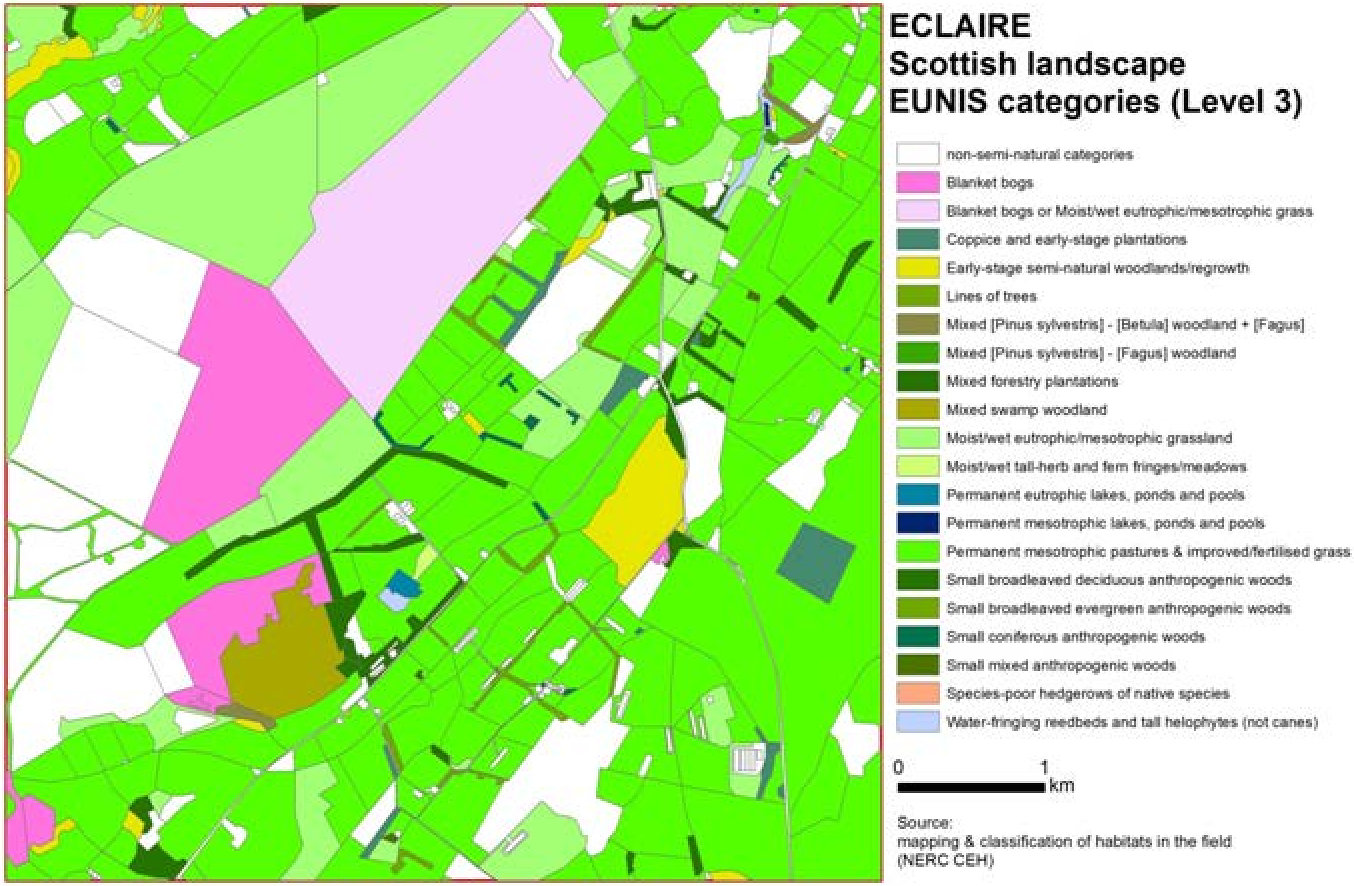

(© The James Hutton Institute 2012) *Soil Map*

*Runoff estimate*



# WP 17: Local variation threshold exceedance

## Application of VSD+ Props at UK landscape (Habitat data)




Habitat Map

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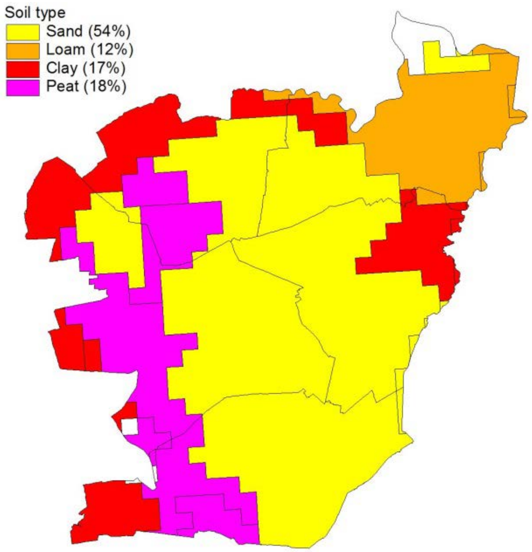
# WP 17: Local variation threshold exceedance

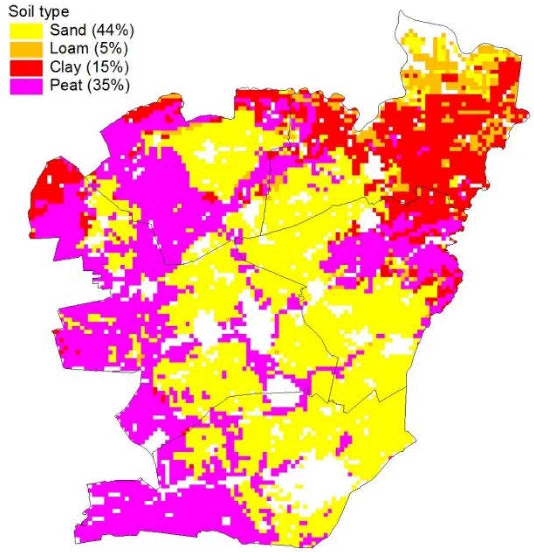
## Application of VSD+ Props at NL landscape (Soil data)




European

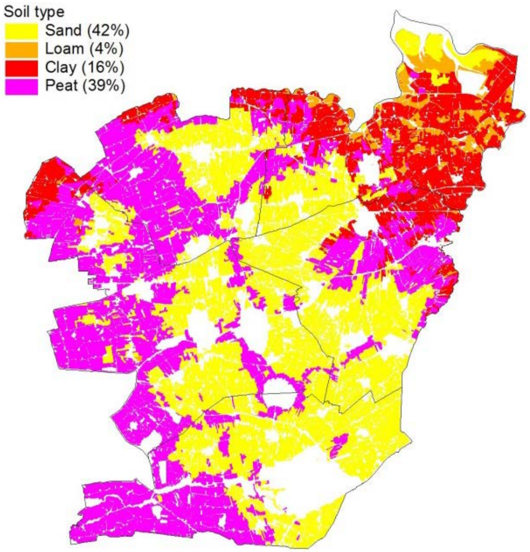
NCU level

(multiple of 1km × 1 km cells)




National

250m × 250m




Landscape

50m × 50m

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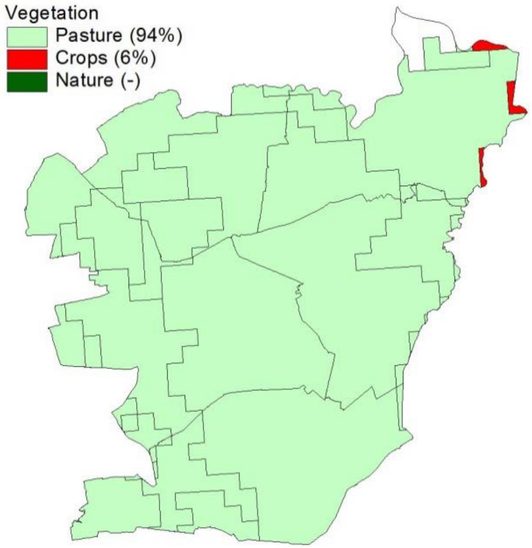
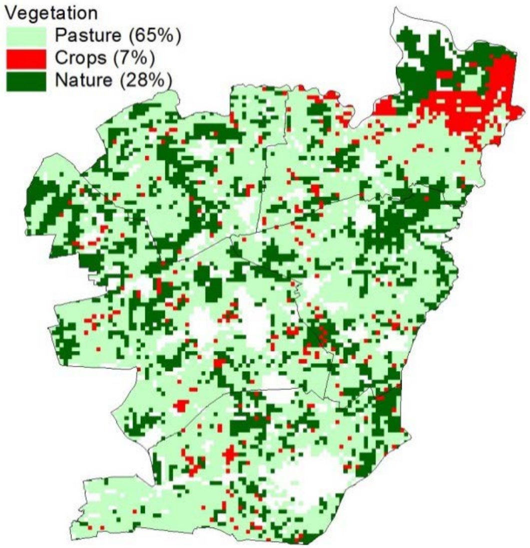
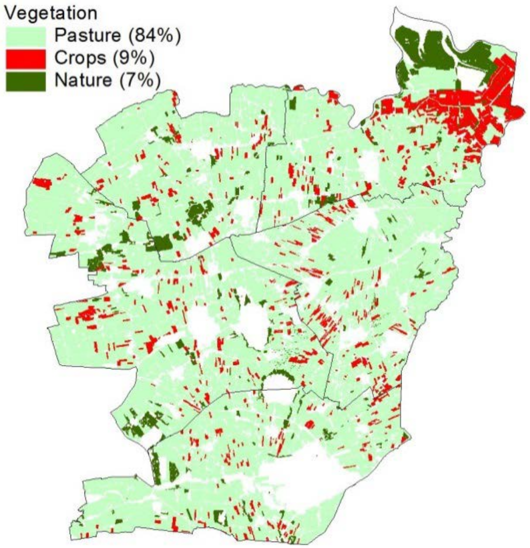
# Land cover

## Application of VSD+ Props at NL landscape (Land cover data)




European
NCU level

National
250m × 250m

Landscape
50m × 50m

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# Discussion issues

- Common C4 meeting: updates on model developments/ results and planning
- Combined C4 meetings with C2, C3 and C5
    - C2-C4 Europe: discuss model intercomparison results based on protocol
    - C2-C4 zooming: input data collection and *first results*
    - C3-C4 Model improvements and agree on model protocol for validation at site scale, sensitivity and scenario analysis
    - C4-C5 Use of C4 model results in GAINS.

# Challenges ahead

- Evaluate combined impacts of Climate, $CO_2$, N deposition and ozone exposure by ECLAIRE models and assess differences and their plausibility in view of literature.

- Inverse application of VSD+-Props (or MADOC-Multi-MOVE) to assess a critical load (CL) from a critical plant species diversity indicator value

- Assessment of this CL at different spatial resolutions to assess impacts of spatial aggregation

# Questions?

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