Climate change and biodiversity

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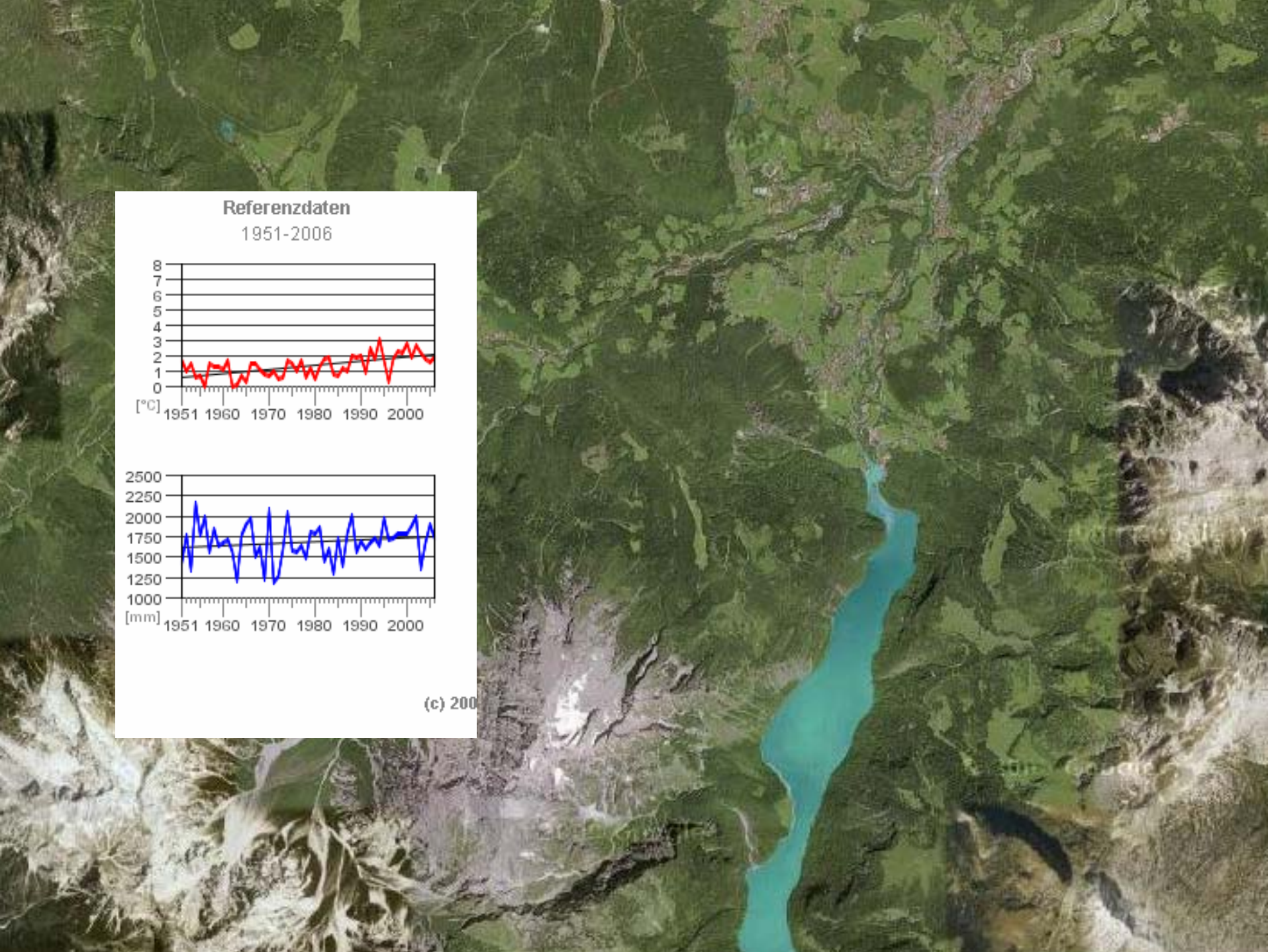
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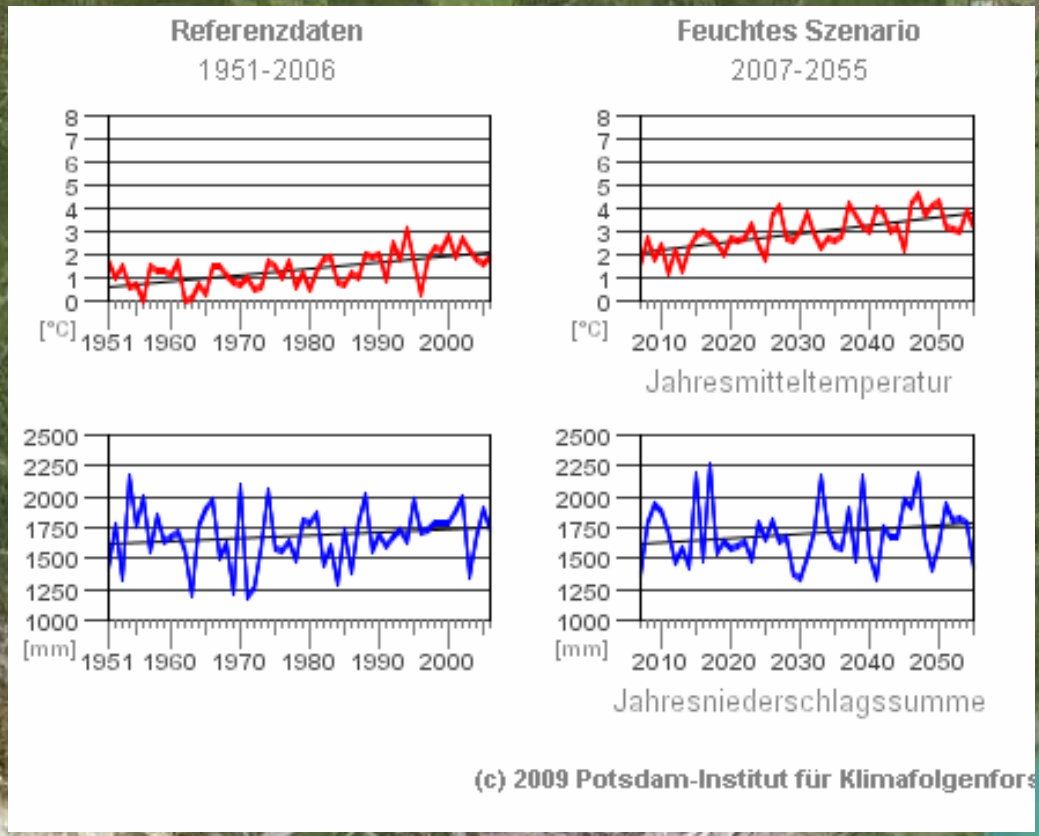
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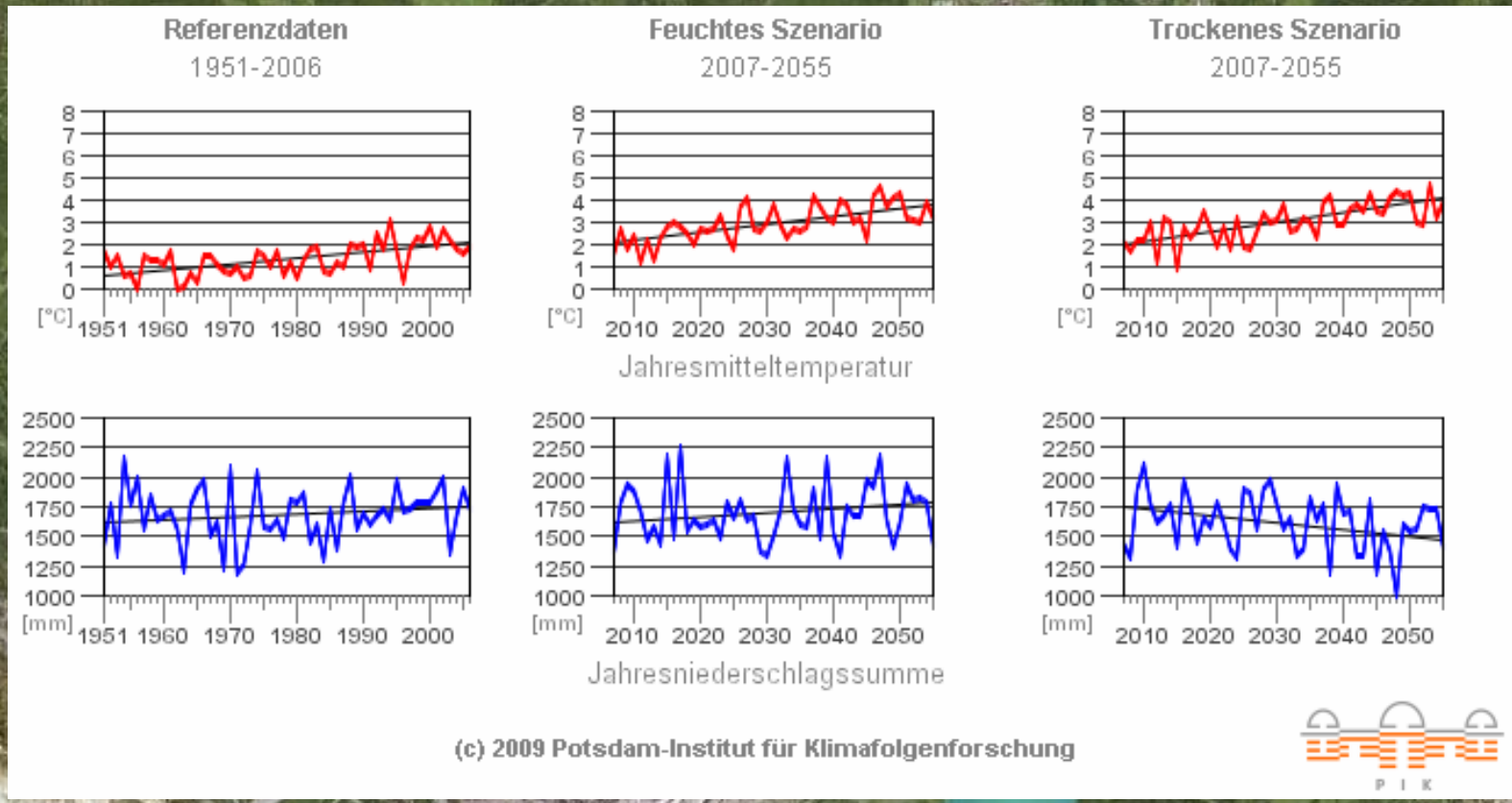
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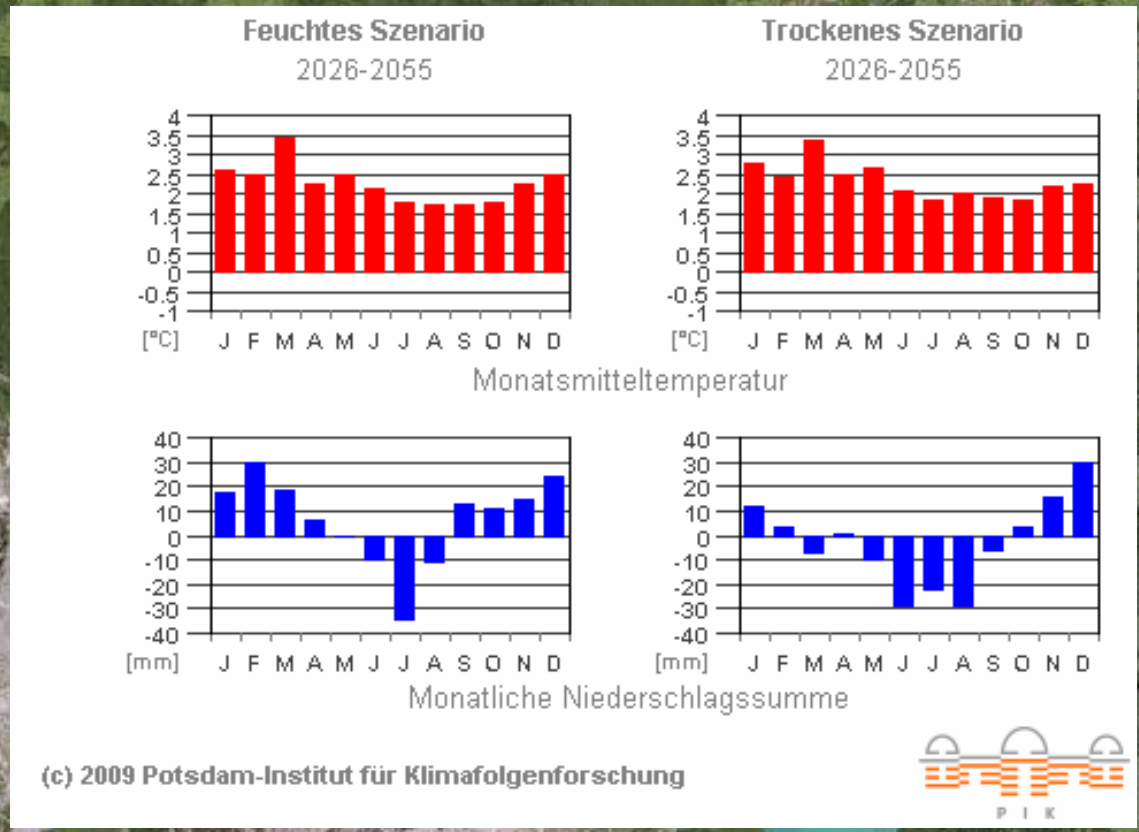
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Global climate change

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Effects on all levels of biodiversity

- Individual level (behavioural patterns)
- Population genetic level (rapid evolution)
- Species level (phenology, range shifts, extinction)
- Community level (composition, functioning)
  - Species interactions
  - Ecosystem services

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Effects on all levels of biodiversity

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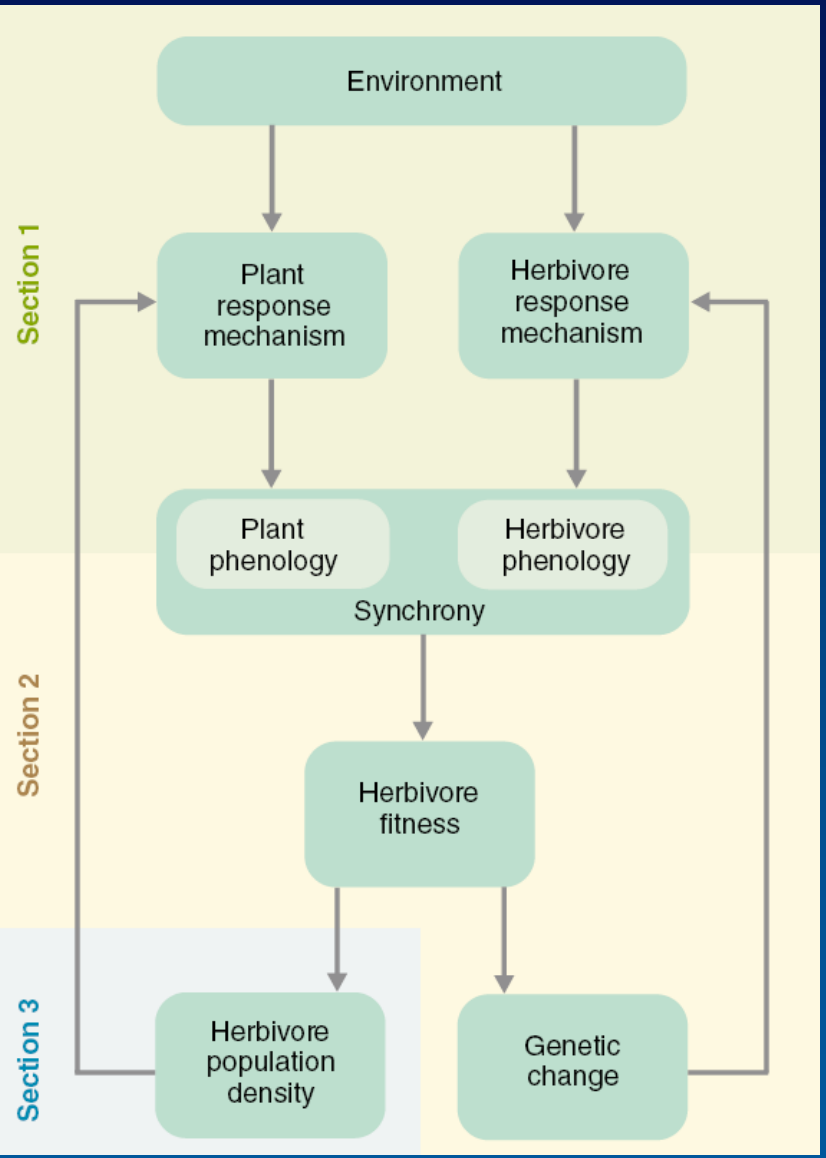
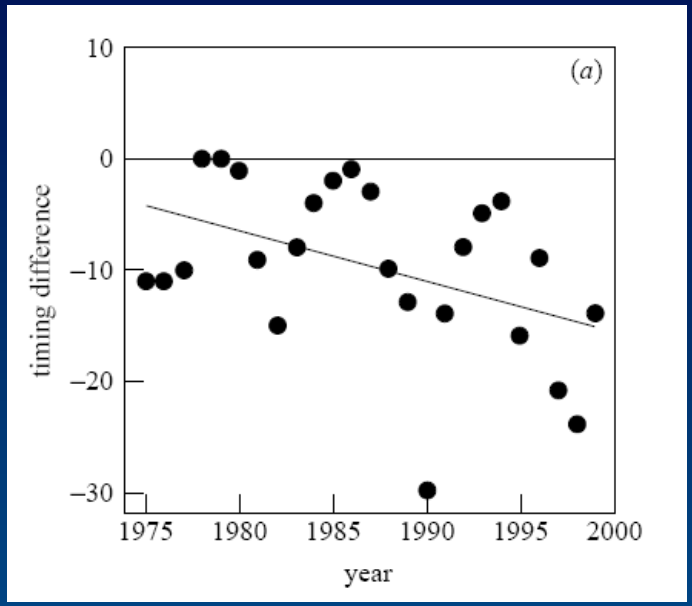
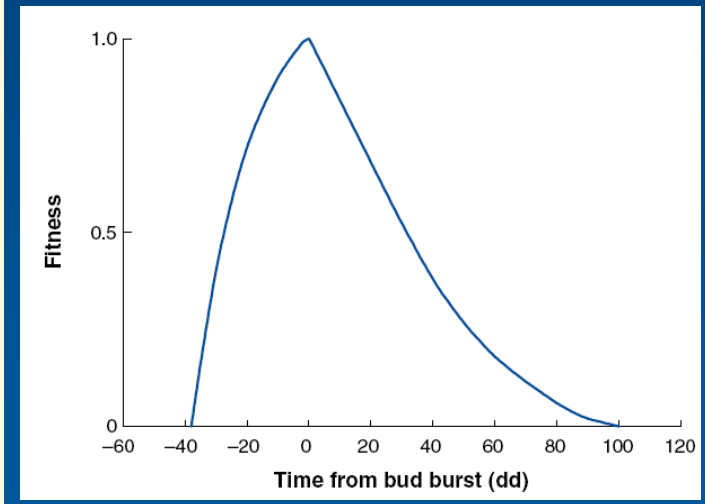
Rapid evolution - Phenology



Van Asch & Visser 2007, Annu Rev Entomol



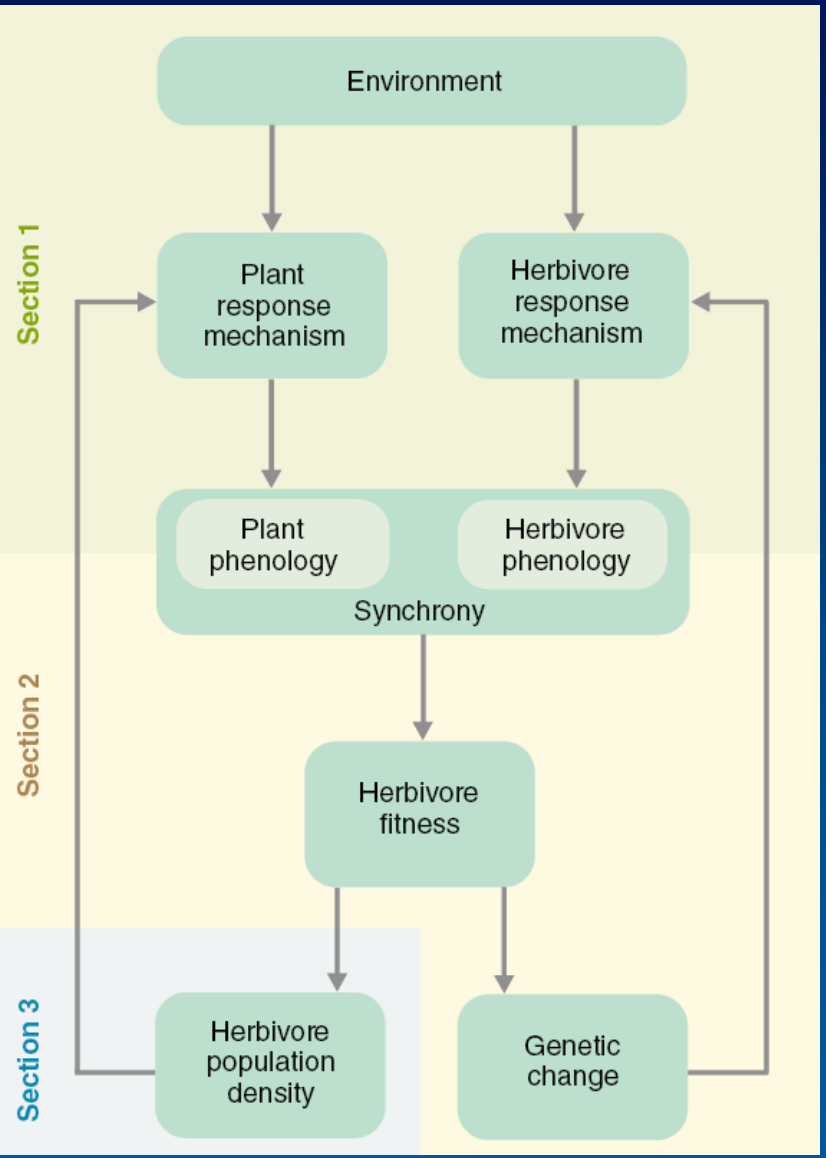
Winter moth egg hatch date has advanced more than bud burst data of pedunculate oak



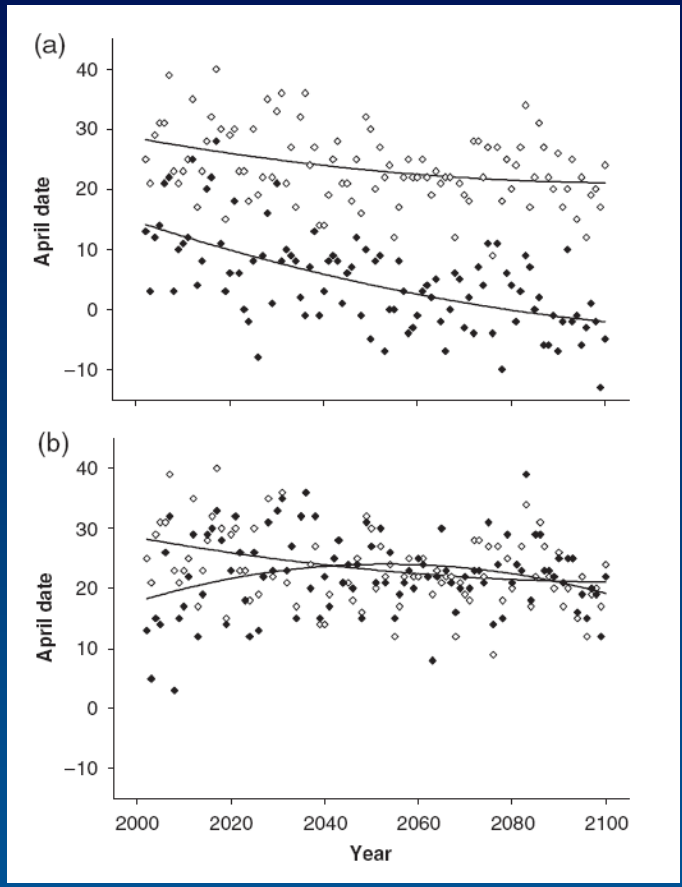
Temporal mismatches have severe fitnes consequences

Visser & Holleman 2001, Proc R Soc B

Rapid evolution - Phenology



Van Asch & Visser 2007, Annu Rev Entomol



Van Asch et al. 2007, Global Change Biology

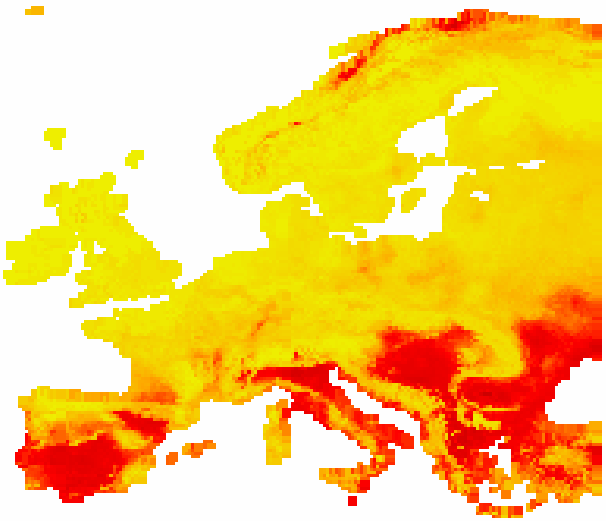
Without adaptation the mismatching will increase

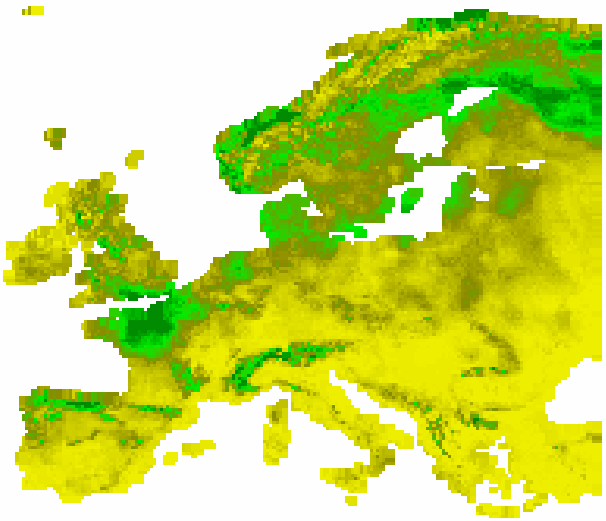
With adaptation synchrony will be restored

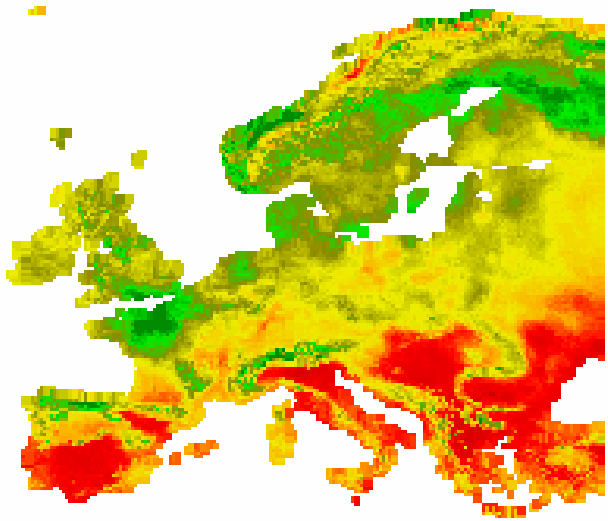
Rapid evolution
Is adaptation possible?

- European butterfly *Aricia agestis*
- Northern range restricted to the host plant *Helianthemum chamaecistus*
- Furhter south, also feeds on *Geranium* and *Erodium*
- In northern areas, *Geranium* habitat were too cool.
- During the last 20 years *Geranium* habitats seem warm enough to be colonised
- Local diet evolution
- Further expansion to the north where *Helianthemum* is absent

Species level – range shifts







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Ecological niche modelling

- Climate envelope modelling
- Species distribution modelling
- Habitat modelling

- Mathematical relationship between a species' distribution and environmental factors
- Assess aspects of a species' ecological niche
- Understand current distribution patterns
- Project future risks of changes

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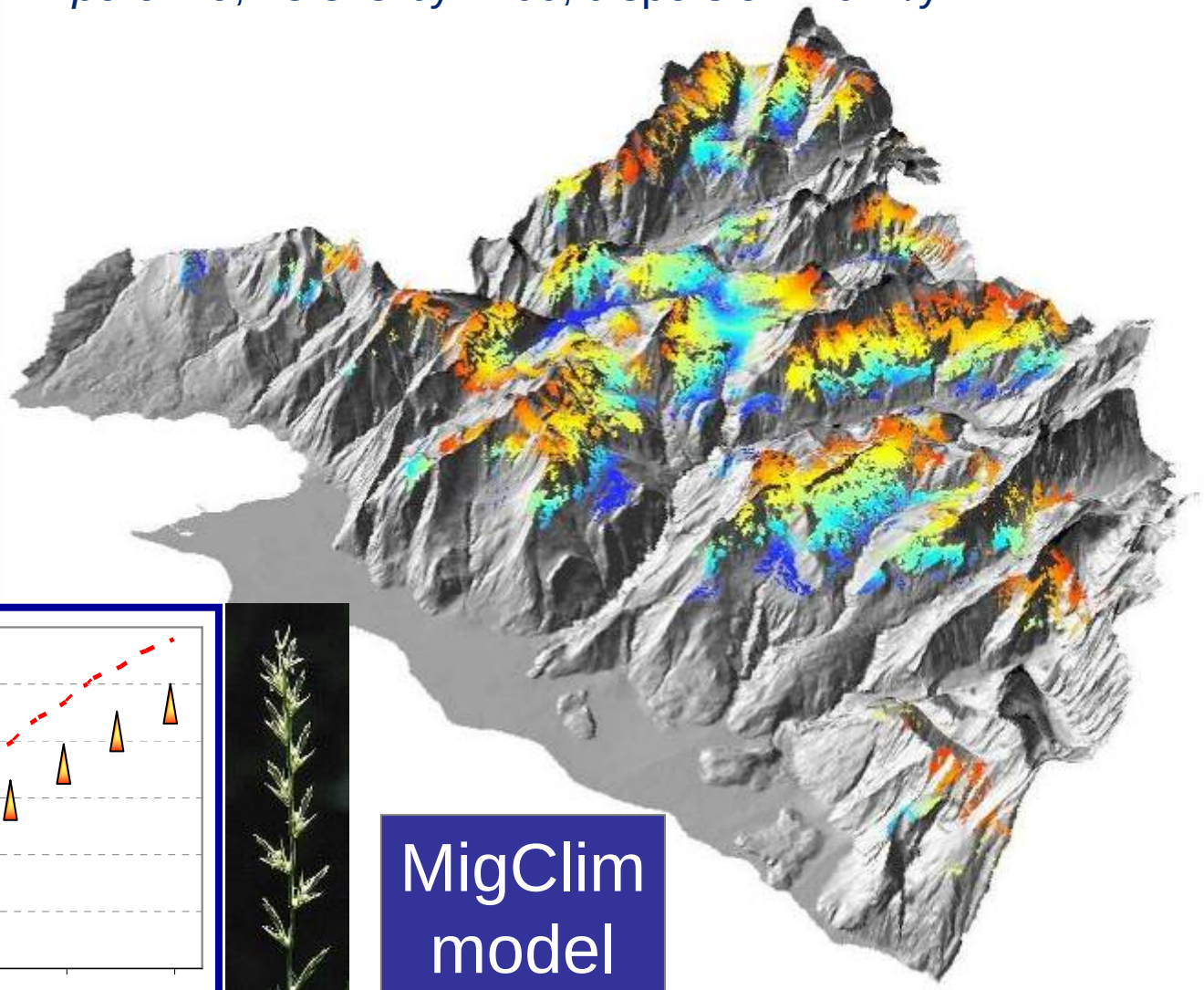
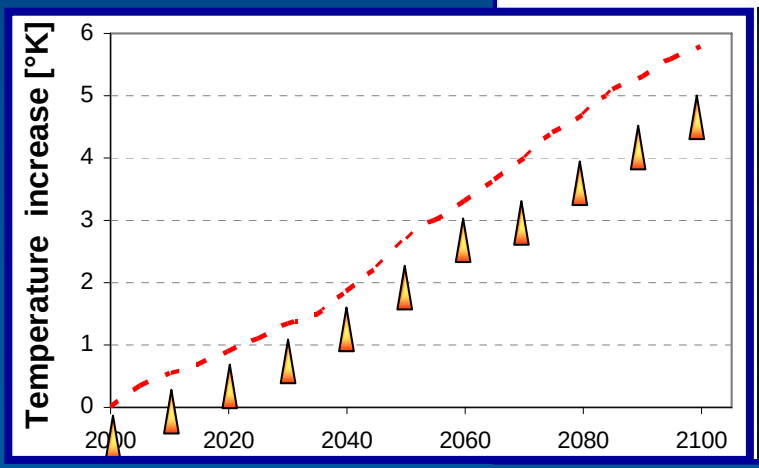
Climate change – future species loss

Colonized surface per 5 years

2000	2050
2005	2055
2010	2060
2015	2065
2020	2070
2025	2075
2030	2080
2035	2085
2040	2090
2045	2095
	2100

L. perenne, +5.8°C by 2100, dispersion: 40 m/yr





MigClim model

Engler & Guisan (in review), Engler et al. (to be submitted)

The overarching aim of the atlas is to communicate the potential risks of climatic change to the future of European butterflies. The main objectives are to: (1) provide a visual aid to discussions on climate change risks and impacts on biodiversity and thus contribute to risk communication as a core element of risk assessment; (2) present crucial data on a large group of species which could help to prioritise conservation efforts in the face of climatic change; (3) reach a broader audience through the combination of new scientific results with photographs of all treated species and some straight forward information about the species and their ecology.

The results of this atlas show that climate change is likely to have a profound effect on European butterflies. Ways to mitigate some of the negative impacts are to (1) maintain large populations in diverse habitats; (2) encourage mobility across the landscape; (3) reduce emissions of greenhouse gasses; (4) allow maximum time for species adaptation; (4) conduct further research on climate change and its impacts on biodiversity.

The book is a result of long-term research of a large international team of scientists, working at research institutes and non-governmental organizations, many within the frame work of projects funded by the European Commission. It is published as Special Issue 1 of BioRisk, a new open-access journal of biodiversity and environmental sciences. It addresses conservationists working in research and/or policy making, ecologists, climatologists, biogeographers, entomologists, and members of the public society who care about the worrying trends in changes to the world's climate and nature.

BioRisk 1 (Special Issue) www.pensoftonline.net/biorisk

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MACIS

ALARM

European Environment Agency

Butterfly CONSERVATION EUROPE

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On the front cover:
Thymelicus lineola (Hesperiidae).
Actual and modeled (2050) distributions.
Photo by Chris van Swaay

Climatic Risk Atlas of European Butterflies

J. Settele
O. Kudrna
A. Harpke
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I. Wynhoff
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PENSOFT

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Special Issue

PENSOFT

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Climatic risks for European butterflies

- Climate envelope models (~ 300 species)
  - Accumulated growing degree days
  - Soil water content
  - Ranges in annual temperature
  - Ranges in annual precipitation

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Climatic risks for European butterflies

- Three future scenarios (ALARM)
  - SEDG (SRES B1): moderate change; 2.4°C until 2080
  - BAMBU (SRES A2): intermediate change; 3.1°C until 2080
  - GRAS (SRES A1FI): maximum change; 4.1°C until 2080
- 2050 and 2080

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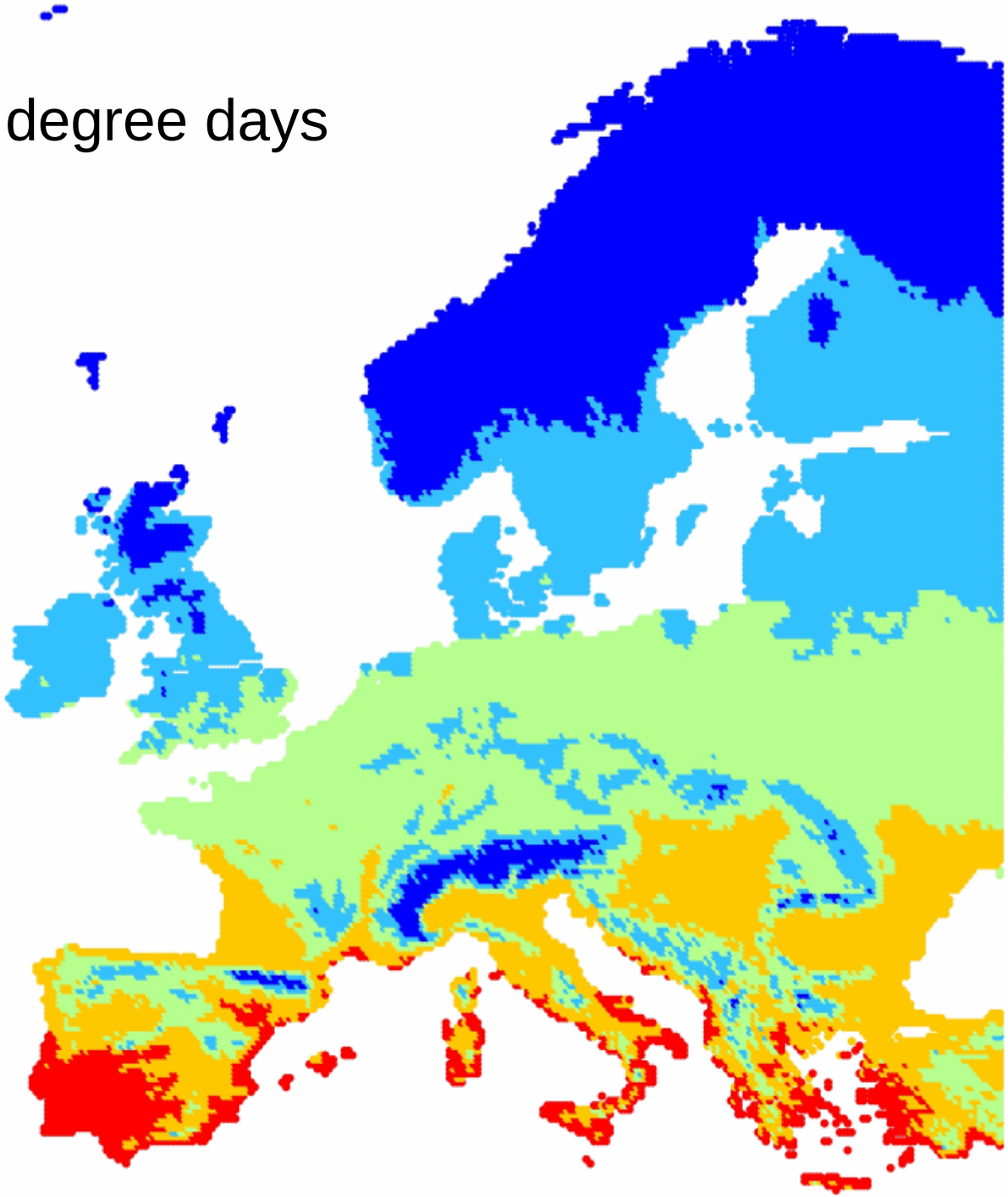
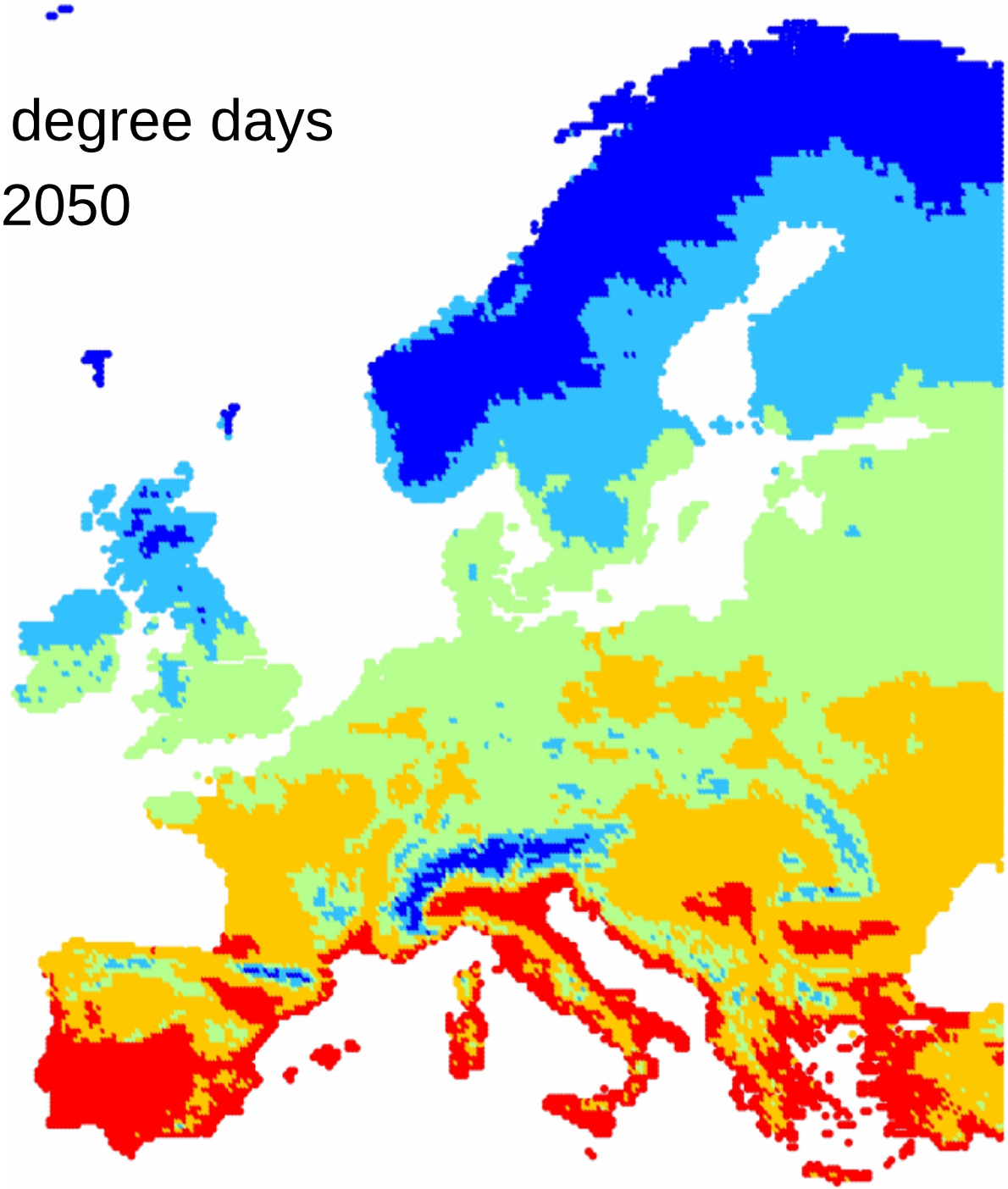
Growing degree days

2000



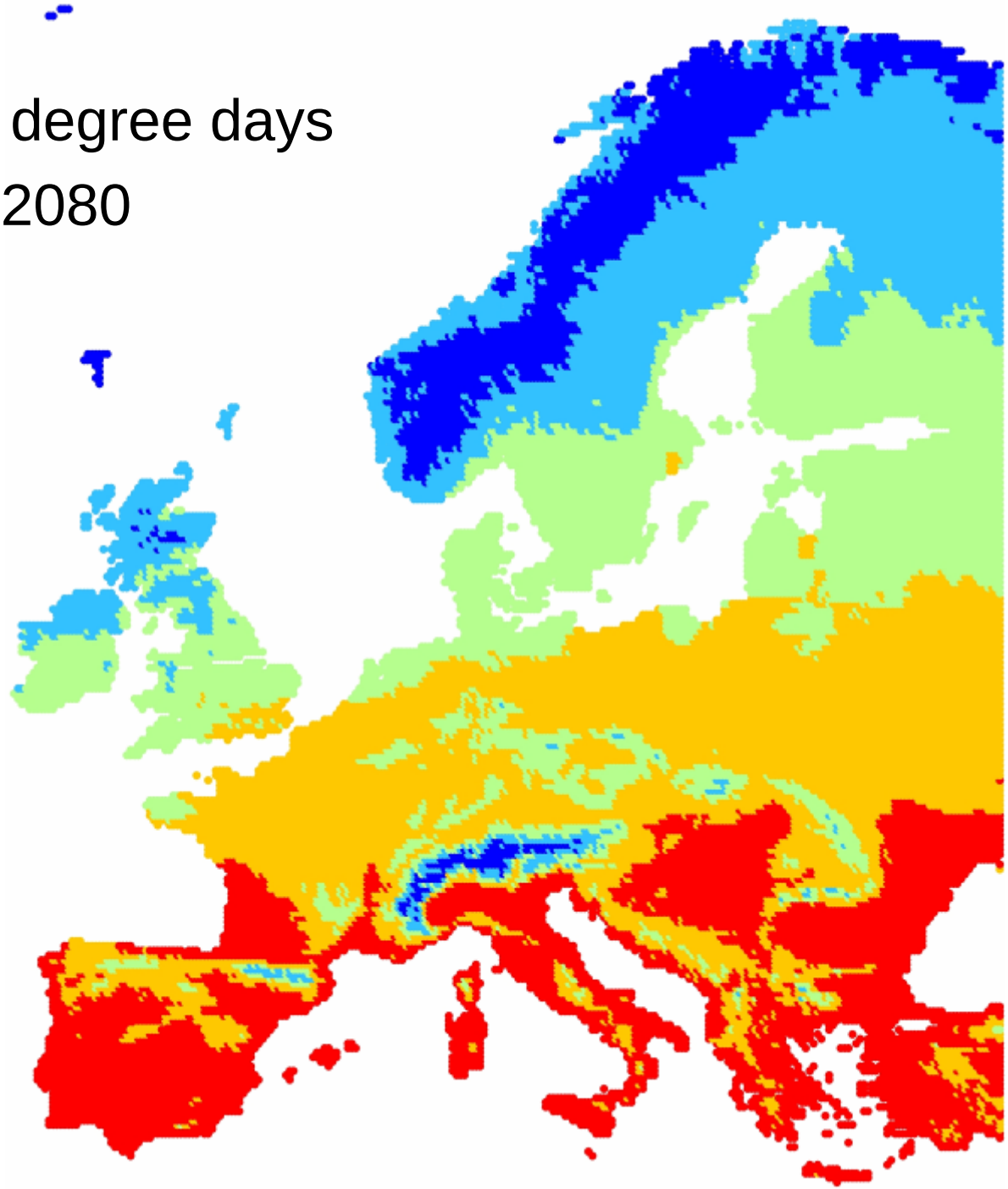
Growing degree days

BAMBU 2050



Growing degree days

BAMBU 2080



Winners and losers …

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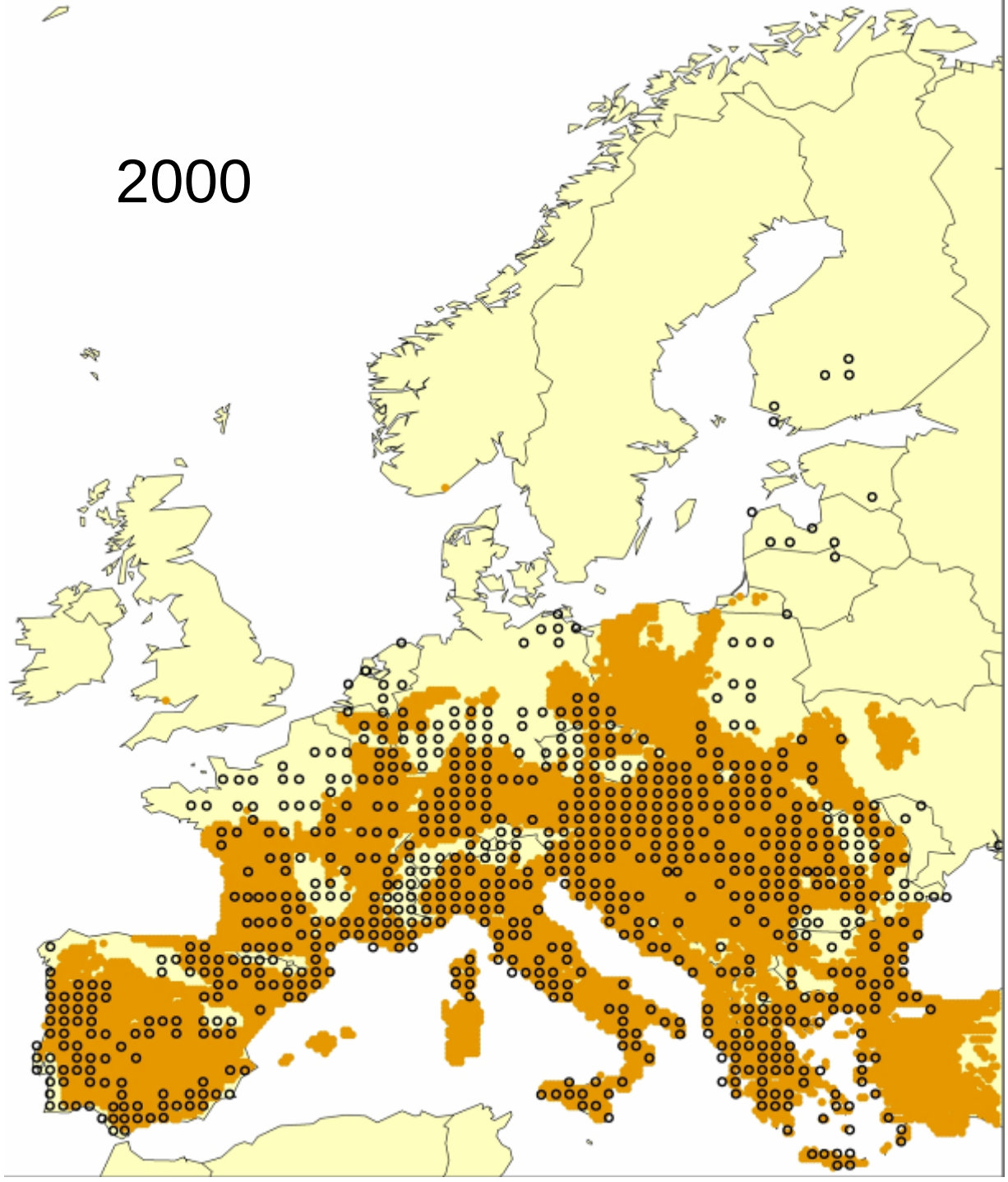
WINNER!

Scarce Swallowtail (*Iphiclides podalirius)* © Chris van Swaay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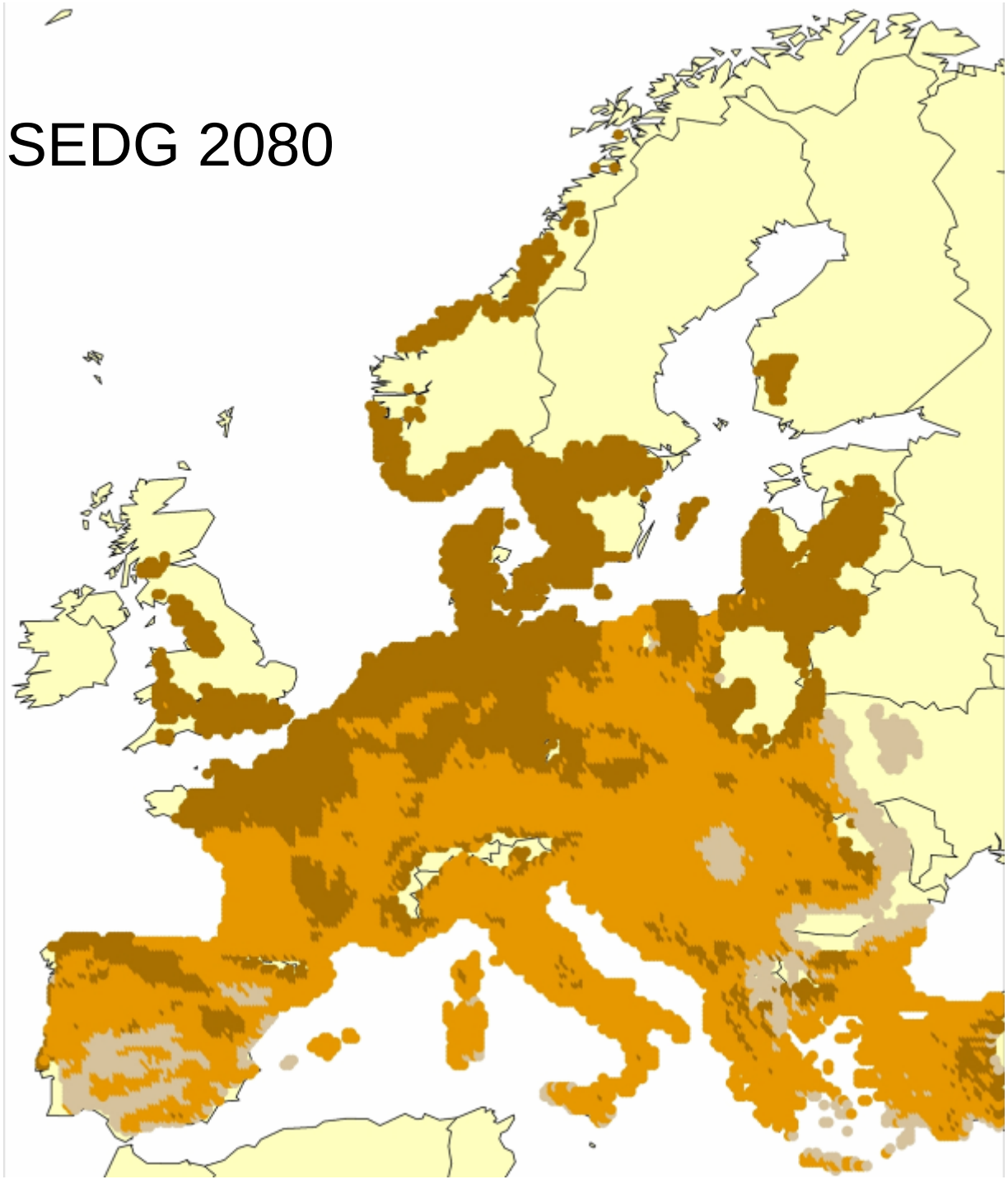
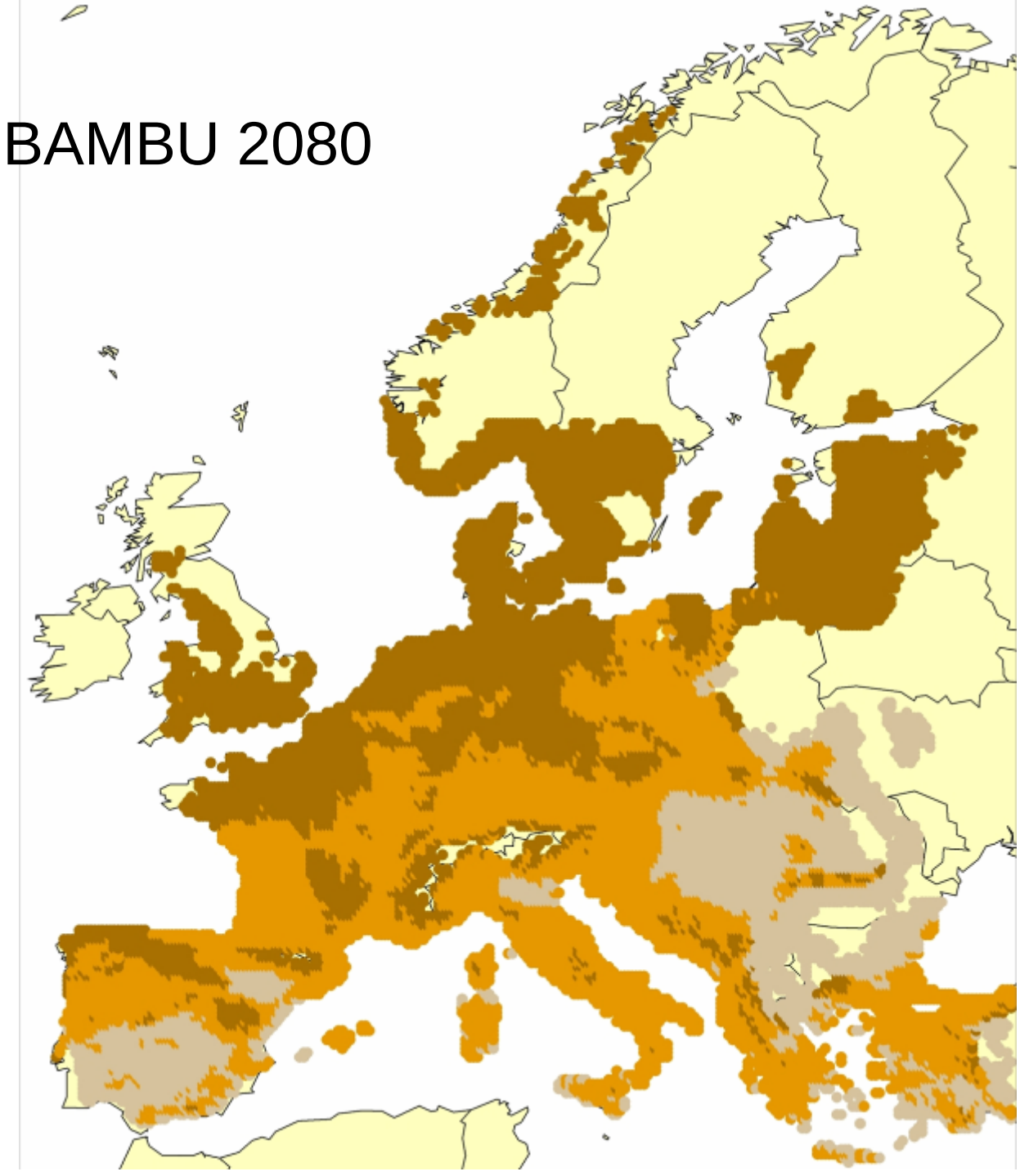

SEDG 2080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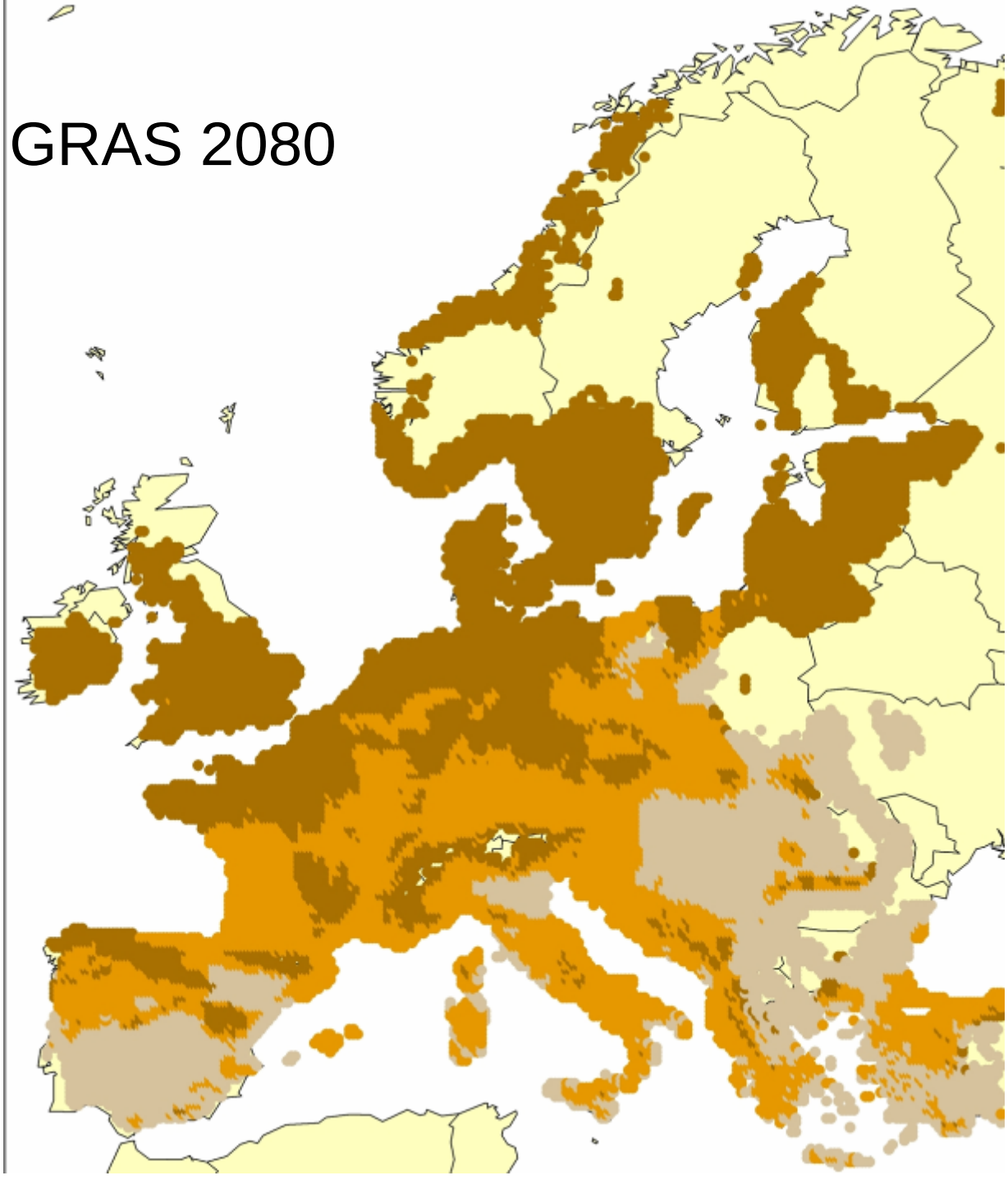
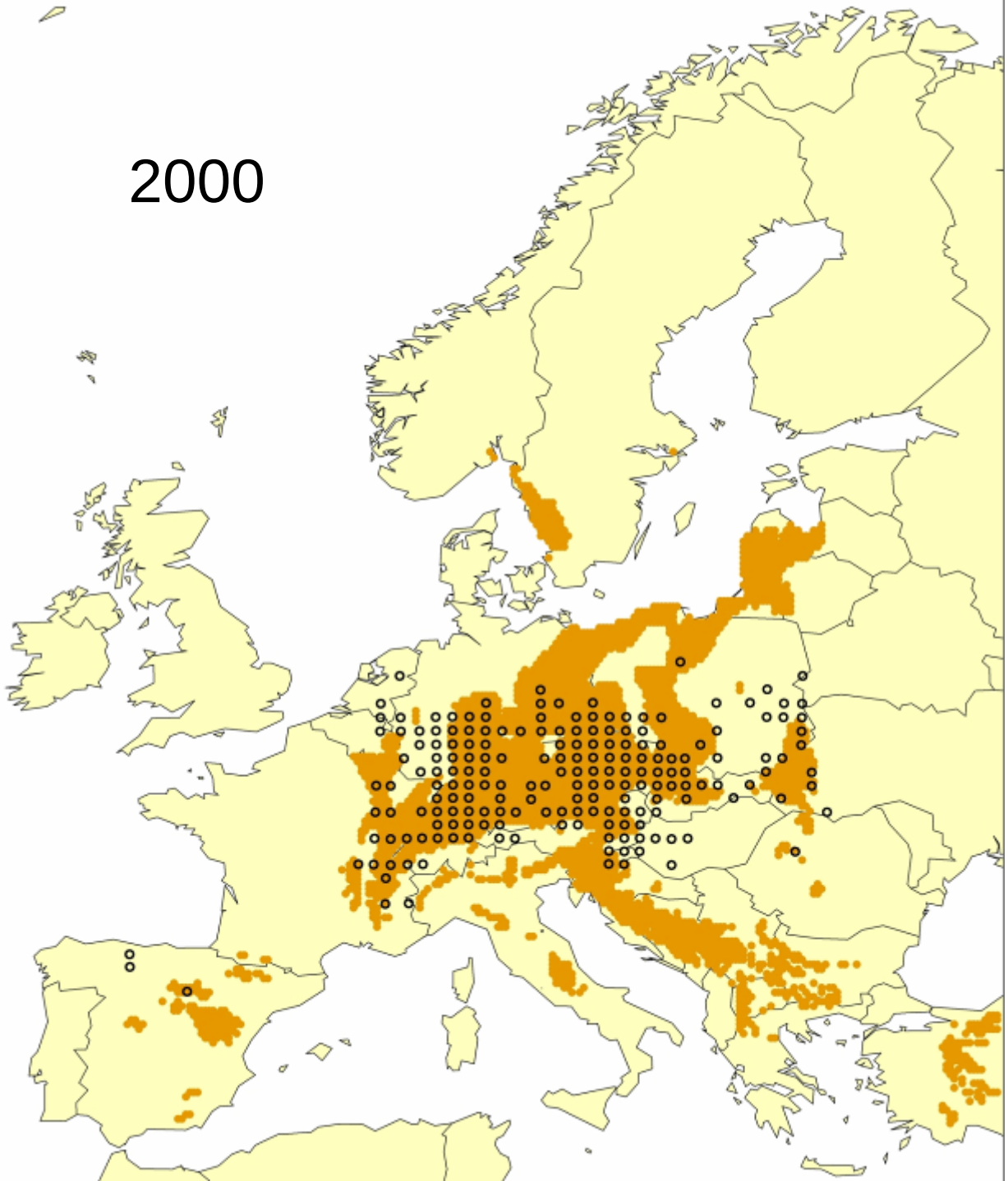

GRAS 2080

LOSER!

Dusky Large Blue (*Phengaris nausithous*) © Josef Settele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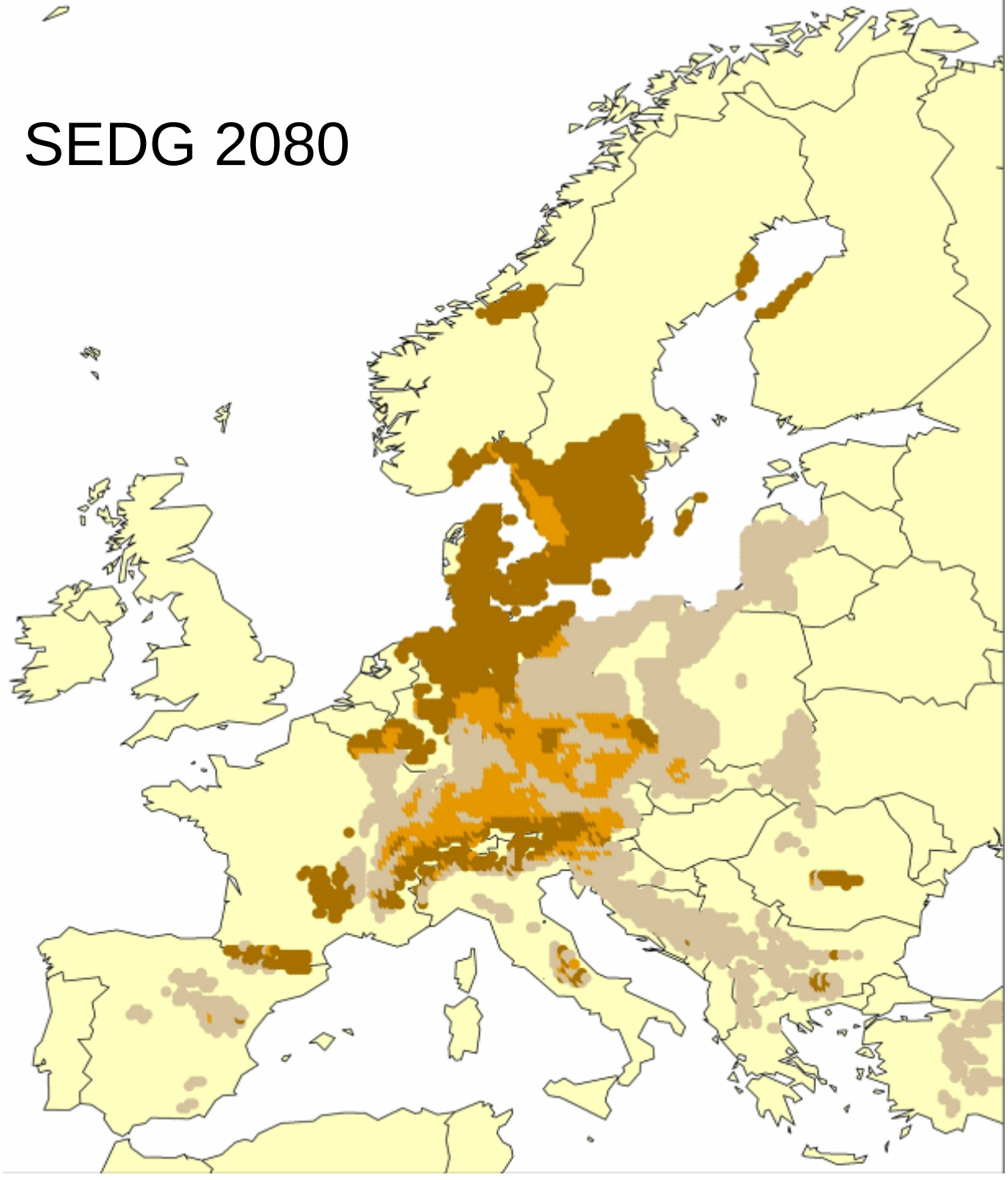
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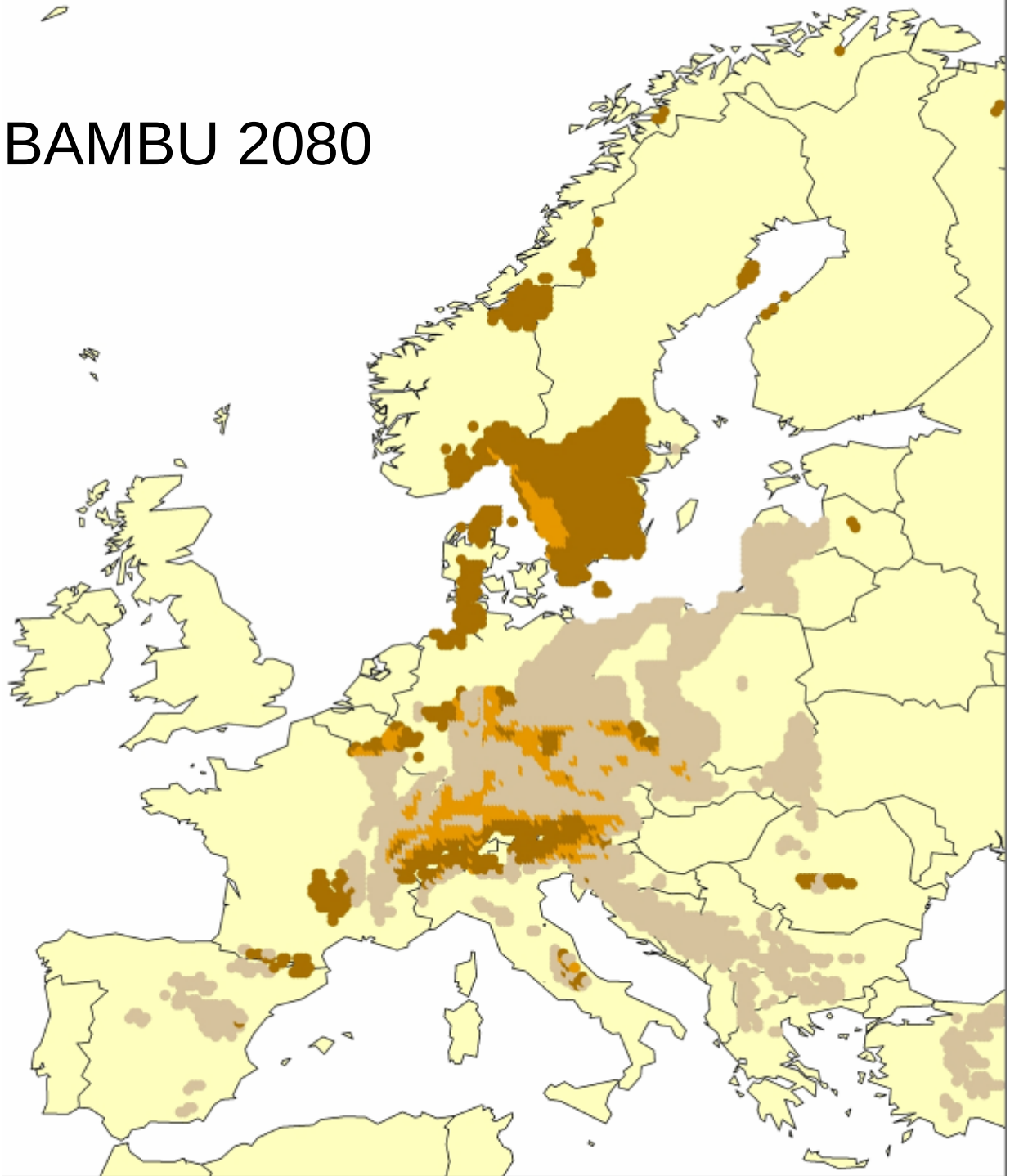
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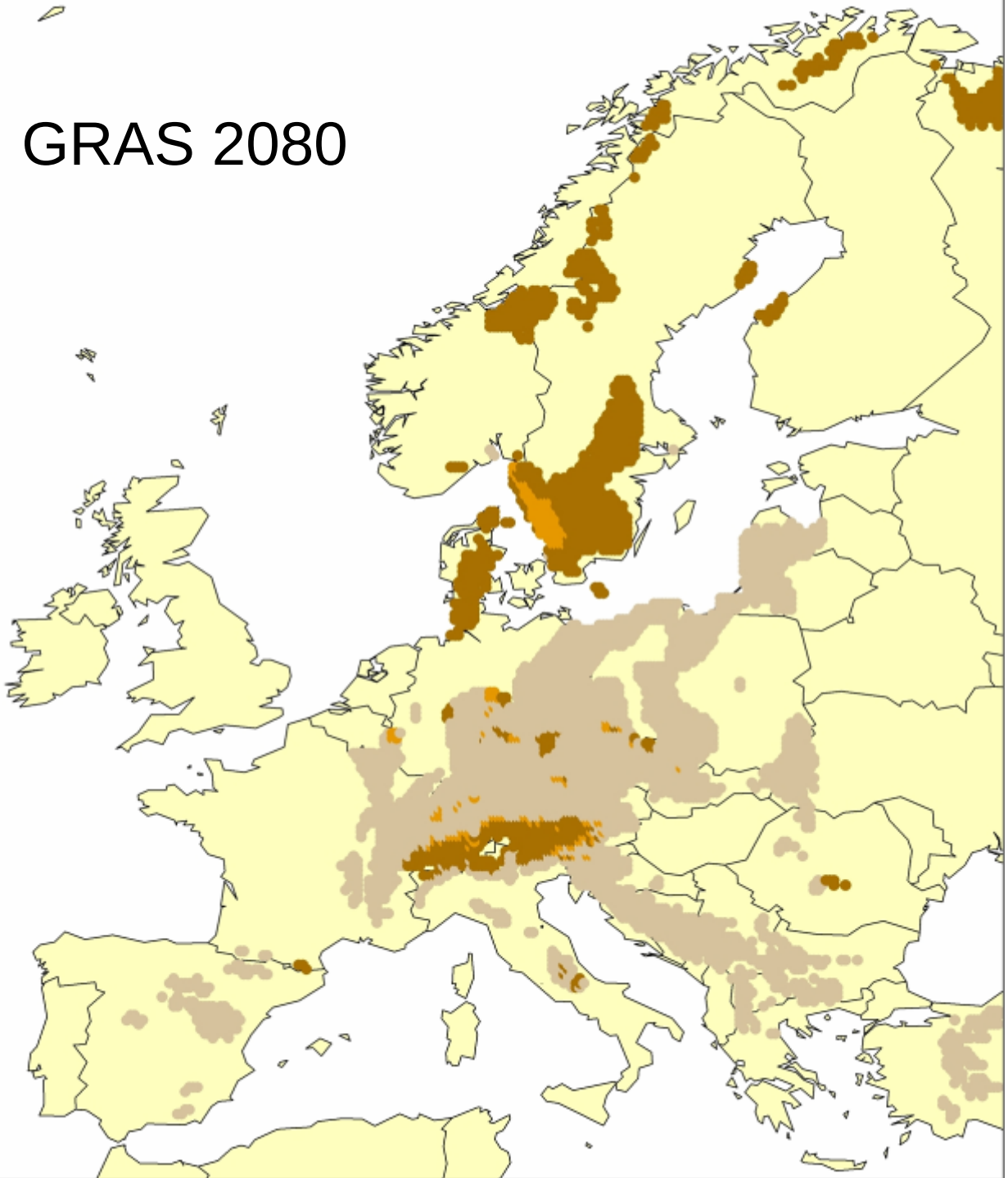
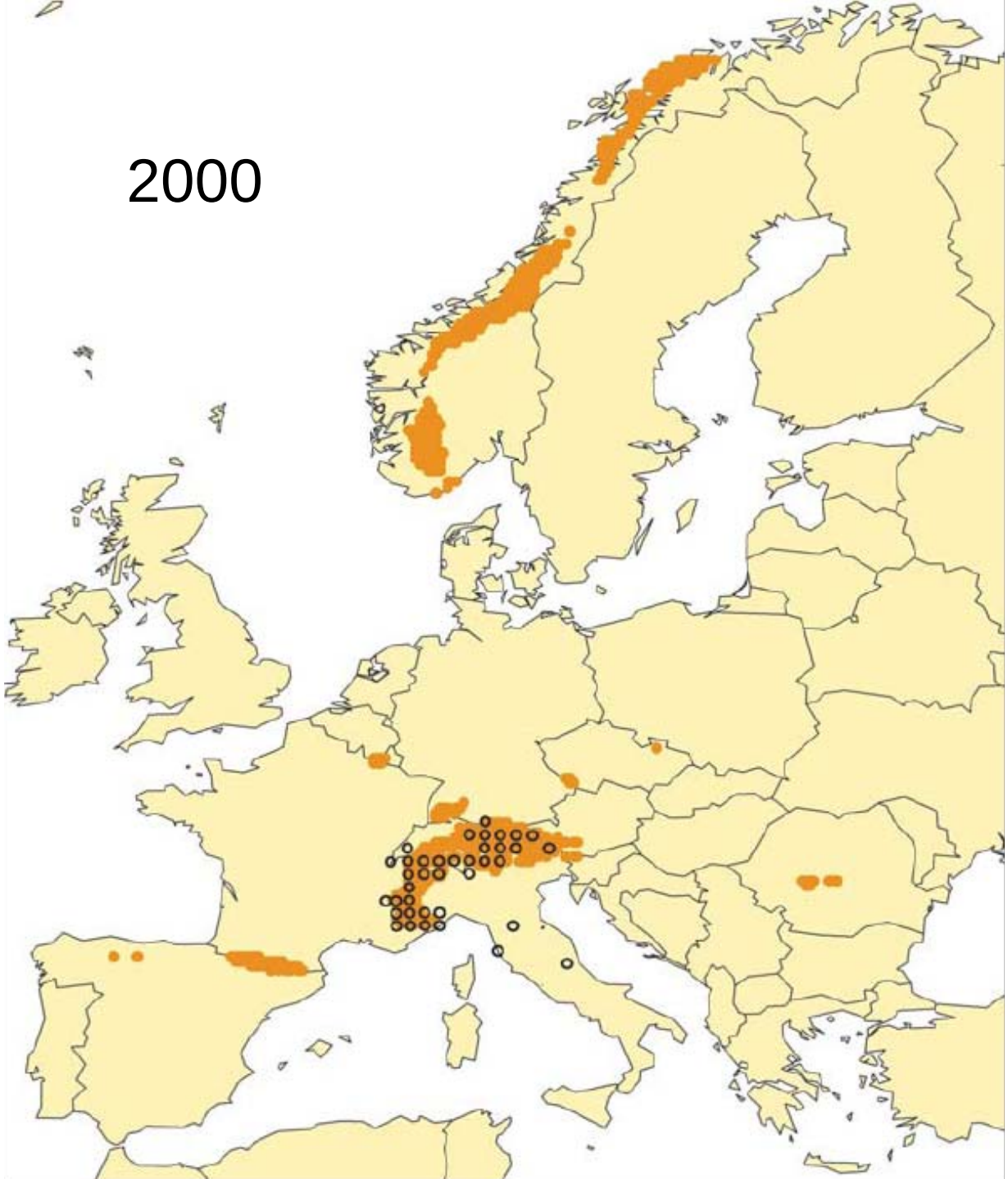

GRAS 2080

Marbled Ringlet (*Erebia montana*)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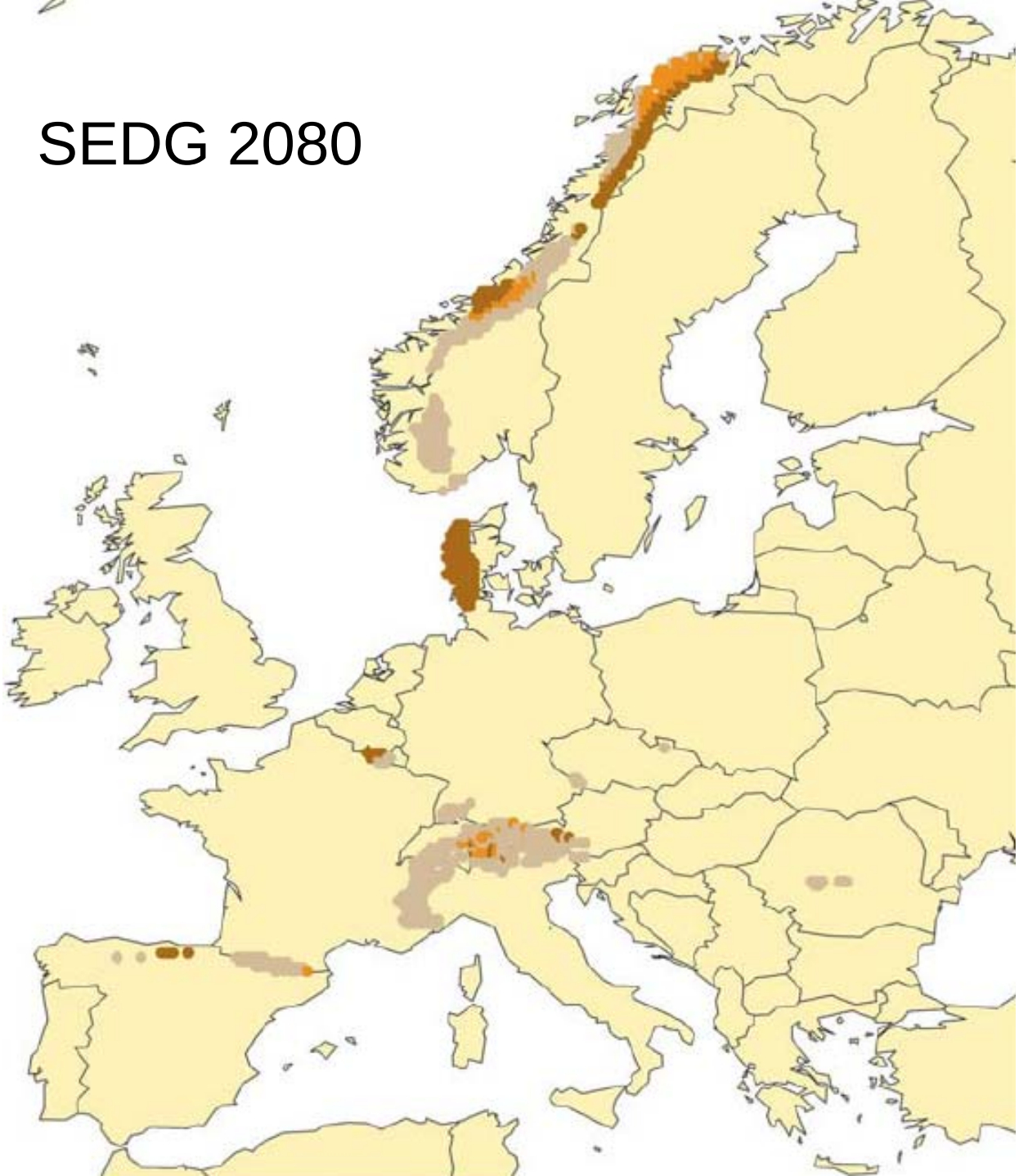
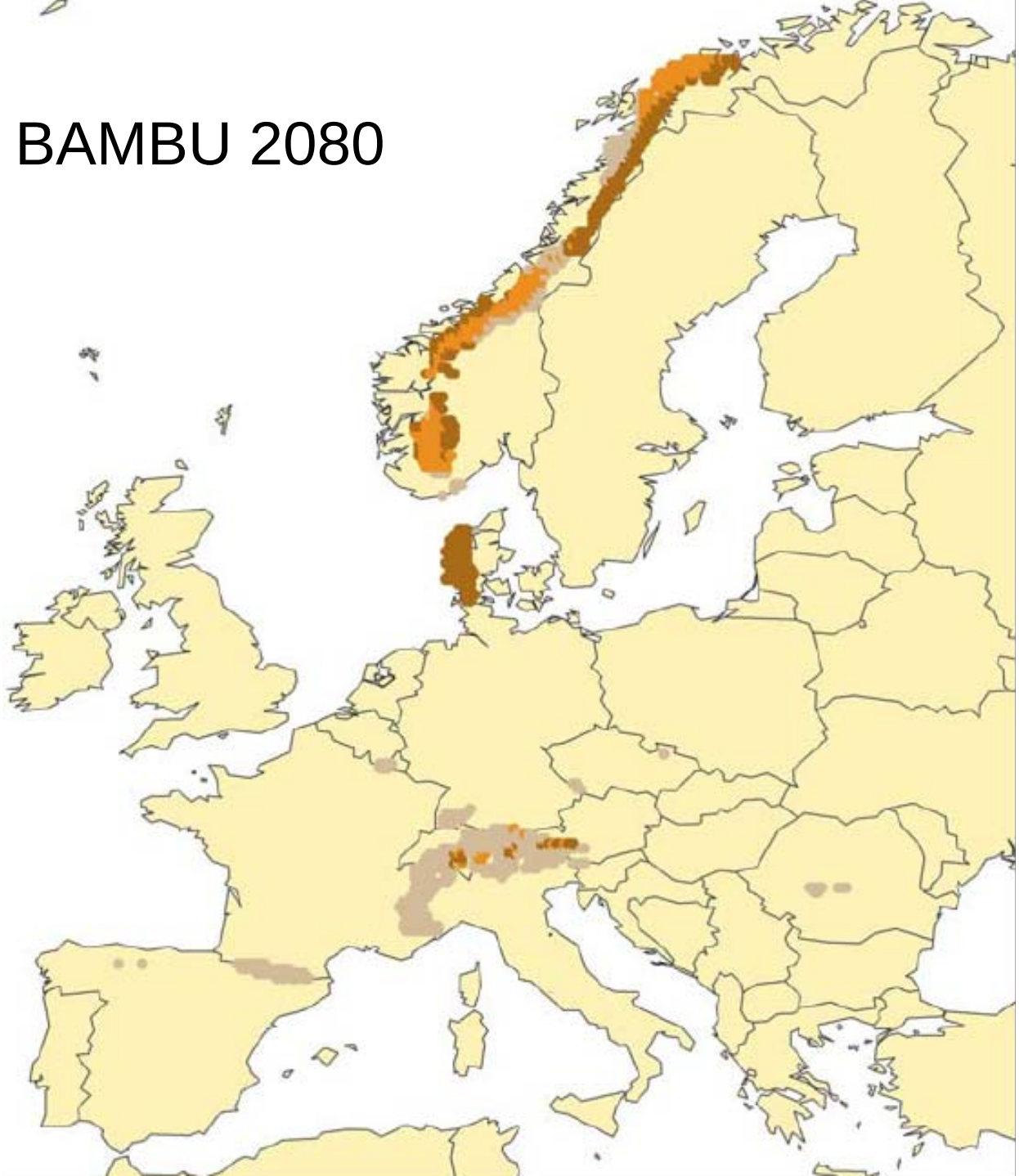
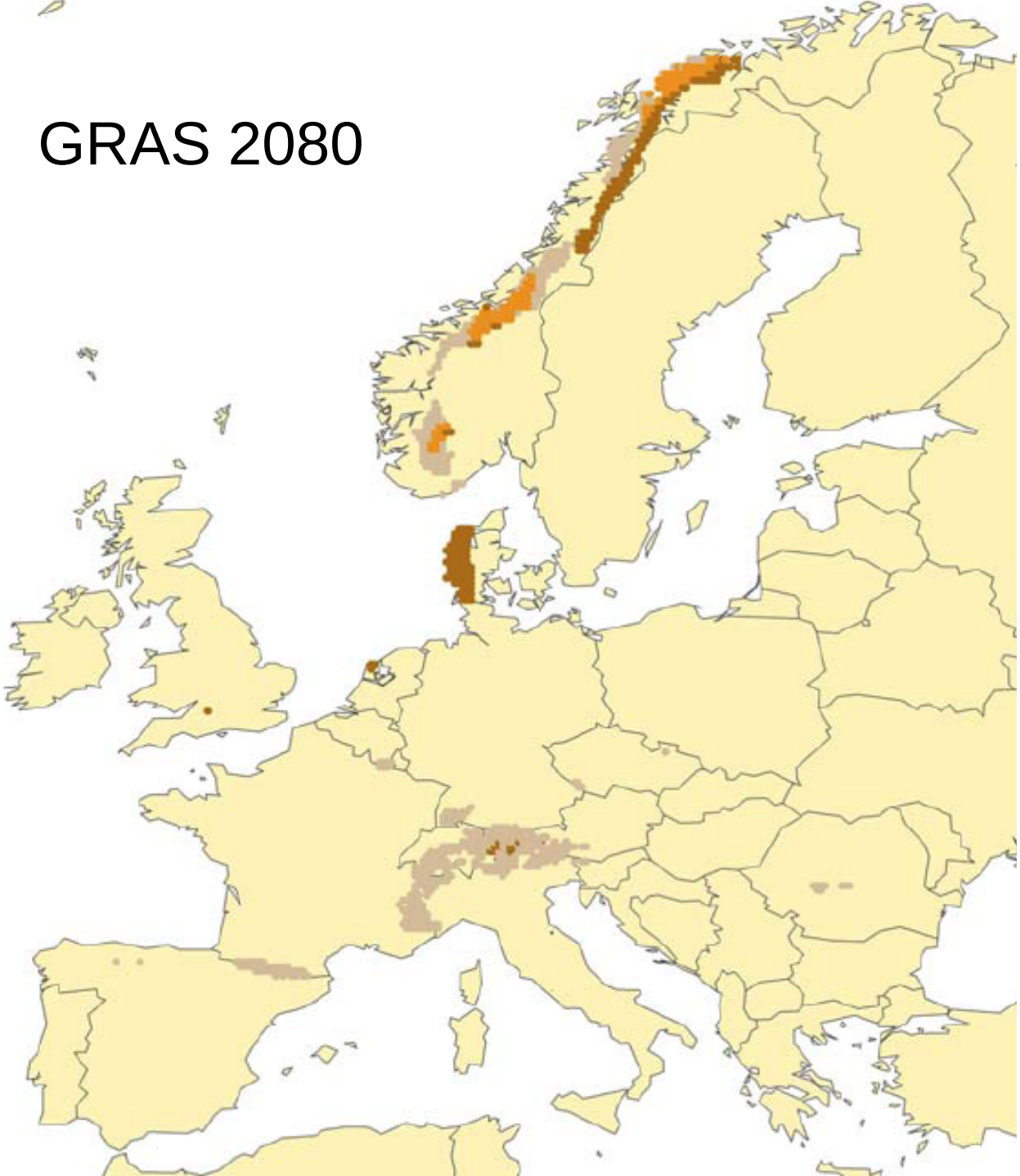
SEDG 2080



BAMBU 2080




GRAS 2080

Climatic risks for European butterflies

- More losers than winners
- 70-80% reduced range

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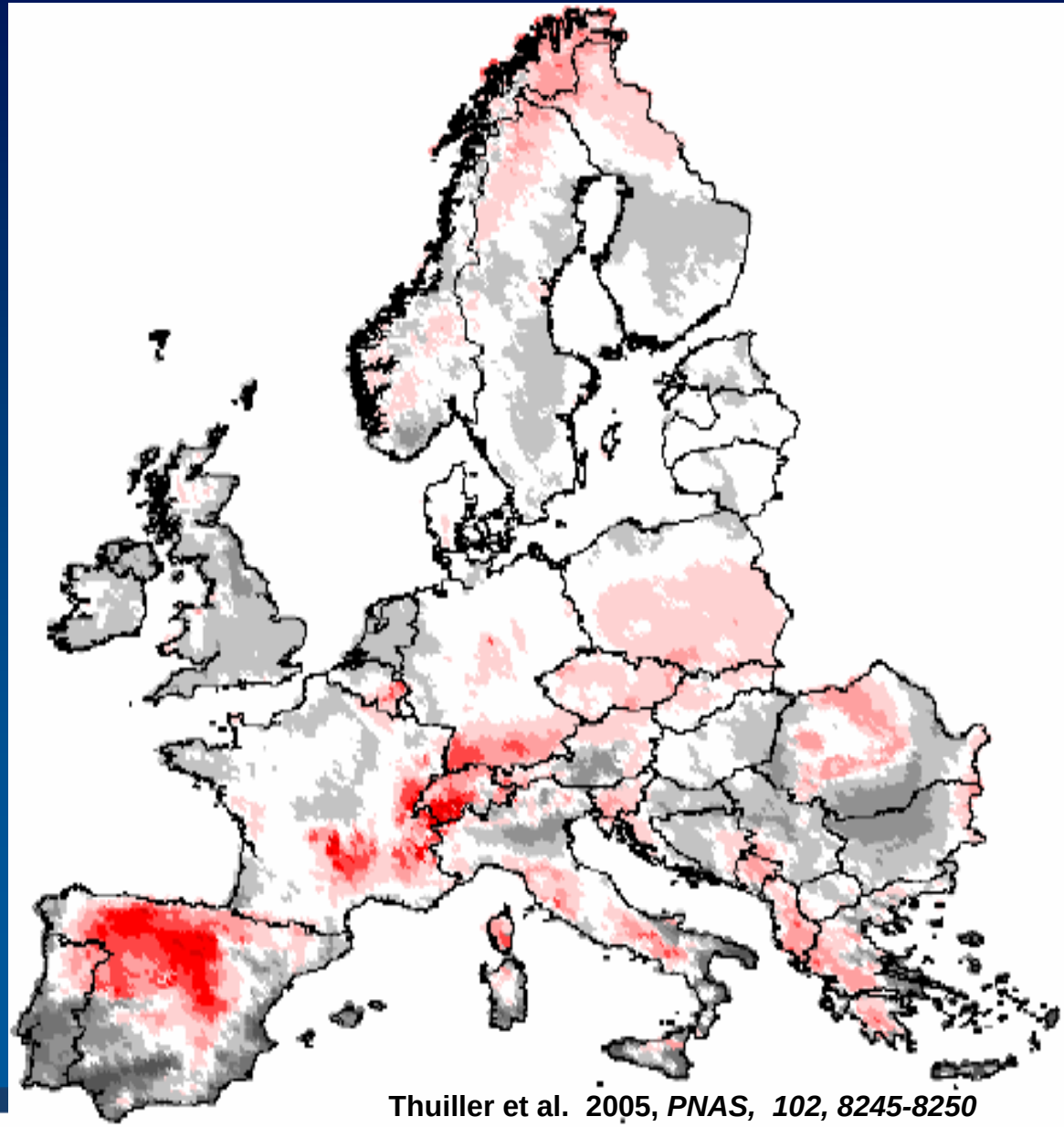
Consistent loss across organisms

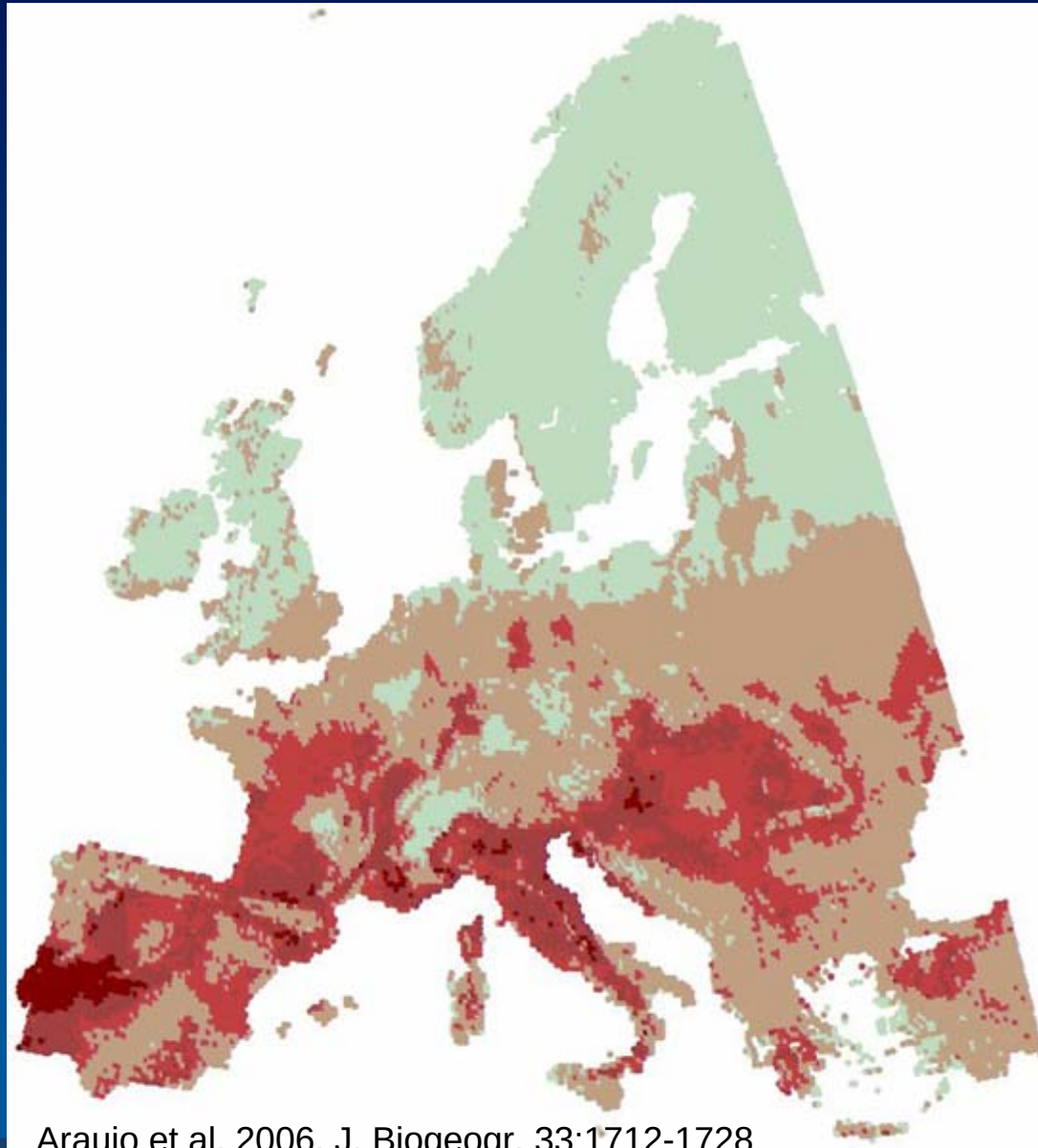
- Plants



Thuiller et al. 2005, *PNAS, 102, 8245-8250*

Consistent loss across organisms

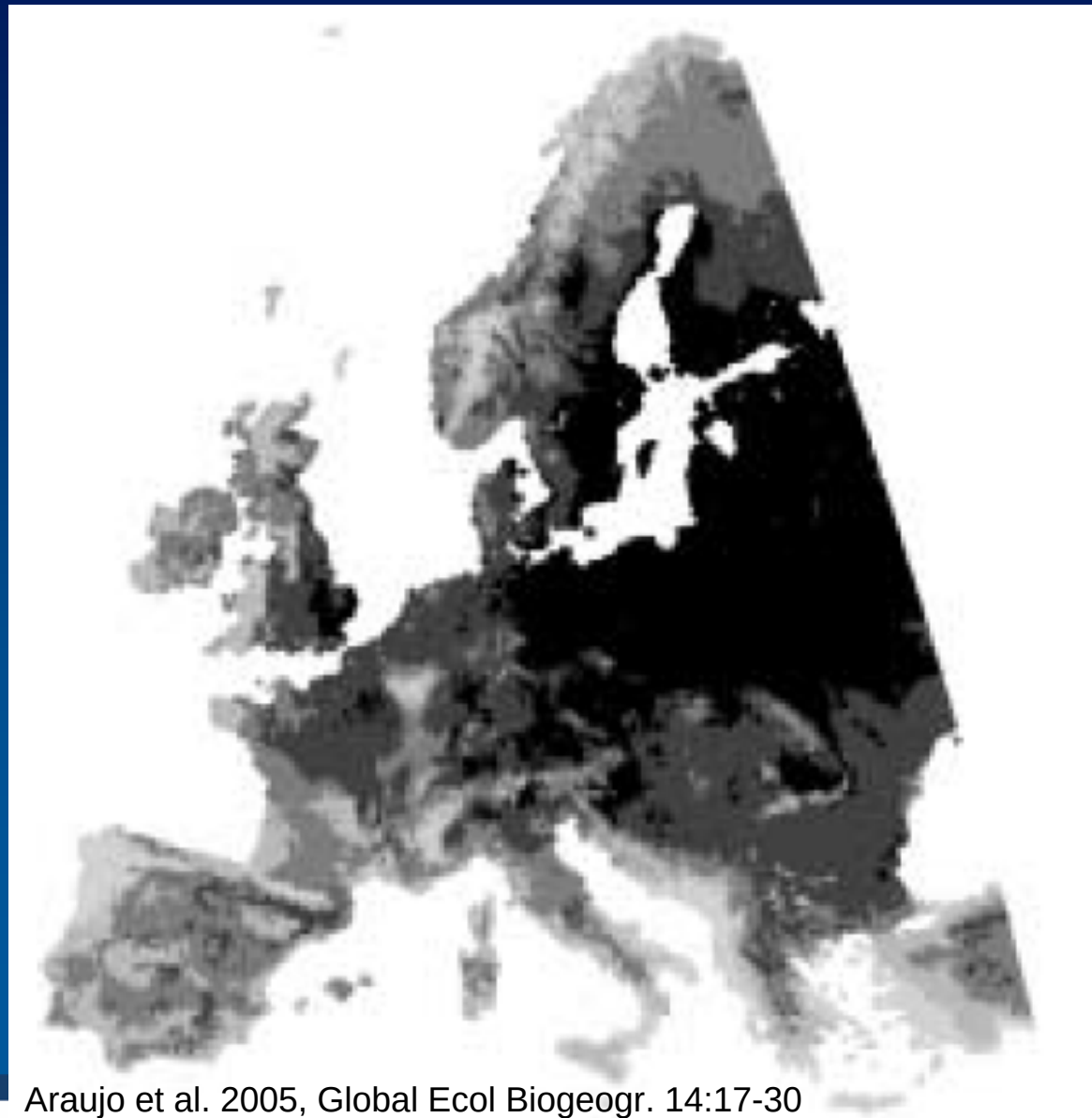
- Plants
- Amphibians
- Reptiles



Araujo et al. 2006, J. Biogeogr. 33:1712-1728

Consistent loss across organisms

- Plants
- Amphibians
- Reptiles
- Birds



Araujo et al. 2005, Global Ecol Biogeogr. 14:17-30

Consistent loss across organisms

- Plants
- Amphibians
- Reptiles
- Birds
- Mammals

Araujo et al. 2005, Global Ecol Biogeogr. 14:17-30

Community level

- Climate change will ultimately lead to generation of novel communities
- Existing species interactions disappear
- Potential for novel interactions emerges
- Sustainable provision of ecosystem services?

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Community level - Species interactions

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Interacting species

- Monophageous butterfly *Boloria titania*
- Host plant *Polygonum bistorta*
- Separate climate envelope models

  (AUC_{Plant} = 0.94; $AUC_{Butterfly}$ = 0.93)
- Projections to future scenarios
- Matching or mismatching: overlap of both projected climatically suitable areas

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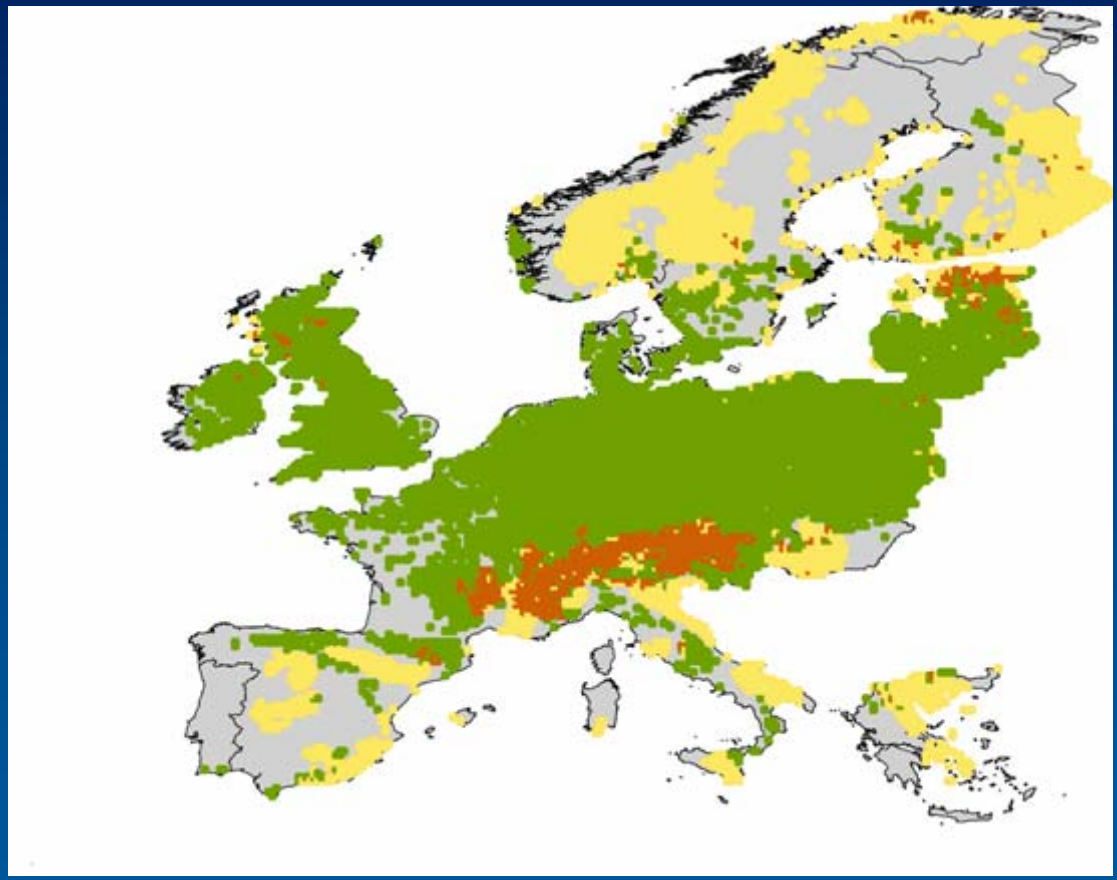
Interacting species:
Boloria titania and *Polygonum bistorta*

Current spatial matching



- Plant (*P. bistorta*)
- Butterfly (*B. titania*)
- Overlap of both

- High level of spatial mismatch
- Butterfly is limited by both climate and host plant

Schweiger et al., *Ecology* 2008, 89: 3472-3479

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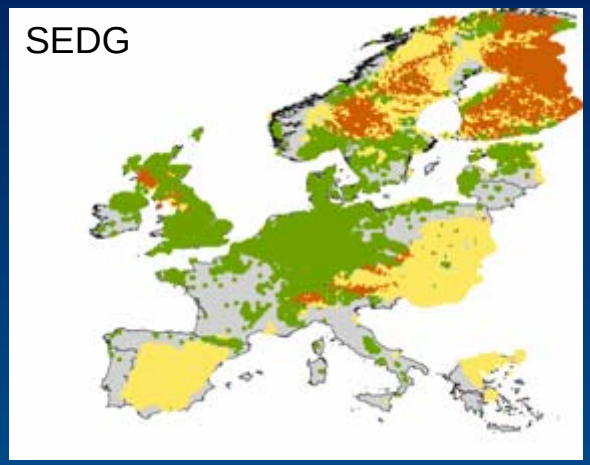
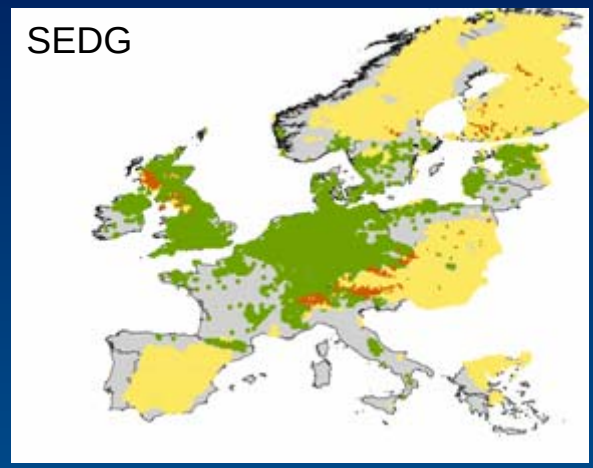
Interacting species: *Boloria titania* and *Polygonum bistorta*

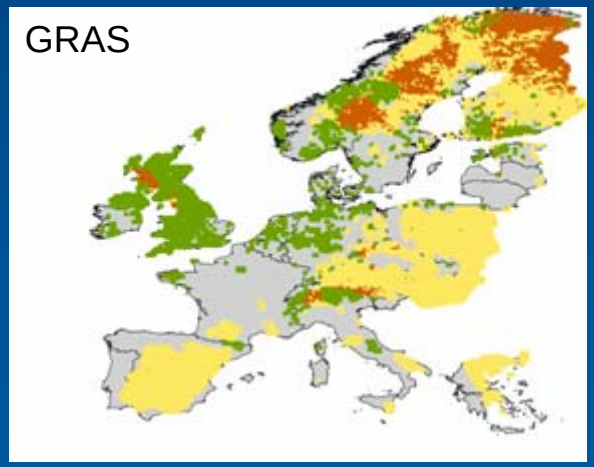
Projected changes in both niche spaces *for 2080*

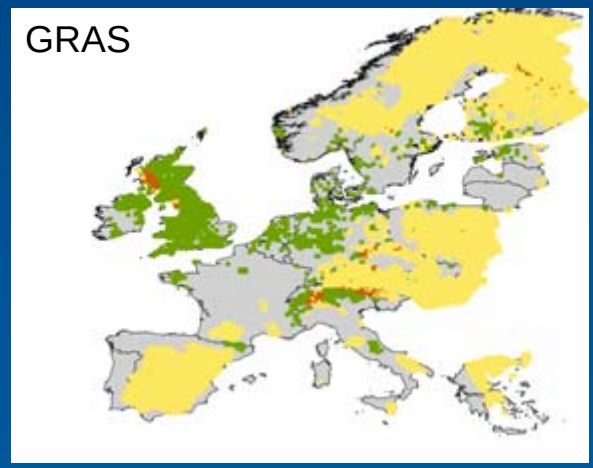
Full dispersal

No dispersal









- Plant
- Butterfly
- Overlap of both

- Pronounced mismatch
- Suitable areas far in the North
- No dispersal: disaster!

Schweiger et al., *Ecology* 2008, 89: 3472-3479

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Interacting species

- Many ways of ecological mismatching (temporal, spatial, behavioural, …)
- More severe effects on future species performance

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Community level – Ecosystem services

Pollination

Rossen 2005; www.digital-nature-photography.com

Ecosystem services – Pollination

- Complex networks
- Affected by multiple drivers

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Invasive species


Psittoculo krameri


Sardina pilchardus


Merops apiaster


Crocothemis erythraea


Trachycarpus fortunei


Cacyreus marshalli


Hemiramphus far


Trapaeolum majus


Thalassoma pavo


Percnon gibbesi

Photo: ESA, MSG-1, 2

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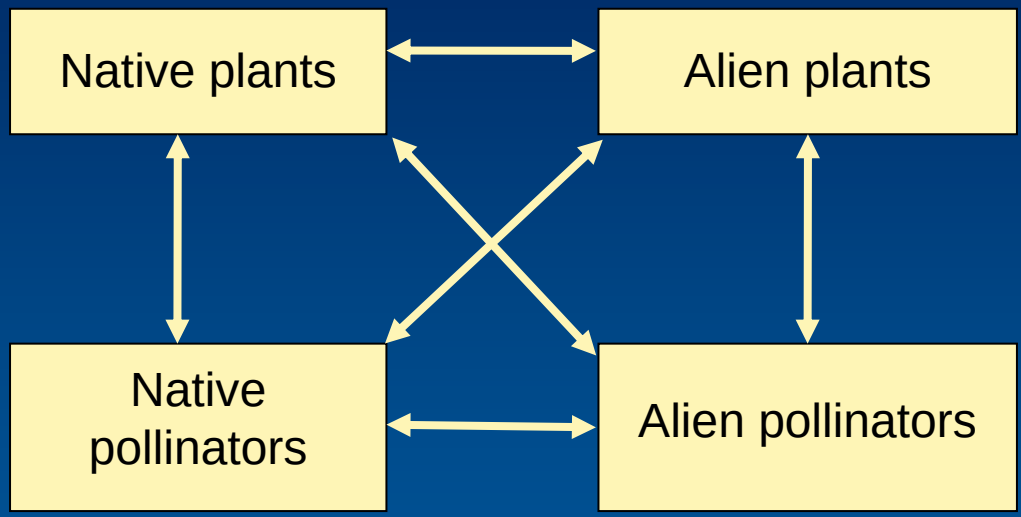
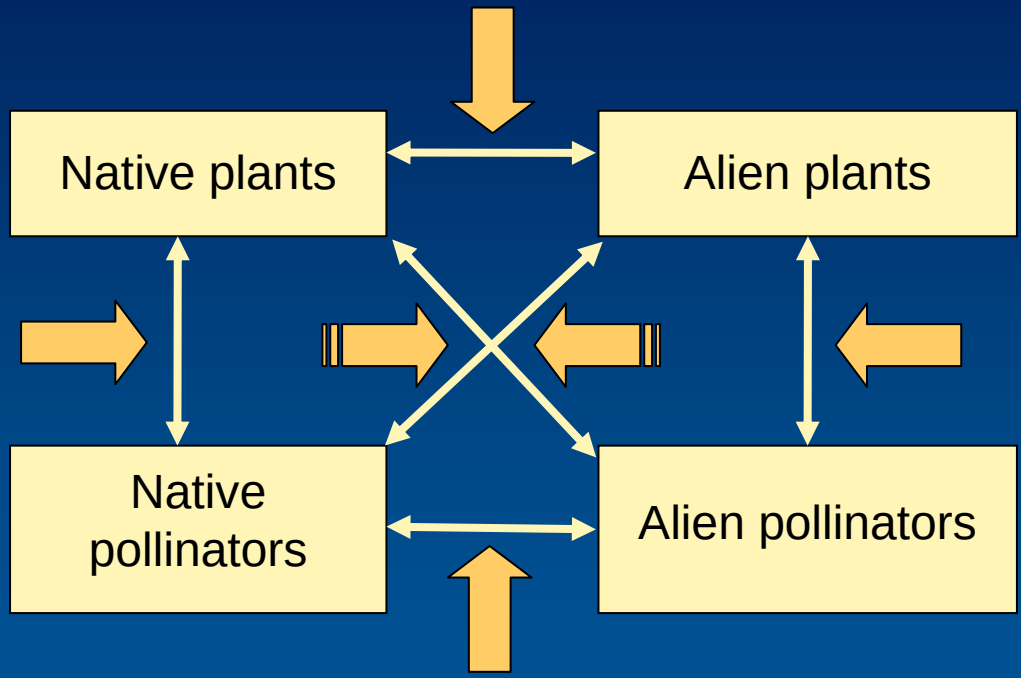
Interaction network



- Direct and indirect effects

Schweiger et al., submitted

Interaction networks – climate change



Schweiger et al., submitted

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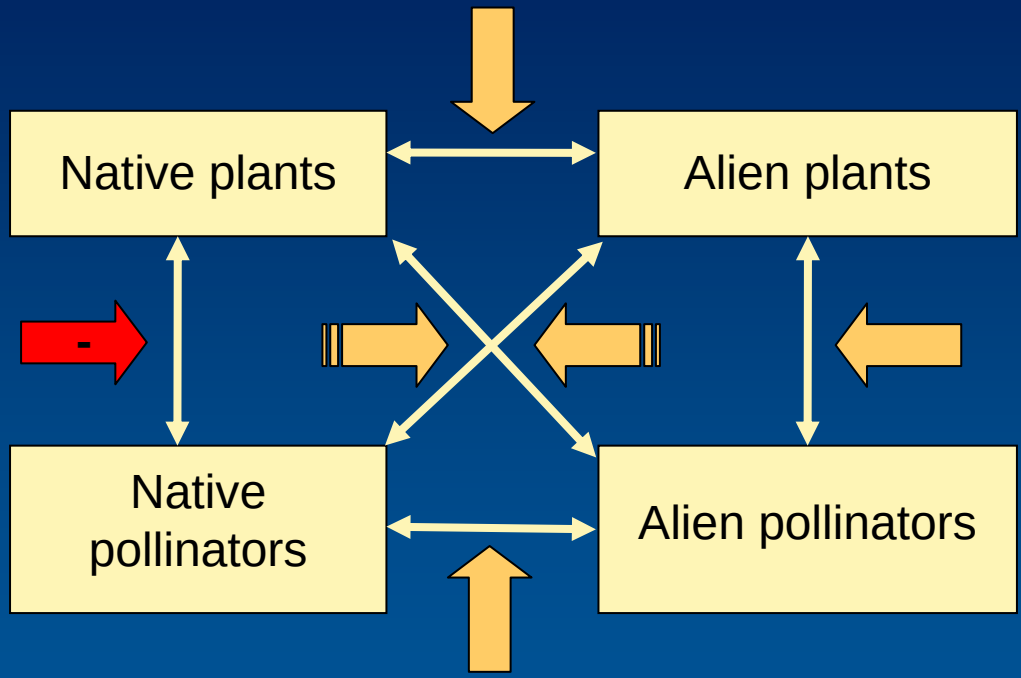
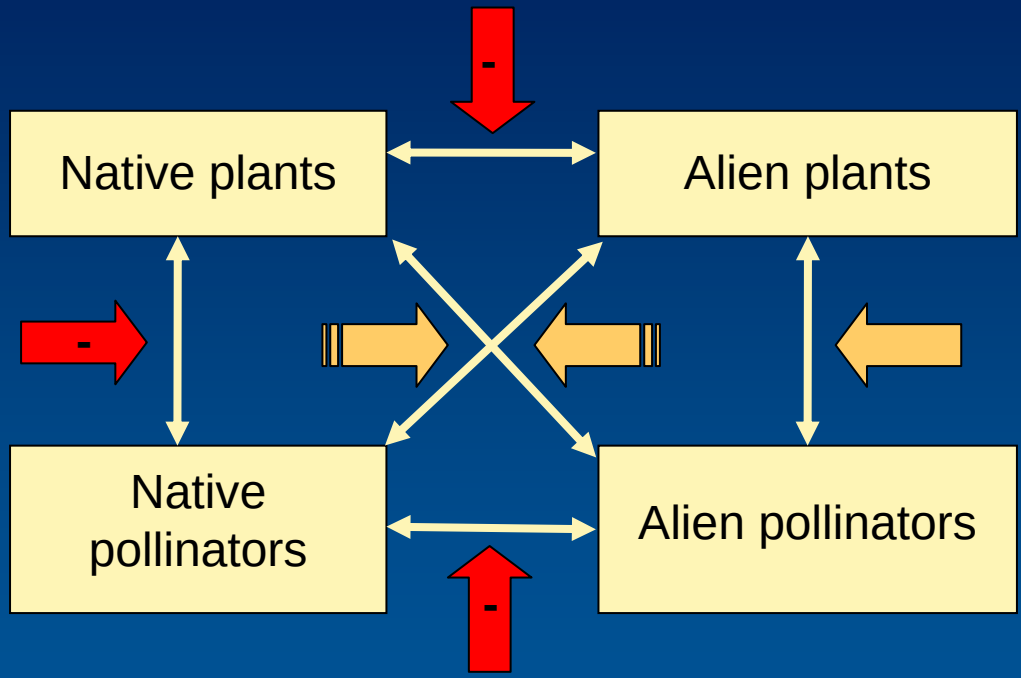
Interaction networks – climate change



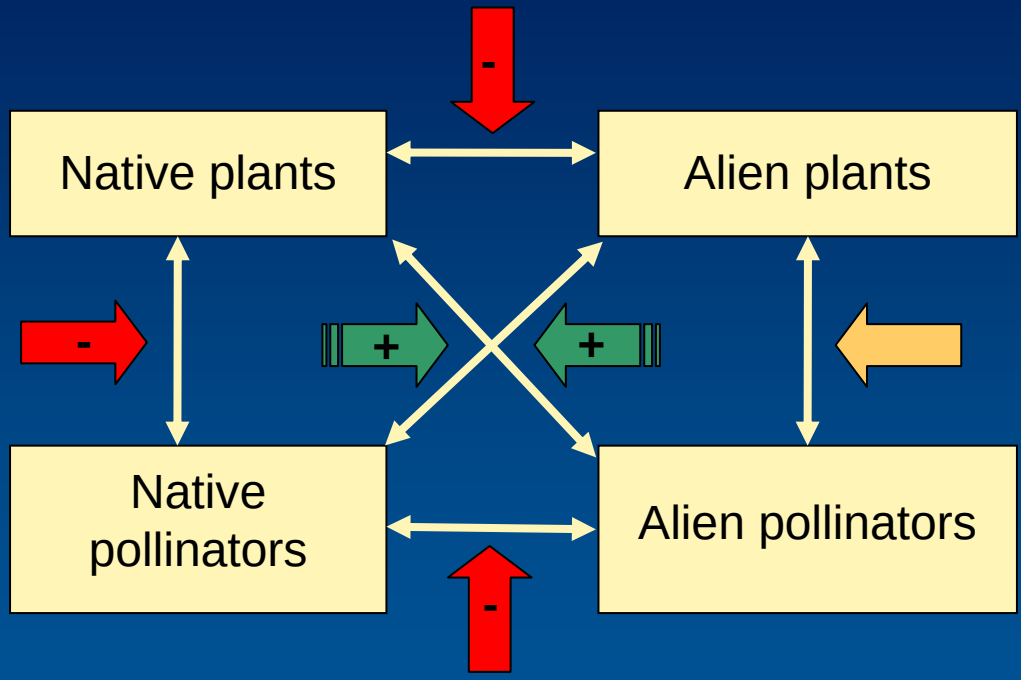
Schweiger et al., submitted

Interaction networks – climate change



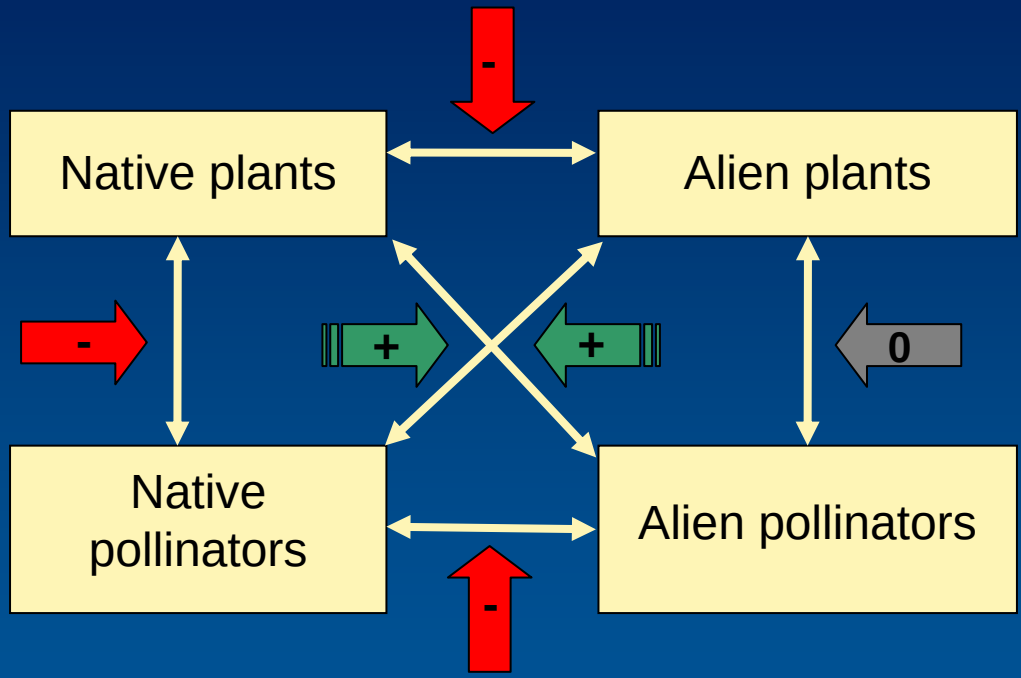
Schweiger et al., submitted

Interaction networks – climate change



Schweiger et al., submitted

Interaction networks – climate change



- Net effects are hard to predict

Schweiger et al., submitted

Conclusions

- Biodiversity is essential for human well being
- Threats are increasing and multi-facetted
- Multiple interacting drivers result in complex mechanisms
- There are buffer mechanisms (adaptation, network architecture, compensation, …)
- Net effects are still hard to predict

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Thanks!

Oliver Schweiger

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