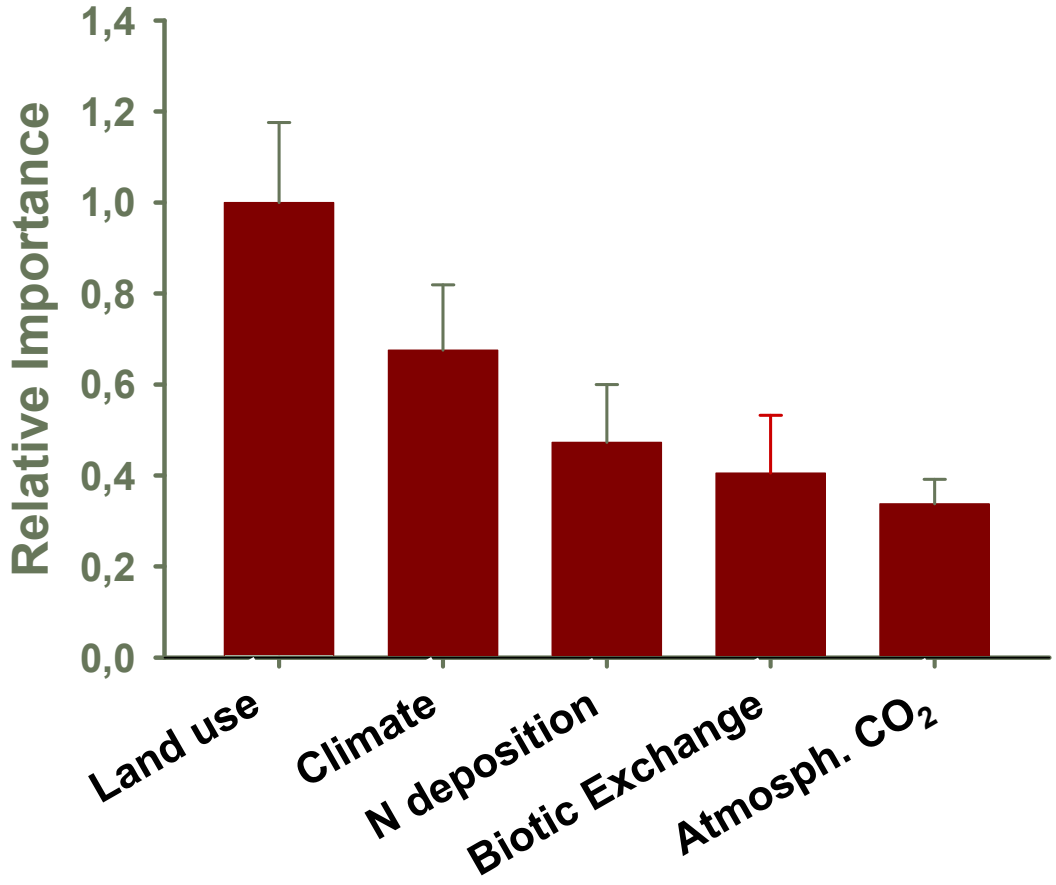
Climate Change, Land Use and Biodiversity – the German Flora and Vegetation – a Case Study

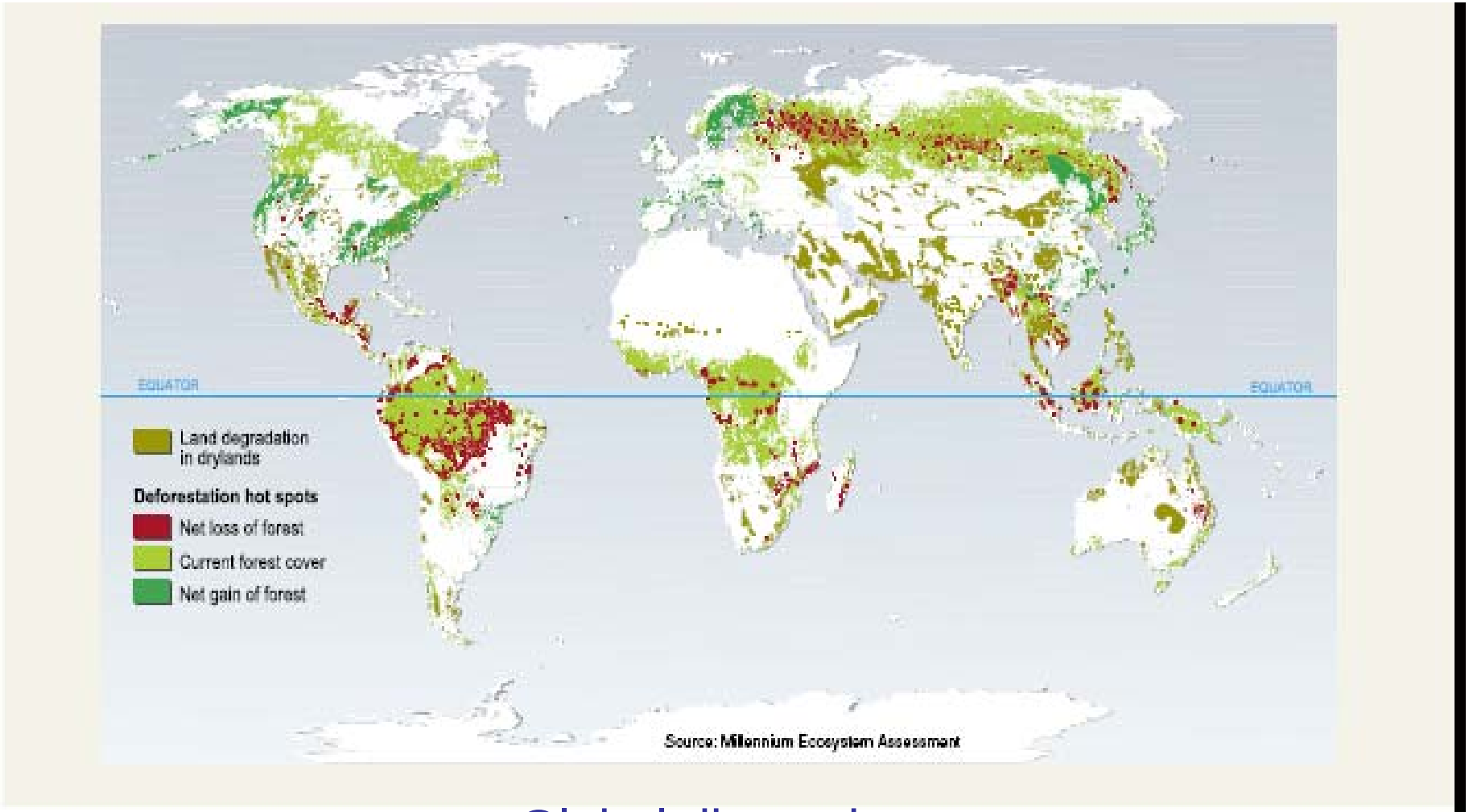
Stefan Klotz, Helmholz Centre for Environmental Research (Halle), Department of Community Ecology

Major drivers of biodiversity change



Source: Sala et al. (2000): Science 287: 1770-1774

Land Use Change

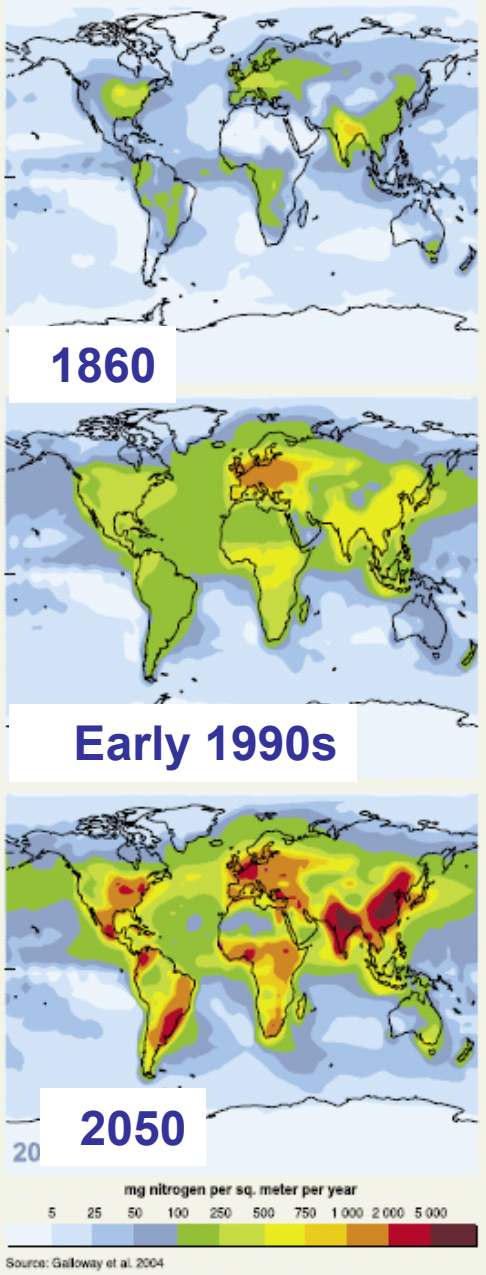


Global dimension

N Deposition

Figure 1.6. Estimated Total Reactive Nitrogen Deposition from the Atmosphere (Wet and Dry) in 1860, Early 1990s, and Projected for 2050 (milligrams of nitrogen per square meter per year) (R9 Fig 9.2)

Atmospheric deposition currently accounts for roughly 12% of the reactive nitrogen entering terrestrial and coastal marine ecosystems globally, although in some regions, atmospheric deposition accounts for a higher percentage (about 33% in the United States). (Note: the projection was included in the original study and is not based on MA scenarios.)

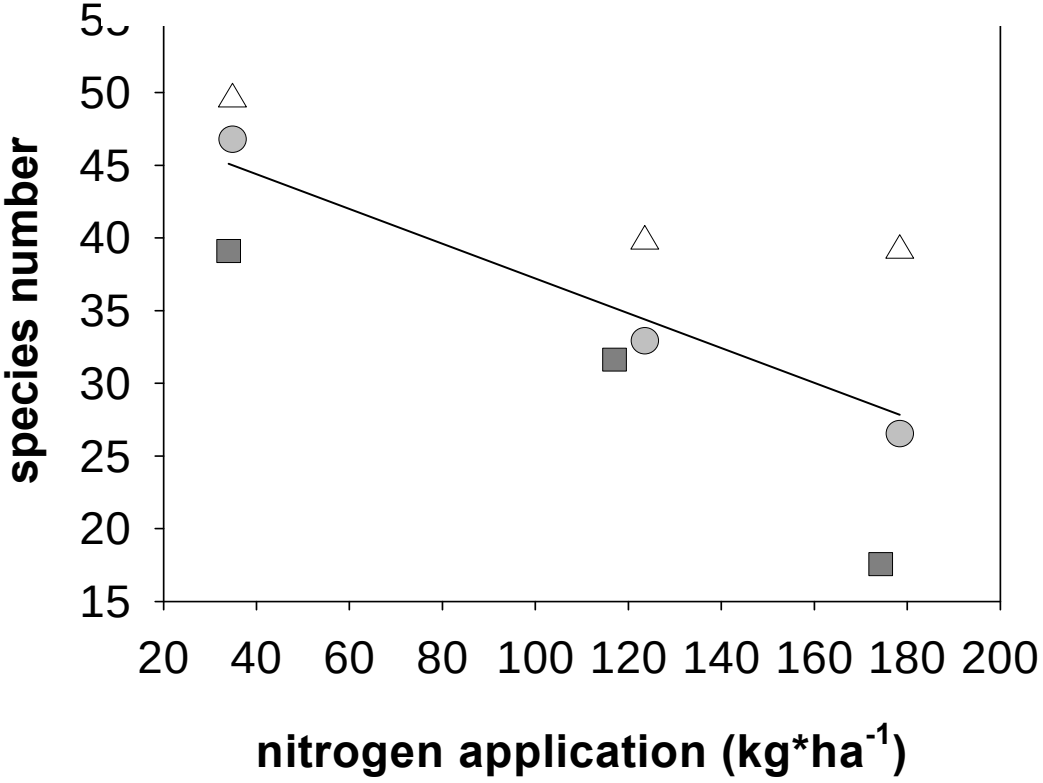


Millennium Ecosystem Assessment

Consequences of nutrient loadings

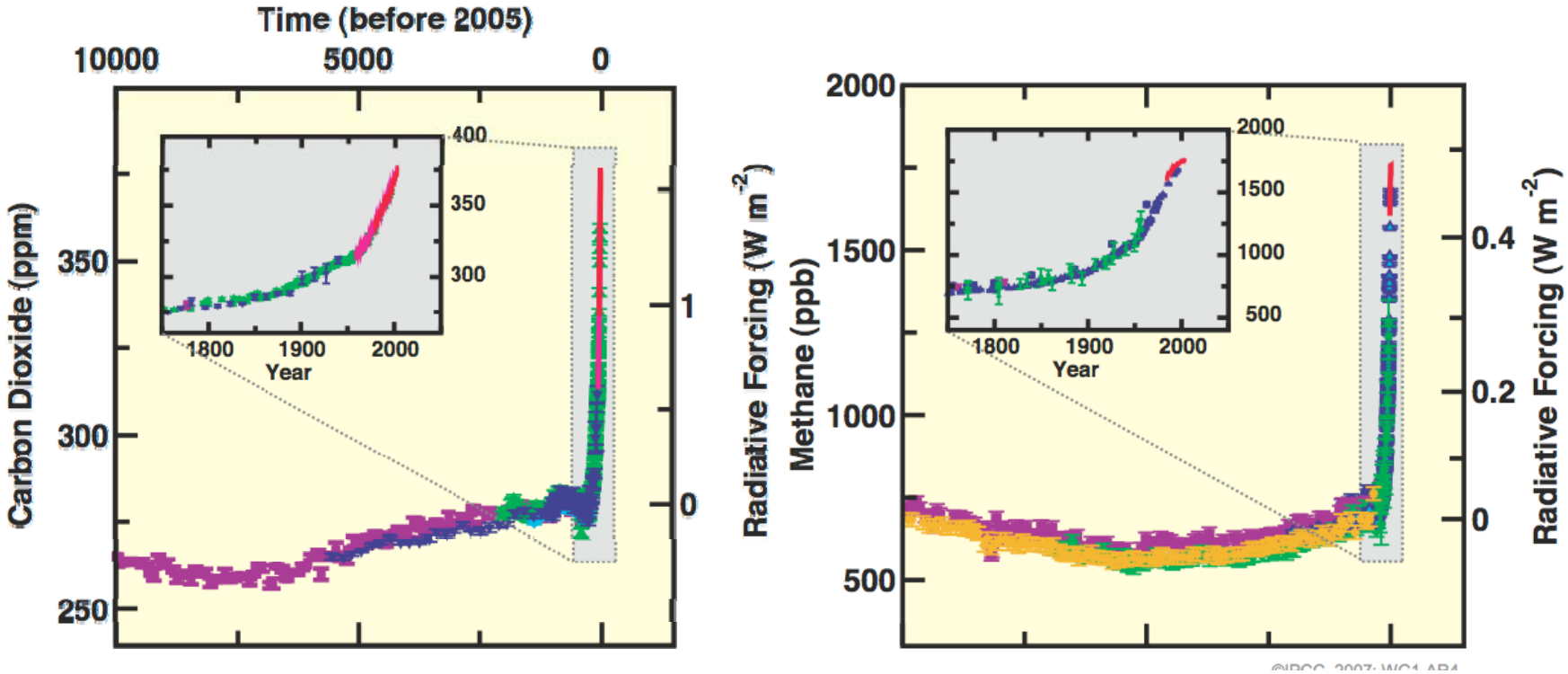
- **Nitrogen loading**
  - **Algal bloom**
  - **Decreased water quality**
  - **Euthrophication of fresh water ecosystems**
  - **N_2O Emissions**
- **Phosphate loading**
  - **Euthrophication of fresh water ecosystems**

Overall effect : a loss of biodiversity in Landscape test sites within the TERENO-site Leipzig-Halle



Greenhouse gas

CO2 **CH4**



(IPCC 2007)

Influences on Biodiversity

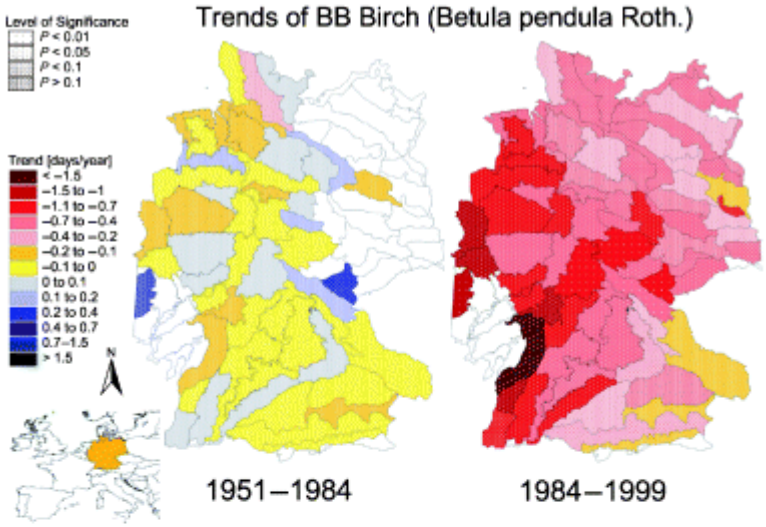
Phenological Changes

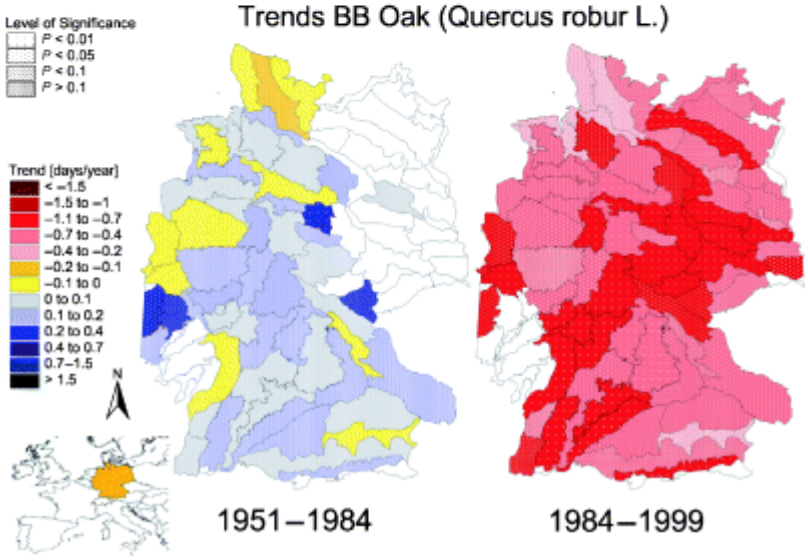
Changes in Distribution Ranges of species

Changes in Species Composition

Changes in Vegetation and Biomes

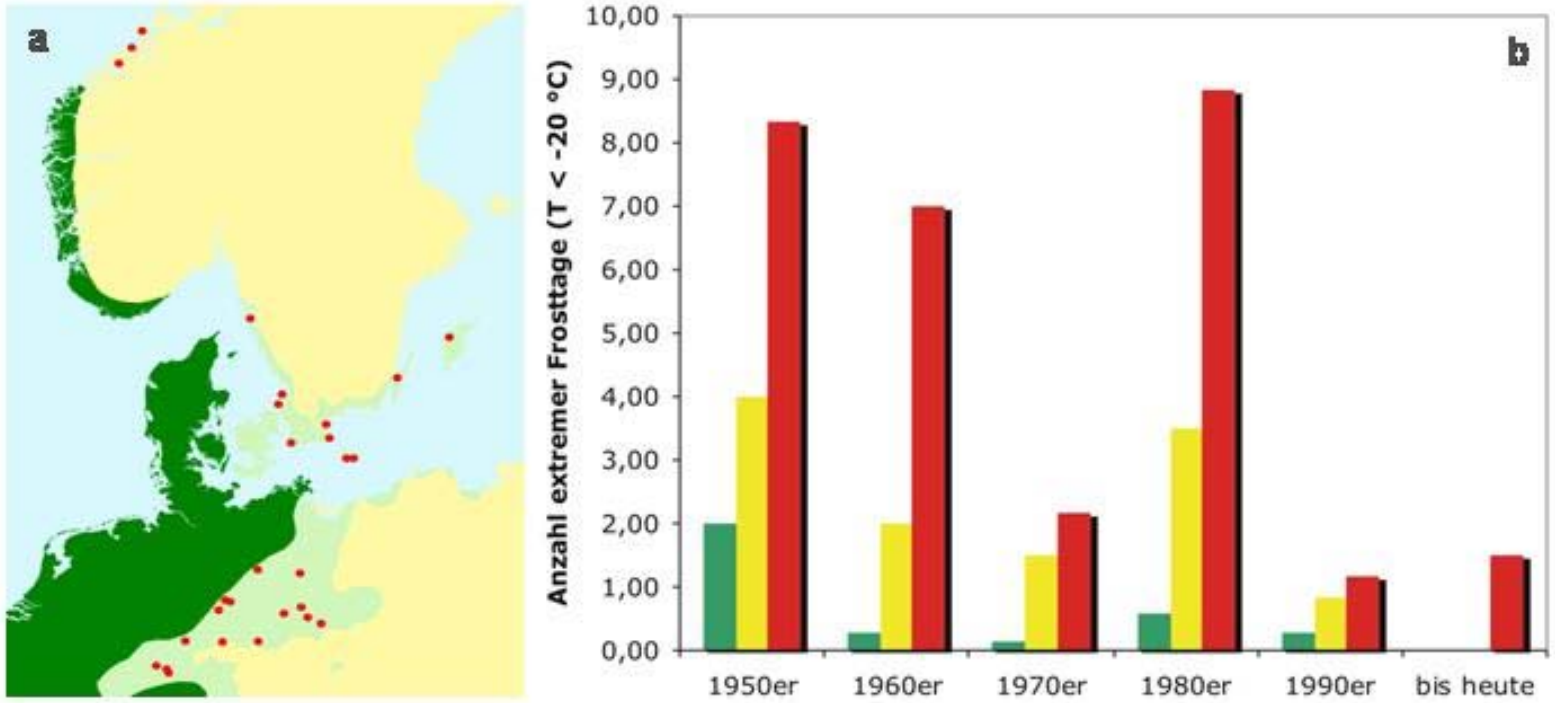
Phenological Changes in Plants





Badeck et al. 2004, *New Phytologist* **162** (2), 295-309.

Observed Expansion of distribution ranges - Ilex aquifolium



Pompe, Berger, Walther, Badeck, Hanspach, Sattler, Klotz, Kühn, *Natur & Landschaft* 1/2009

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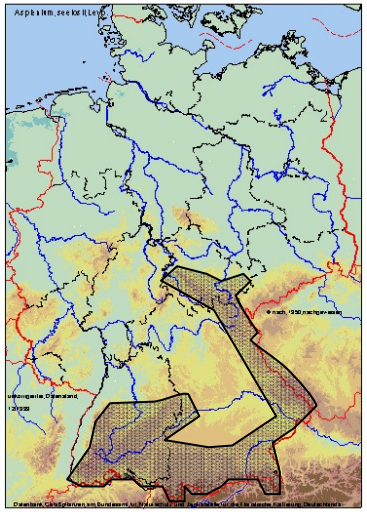
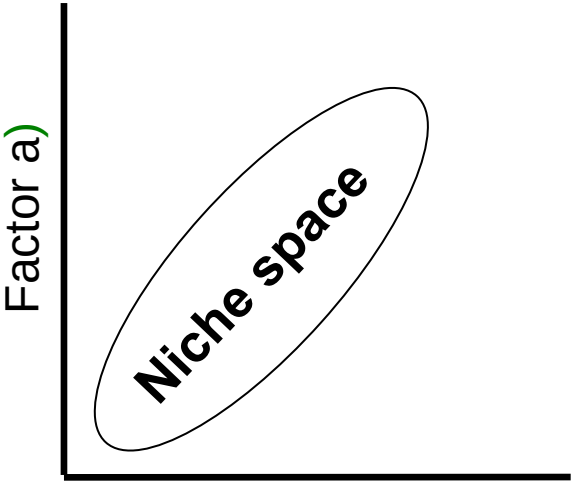
Statistical models of species re-distribution

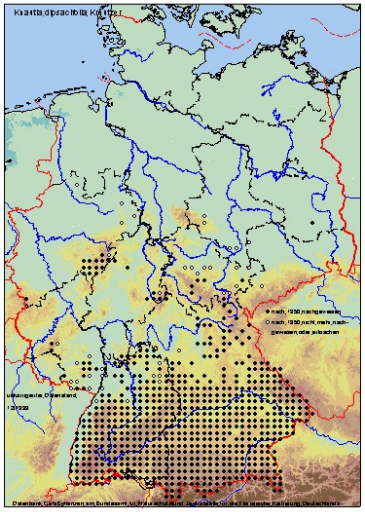
Scenarios of distribution



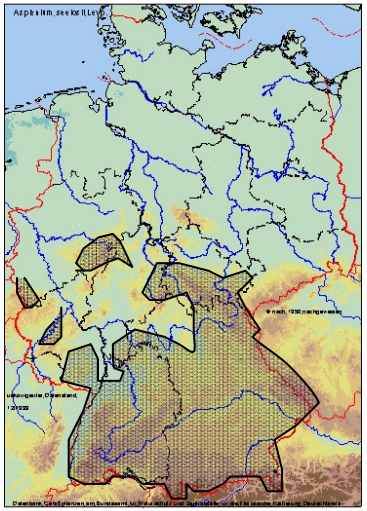
Modelling of ecological niche



Geographical space

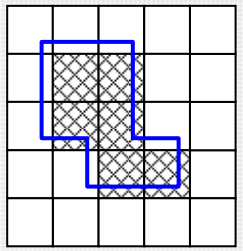


Projection into geographical space

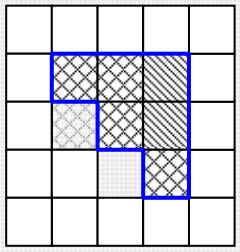


Climate change and land use scenarios

Calculation of Changes in Distribution Ranges



Modell



Present range (A)

Distribution range

Environmental variables characterizing the distribution range of a species

Projected range (B)

New rangel

Lost range

Climate change results in changes in the potential rangel

Pompe, Kühn et al., *BfN*

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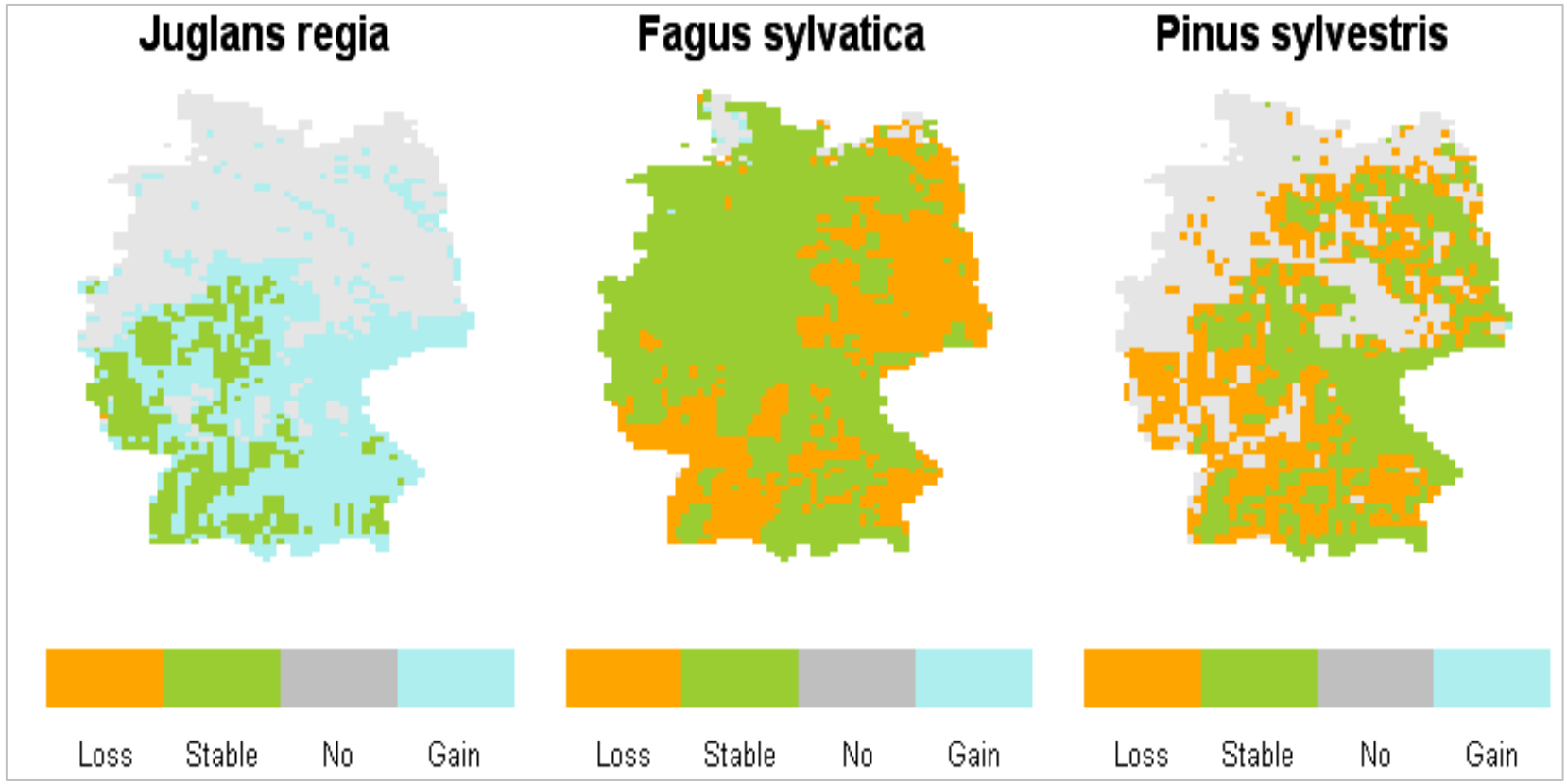
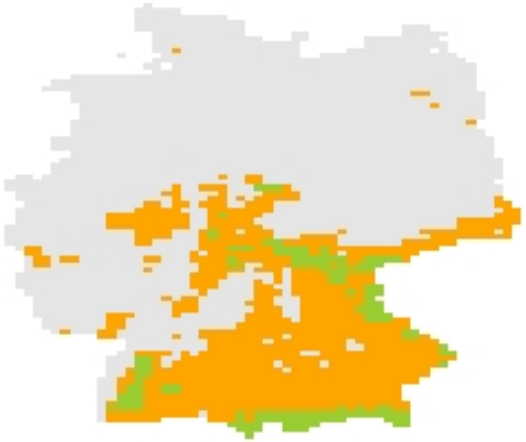
+4°C distribution scenarios 2080

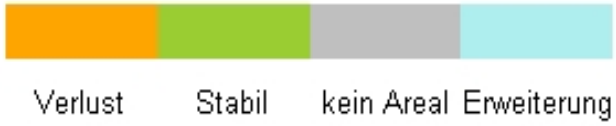


Scenario 2080

Picea abies (Spruce)

+4°C





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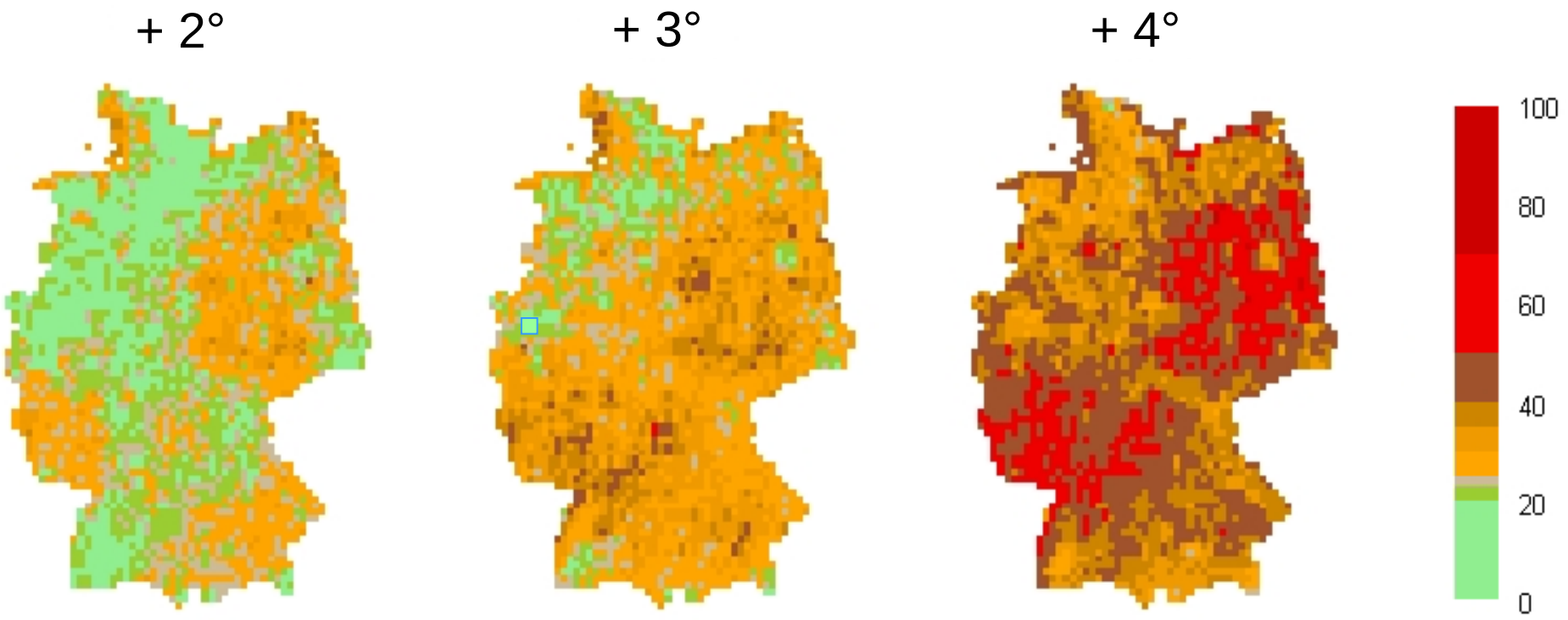
Plant Species Change in Germany up to 2080



Pompe, Badeck, Hanspach, Klotz, Thuiller & Kühn, *Biology Letters*, in press

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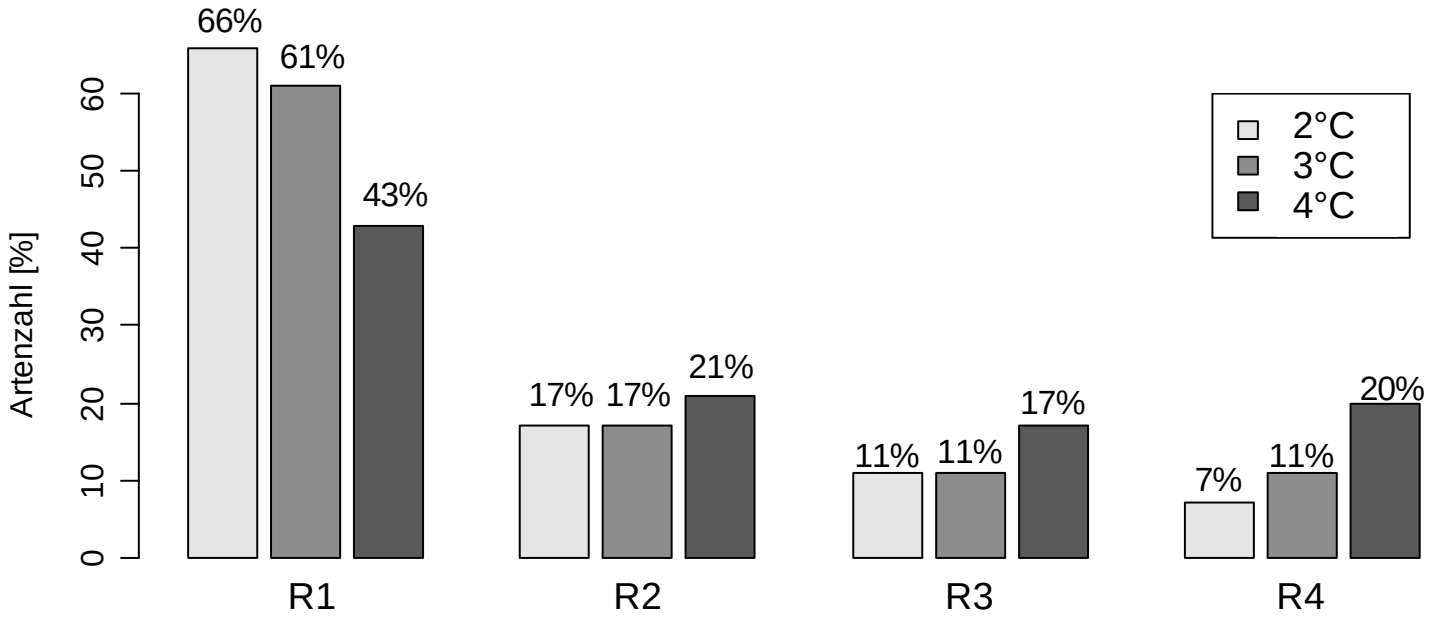
Proportion of species risk groups (Red list of Plants)



Data from:
Pompe, Berger, Walther, Badeck, Hanspach, Sattler, Klotz, Kühn, *Natur & Landschaft* 1/2009

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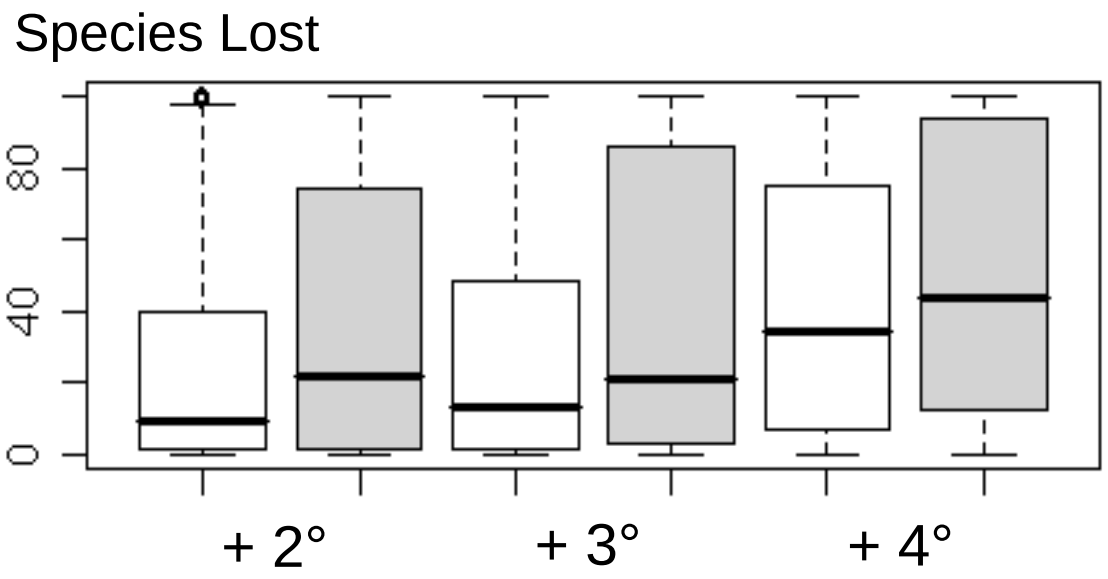
Impact on Red List Species in Germany



→ Red List Species (grey) more impacted by climate change than other species (white)

Data from::
Pompe, Berger, Walther, Badeck, Hanspach, Sattler, Klotz, Kühn, *Natur & Landschaft* 1/2009

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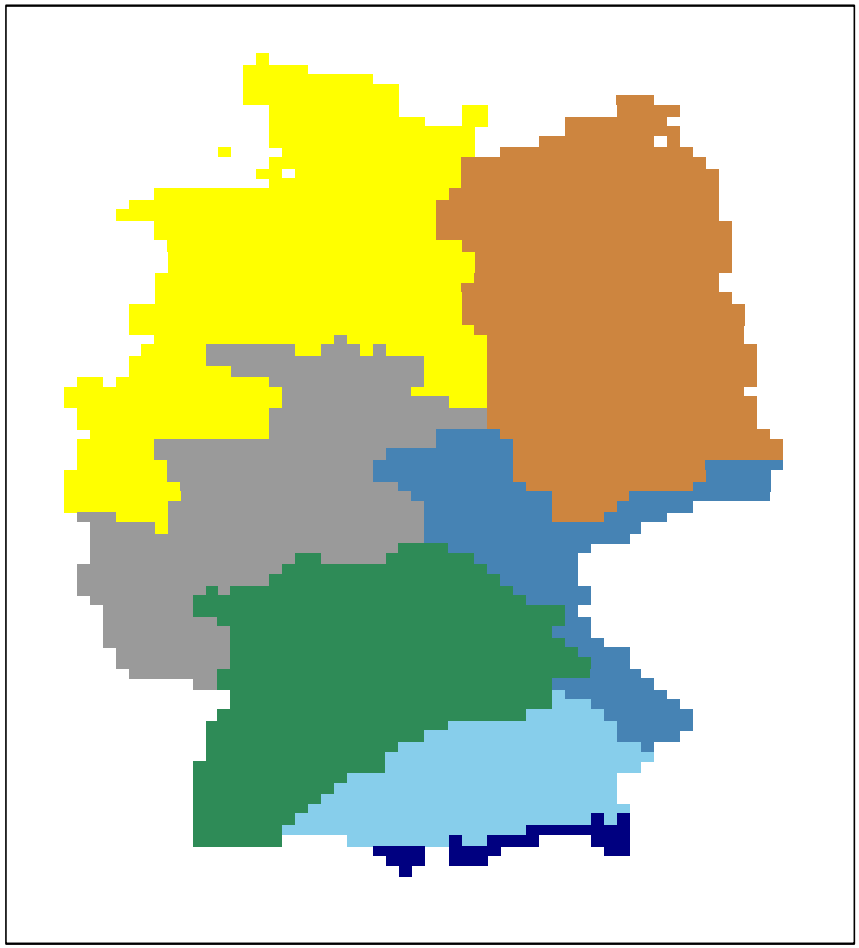
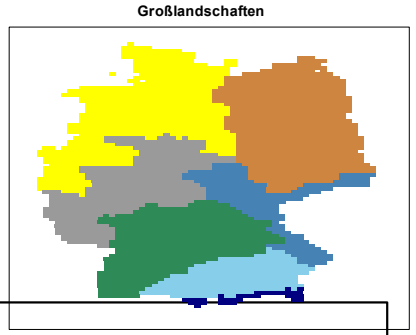
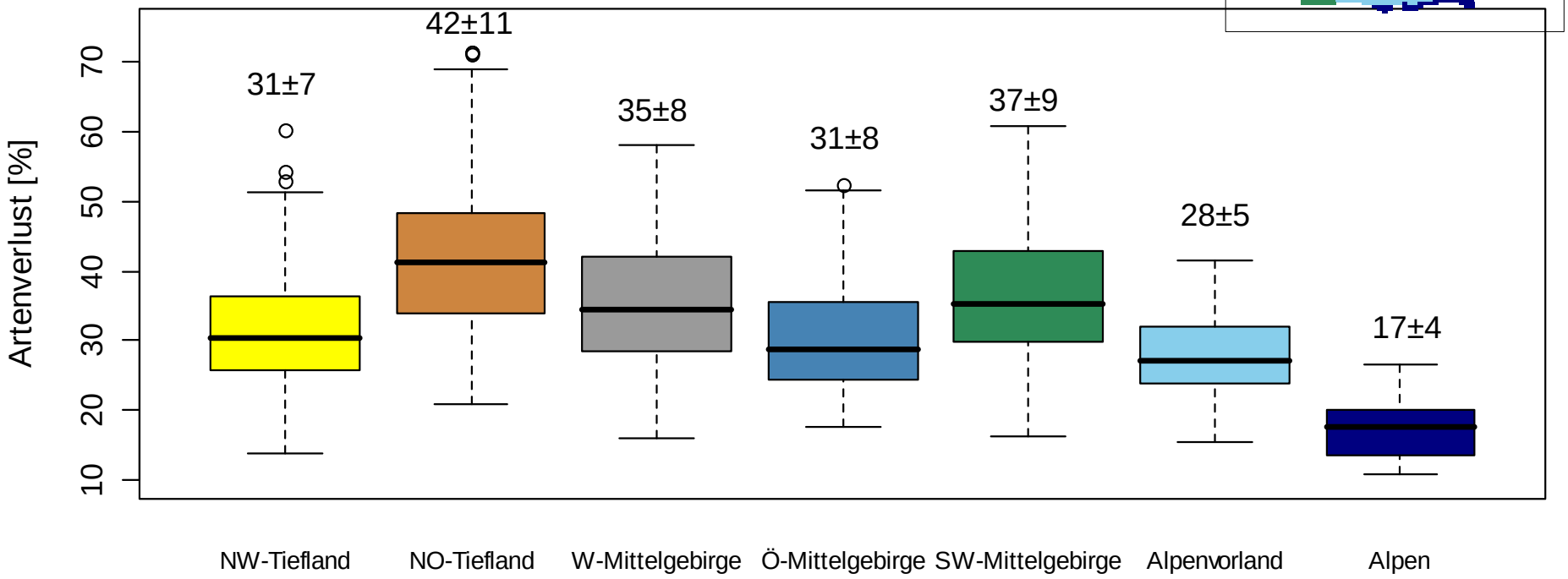
Biogeographical Regions of Germany



Source: Biogeographical Regions of Germany – Federal Agency for Nature Conservation.

Species Lost, 4°C Scenario 2080





Modeling of 845 Species, (without spread)

Pompe, Kühn et al., in prep.

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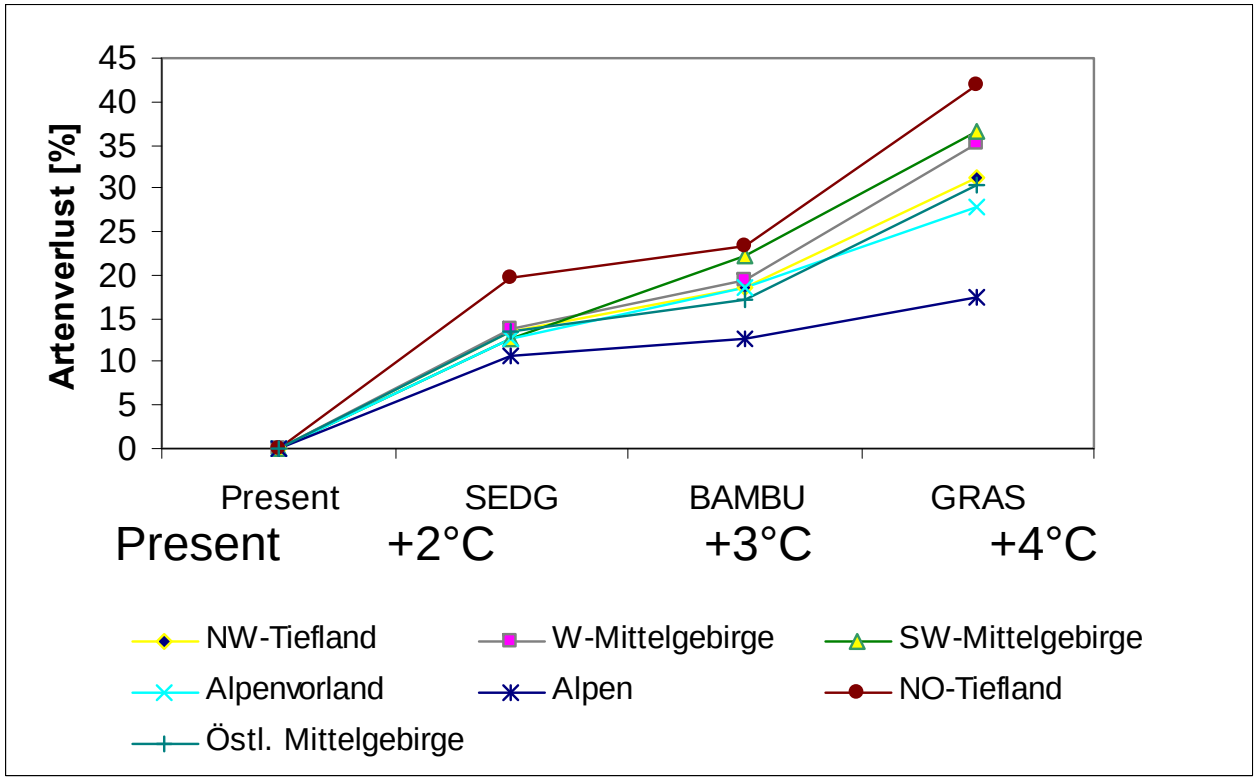
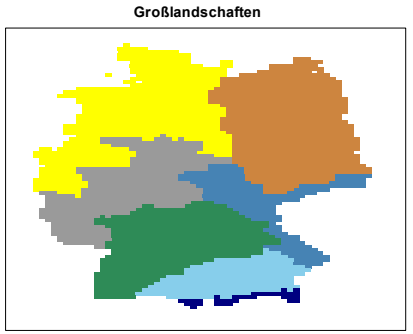
Species Lost Scenarios





n=845 species, 2995 grid cells

Pompe, Kühn et al., in prep..

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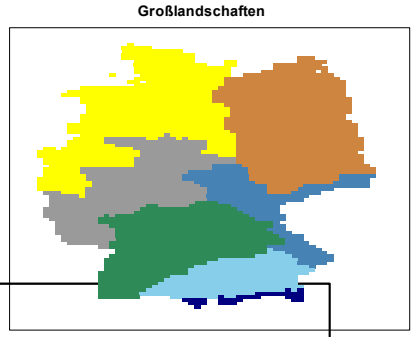
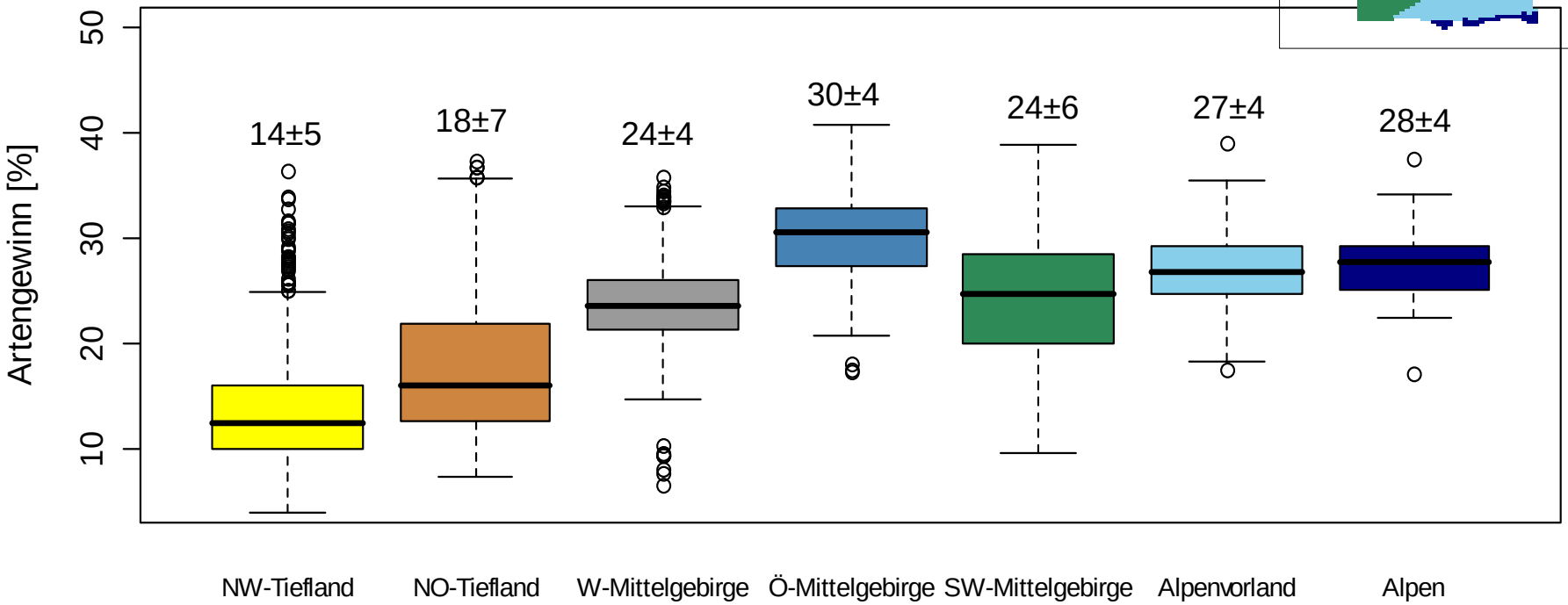
Species Gains, 4°C Scenario 2080





Modeling of 845 species

Pompe, Kühn et al., in prep.

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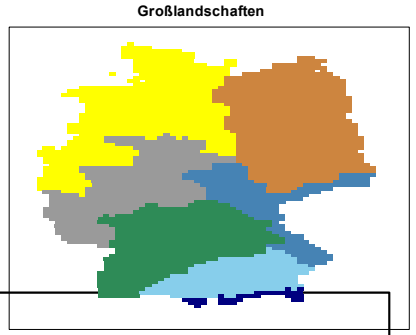
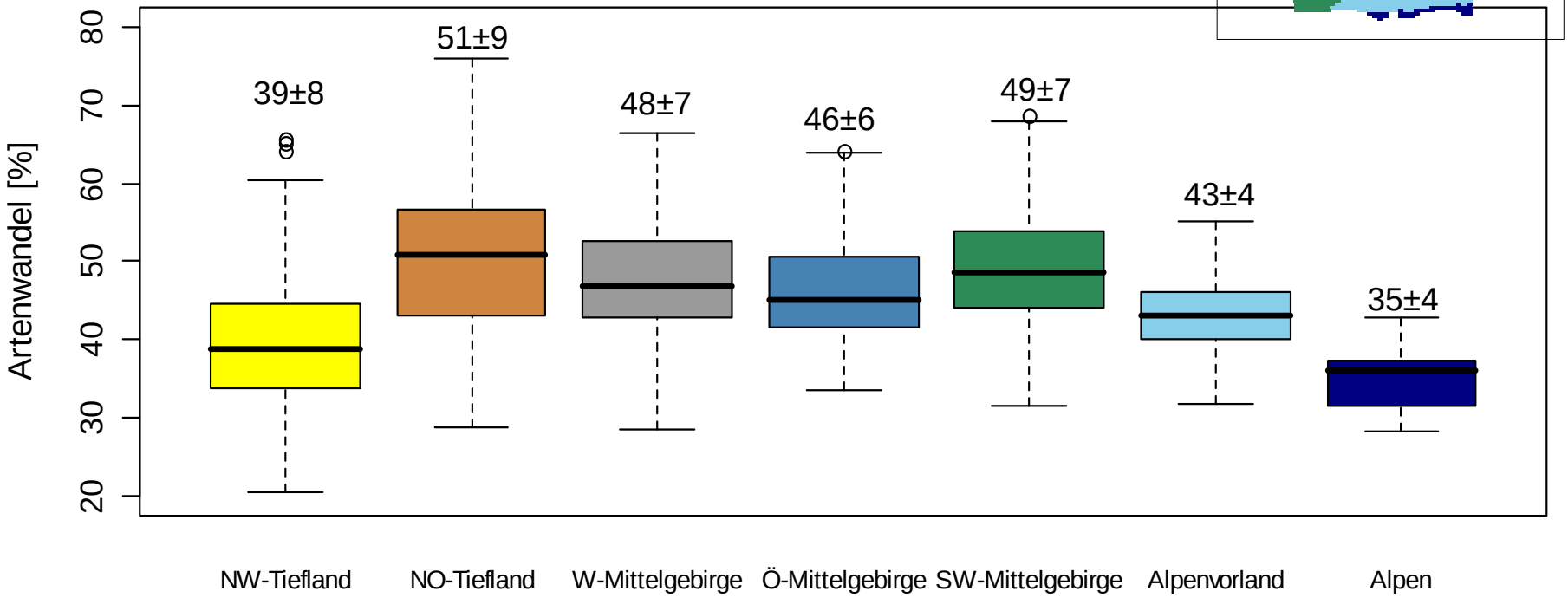
Species Turnover, 4°C Scenario 2080





Modeling of 845 Species

Pompe, Kühn et al., in prep.

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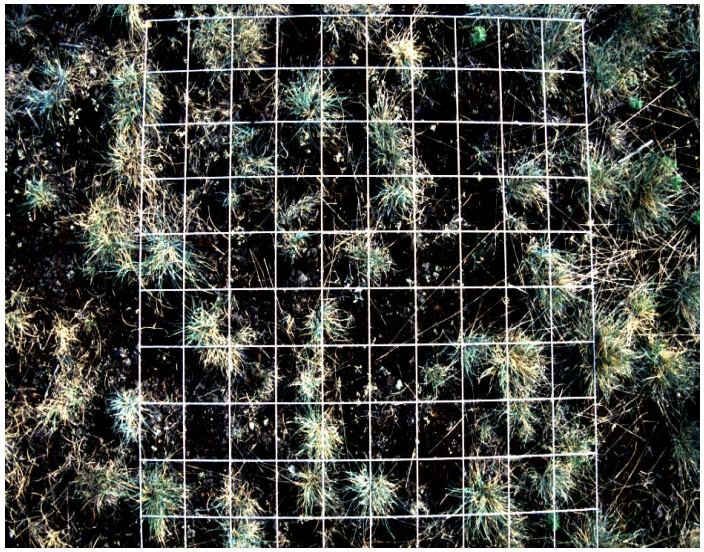
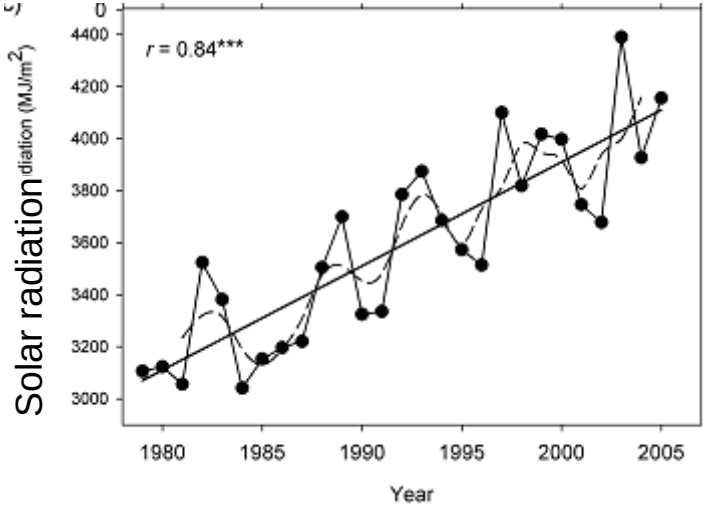
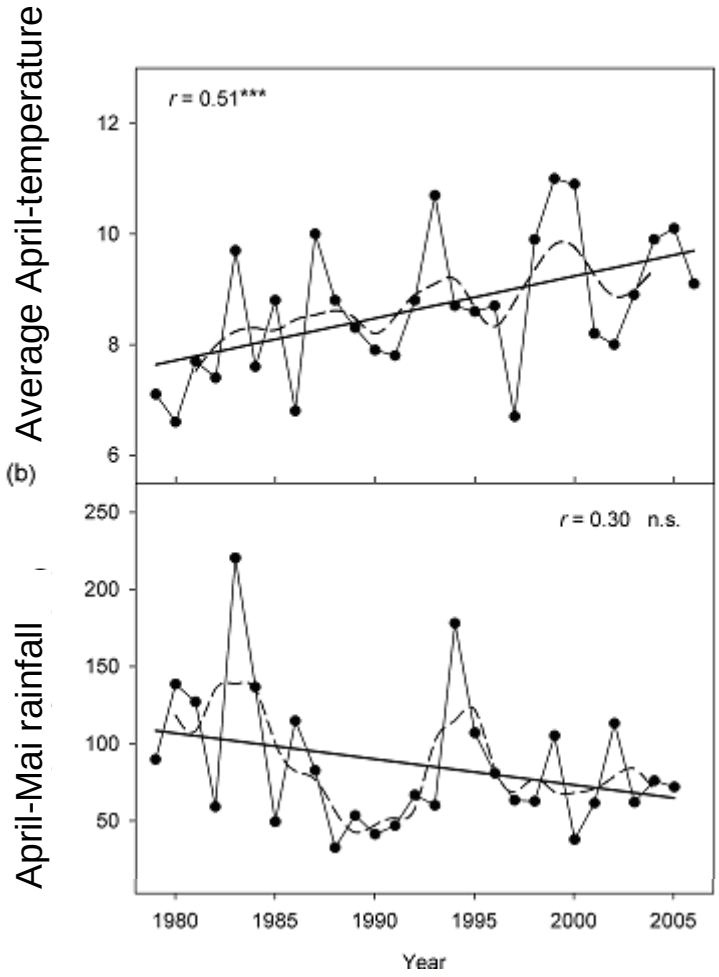
25 years of Monitoring in Dry Grasslands in Central Germany TERENO-Site Leipzig-Halle







Matesanz, Brooker, Valladares, Klotz, *Journal of Vegetation Science* 2008

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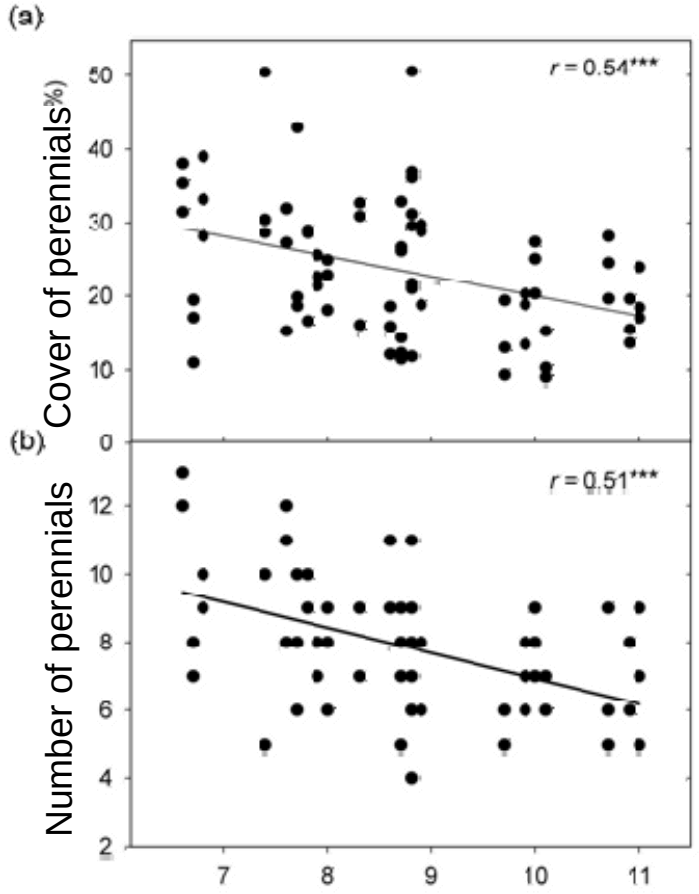
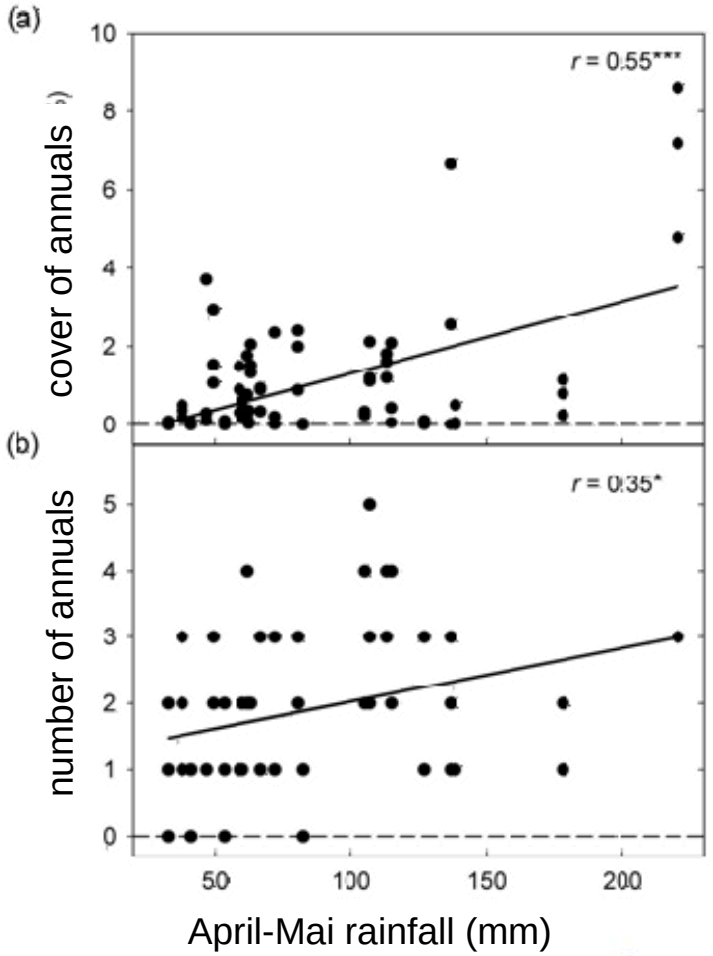
Observed Changes in Dry Grasslands in Central Germany – TERENO-site Leipzig-Halle





Matesanz, Brooker, Valladares, Klotz, *Journal of Vegetation Science* 2008

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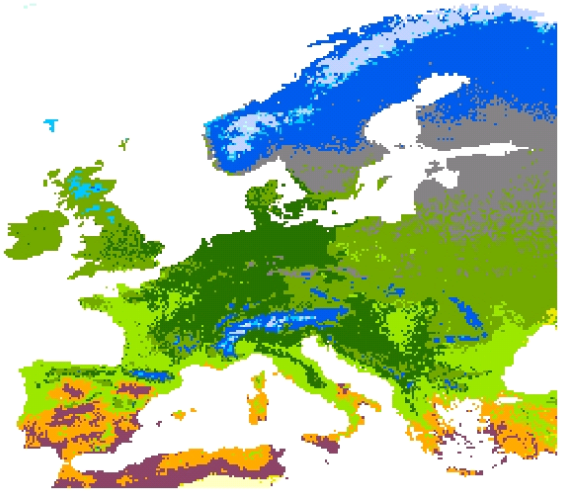
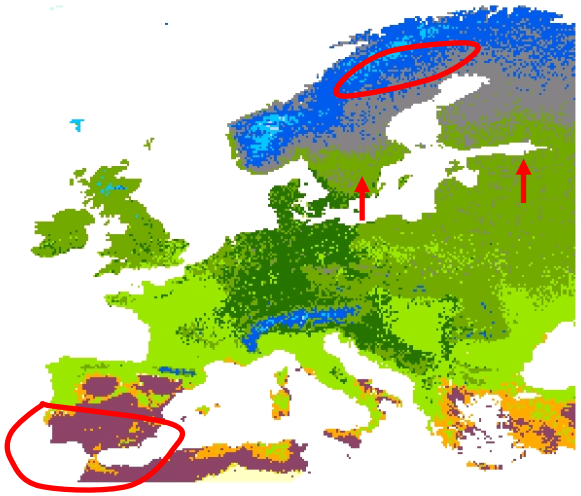
Dynamic vegetation models

Modelled vegetation 1961-1980



Modelled vegetation 2091-2100 HadCM3 A2



- Arctic/alpine desert
- Arctic/alpine tundra
- Boreal/alpine birch forest/woodland
- Boreal/alpine conifer forest/woodland
- Hemiboreal mixed forest
- Temperate beech and mixed beech forest
- Temperate mixed broad-leaved forest
- Thermophilous mixed broad-leaved forest
- Mediterranean sclerophyllous forest/woodland
- Mediterranean sclerophyllous scrub
- Steppe woodland
- Steppe

Hickler, Sykes, et al., Univ. Lund, Sweden

Biological Interactions and Climate Change

- The Butterfly *Boloria titania (Caterpillar)* is monophagous on *Bistorta officinalis*

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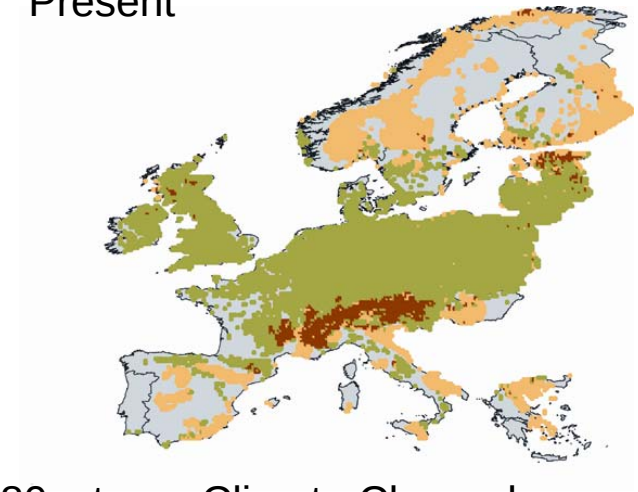
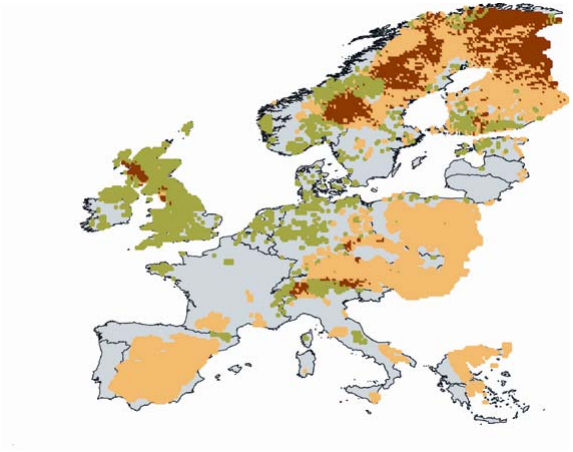
Biological Interactions and Climate Change

Present

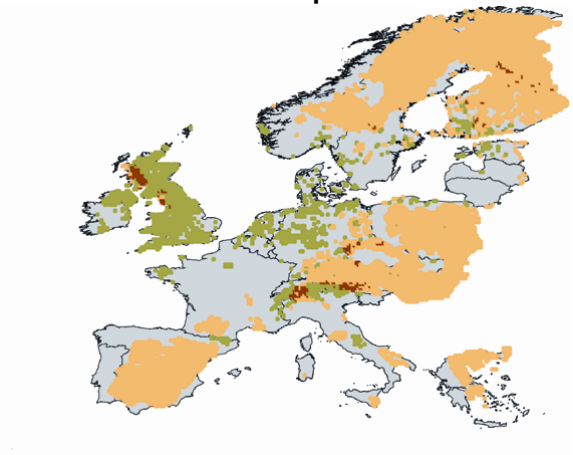


Orange: niche space of the butterfly
Green: niche space of the plant
Red: crossing over

2080, strong Climate Changel
Spread without limitations



2080, strong Climate Change
No or limited spread



Schweiger, Settele, Kudrna, Klotz & Kühn, *Ecology, in press*

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Conclusion

- Moderate Climate Change (2°C)
  - 60% of all species will lose more than they will win.
  - 7% of all species will lose >2/3 of the present range.
- Strong Climate Change (4°C)
  - 68 % of all species will lose more than they will win.
  - 20% of all species will lose >2/3 of the distribution range.
- Biological Interactions influence the impact of Climate Change drastically.

Gaps and Future Plans – The TERENO-Dimension

- Detailed Biodiversity Observation
  - On population, species, community and landscape level.
  - Complex observation of soil, hydrology, land use and climate.
  - Gradient Position of the Landscape Test sites (Bode catchment, and Harz-Leipzig gradient)
- Biodiversity Experiments
  - Core and Sattelite experiments including the tree-diversity-experiment Kreinitz, long – term agricultural experiments at Bad Lauchstaedt and the EVENT-experiment.
  - Large Investment: Global Change Environmental Facility (GCEF).
- Focus on: Complex niche models, Process models, Biological Interactions, Community and Ecosystem dynamics, Ecosystem functioning and Ecosystem services.

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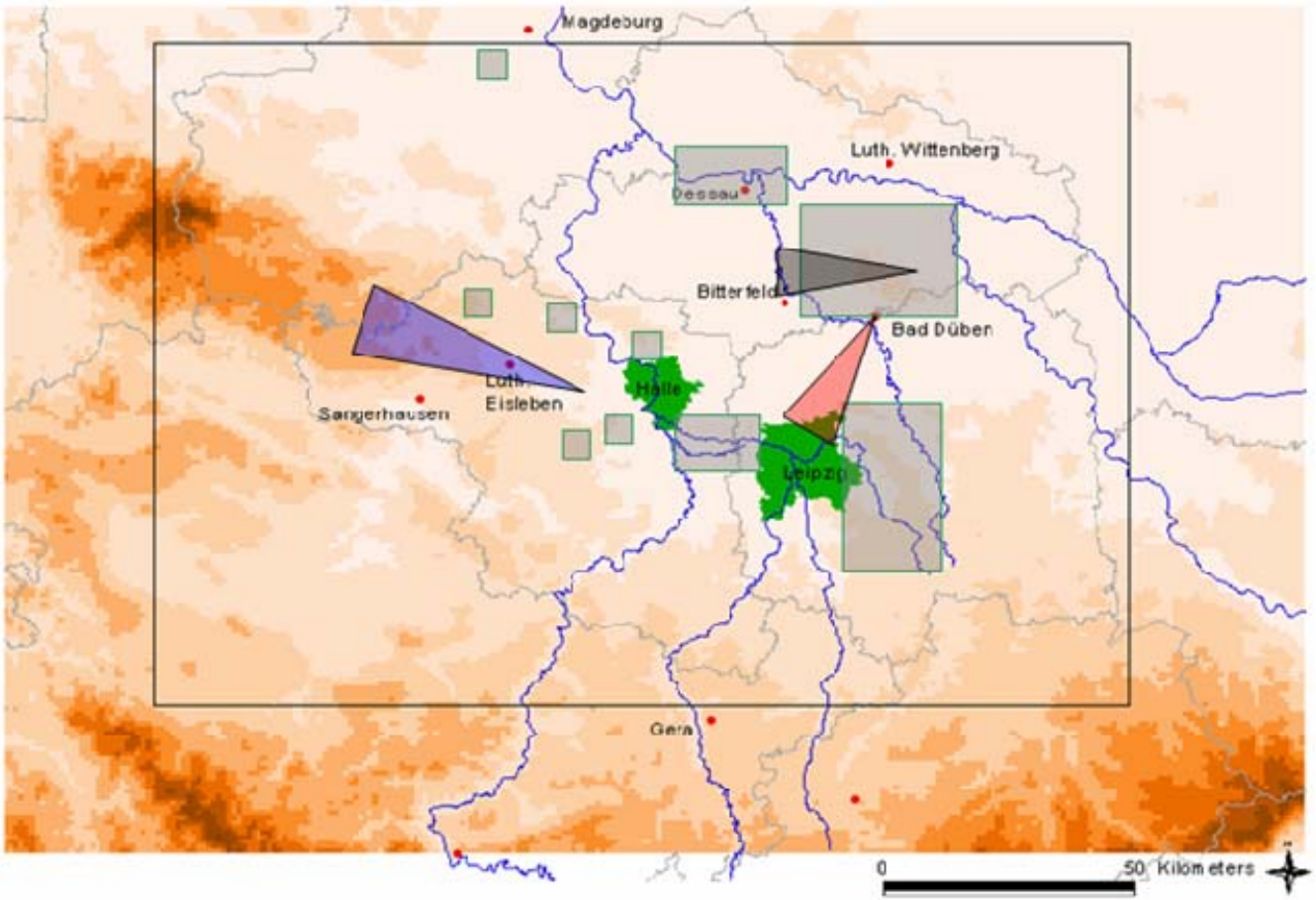
Site structure



Gradients

Precipitation

Temperature

Land Use

Elevation

Emissions

Urbanity

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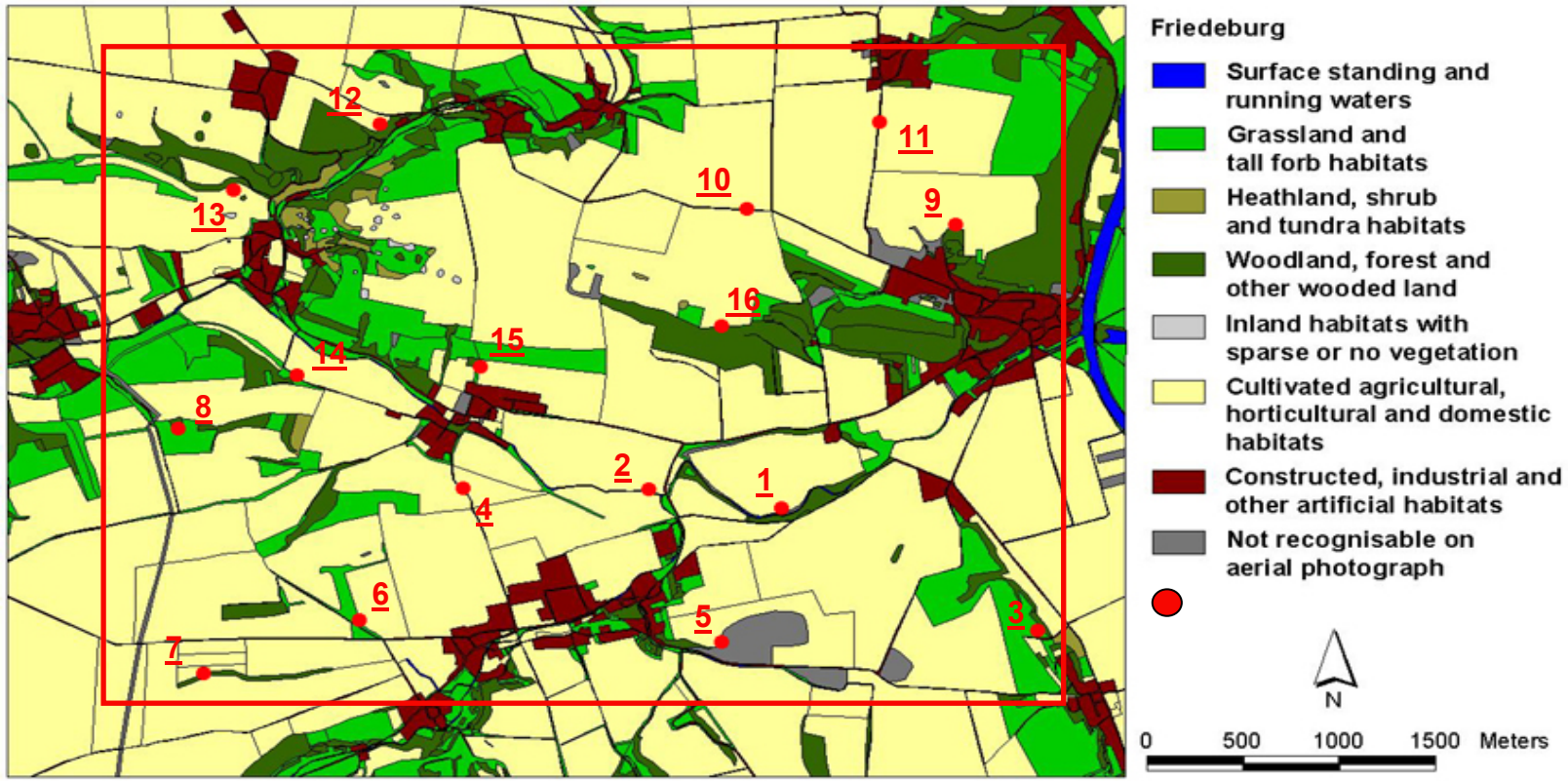
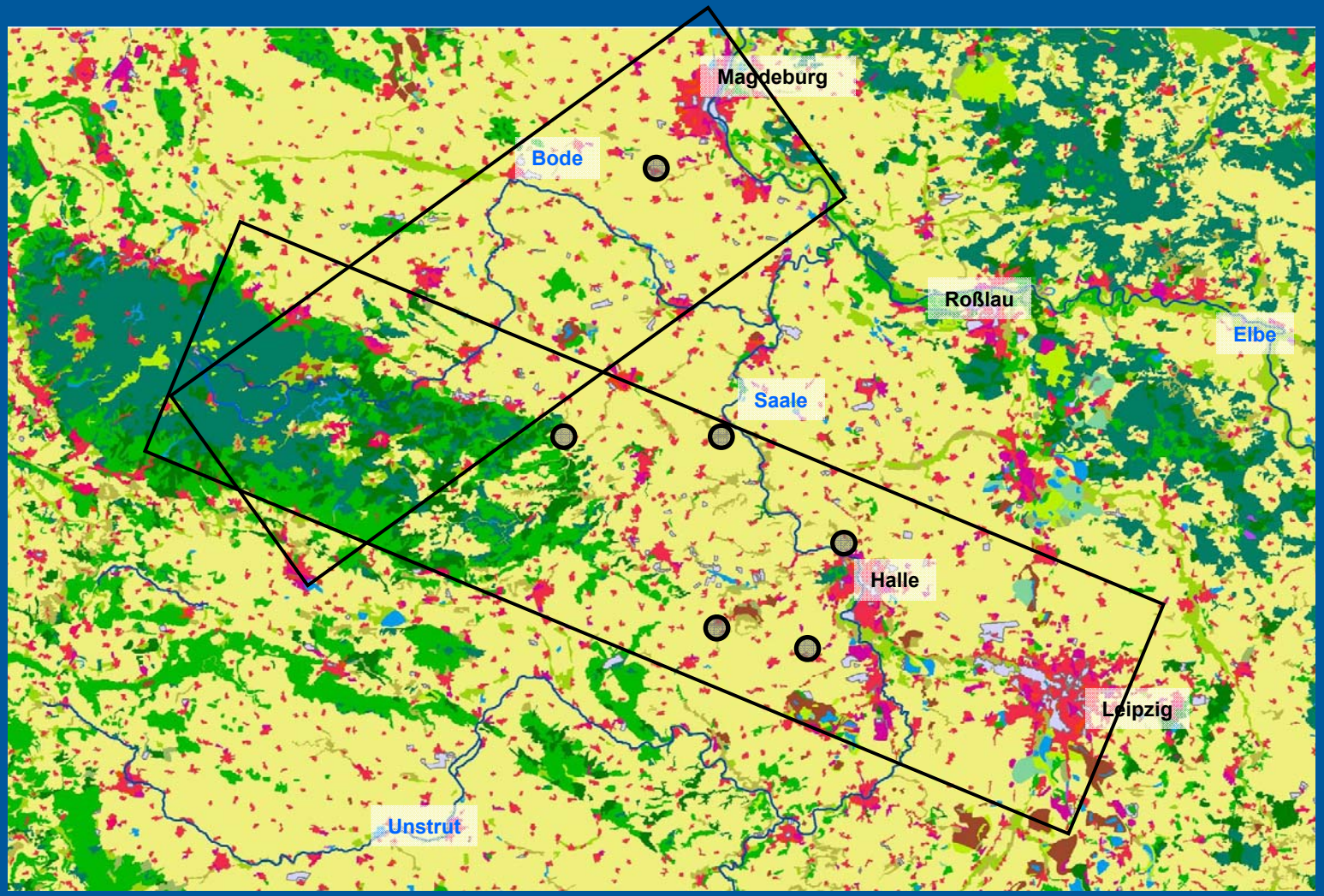
TERENO-site Leipzig-Halle: Example of Landscape Test Site



69% arable land, 23% semi-natural habitats

(EU-Project GREENVEINS)

TERENO-Region UFZ: CORINE land cover



Sites with data sets hold at BZF; additional locations not selected yet

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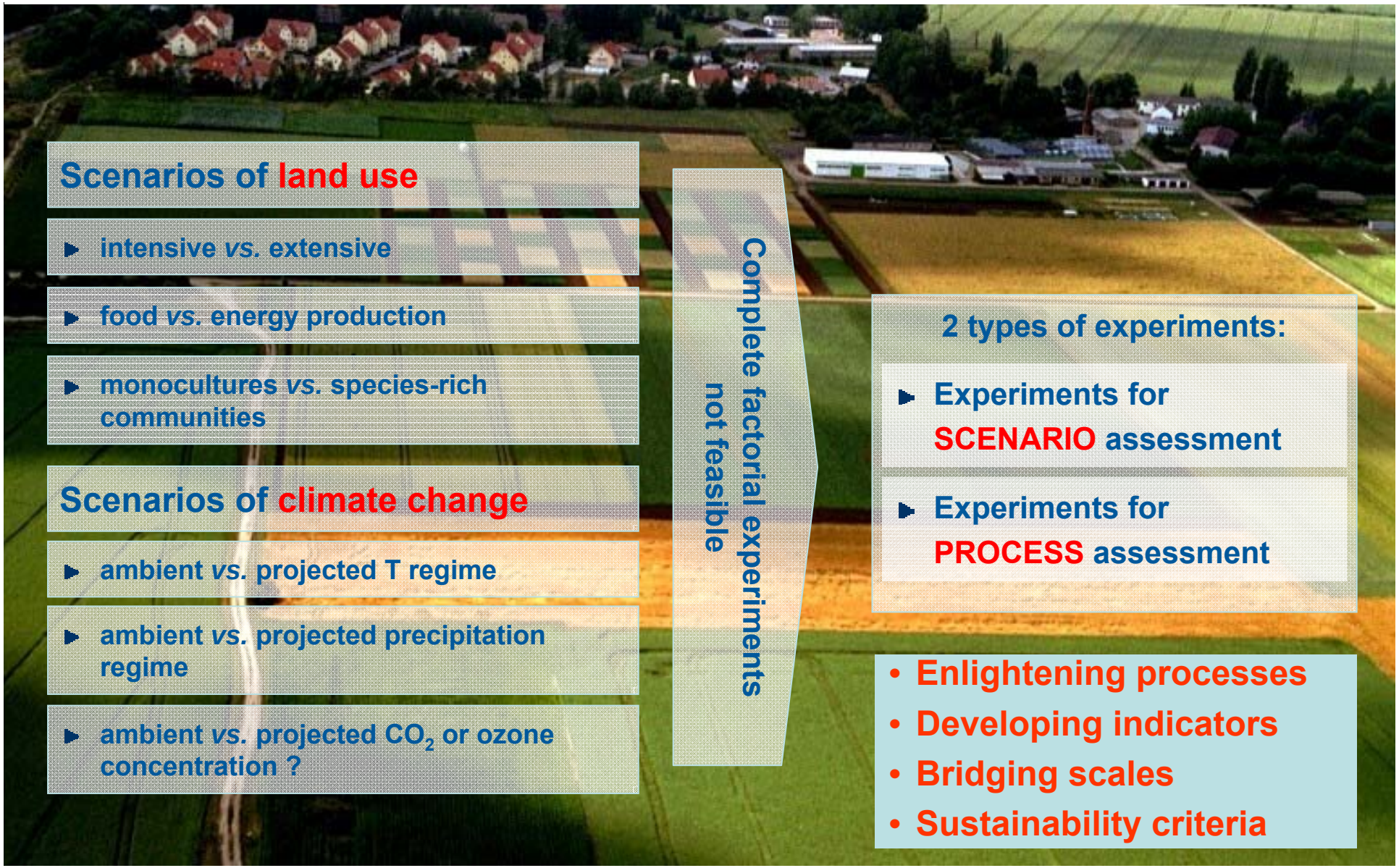
Using long term agriculture field experiments: e.g. Bad Lauchstädt (D)

From Bad Lauchstädt to a Global Change Experimental Facility (GCEF)



Acknowledgment

TERENO-Project

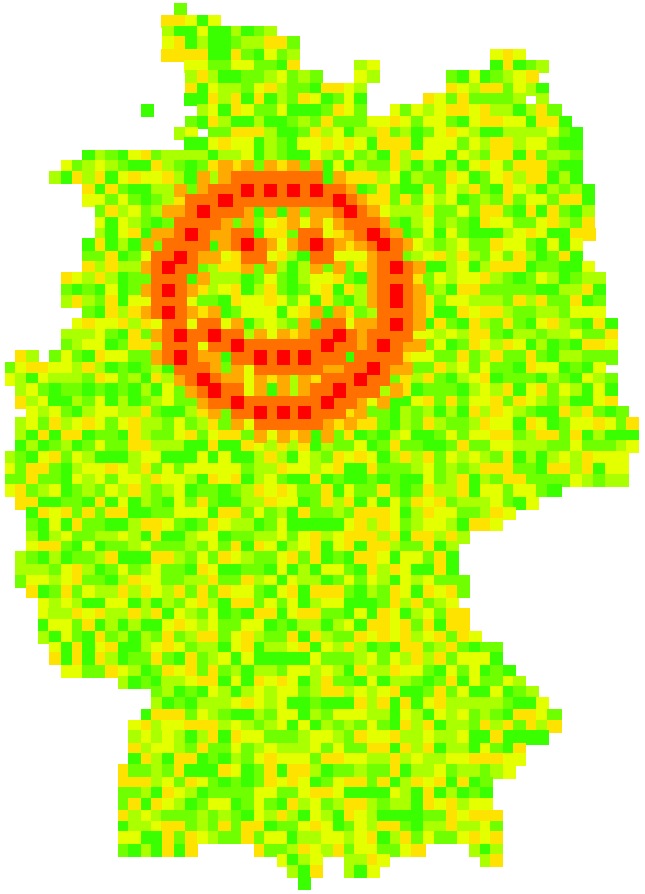
Federal Agency for Nature Conservation

Network Phytodiversity of Germany

Thousands of volunteers monitoring the German Floracollaborators

EU-Project ALARM: Assessing LArge-scale environmental risks for biodiversity with tested methods www.alarmproject.net, for

rios



Many thanks for your attention!

www.ufz.de/klimawandel-flora/

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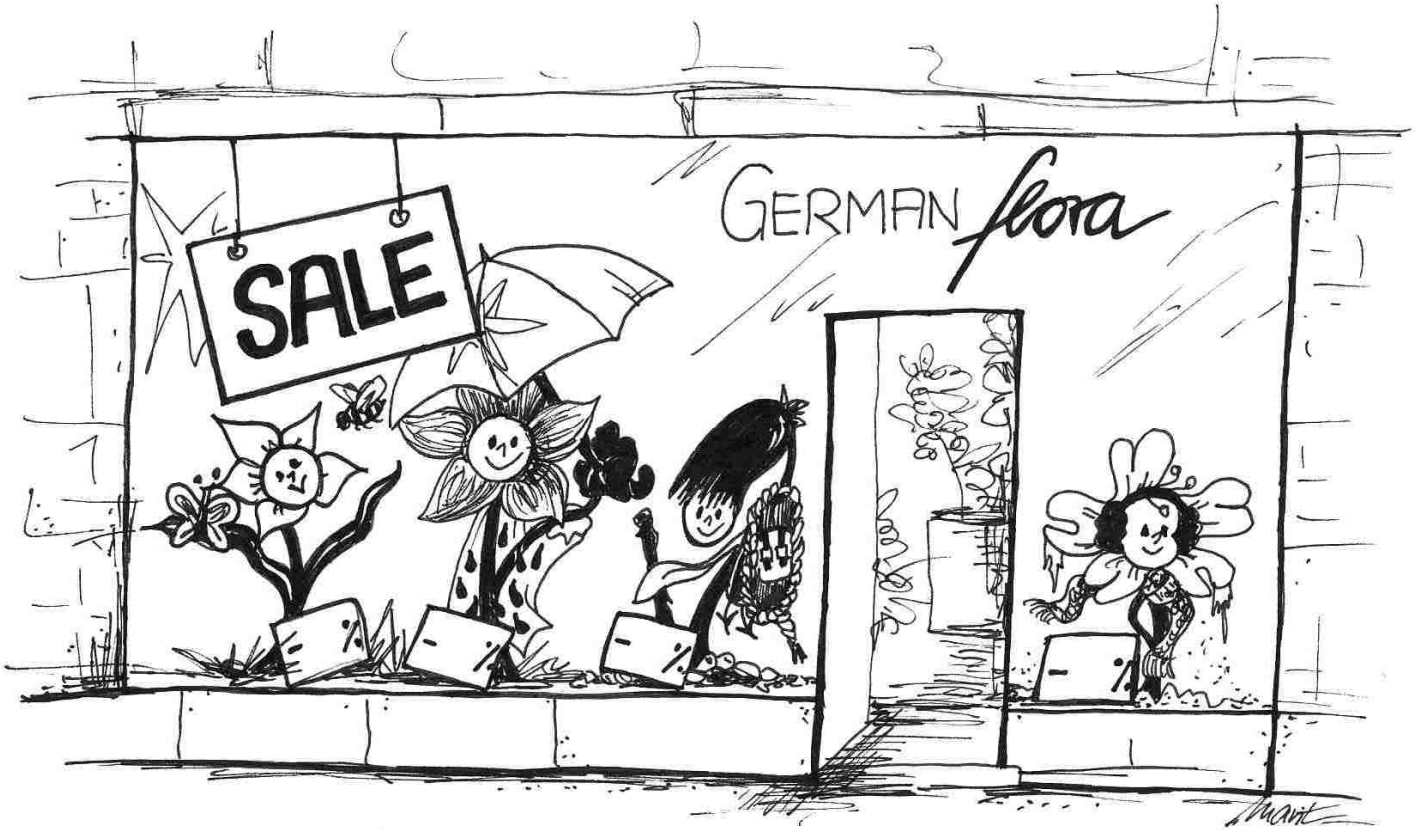

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