Assessing threats to biodiversity

EU projects ALARM, MACIS and COCONUT

Oliver Schweiger

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Biodiversity and ecosystem services at risk

Bombus lapidarius
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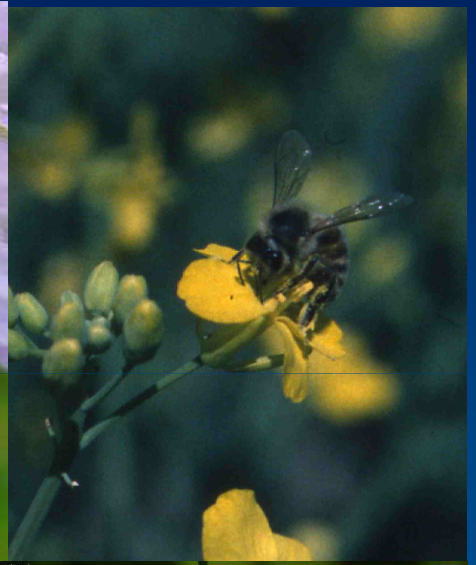

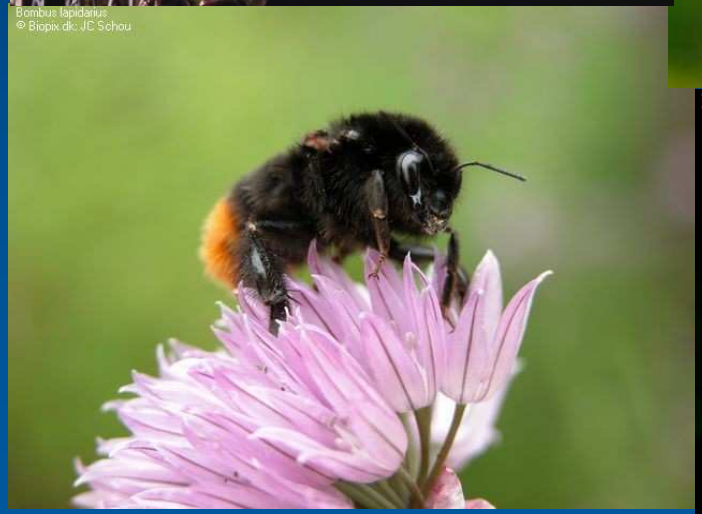

Syrphus ribesii
© Biopix.dk: JC Schou

Aurora (Anthocharis cardamines)
© Biopix.dk: N Sloth

Climate change

1941

2004

Global temperature increase in last 100 years: +0.7℃

(IPCC 4th Assessment Report, 2007)

SOURCE: Photo: Field WO (1941), Molnia BF (2004). Muir Glacier, Alaska
From the Online glacier photograph database. Boulder, Colorado USA: National Snow and Ice Data Center/World Data Center for Glaciology. Digital media.

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Land conversion

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Alien species

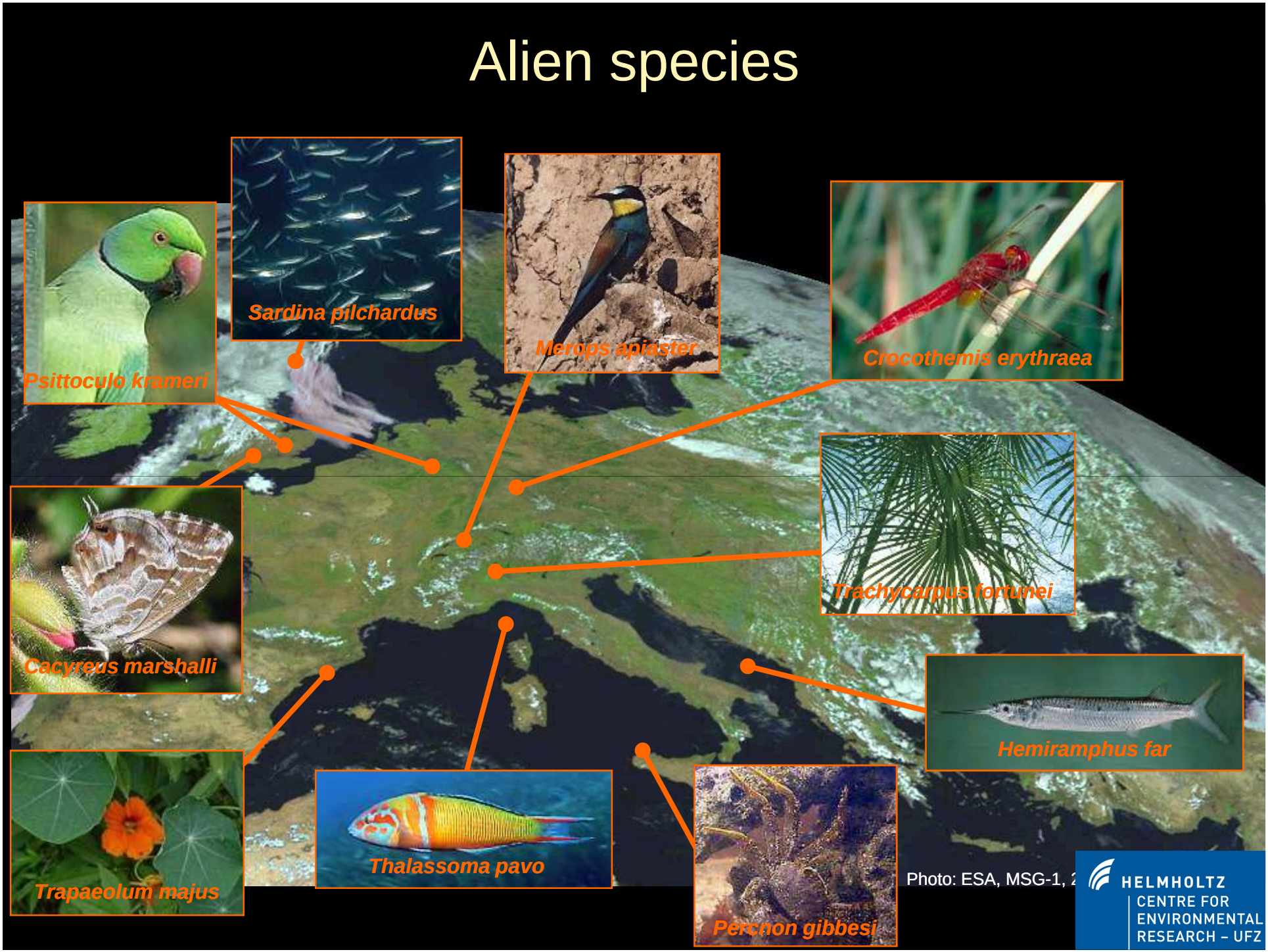

Photo: ESA, MSG-1, 2

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FP6 projects

ALARM

MACIS

COCONUT

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ALARM

Assessing LArge scale Risks for biodiversity with tested Methods

EU FP6 “Integrated Project”

2004 – 2009

Co-ordinator: Josef Settele, UFZ

josef.settele@ufz.de

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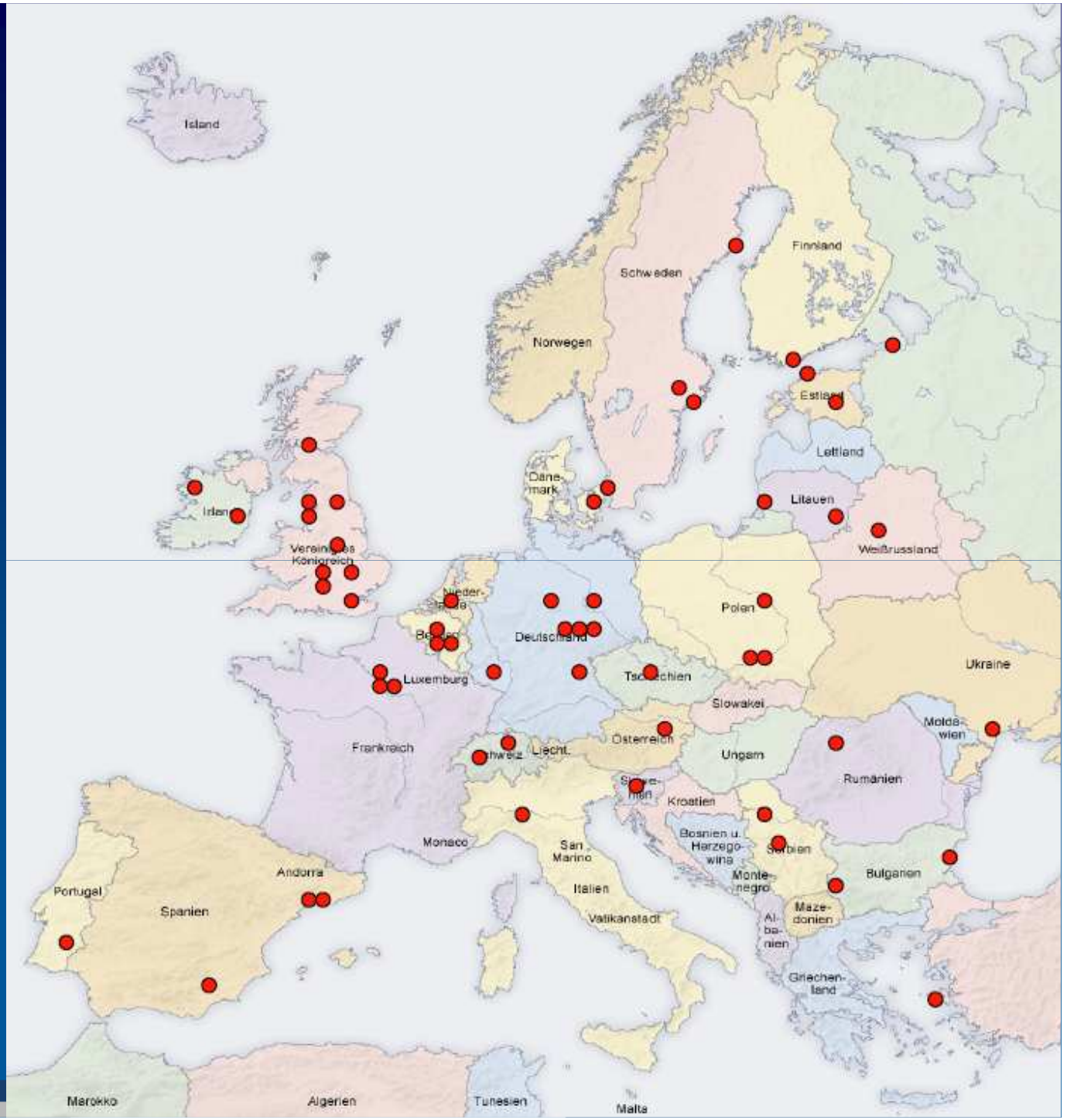
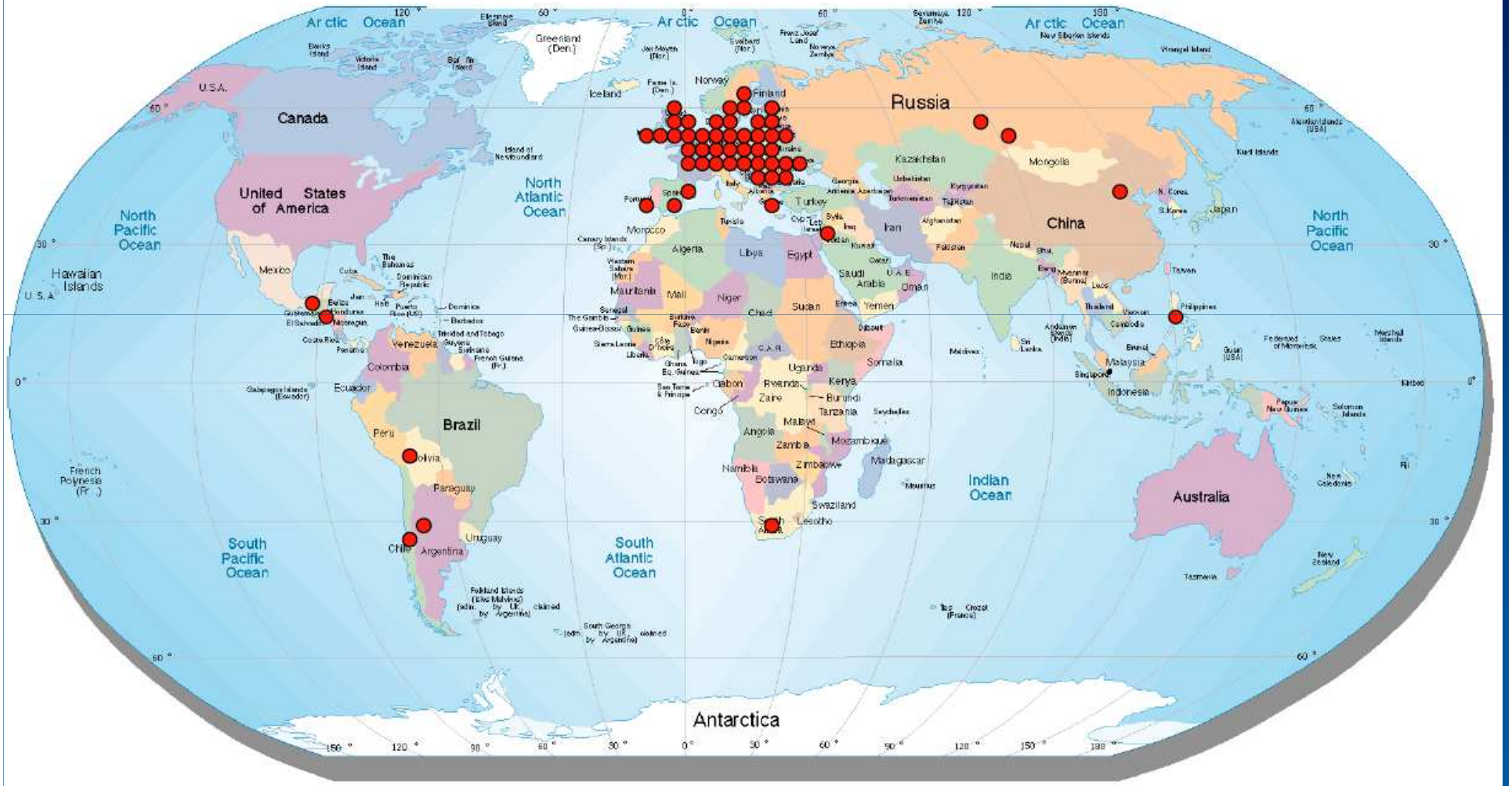
ALARM partnership: 80 institutes

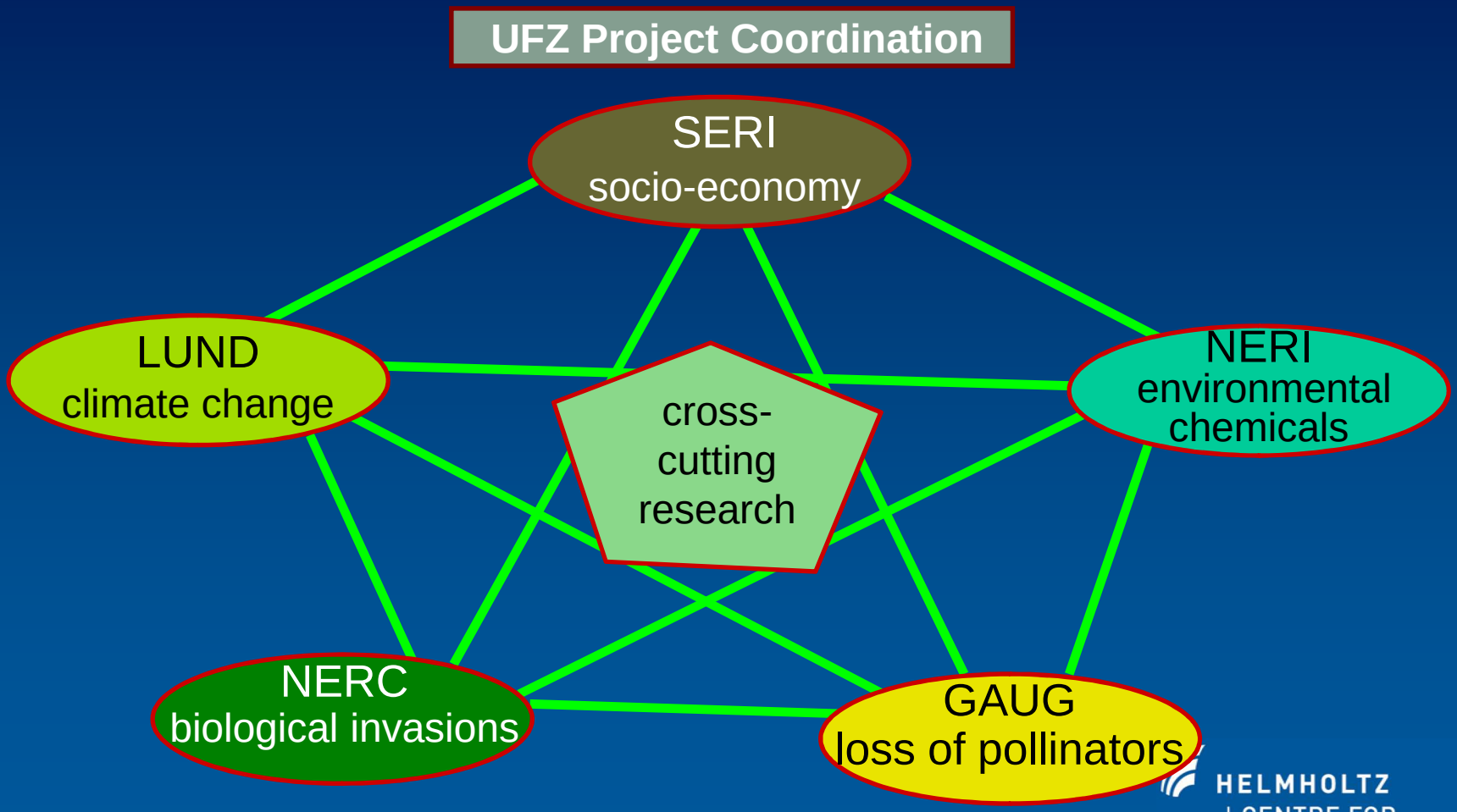


ALARM partnership



©1994 Magellan Geographix℠ Santa Barbara, CA (800) 929-4MAP Robinson Projection

ALARM was an Integrated Project!



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ATLAS of Biodiversity Risk

Edited by
Josef Settele, Lyubomir Penev, Teodor Georgiev, Ralf Grabaum, Vesna Grobelnik,
Volker Hammen, Stefan Klotz & Ingolf Kühn

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MACIS

MACIS

Minimisation of and Adaptation to Climate change Impacts on biodiverSity

EU FP6 “Scientific Support to Policy project”

2006 – 2008

Co-ordinator: Ingolf Kühn, UFZ

ingolf.kuehn@ufz.de

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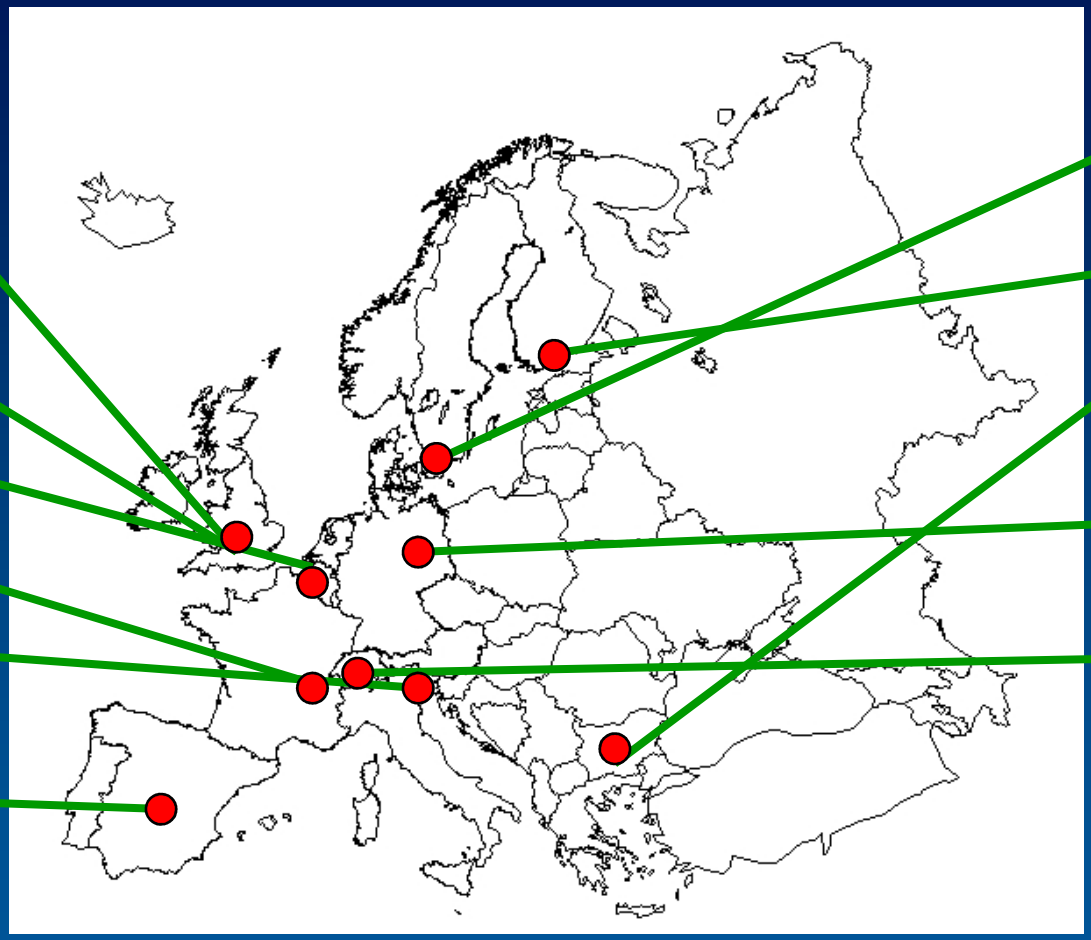
The partners in MACIS



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UNIL Université de Lausanne

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COCONUT

COCONUT

Understanding effeCts Of land use Changes ON ecosystems to halt loss of biodiversity due to habitat destrUction, fragmenTation and degradation

EU FP6 “Scientific Support to Policy project”

2006 – 2009

Co-ordinator: Riccardo Bommarco, SLU

riccardo.bommarco@entom.slu.se

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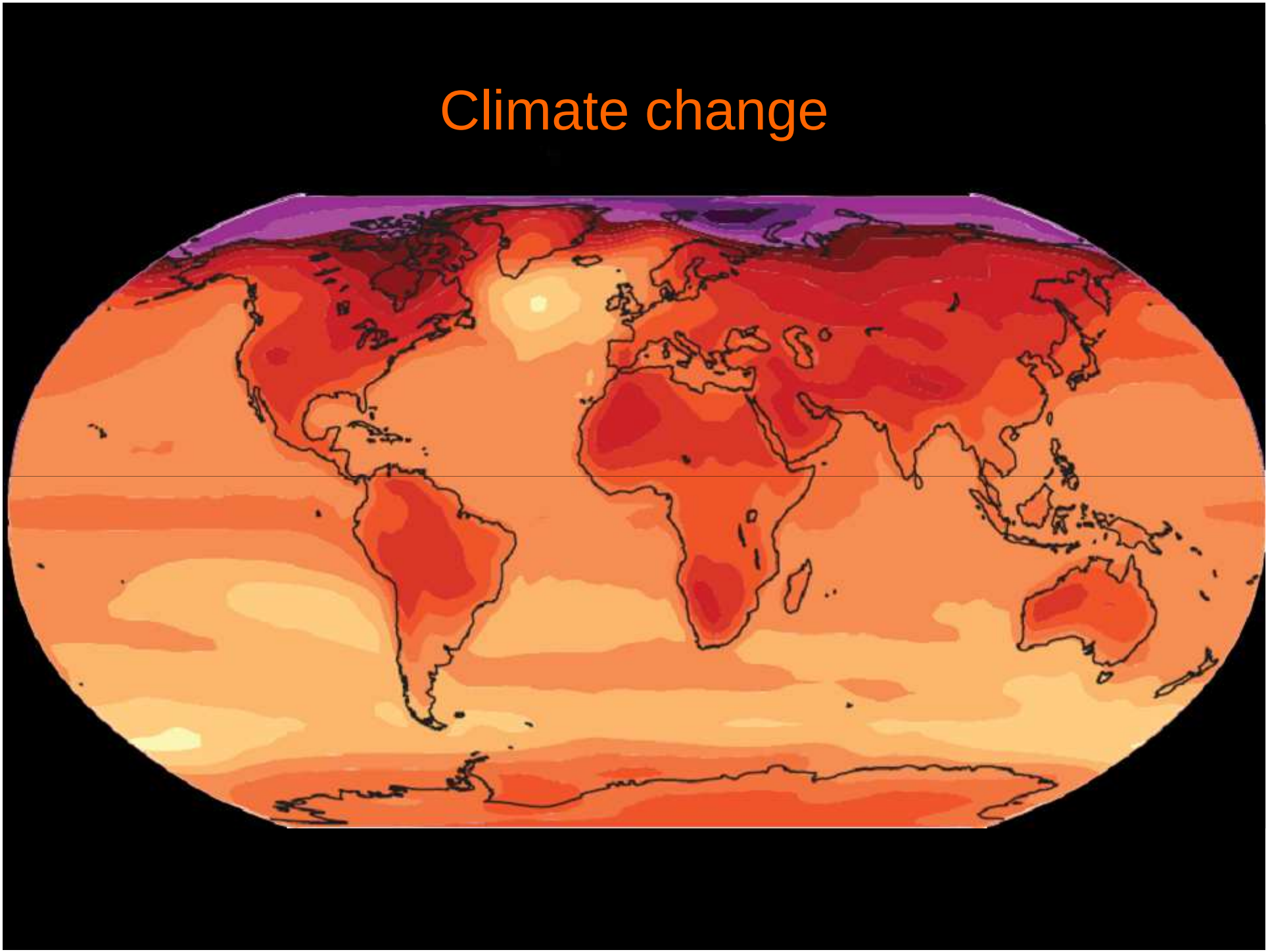
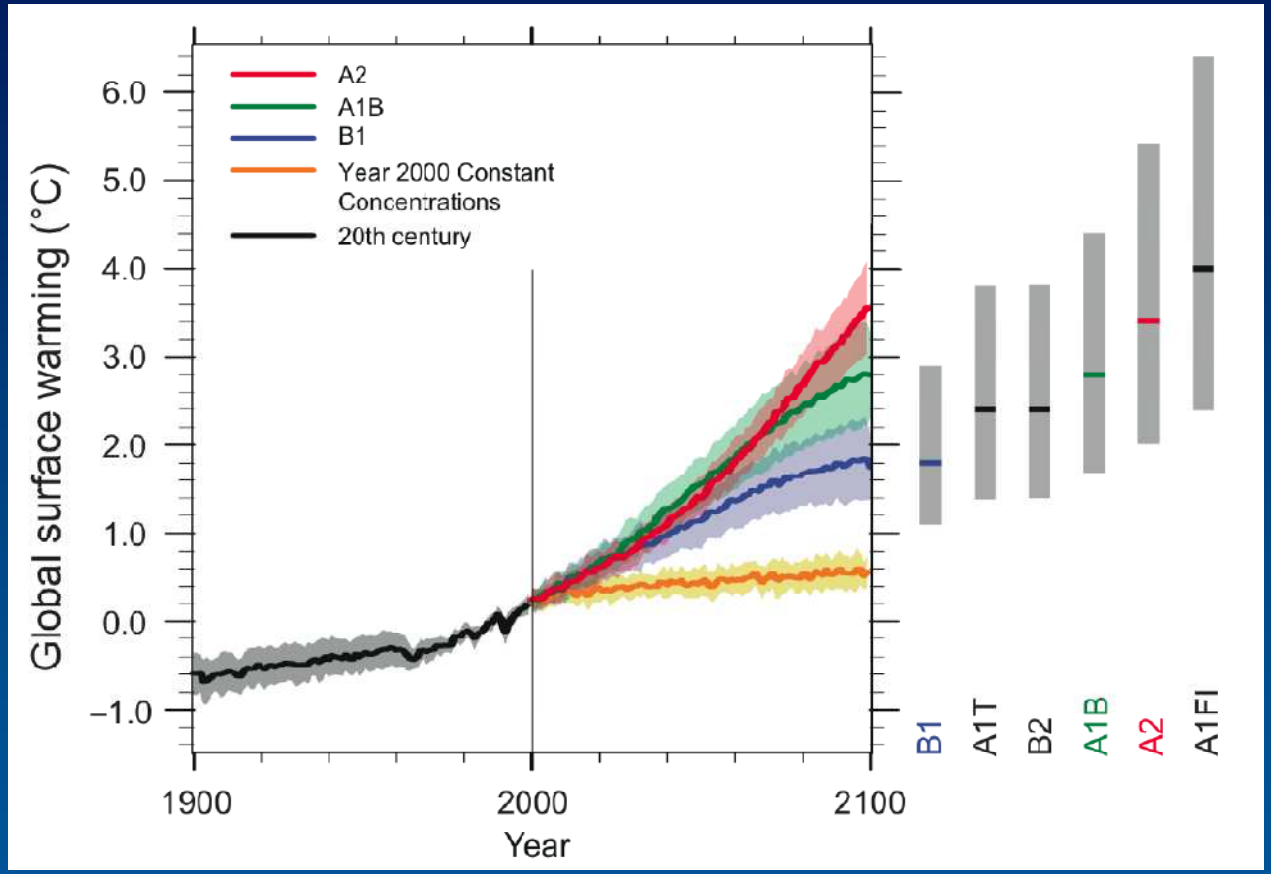
Climate change



Climate change



IPCC 4th Assessment Report, 2007

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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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- Community level (composition, functioning)
  - Species interactions
  - Ecosystem services

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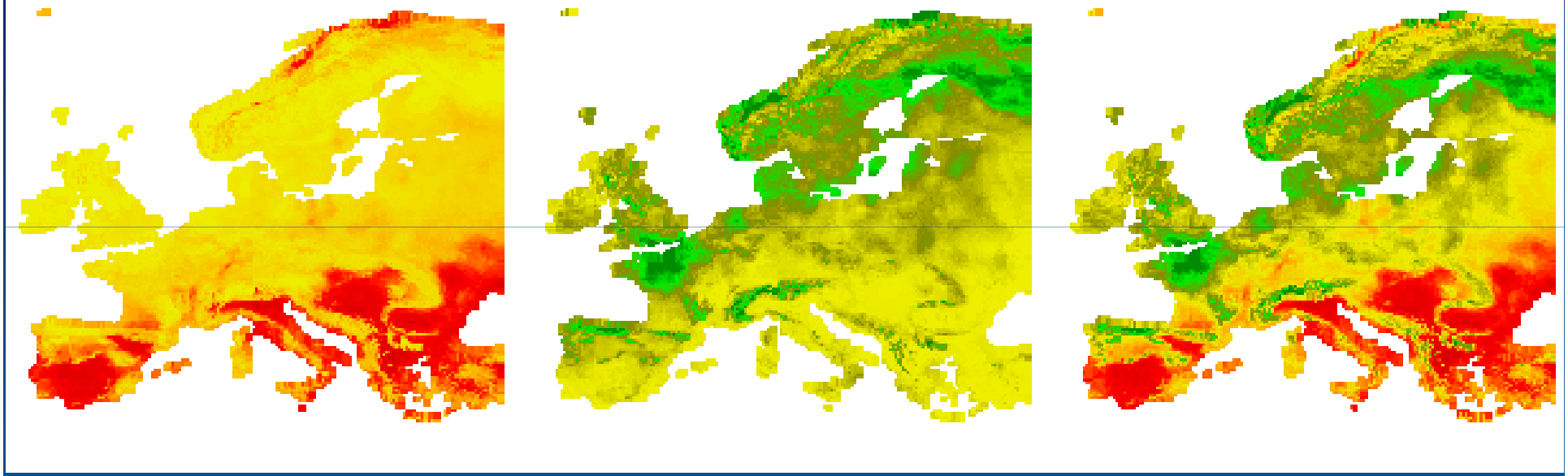
Species level – range shifts



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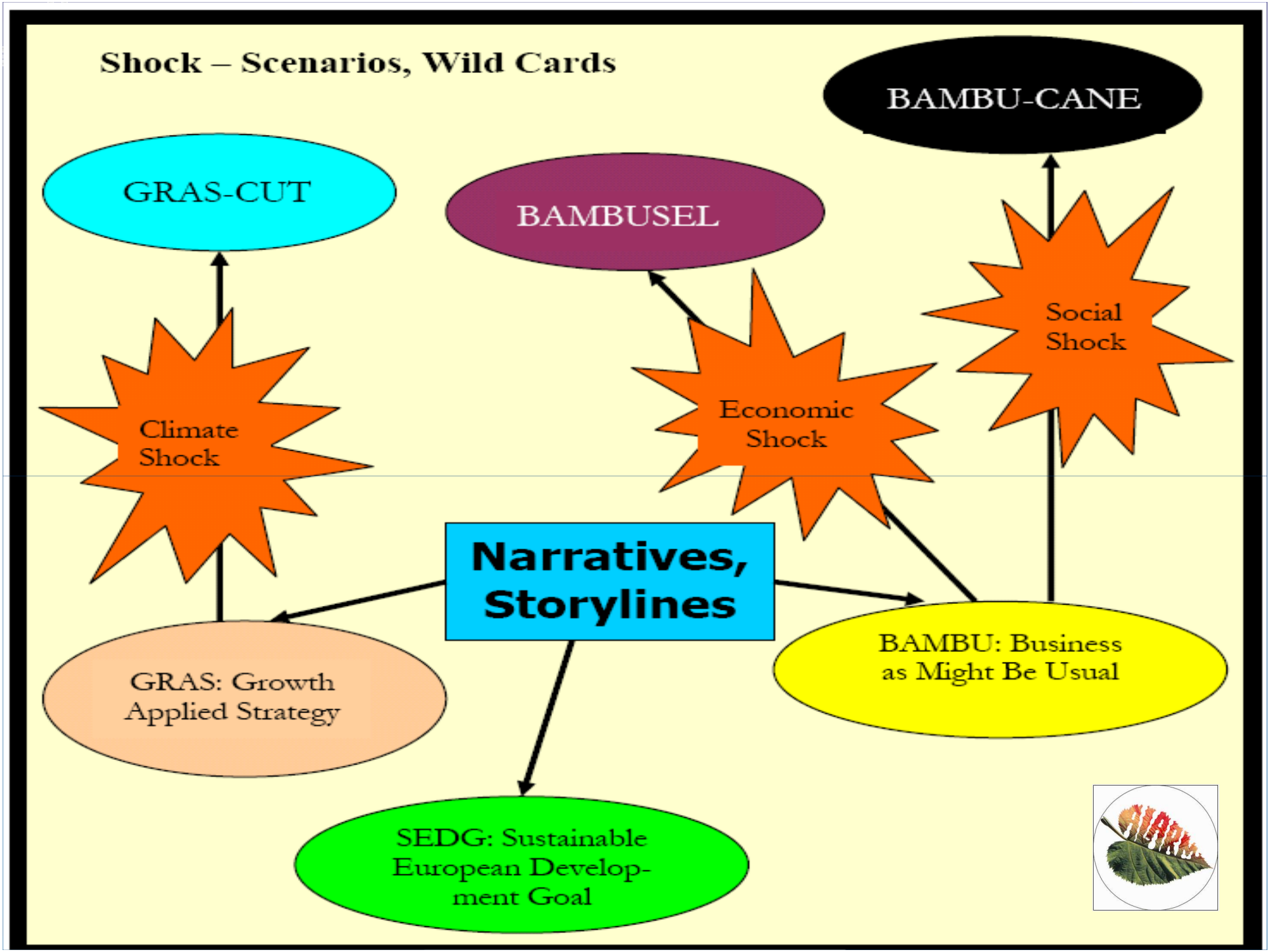
Shock – Scenarios, Wild Cards
BAMBU-CANE
GRAS-CUT
BAMBUSEL
Social Shock
Climate Shock
Economic Shock
Narratives, Storylines
GRAS: Growth Applied Strategy
BAMBU: Business as Might Be Usual
SEDG: Sustainable European Develop-ment Goal

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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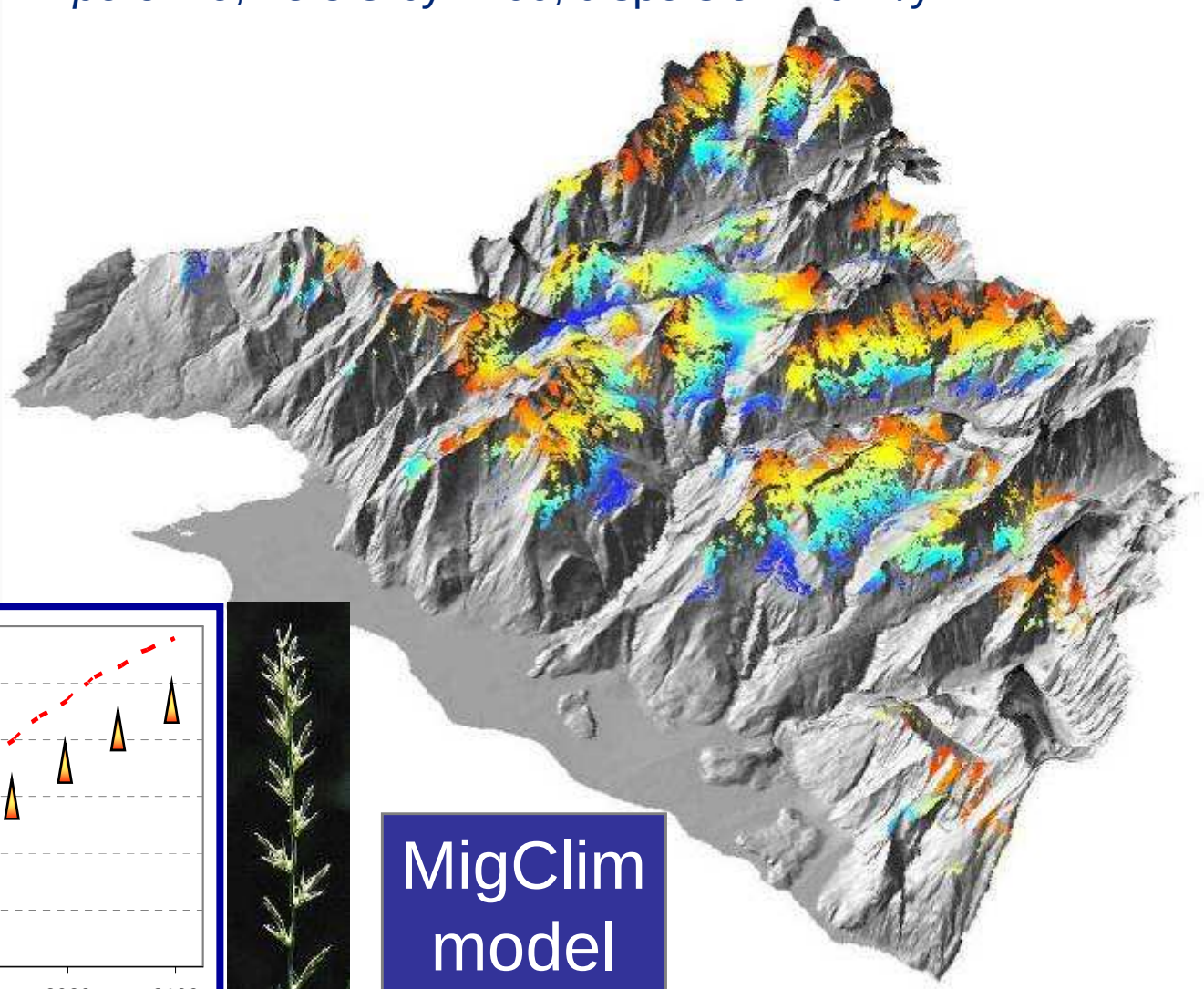
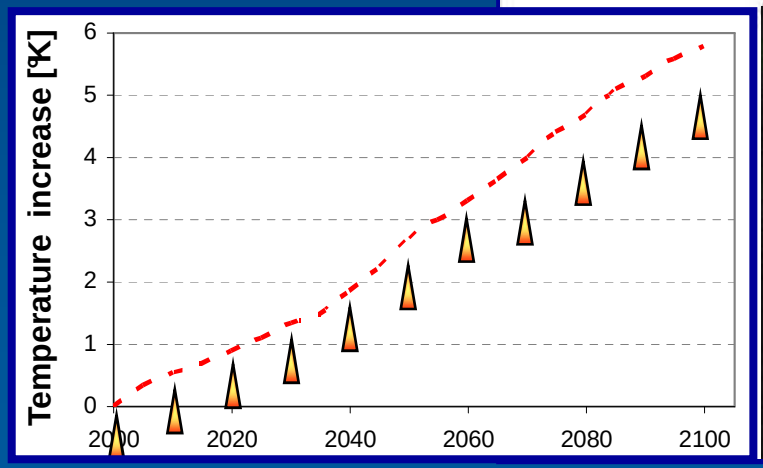
Climate change – future species loss

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℃ by 2100, dispersion: 40 m/yr





MigClim model

Engler & Guisan 2009, *Diversity and Distribution*)

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 framework 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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ISBN 978-954-642-455-6 (hardback)
ISBN 978-954-642-456-3 (e-book)

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
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C. van Swaay
R. Verovnik
M. Warren
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K. Veling
A. Vliegenthart
I. Wynhoff
O. Schweiger

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BioRisk 1
Special Issue

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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℃ until 2080
  - BAMBU (SRES A2): intermediate change; 3.1℃ until 2 080
  - GRAS (SRES A1FI): maximum change; 4.1℃ until 2080
- 2050 and 2080

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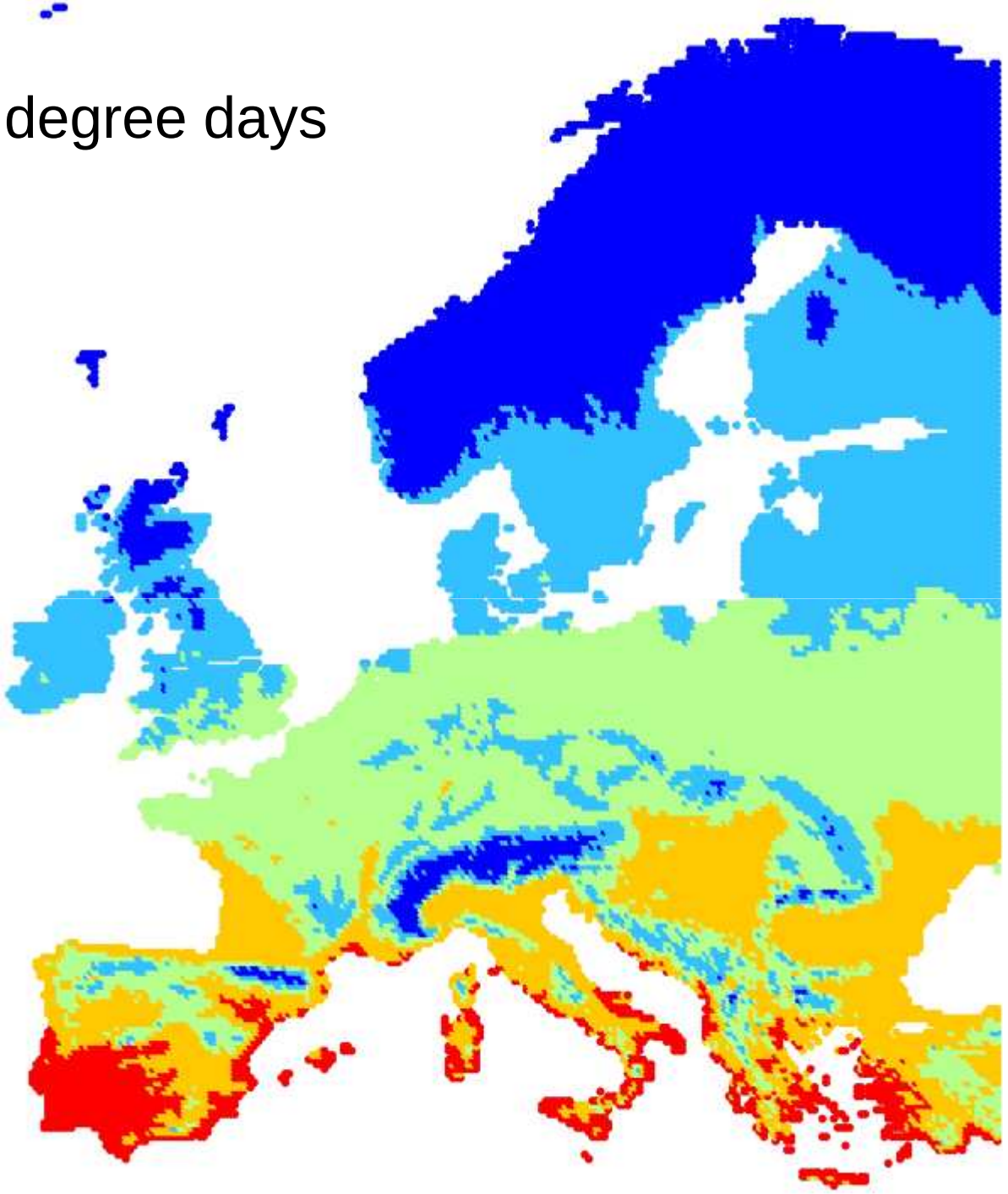
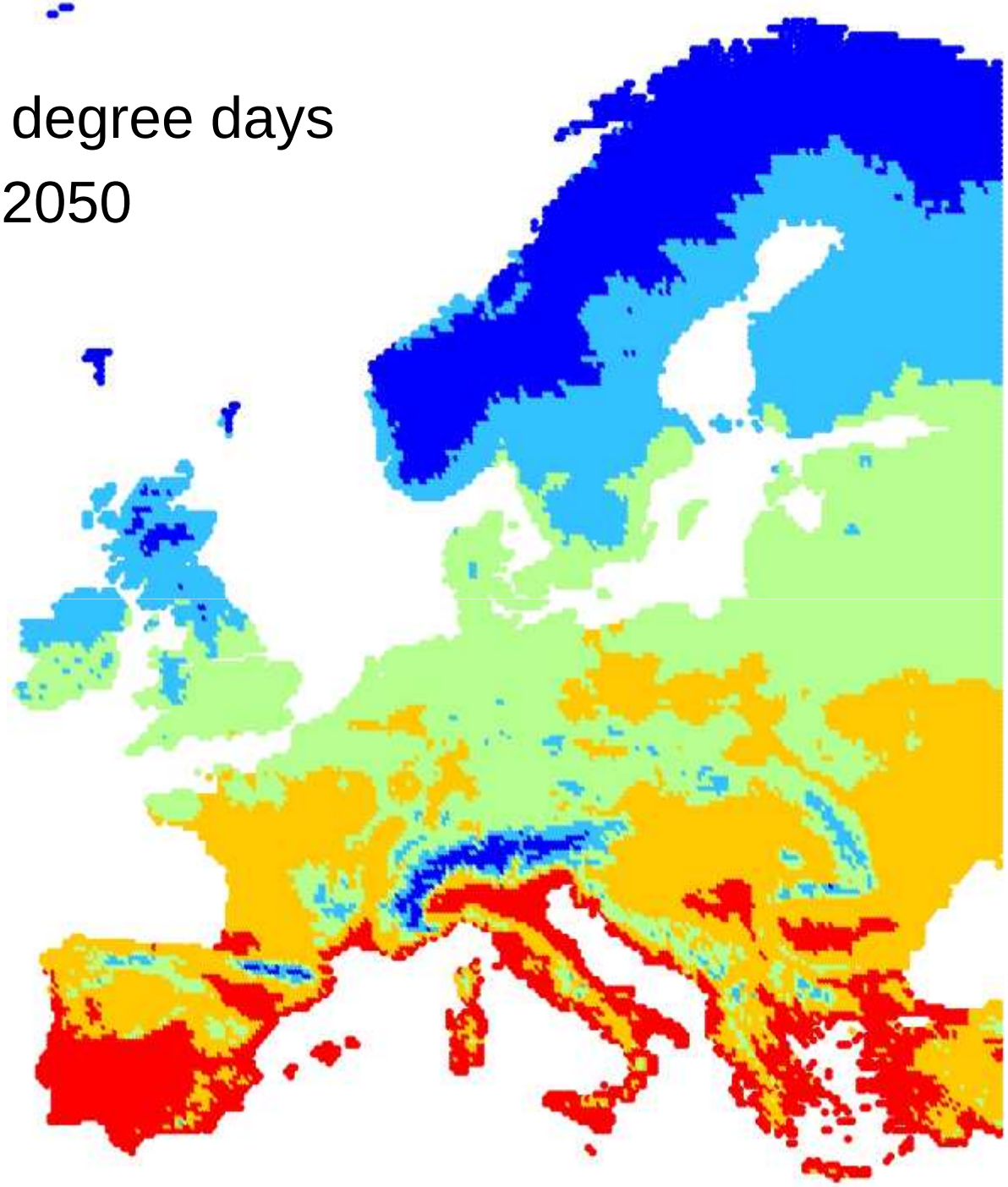
Growing degree days

2000



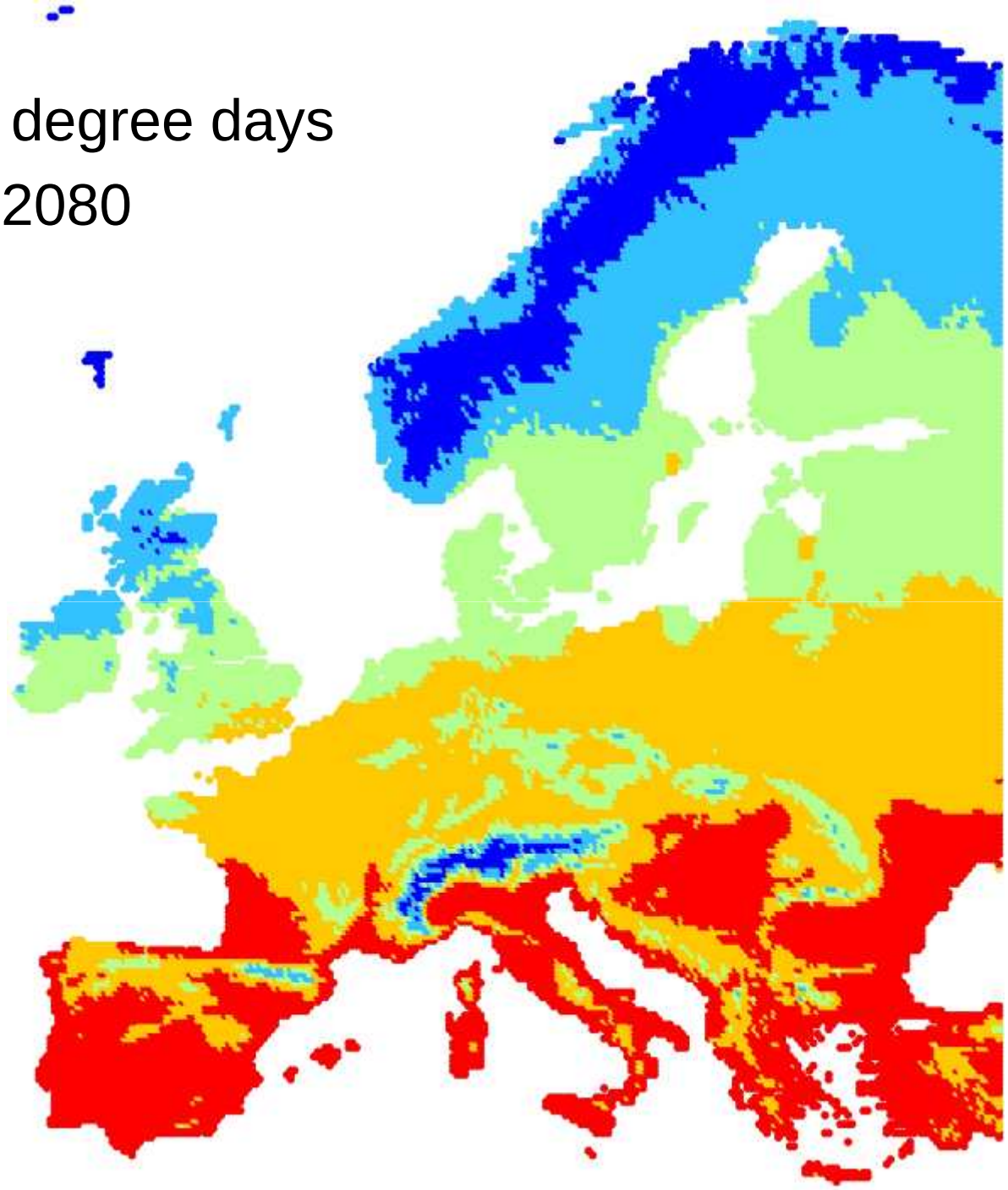
Growing degree days

BAMBU 2050



Growing degree days

BAMBU 2080



Winners and losers …

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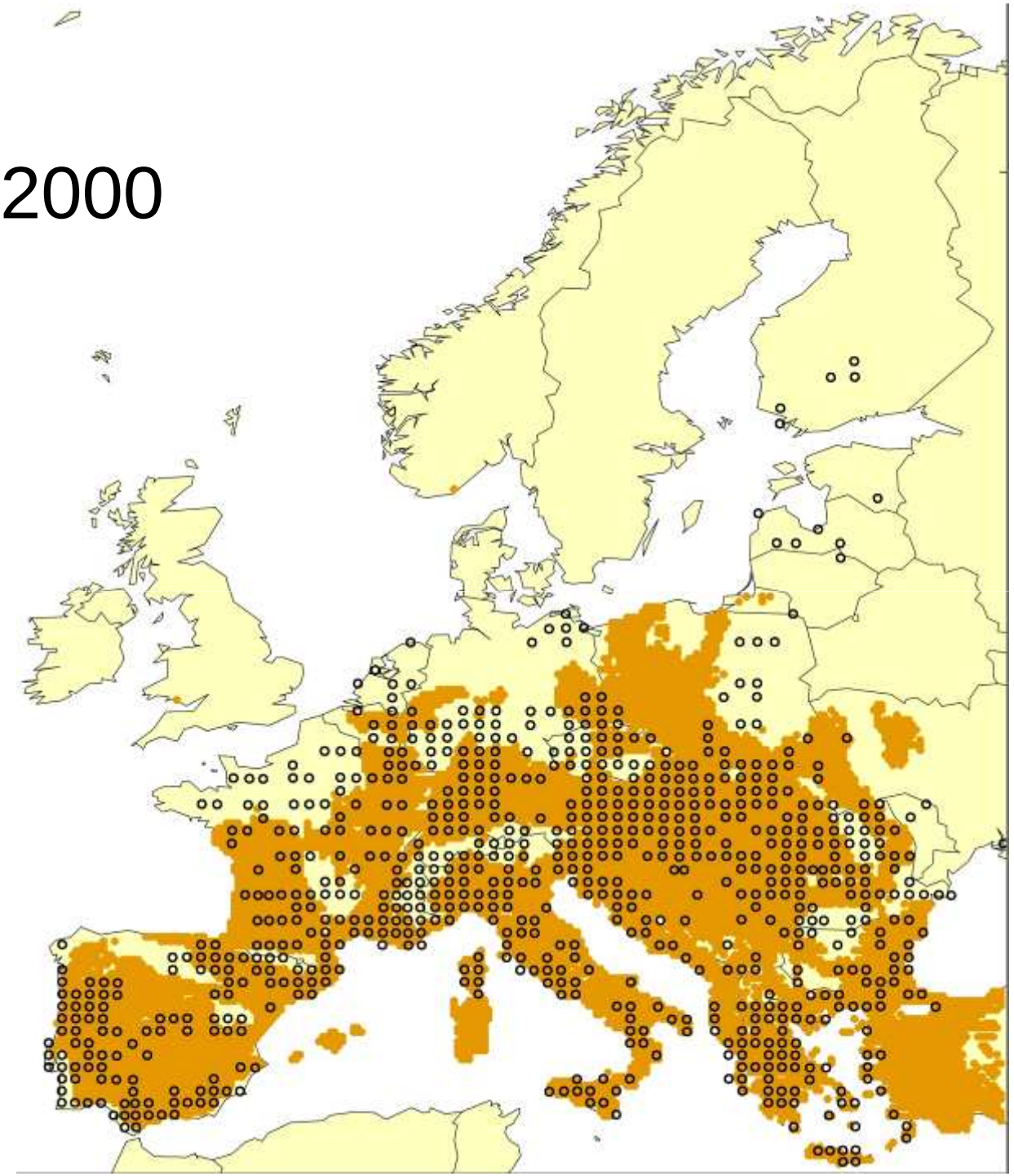
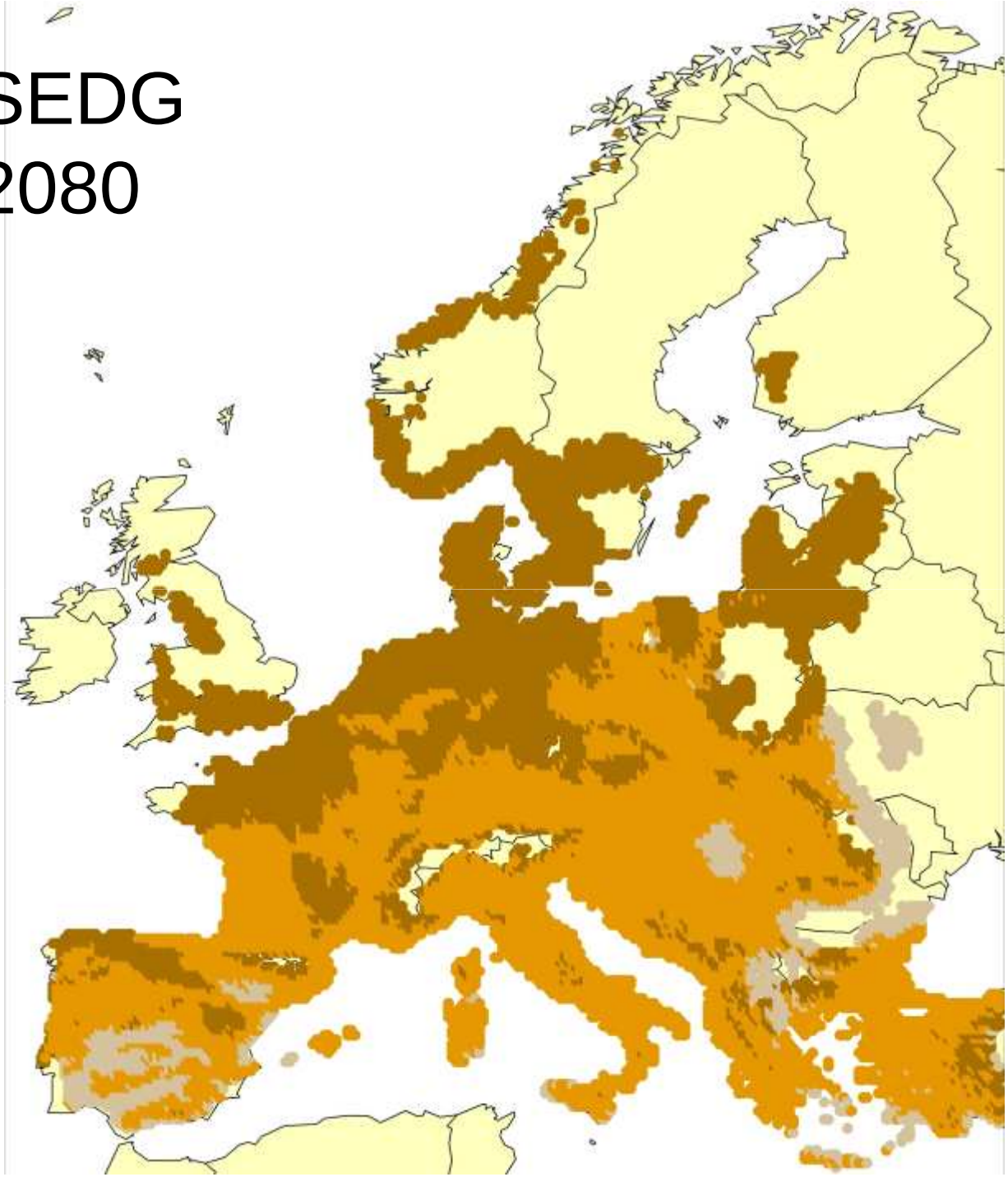
WINNER!

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

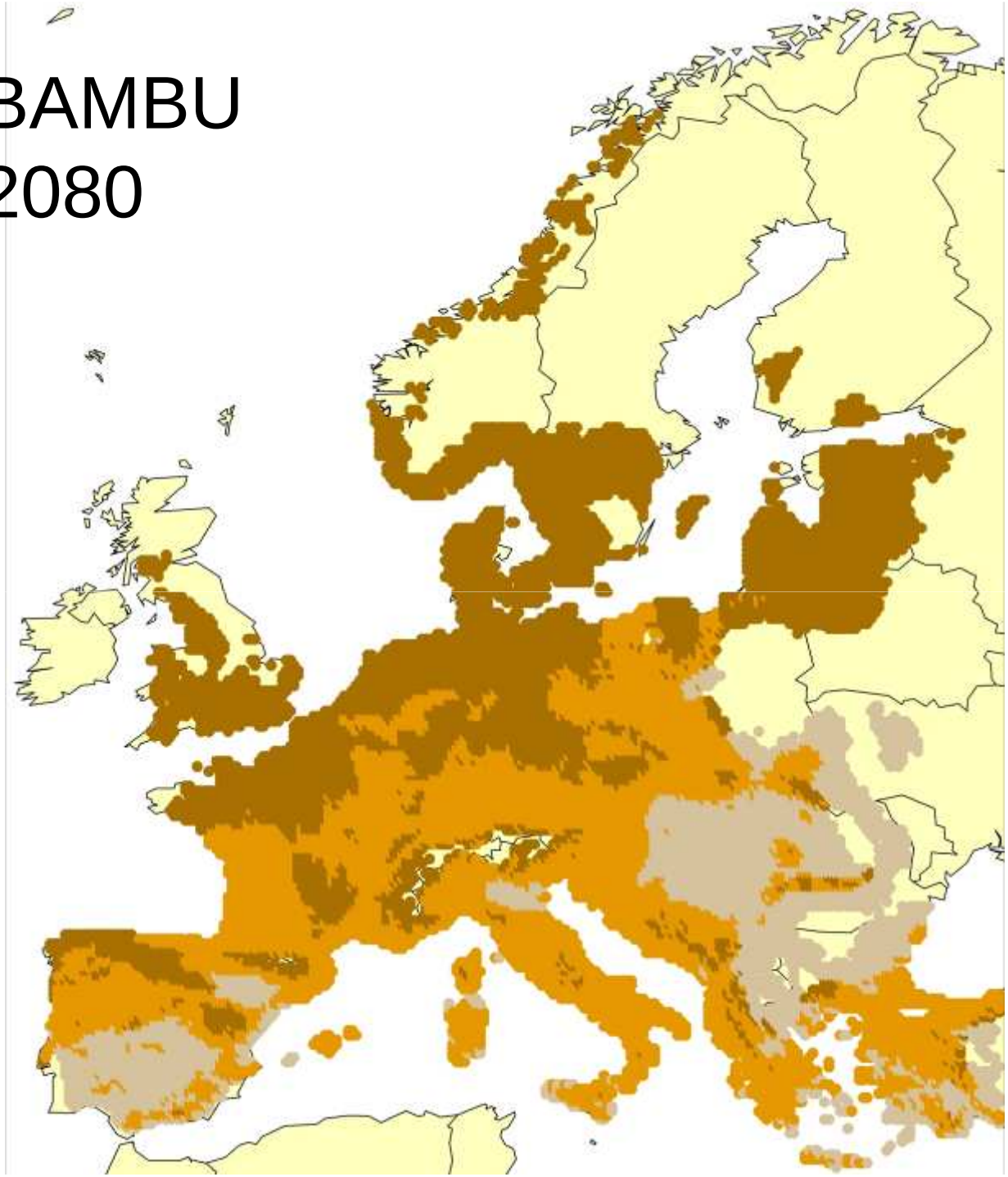
2000



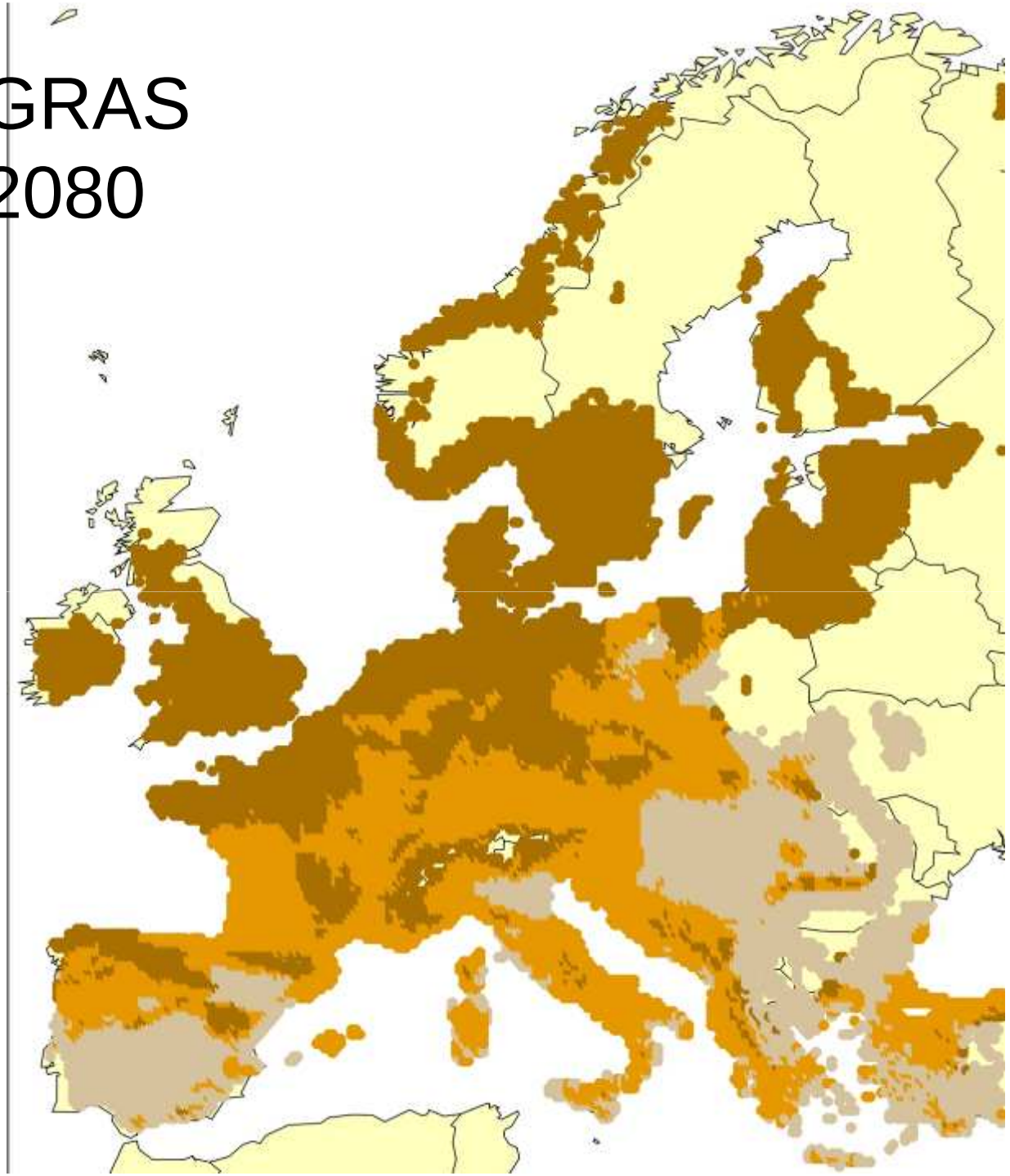
SEDG
2080



BAMBU
2080



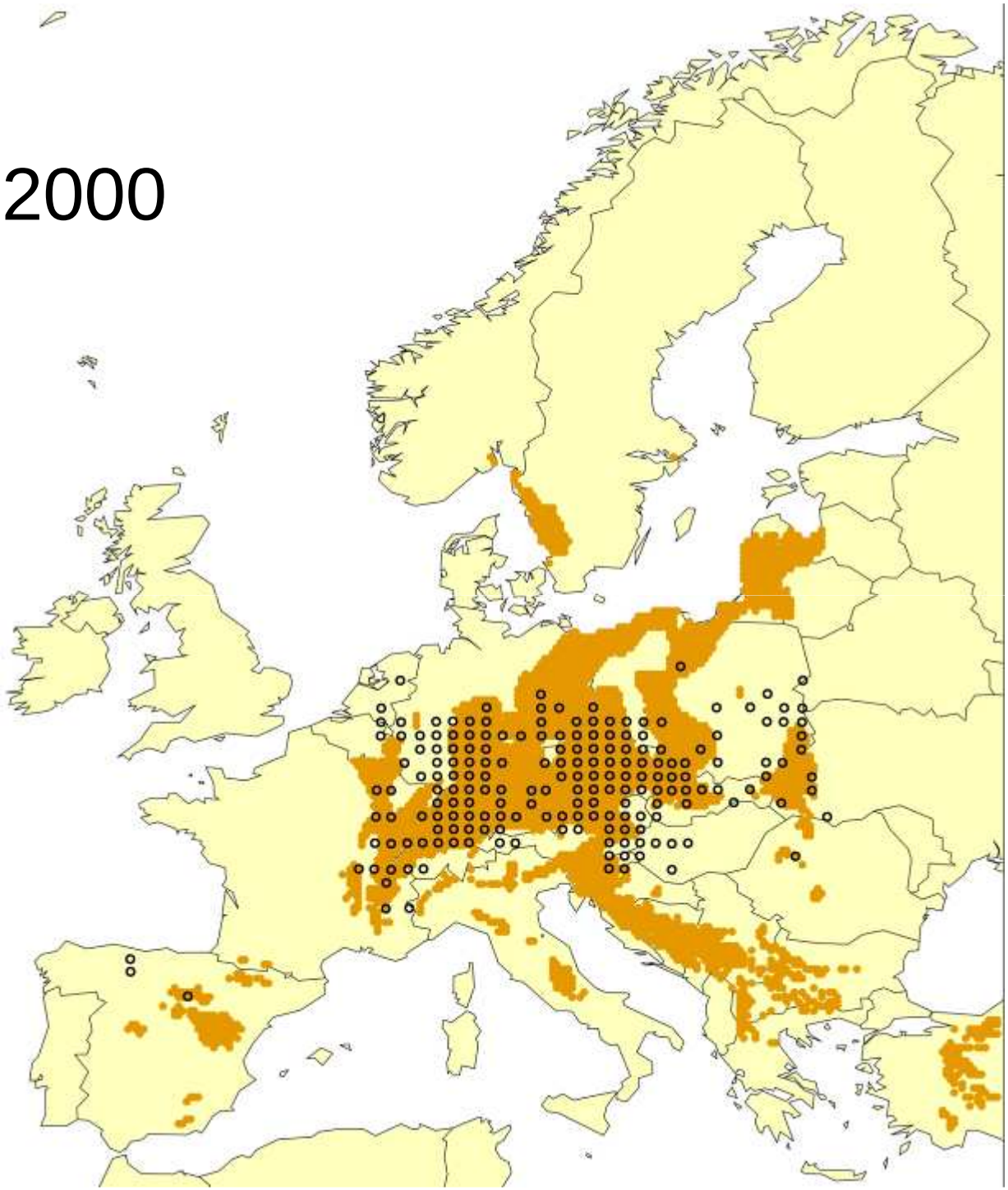
GRAS
2080



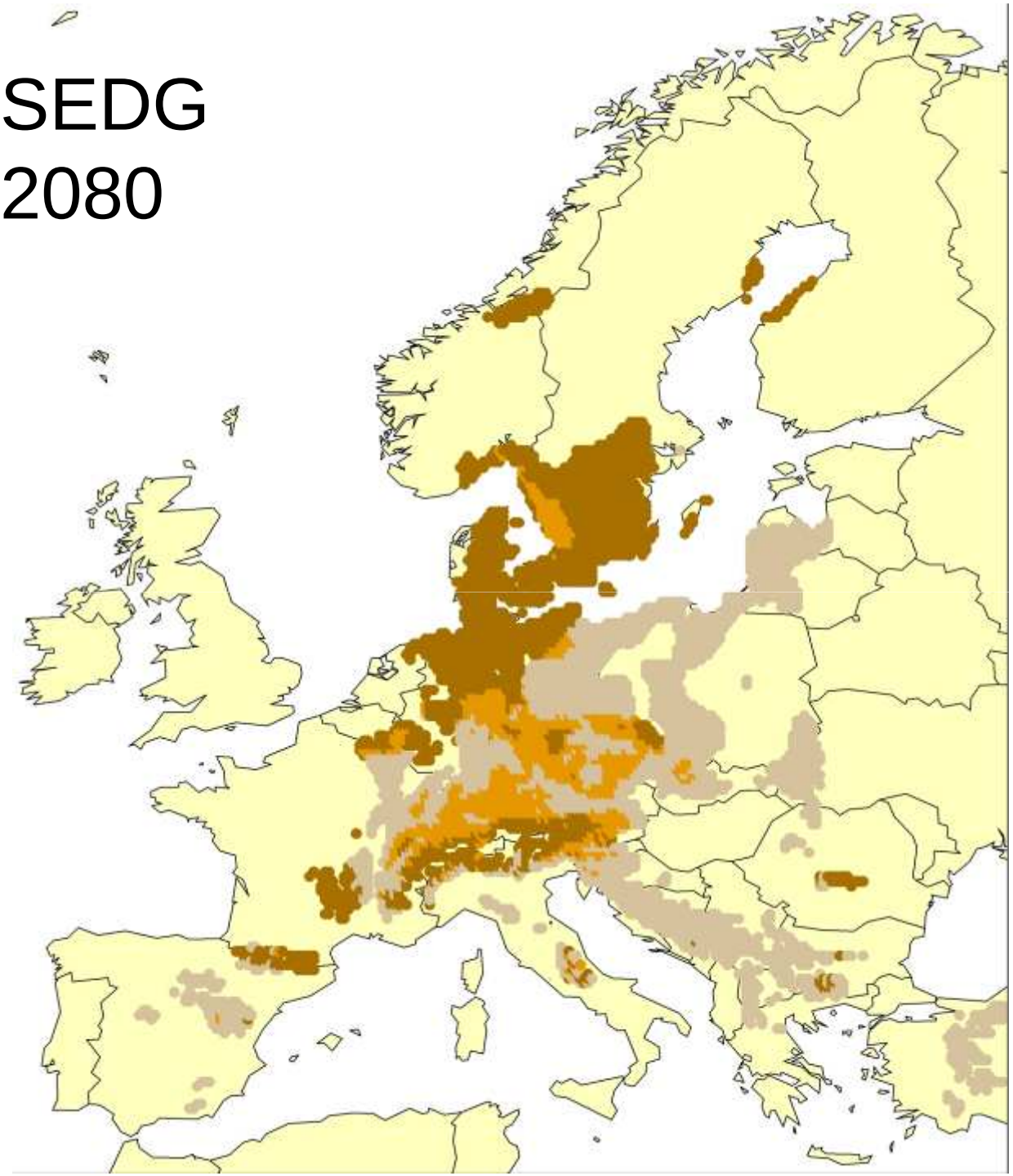
LOSER!

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

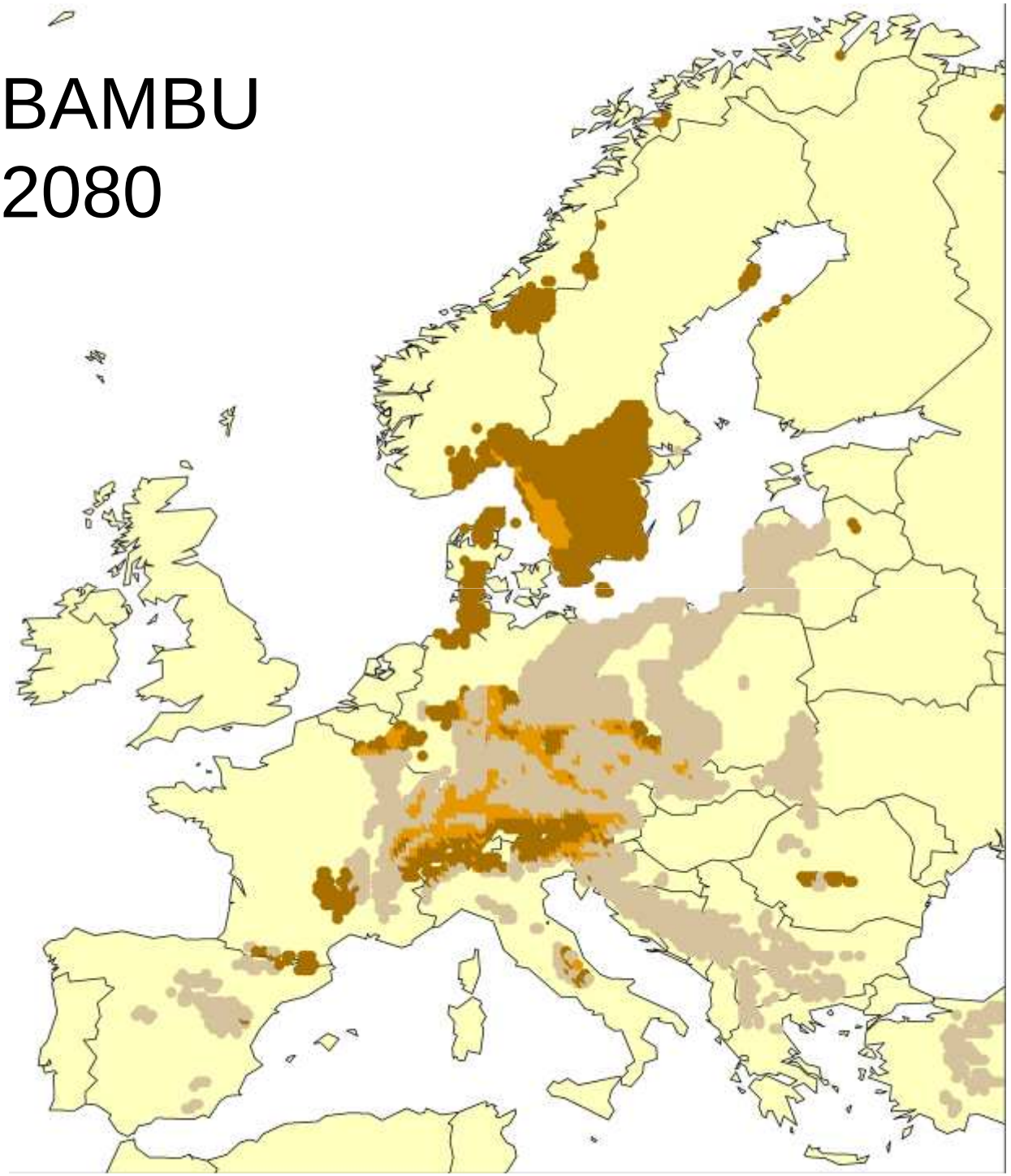
2000



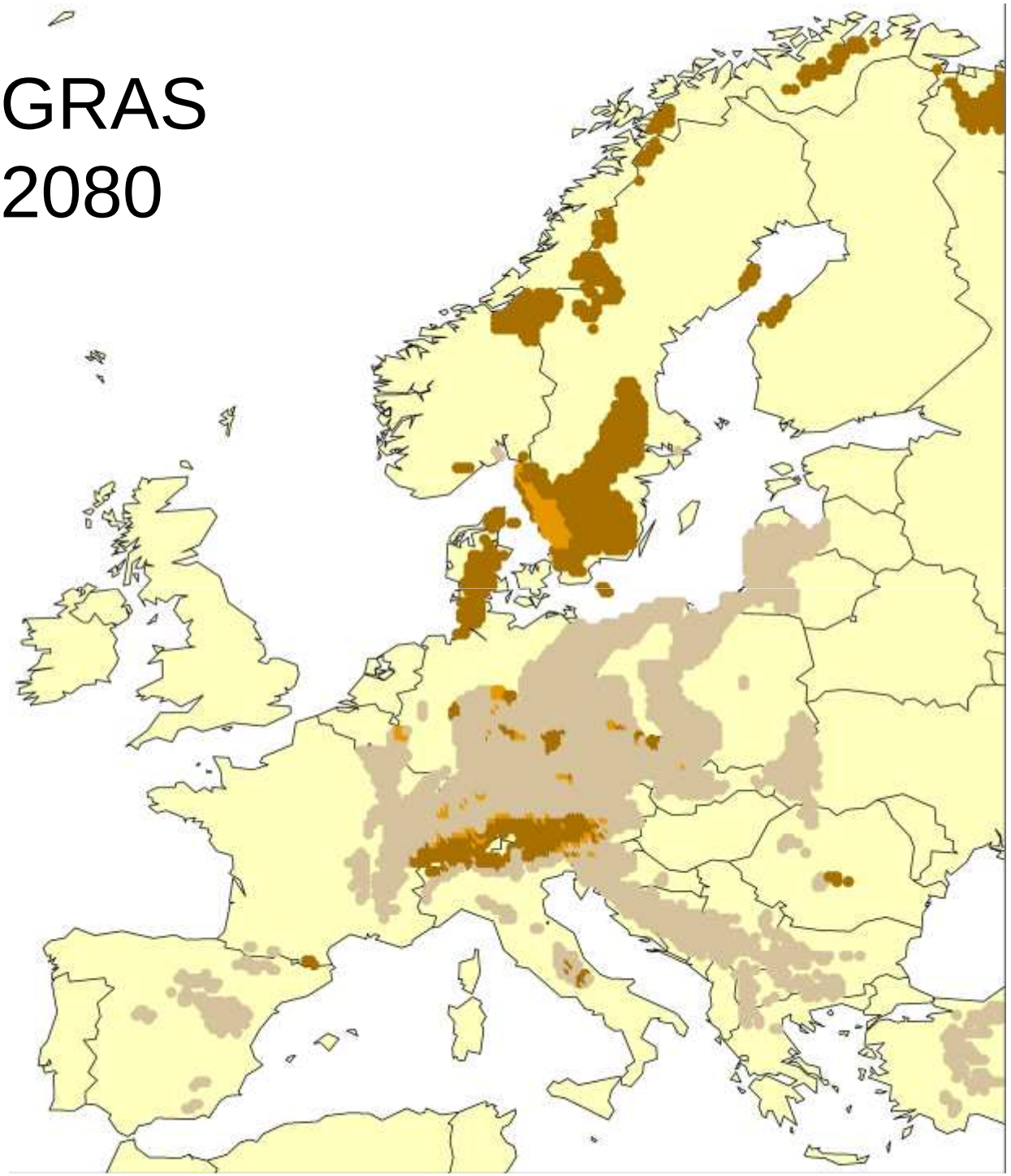
SEDG
2080



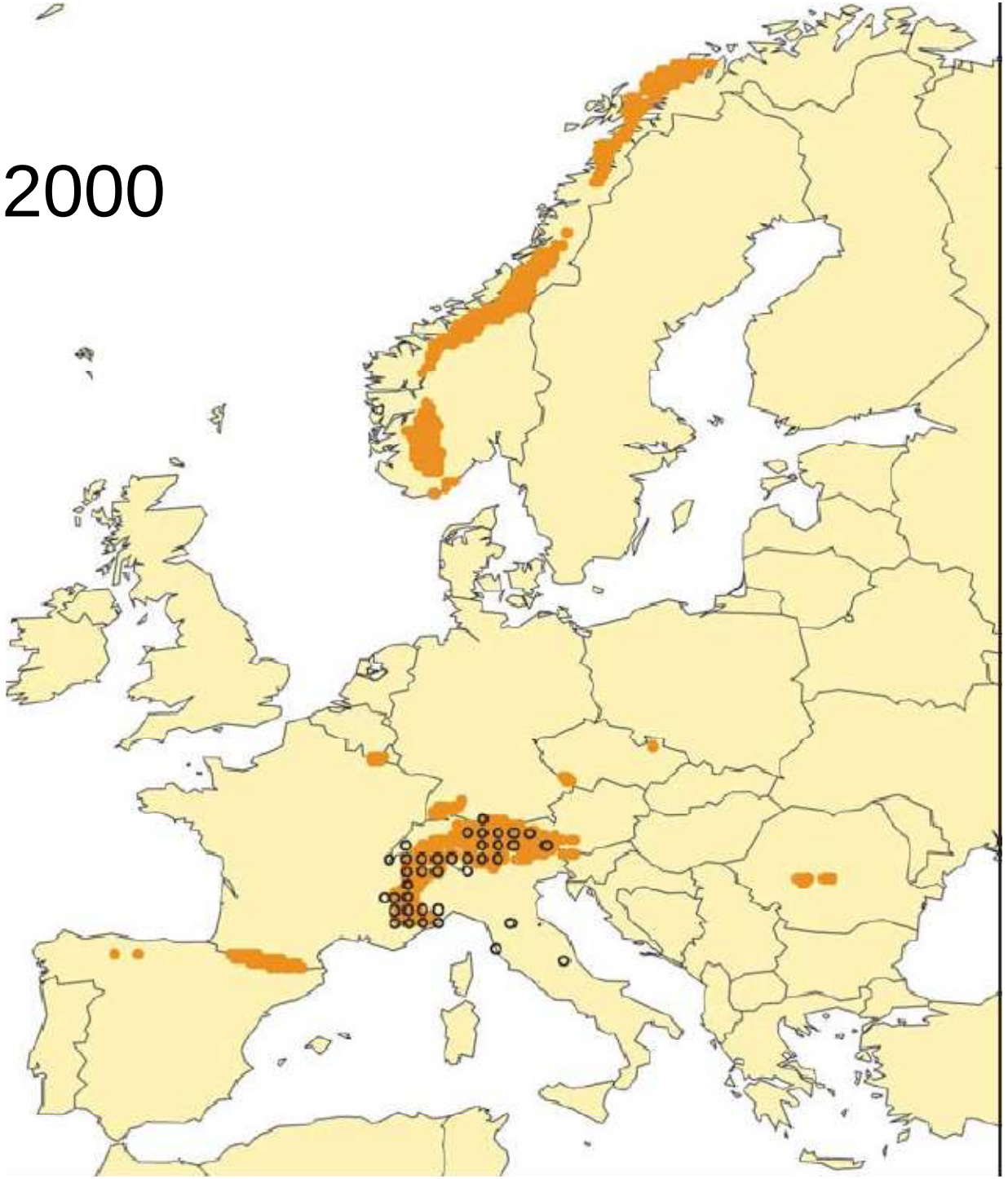
BAMBU
2080



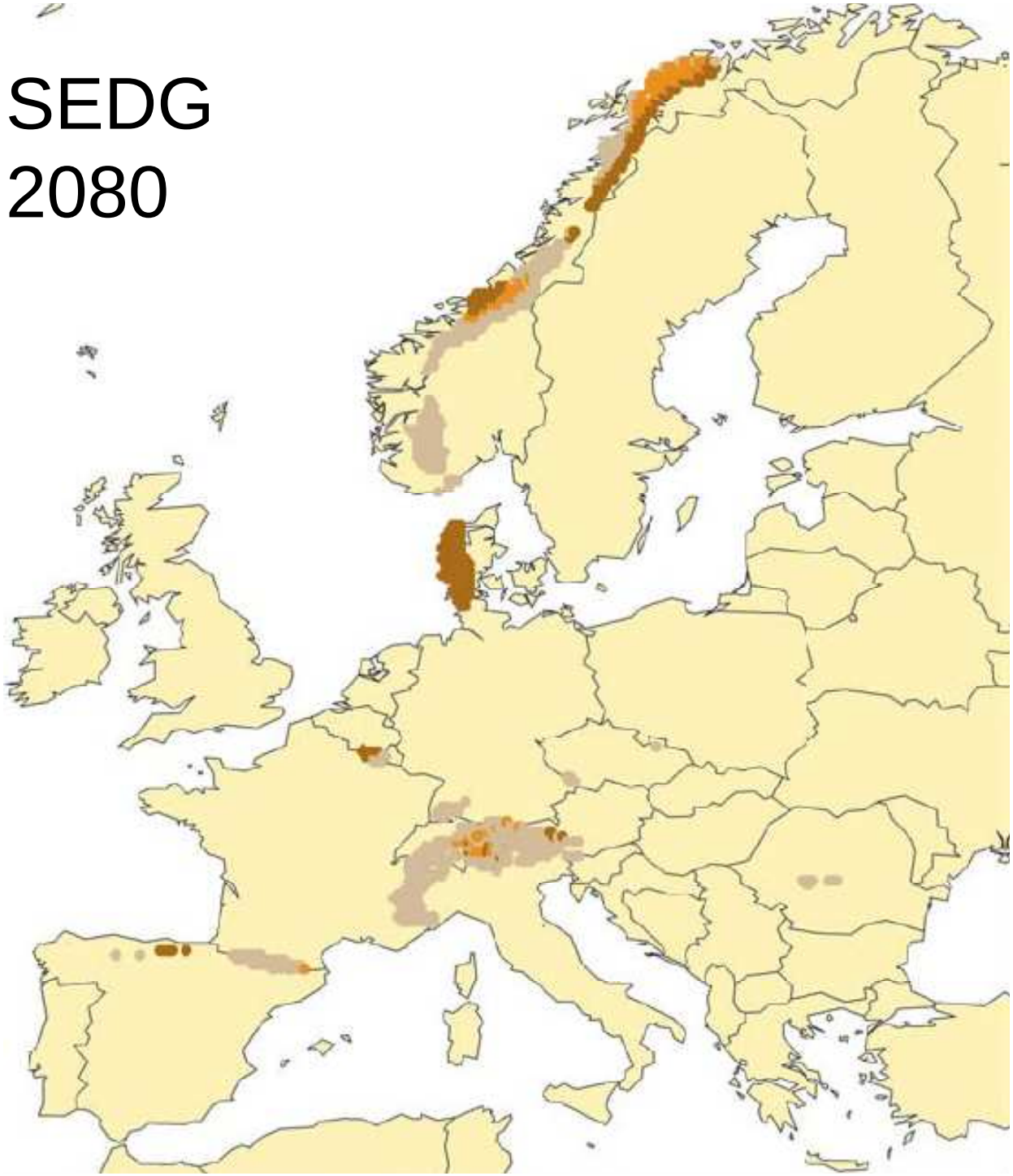
GRAS
2080



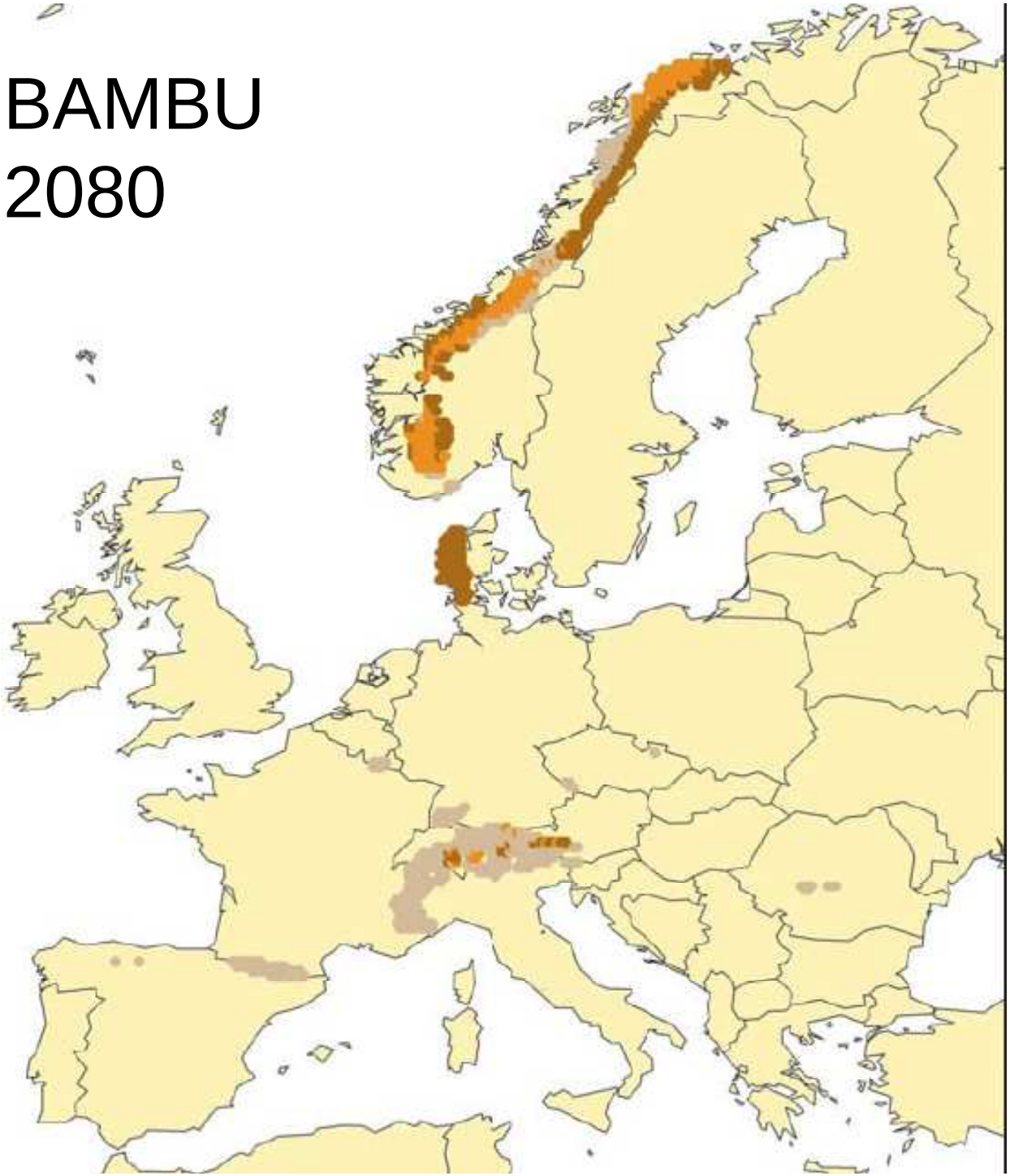
Marbled Ringlet (*Erebia montana*)
© Neil Thompson


2000

SEDG
2080



BAMBU
2080



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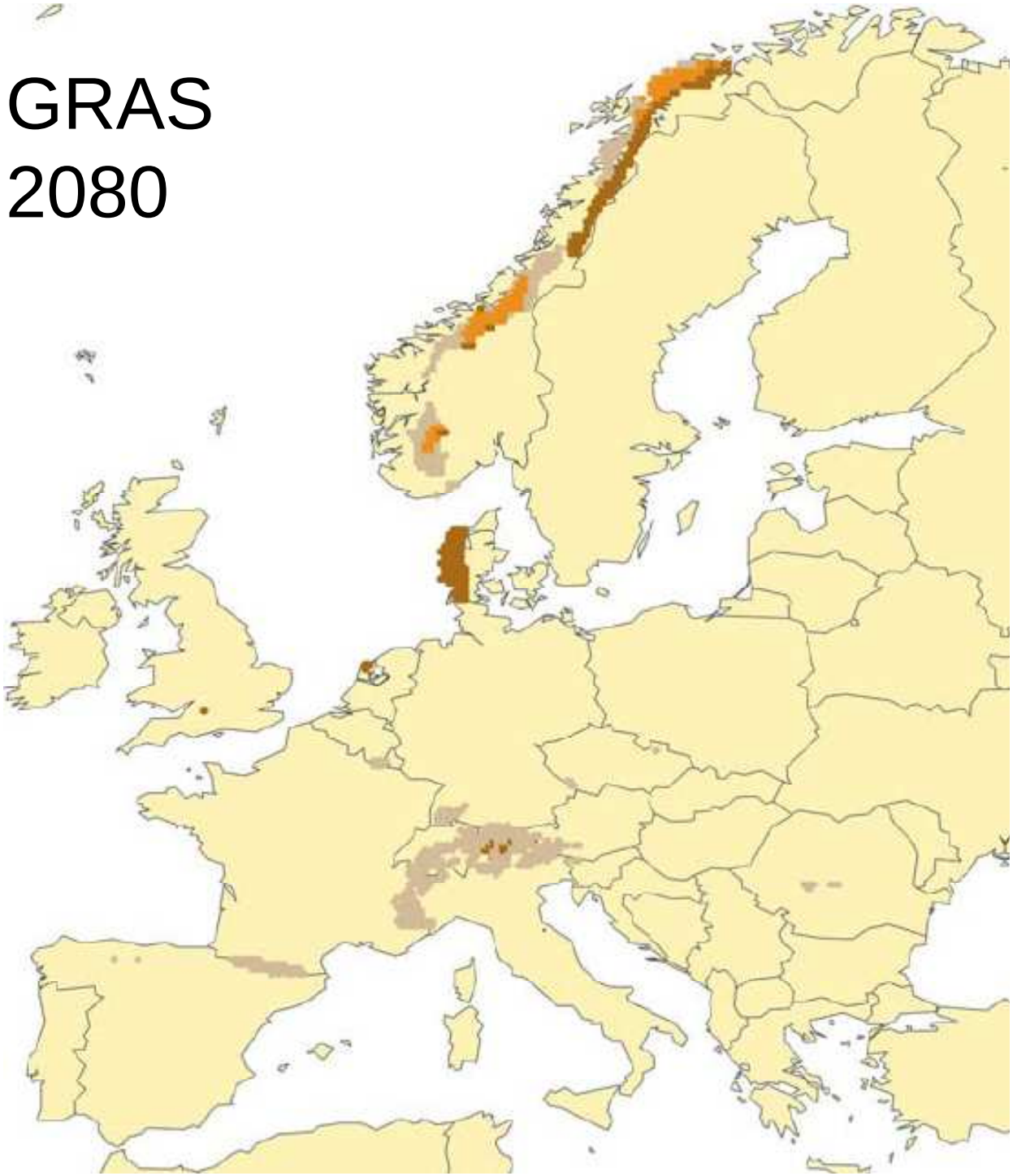
2080



Climatic risks for European butterflies

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

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Butterfly diversity across Europe

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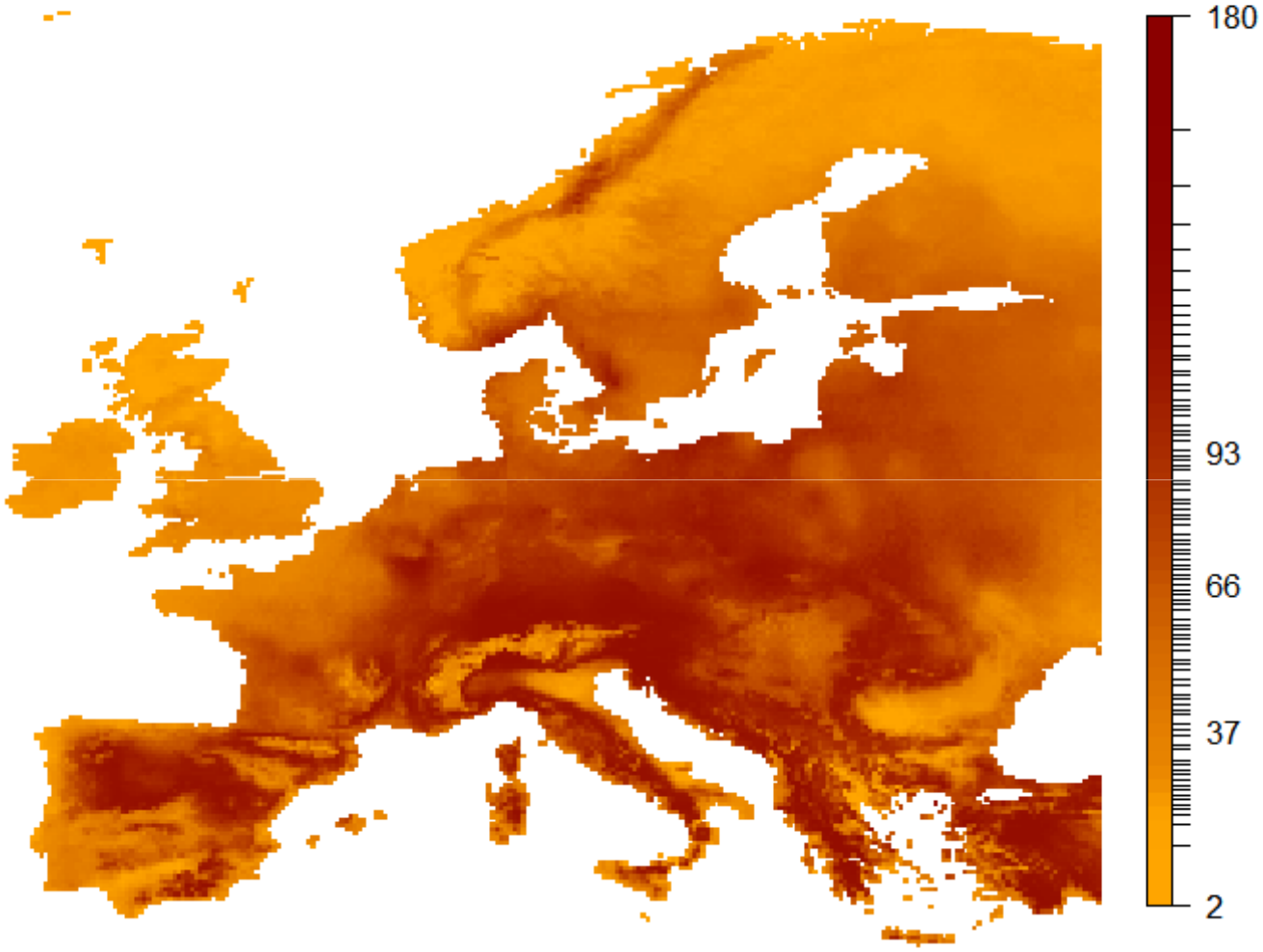
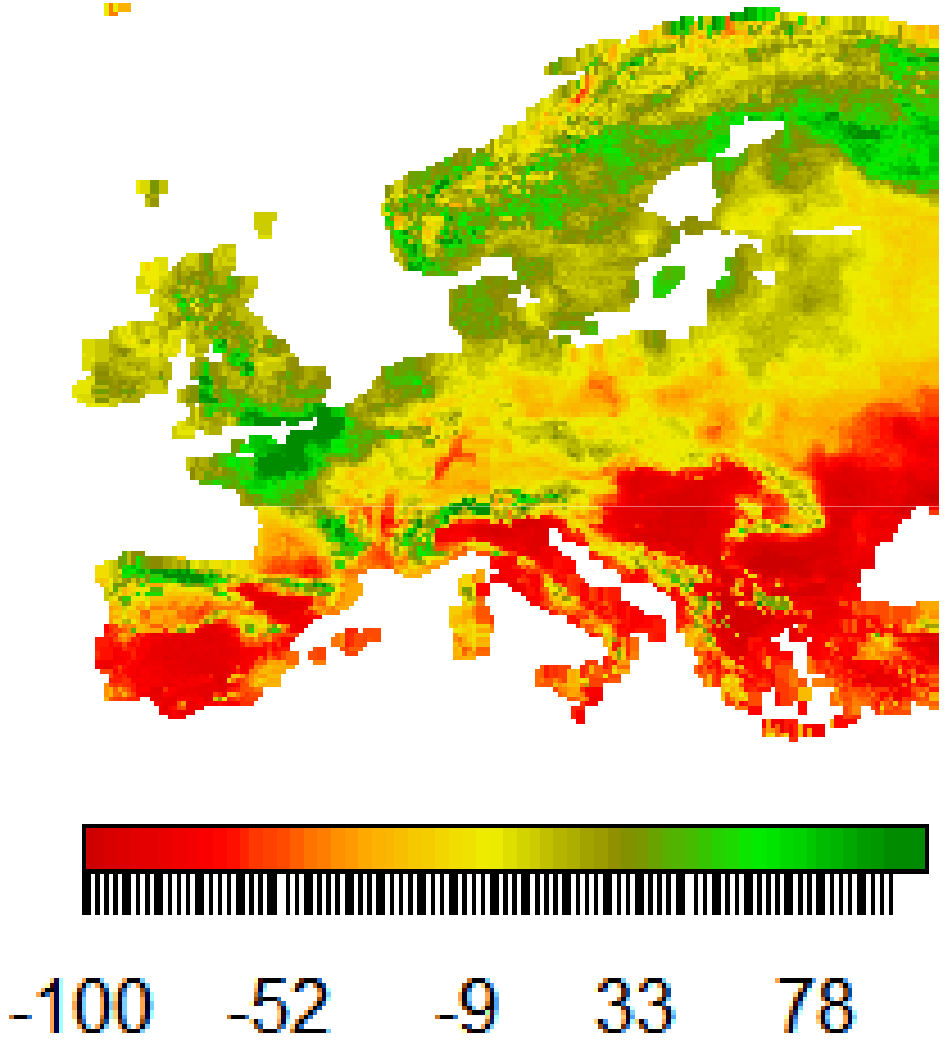
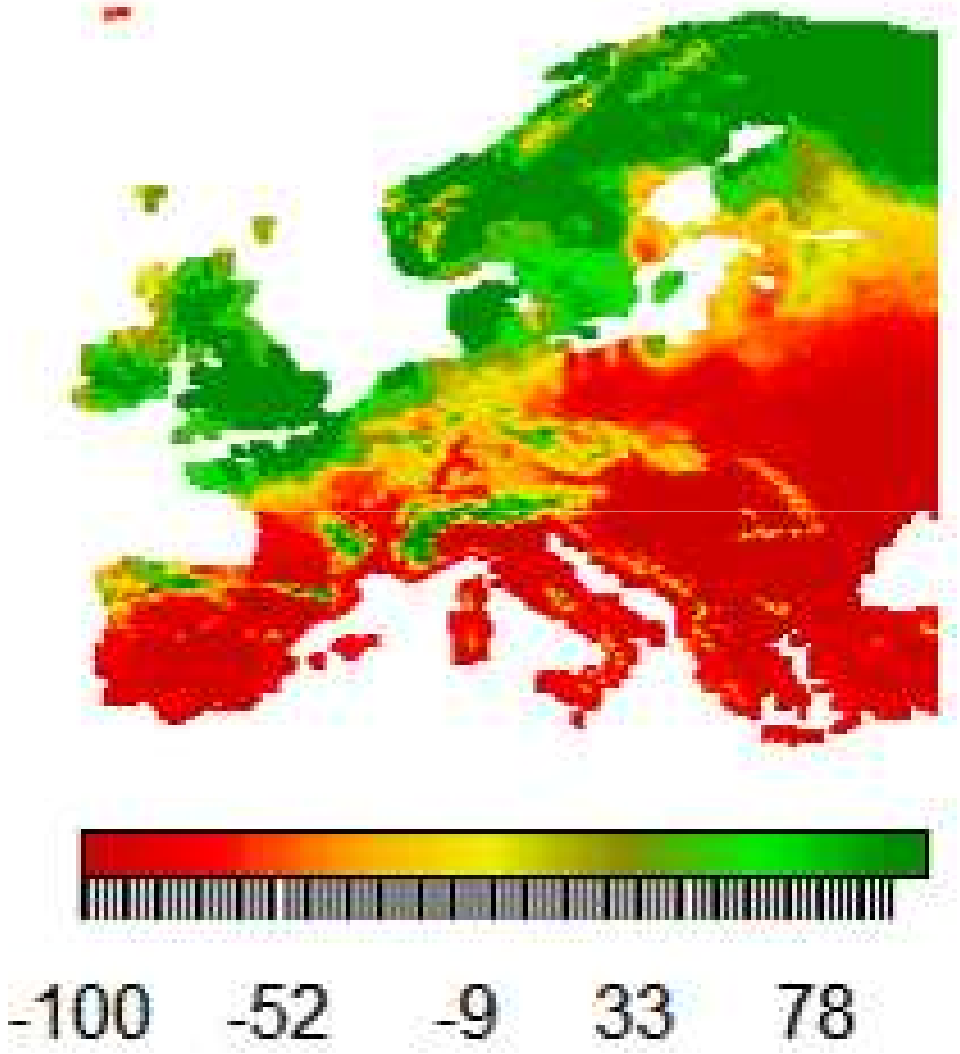
Current richness



GRAS 2050

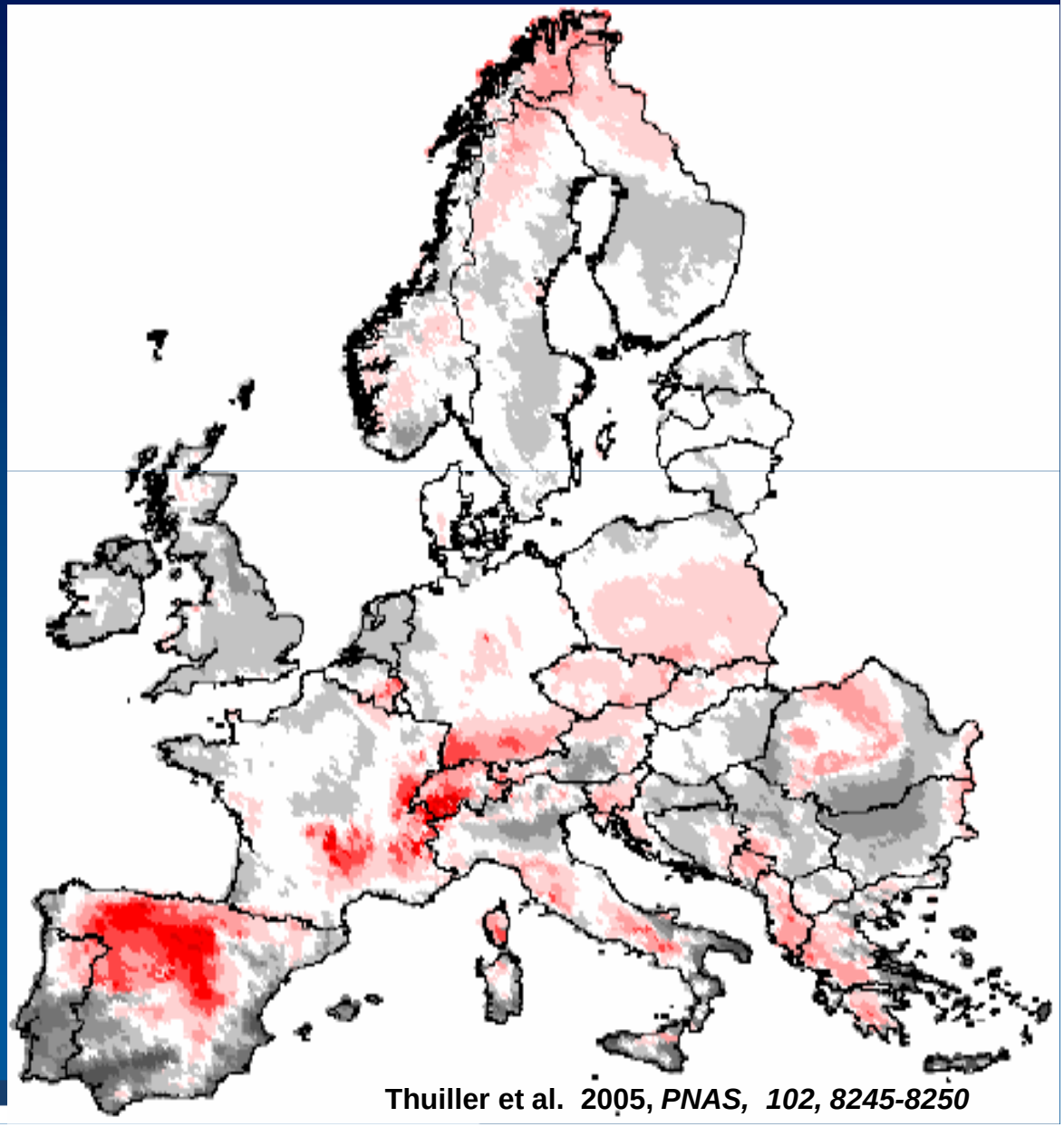


GRAS 2080



Consistent loss across organisms

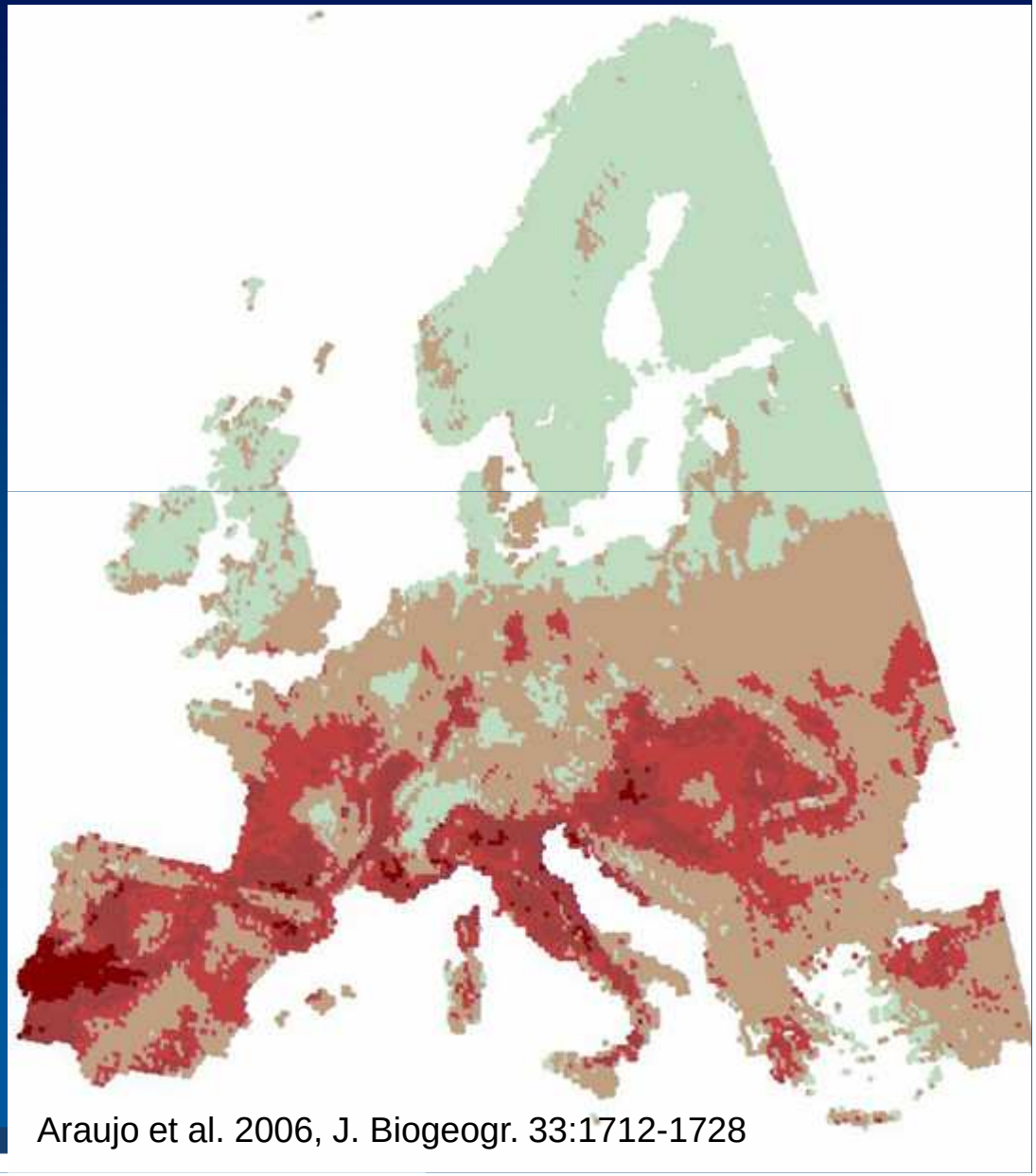
- Plants



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

Consistent loss across organisms

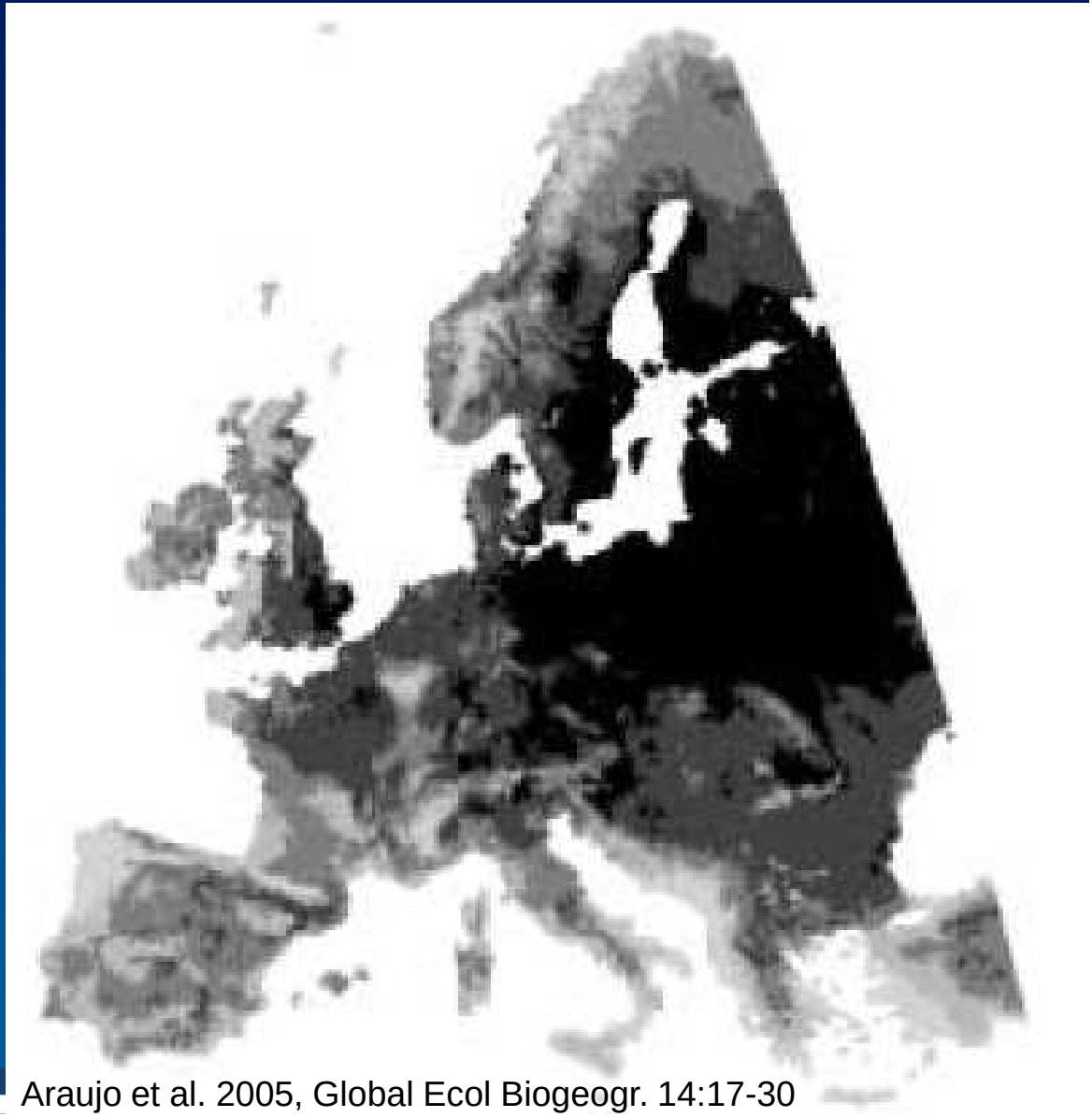
- Plants
- Amphibians
- Reptiles



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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Biesmeijer et al. 2006, *Science*

Polliation

Pollination efficiency depends on ecological matching

- Spatio-temporal matching
- Morphological matching
- Ecophysiological matching

- Many drivers: land-use change, climate change or alien species
- Affects spatial and temporal occurrence, individual performance

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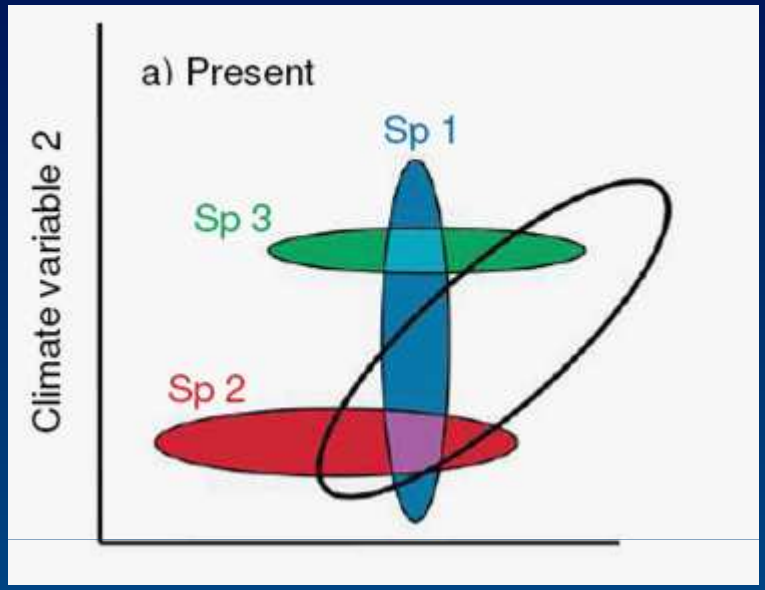
Species composition



Schweiger et al. 2010, *Biol Rev*

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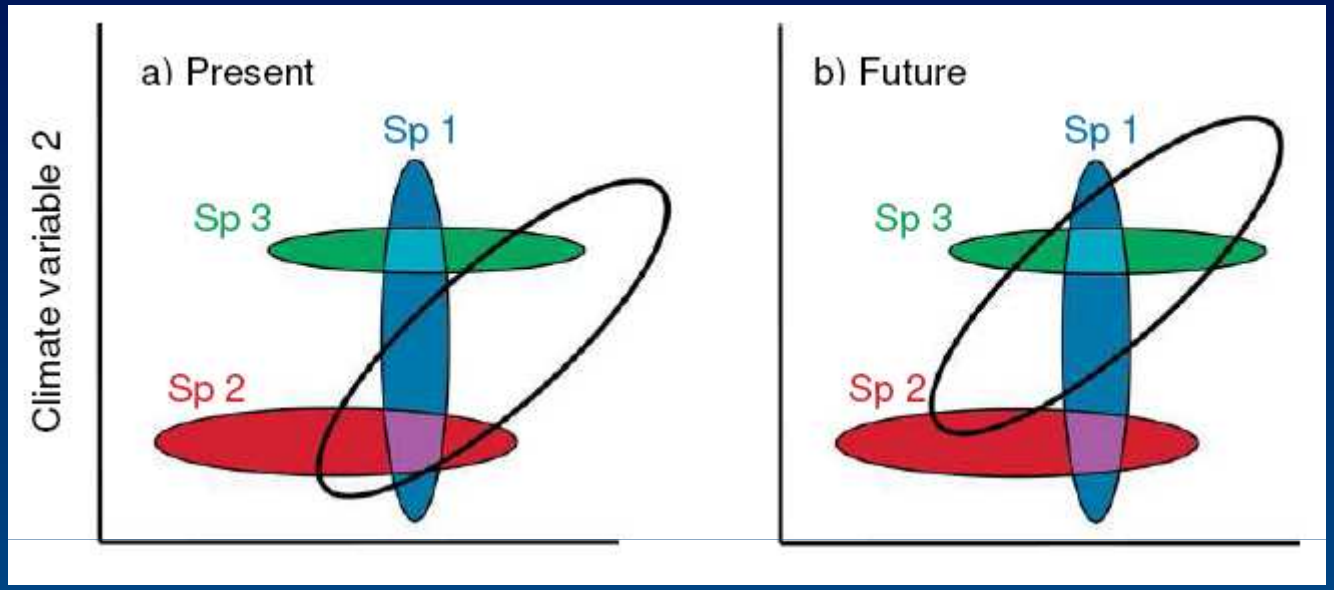
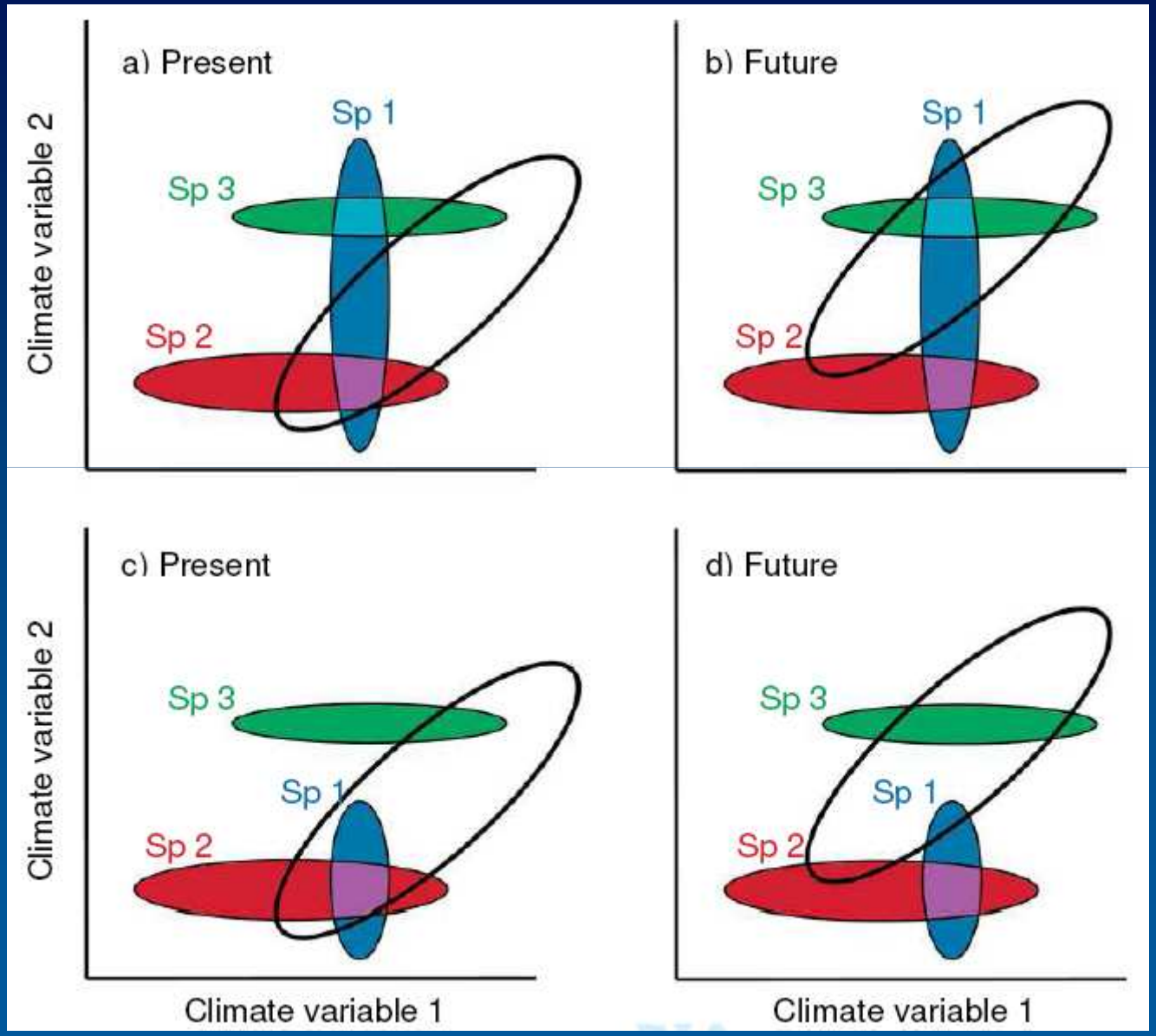


Schweiger et al. 2010, *Biol Rev*

Species composition



Schweiger et al. 2010, *Biol Rev*

Species composition

- Generation of novel communities
- Existing species interactions disappear
- Potential for novel interactions emerges
- New functional strucuture

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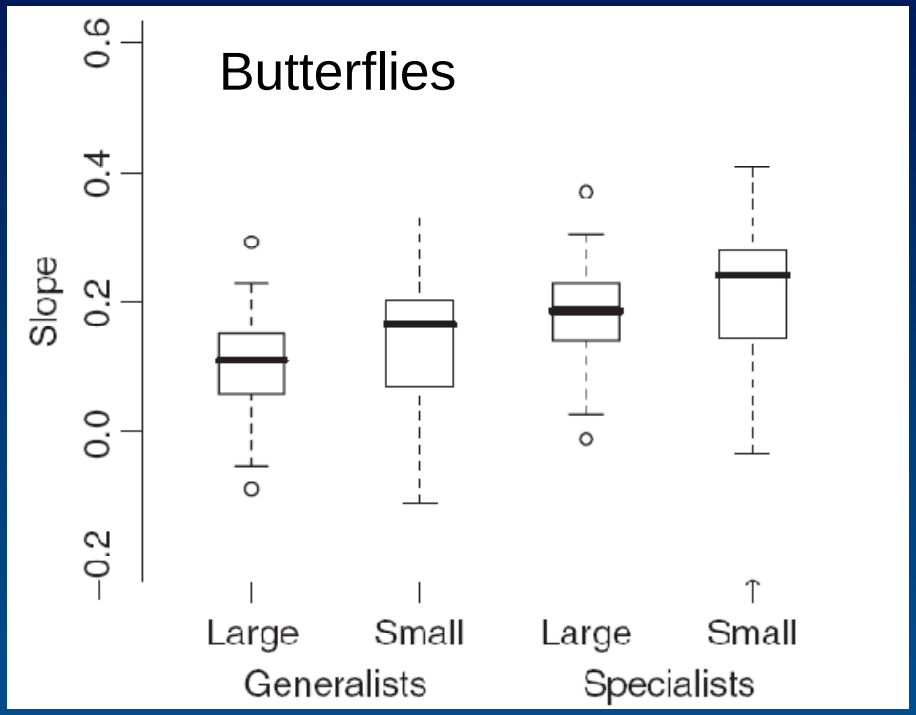
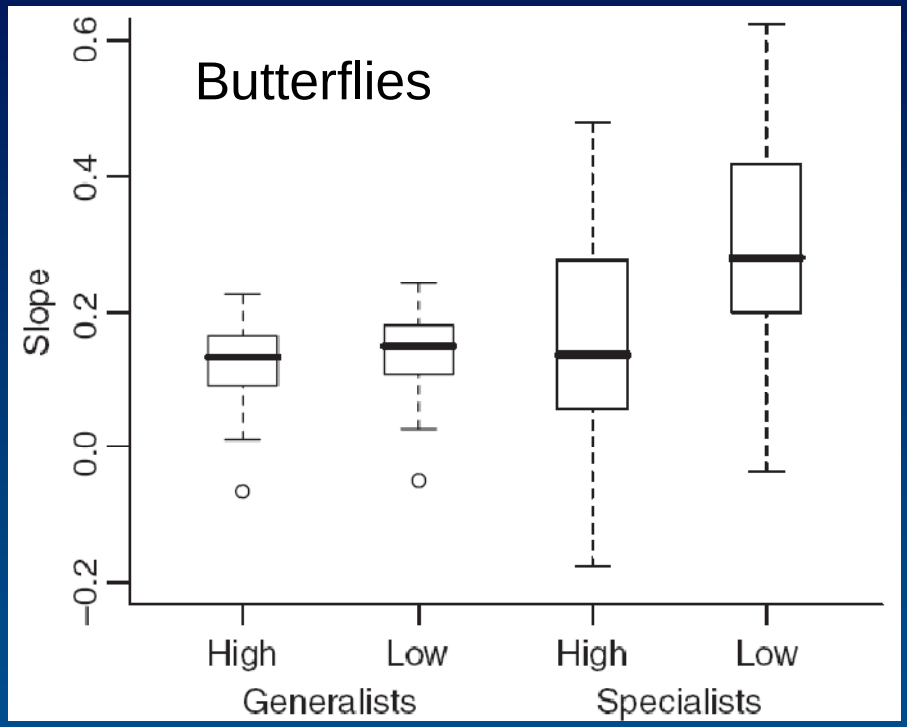
Land use

Land use – pollinator functional aspects





Öckinger et al. 2010, *Ecol Lett*

- Habitat loss affects ecological groups differently
- Community structure

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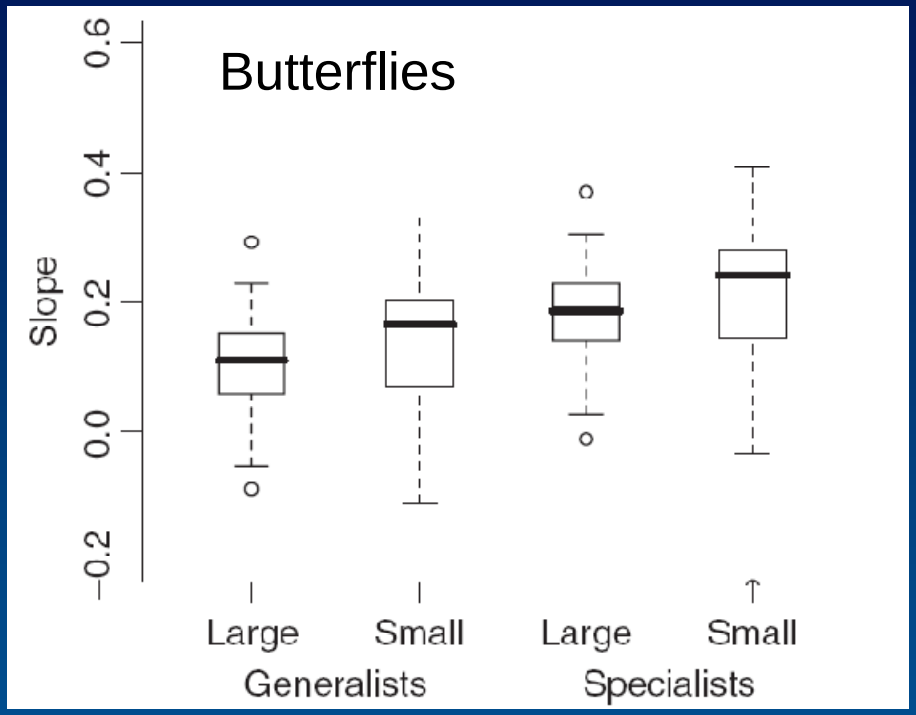
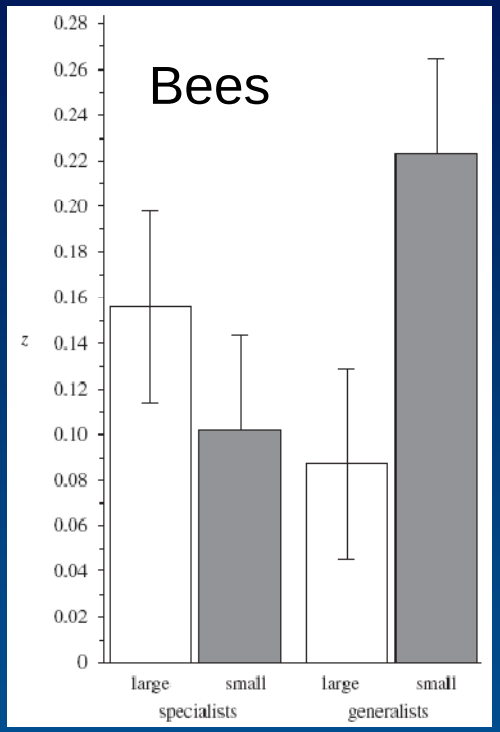
Land use – pollinator functional aspects



Öckinger et al. 2010, *Ecol Lett*

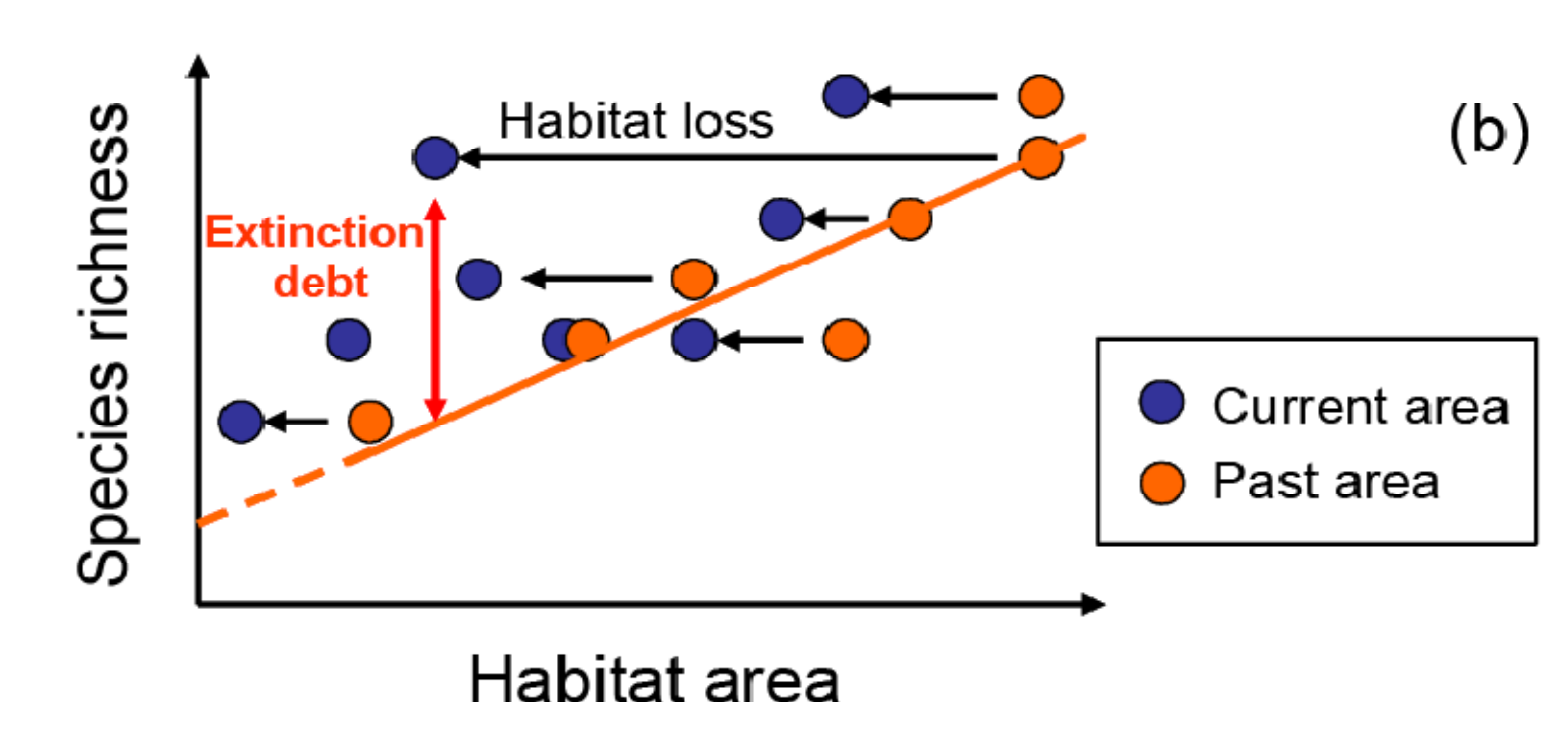


Bommarco et al. 2010, *Proc. R. Soc. B*

- Habitat loss affects ecological groups differently
- Community structure
- Different responses among taxonomical groups

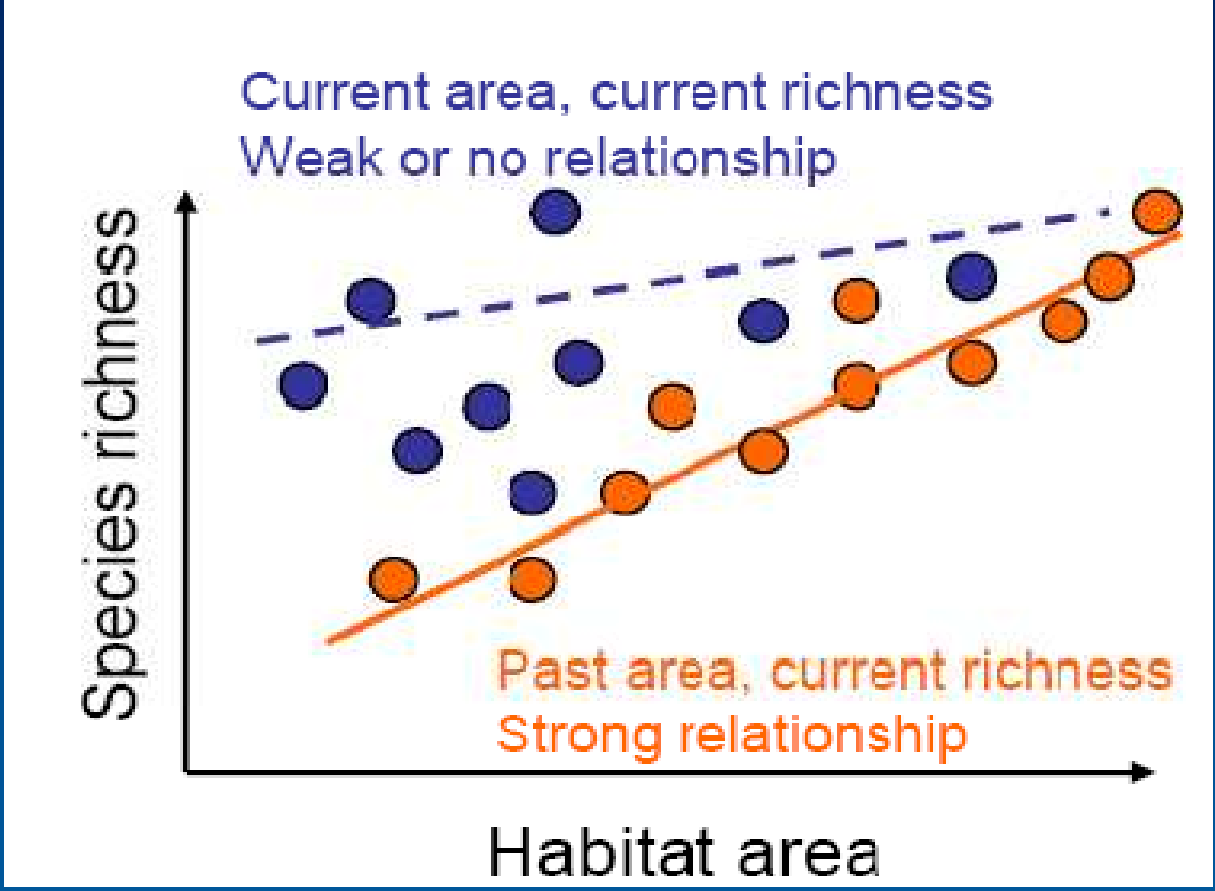
Extinction debt

= number of species not yet extinct following habitat loss



Kuussaari et al. 2009 TREE

Detecting extinction debts



Kuussaari et al. 2009 TREE

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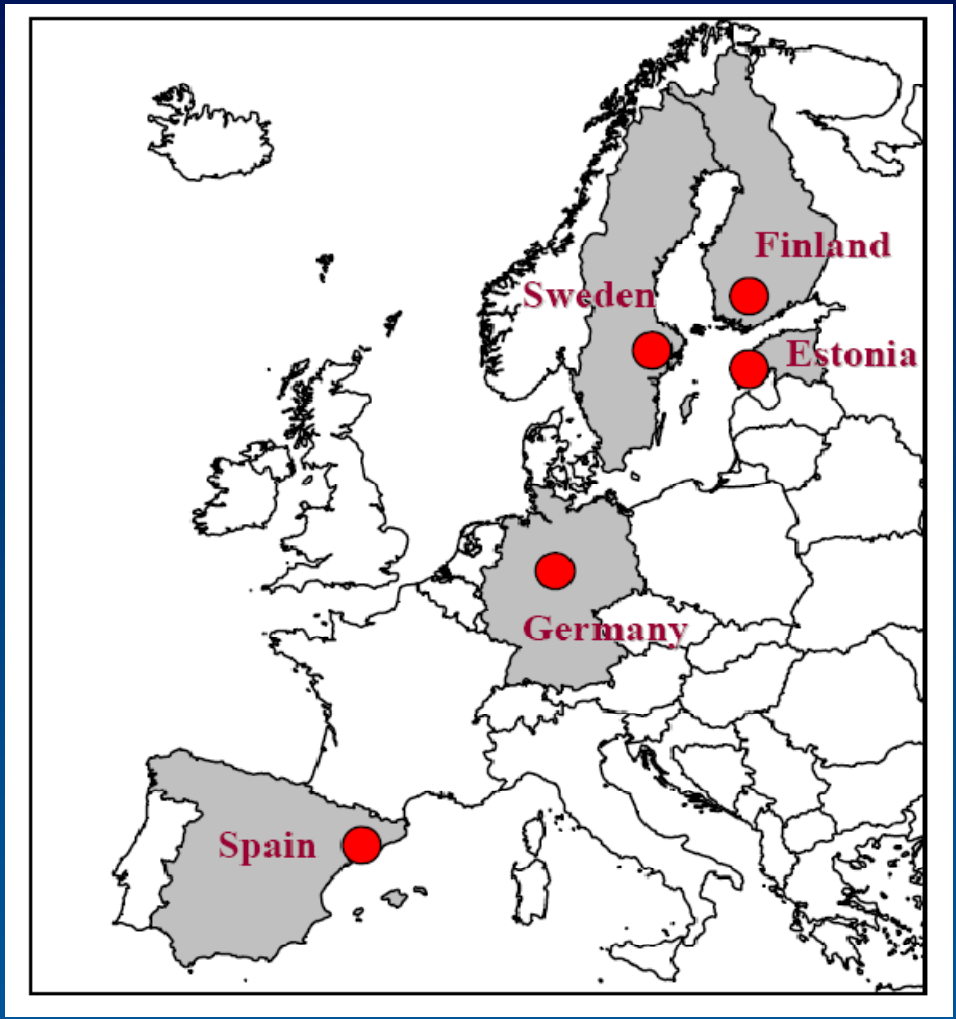
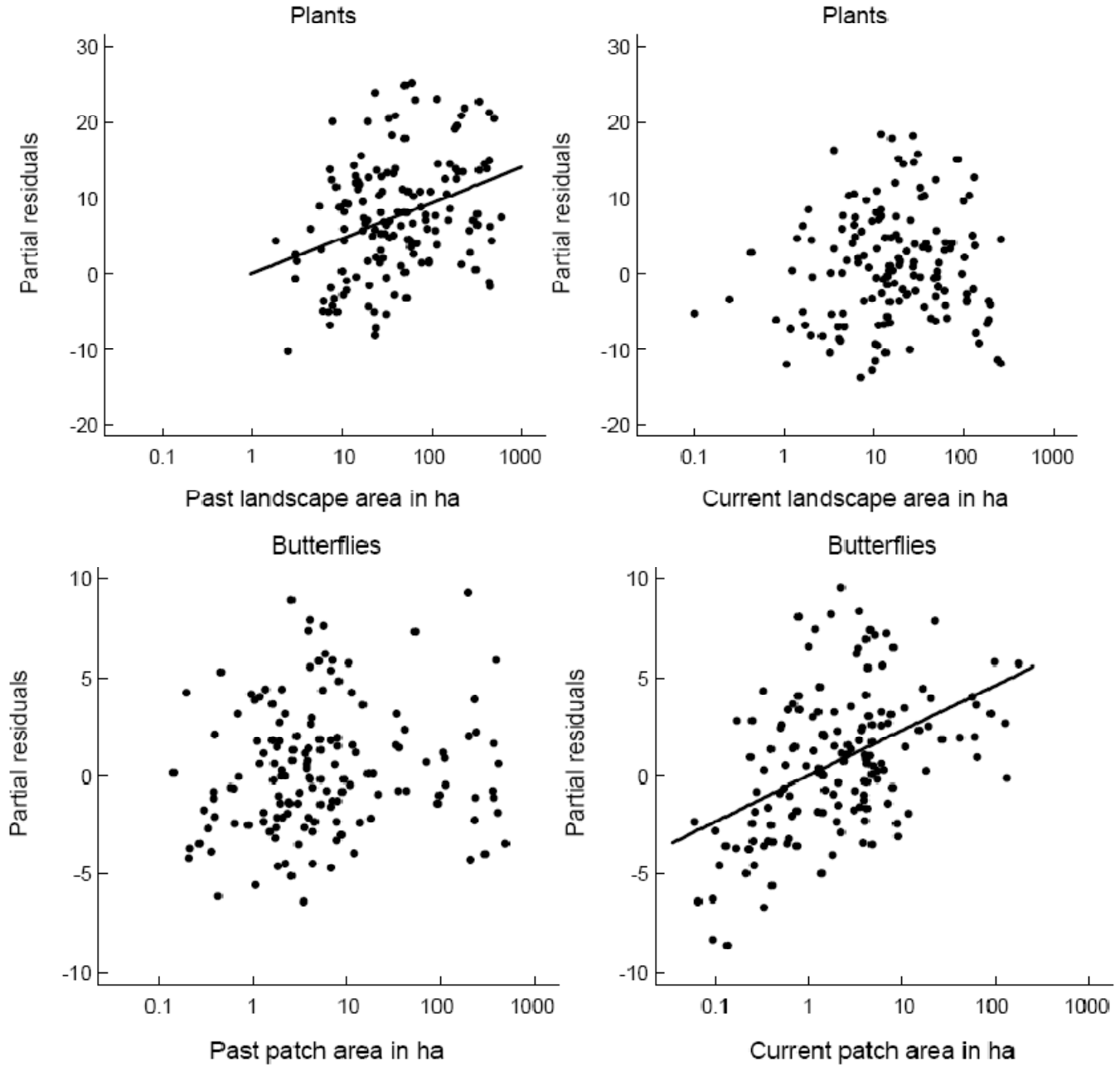
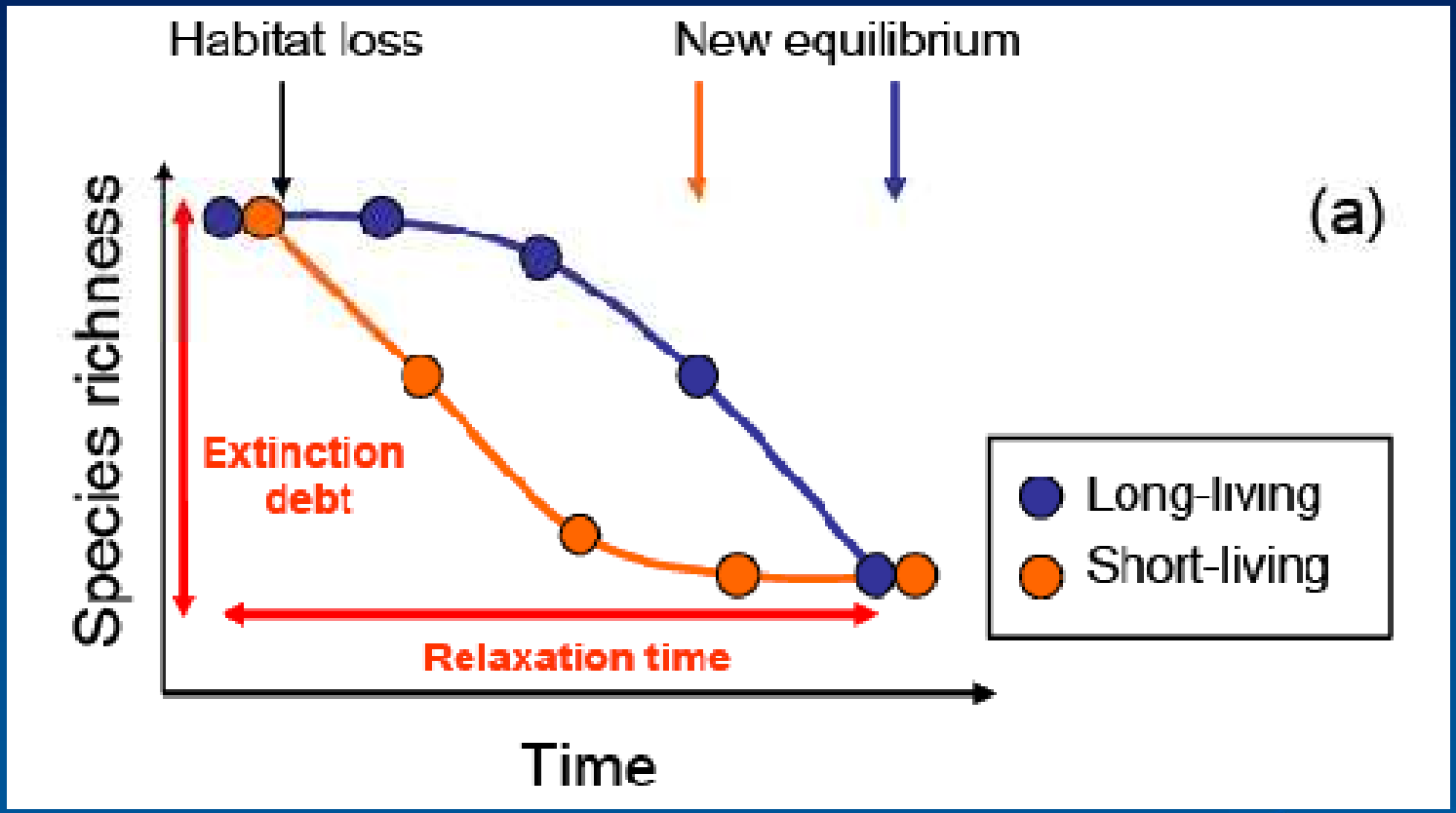


Krauss et al. 2010, *Ecol Lett*



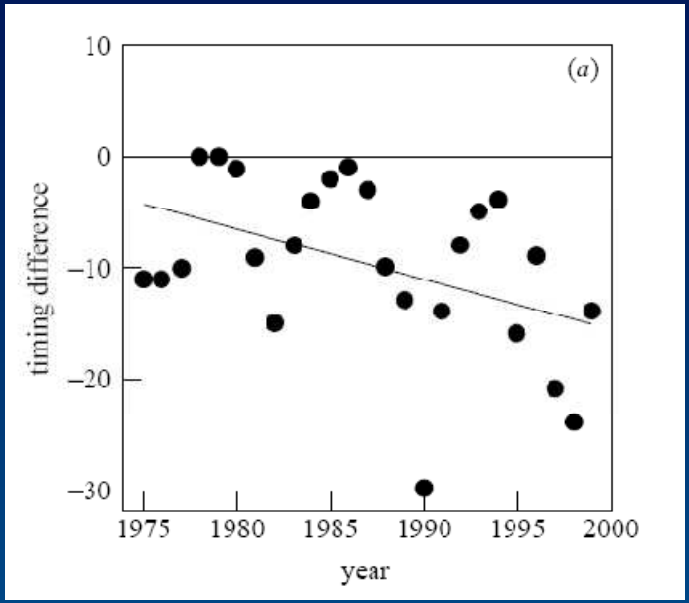
Krauss et al. 2010, *Ecol Lett*



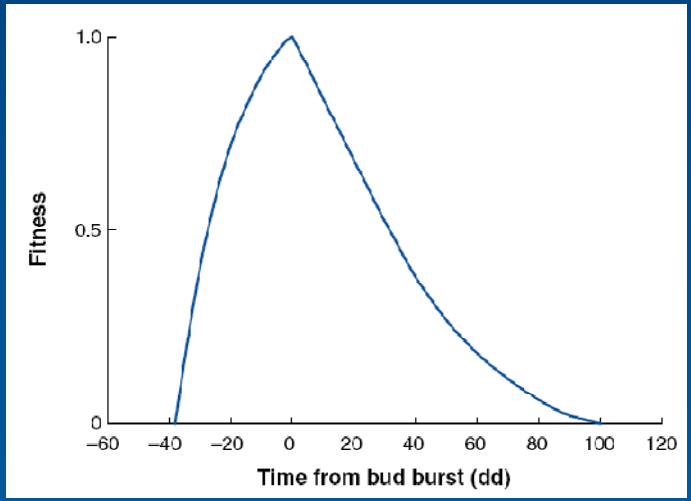
Kuussaari et al. 2009 TREE

Climate change

Temporal mismatching



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

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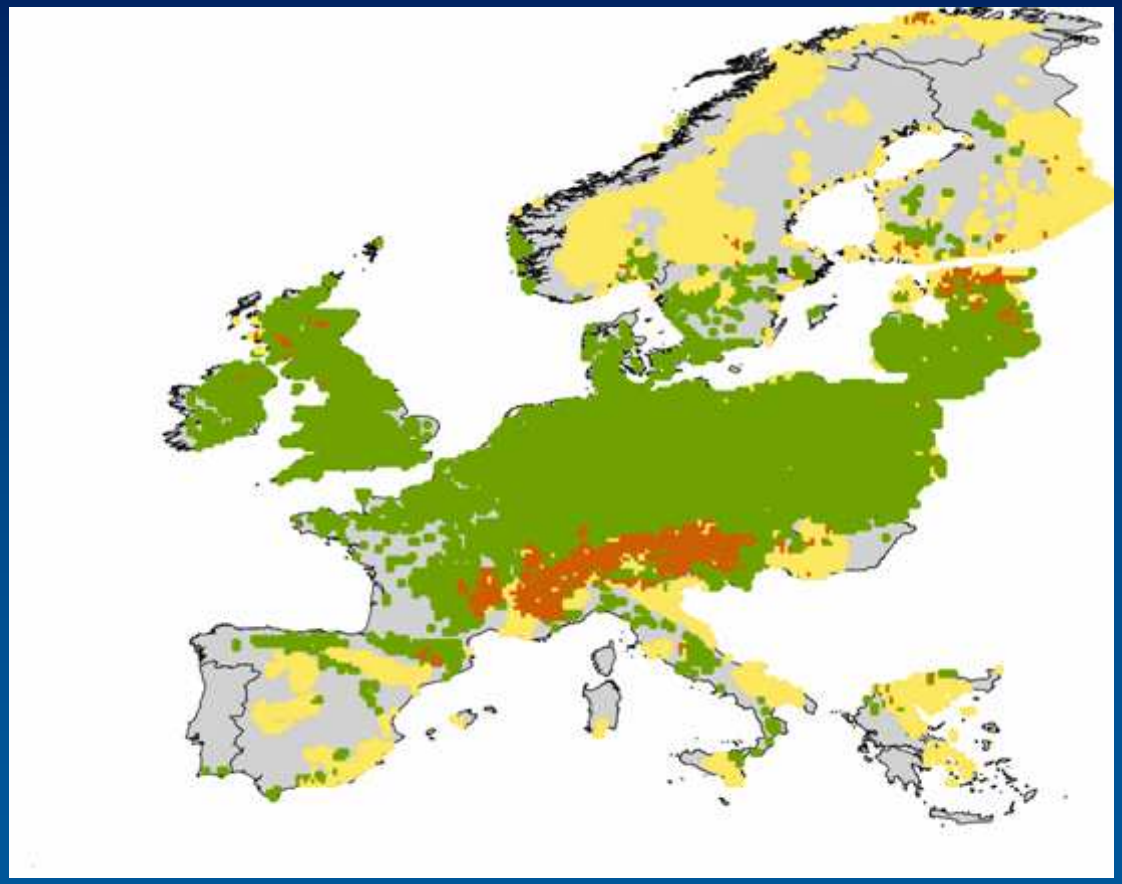
Spatial mismatching

Species interactions:
Boloria titania and *Polygonum bistorta*

Current spatial matching

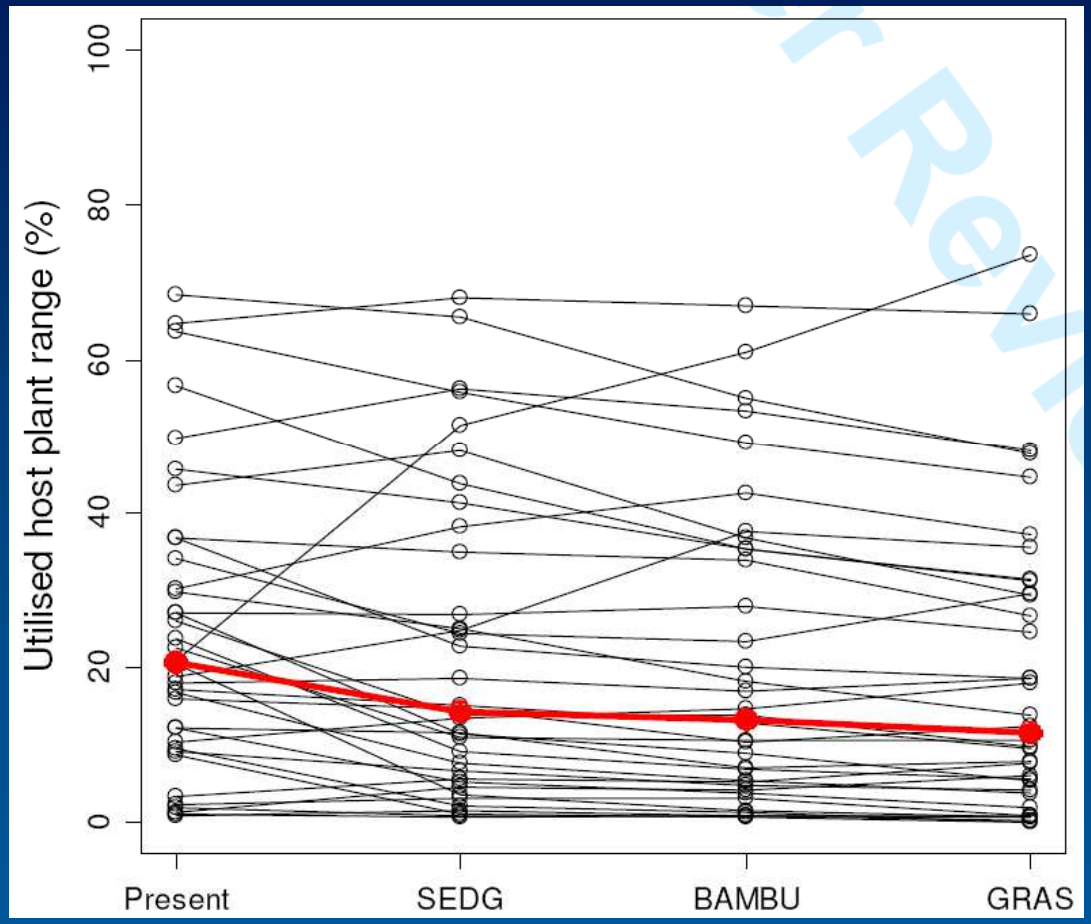


- Plant (*P. bistorta*)
- Butterfly (*B. titania*)
- Overlap of both

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

Schweiger et al.2008, *Ecology*

Spatial mismatching

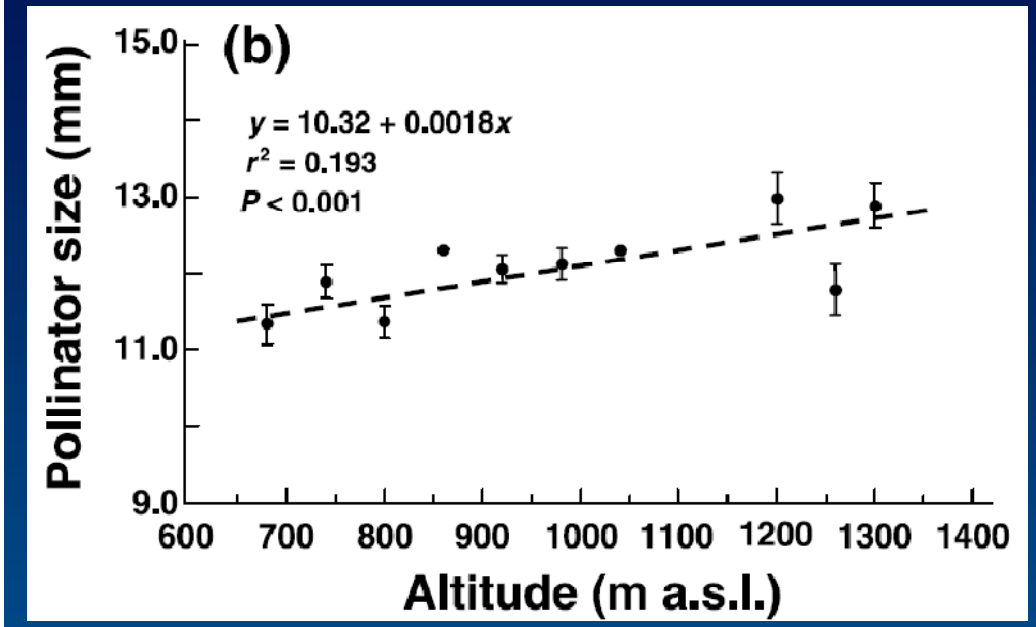


Schweiger et al. in press, *GEB*

- 36 Butterflies
- 115 host plants

- Most butterflies utilise the range of their hosts inefficiently
- Most butterflies are limited by climate
- Most changes are unaffected by host plant
- Butterflies with hosts having small ranges seriously suffer from mismatch

Morphological mismatching



Malo & Bonza 2002, *Diversity and Distribution*

- Average body size in pollinator communities increases with altitude

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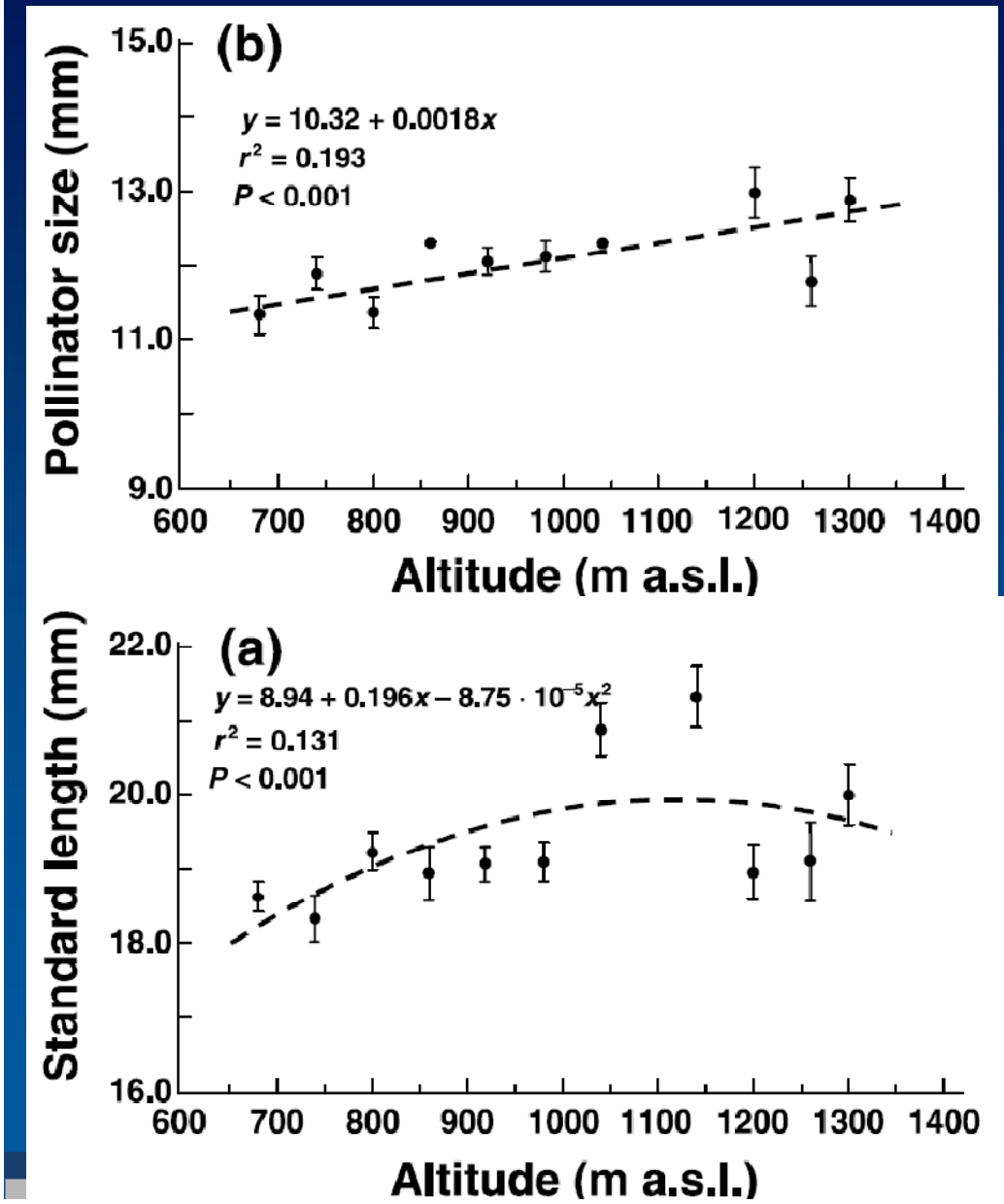
Morphological mismatching



- Average body size in pollinator communities increases with altitude
- Corresponding increase of flower size of *Cytisus scoparius*

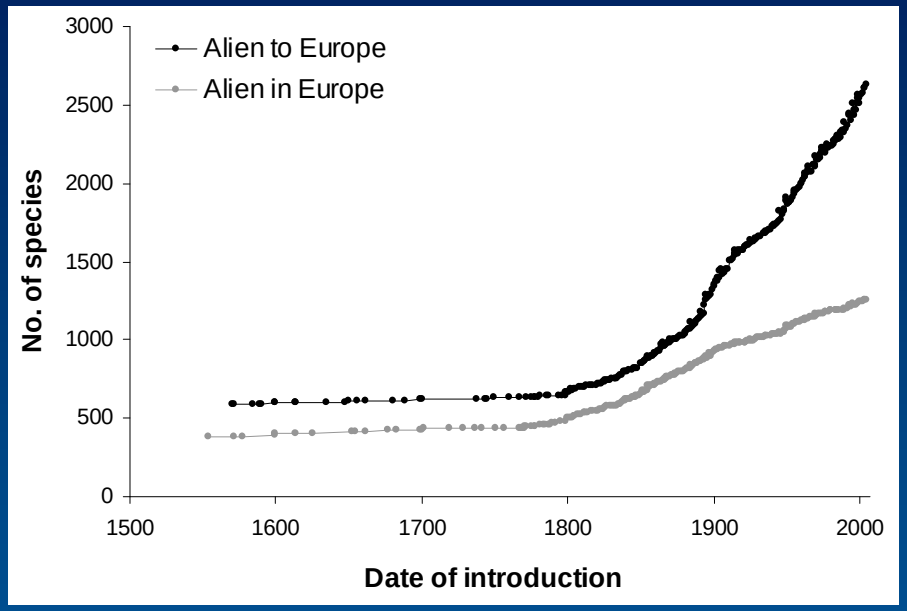
Malo & Bonza 2002, *Diversity and Distribution*

Alien species

Oliver Schweiger

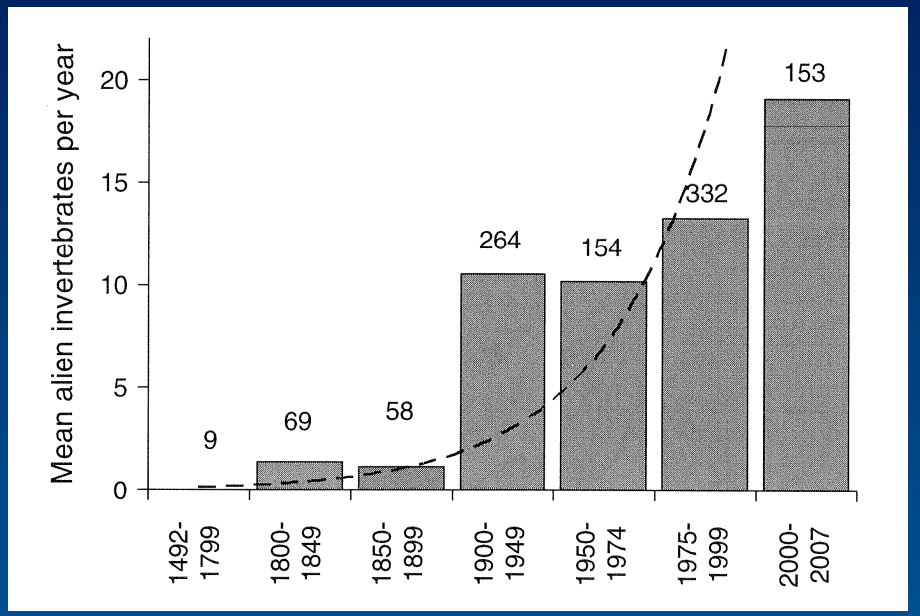
Temporal dynamics of invasions in Europe

Plants



Lambdon et al. 2008, Preslia 80: 101-149

Invertebrates



Roques et al. 2009, in Daisie

- Number of invasions increases

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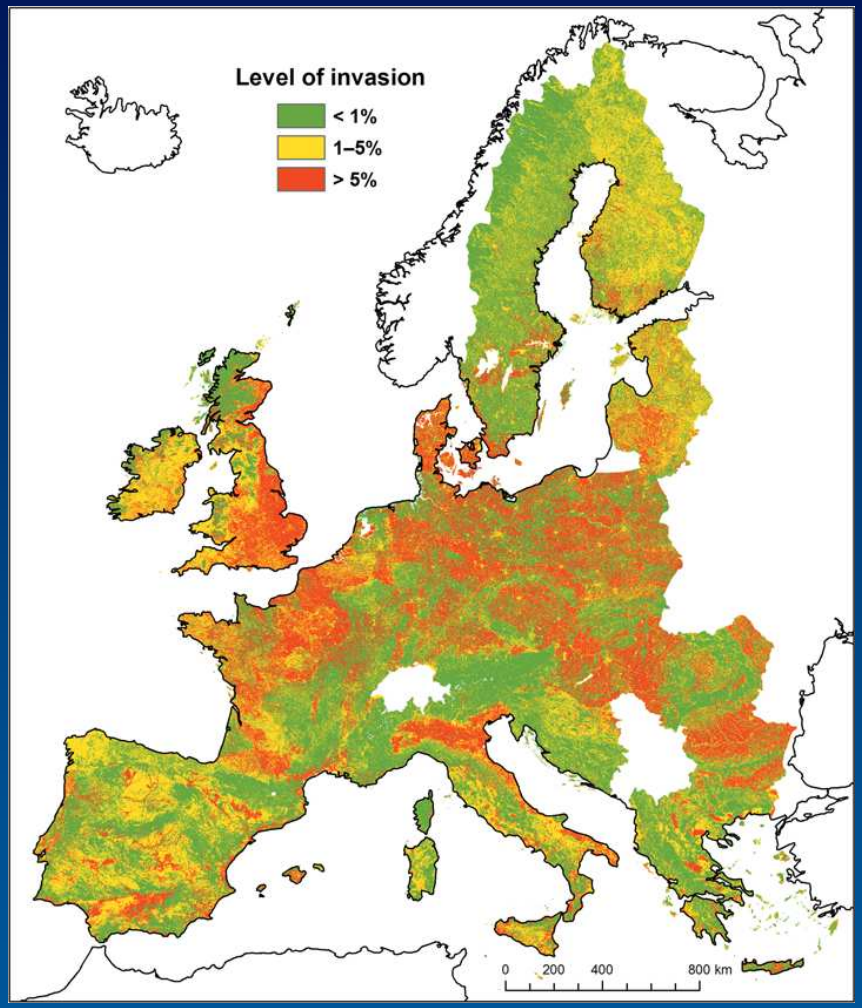
Spatial dynamics of invasions in Europe



Chytrý et al. 2009, Diversity & Distributions

Map of plant invasions in Europe based on invasibility of EUNIS habitats (translated to CORINE land-cover) in three biogeographical regions. Based on vegetation plot data from Chytrý et al., J. Appl. Ecol. 2007

- Invasibility differs across Europe

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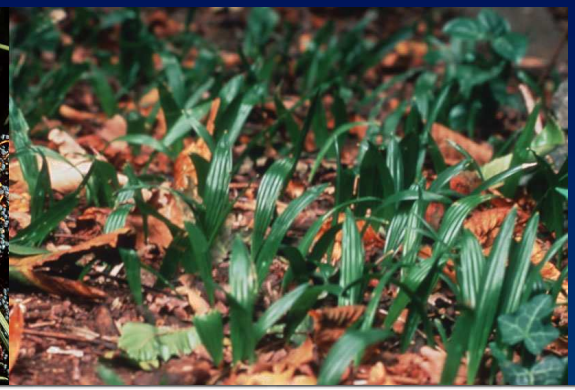
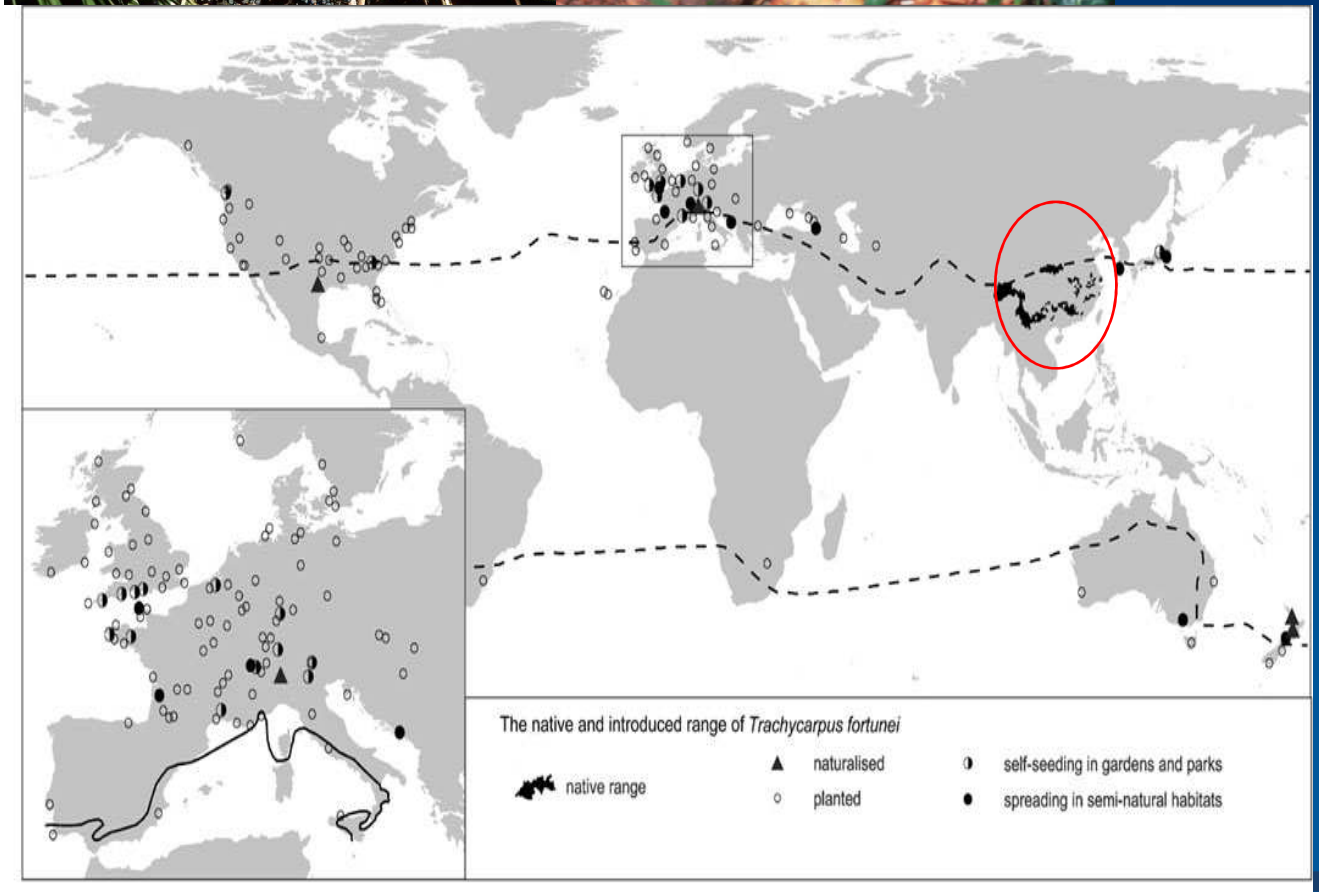
Establishment of an invasive species driven by climate change



Trachycarpus fortunei



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Complex network of disrupted and novel interactions

Potential buffer mechanisms?

- Adaptation
- Network architecture
- Novel communities

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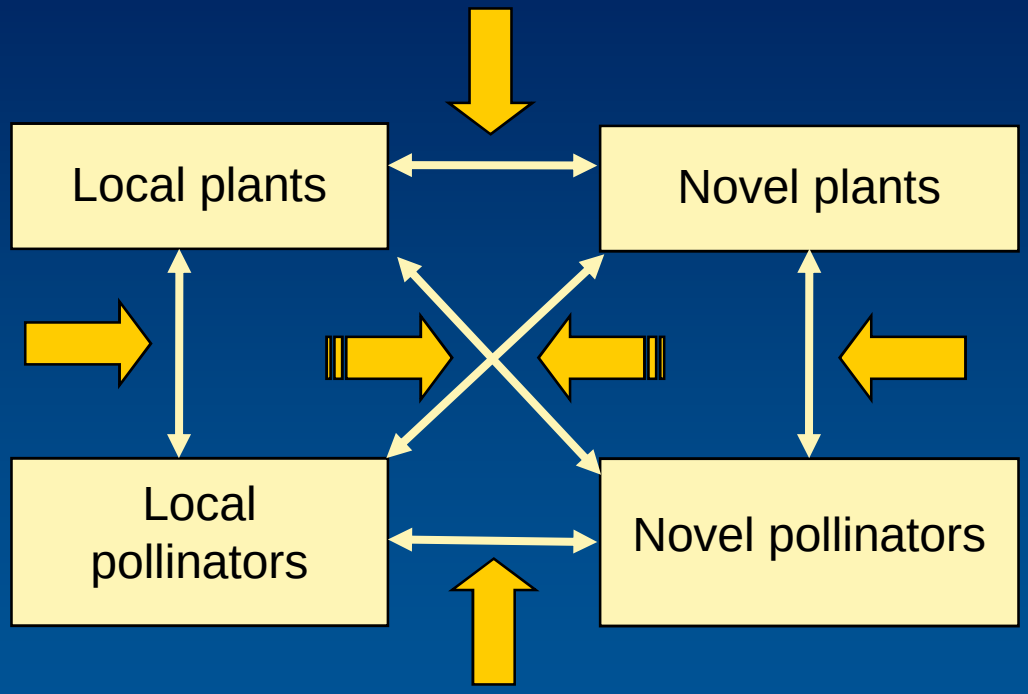
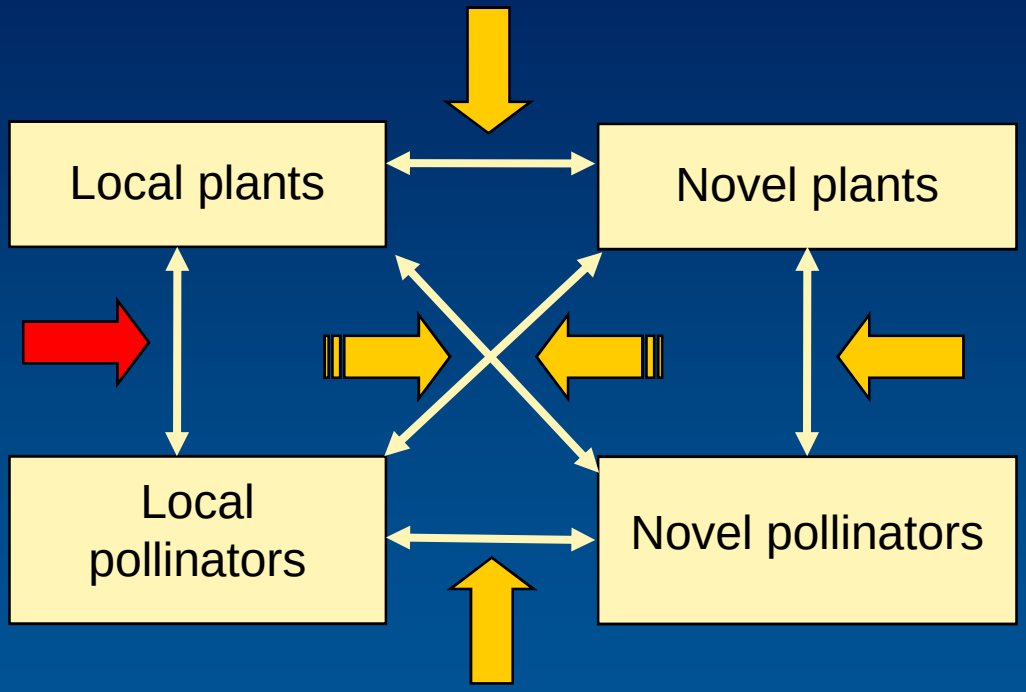
Novel communities



Schweiger et al. 2010, *Biol Rev*

Novel communities

Affected ecological matching



Schweiger et al. 2010, *Biol Rev*

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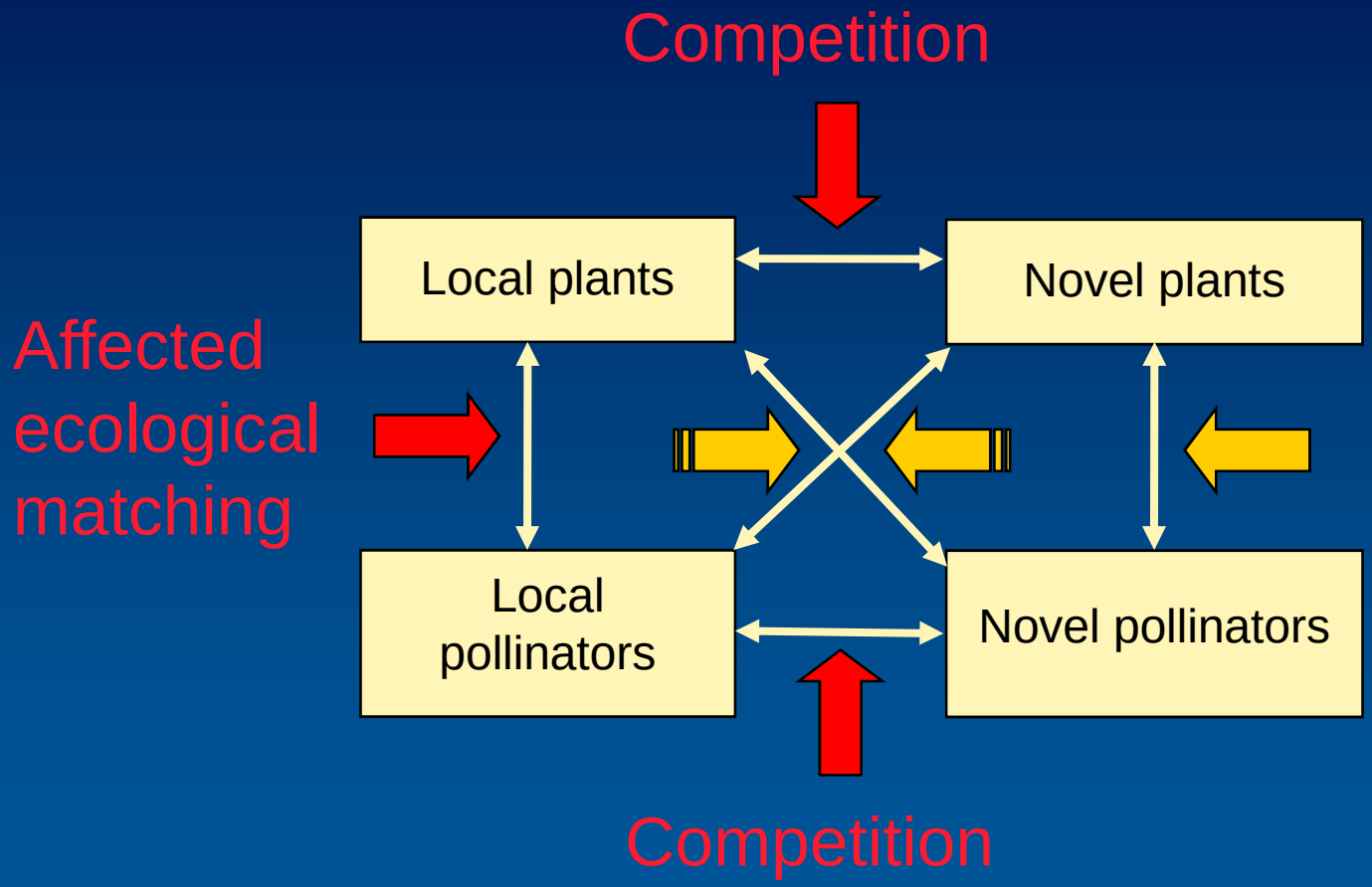
Novel communities



Schweiger et al. 2010, *Biol Rev*

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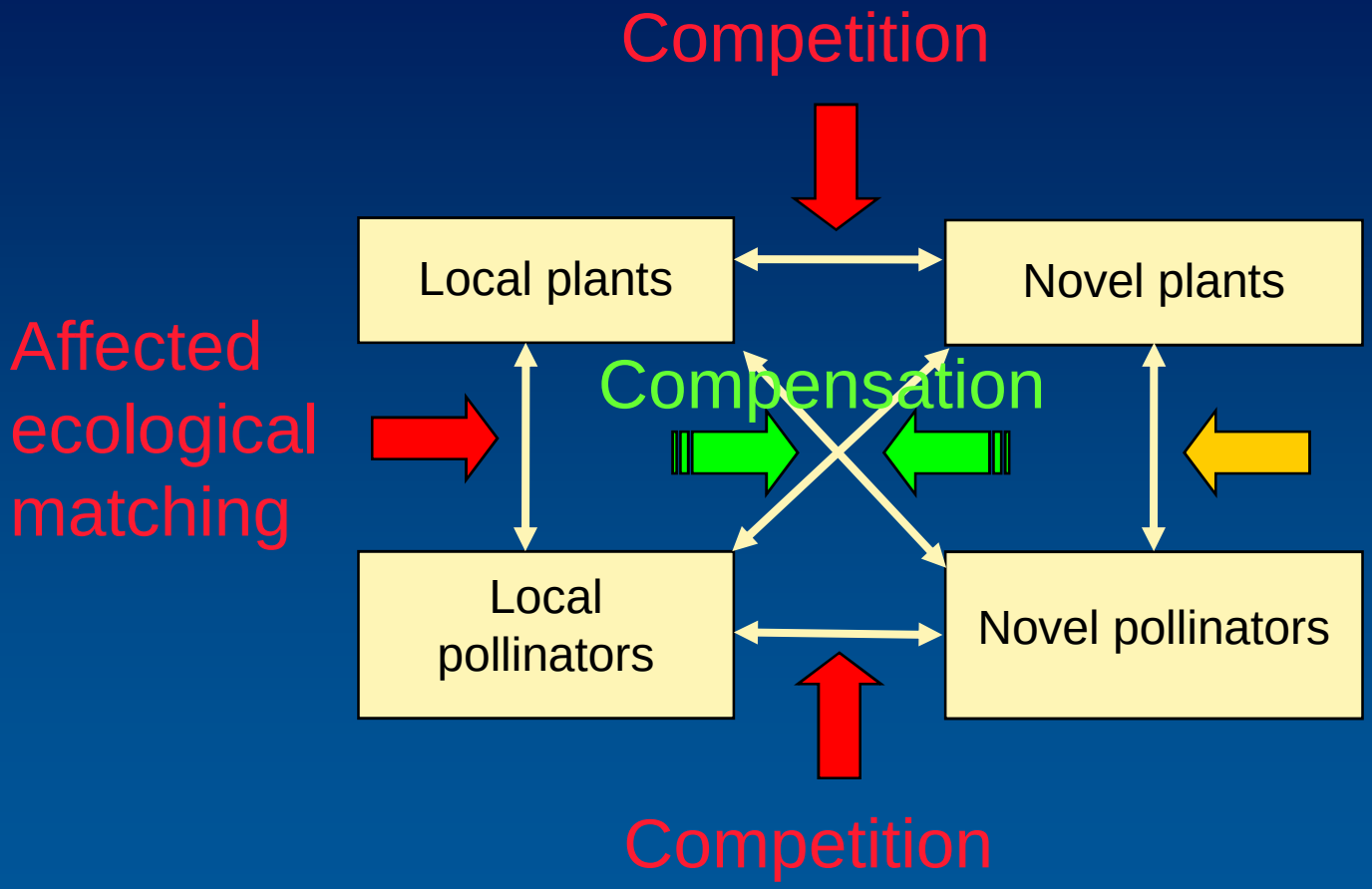
Novel communities



Schweiger et al. 2010, *Biol Rev*

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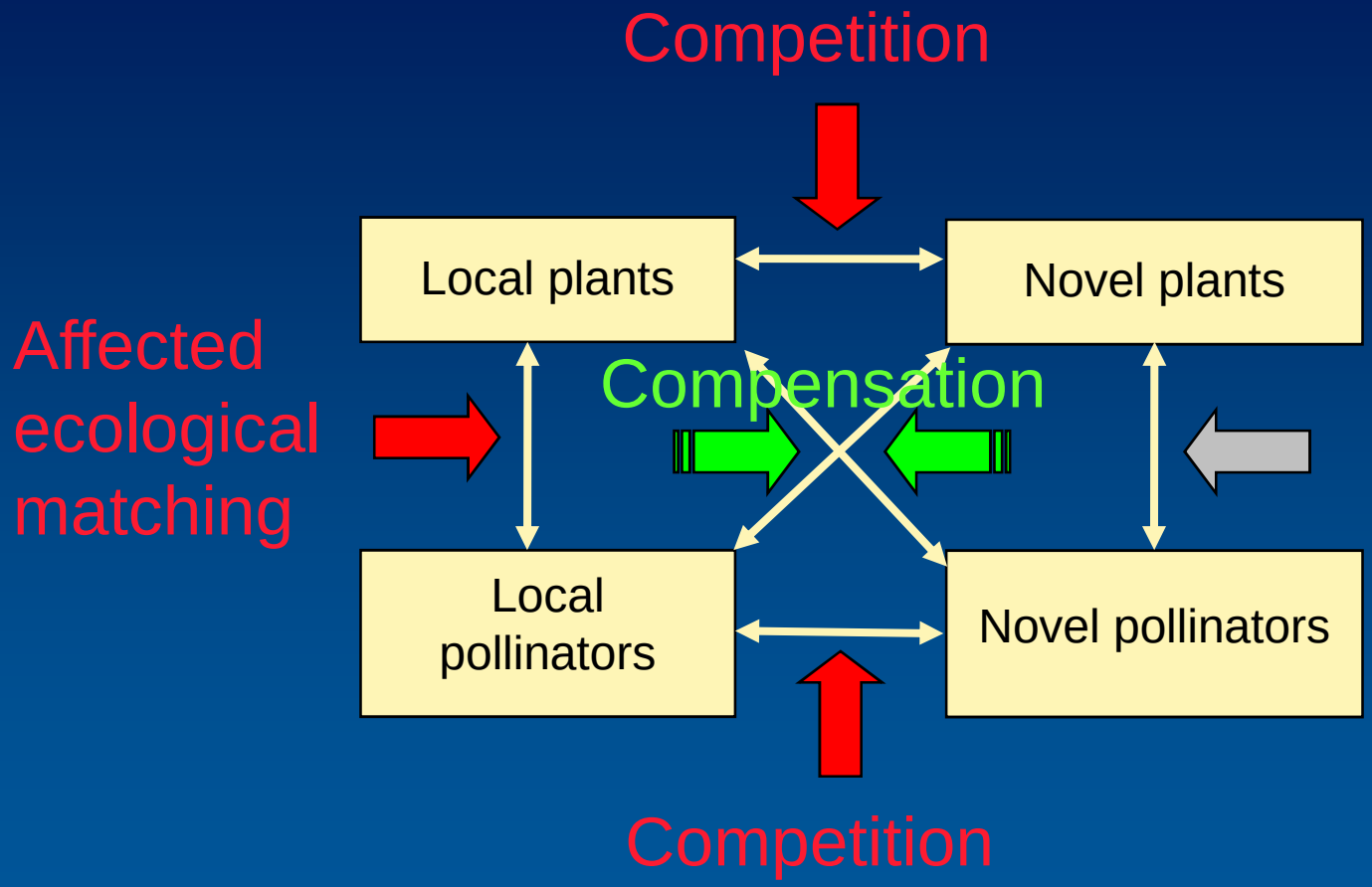
Novel communities



Schweiger et al. 2010, *Biol Rev*

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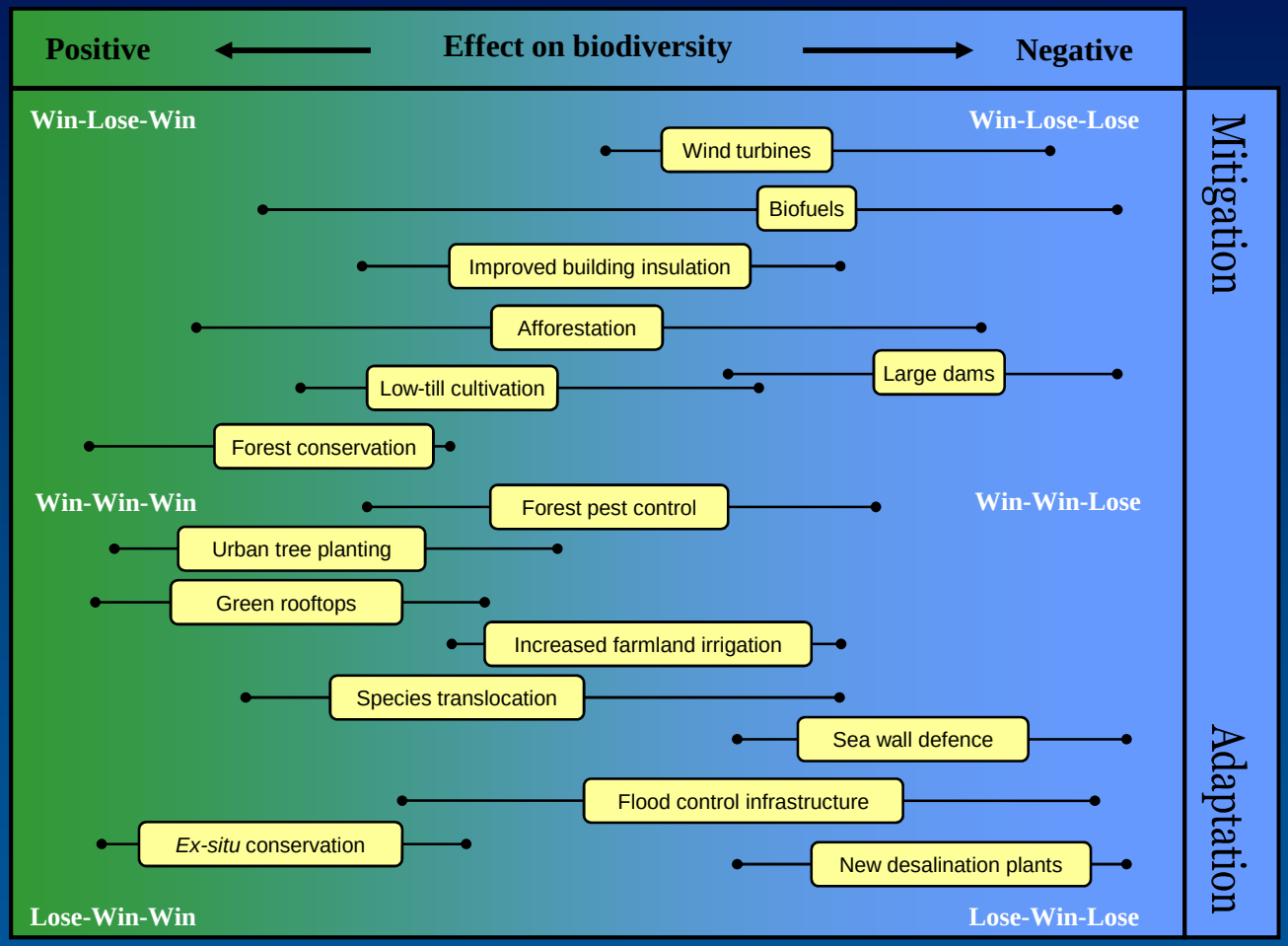
Impacts of adaption and mitigation



Paterson et al.2010, Conservation Biology

- Mitigation and adaptation may be negative for biodiversity

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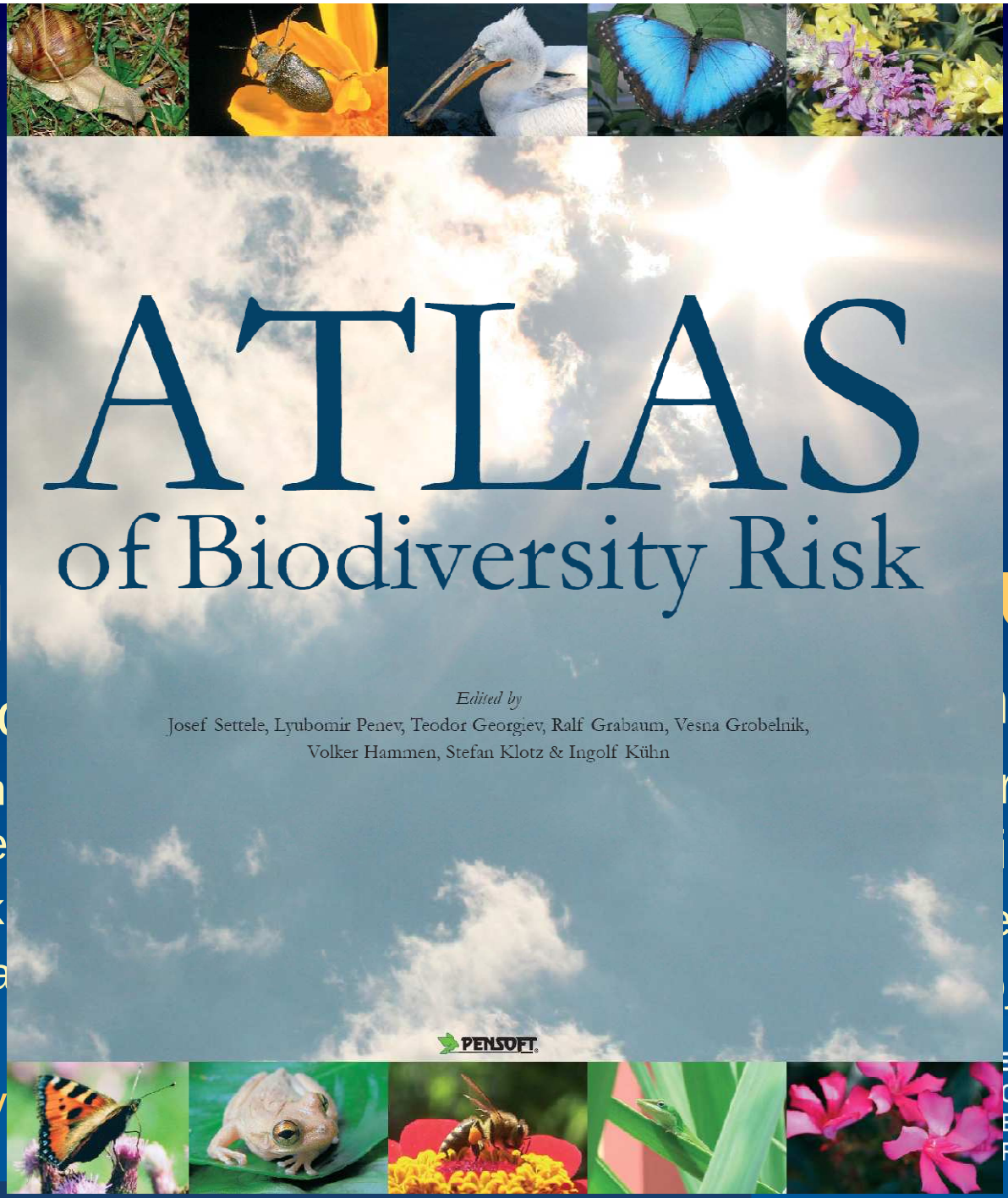

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Thanks!

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BAMBU:
Business-As-Might-Be-Usual

- **Policy decisions already made** in the EU are implemented and enforced.
- Internationally, there is **free trade**.
- Environmental problems and sustainability are **perceived as another technological challenge**.
- Biodiversity conservation: focus on protected areas.
- Climate: IPCC SRES A2

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GRAS: GRowth Applied Strategy

- **Deregulation, free trade, growth and globalisation** will be policy objectives actively pursued.
- Environmental policies will focus on **damage repair.**
- Sustainability is expected from the **self-regulating market mechanism**.
- **No emphasis on biodiversity.**
- **Climate: IPCC SRES A1FI**

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SEDG: Sustainable European Development Goal

- Enhancing the **sustainability of development** by integrated social, environmental & economic politics.
- The policies aim at the **stabilisation of atmospheric GHG concentrations**.
- Climate: IPCC SRES B1

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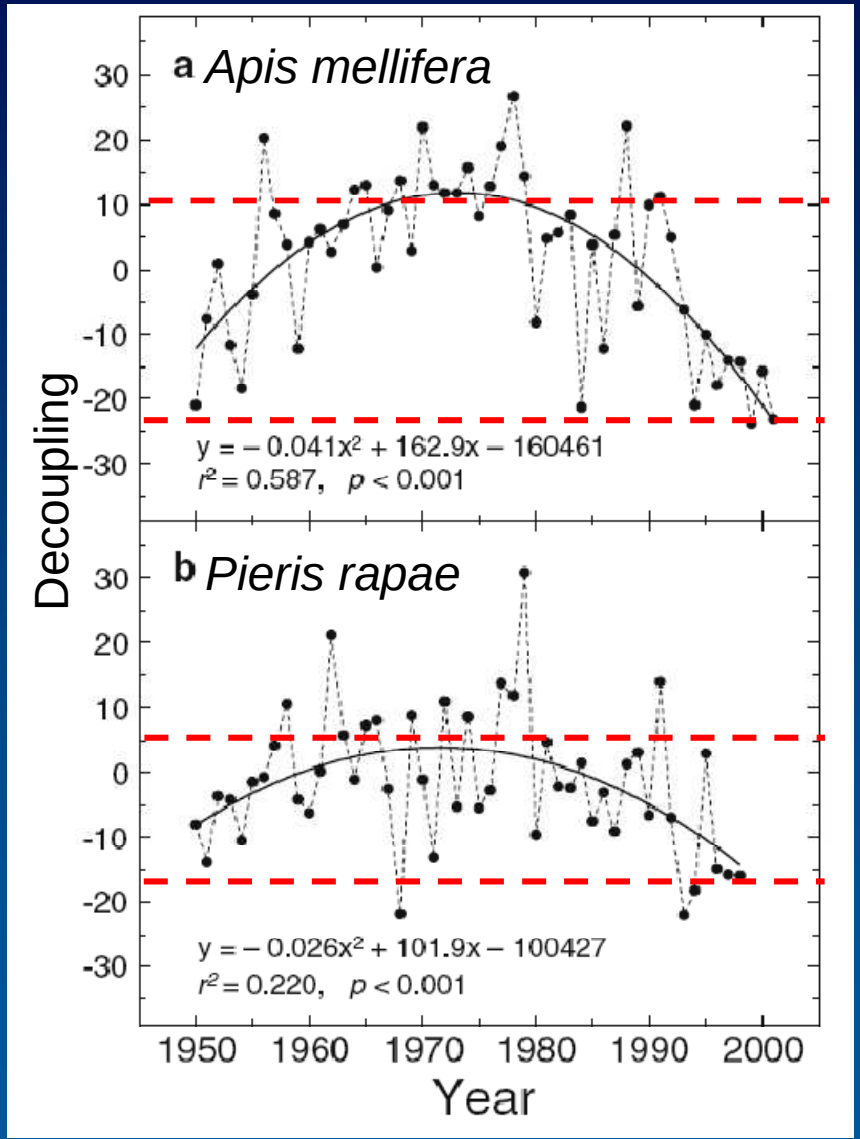
Temporal mismatching



10 days later

25 days earlier

5 days later

15 days earlier

Gordo and Sanz 2005, *Oecologia*

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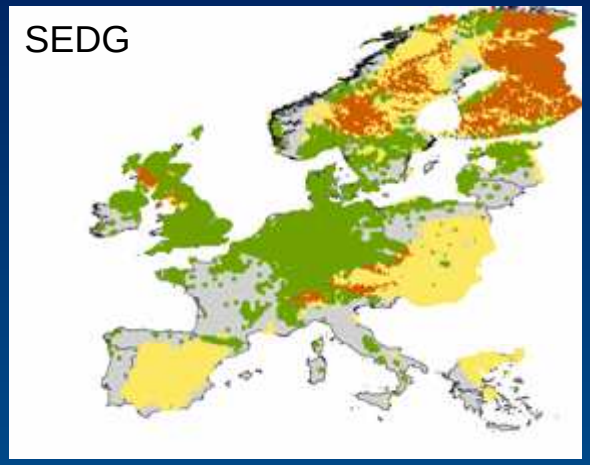
Species interactions:
Boloria titania and *Polygonum bistorta*

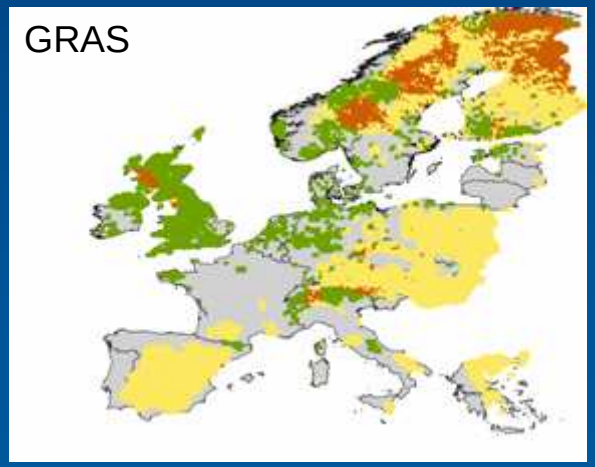
Projected changes in both niche spaces *for 2080*

Full dispersal

SEDG

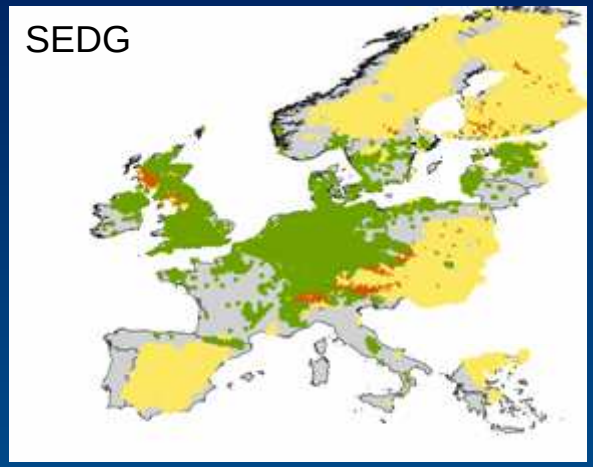


GRAS

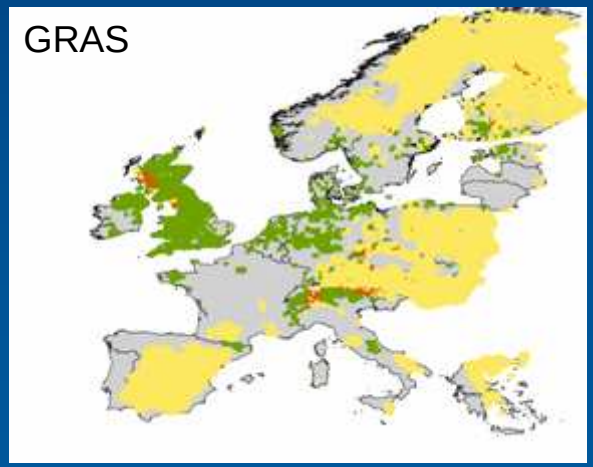


No dispersal

SEDG



GRAS



- Plant
- Butterfly
- Overlap of both

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

Schweiger et al., *Ecology* 2008, in press

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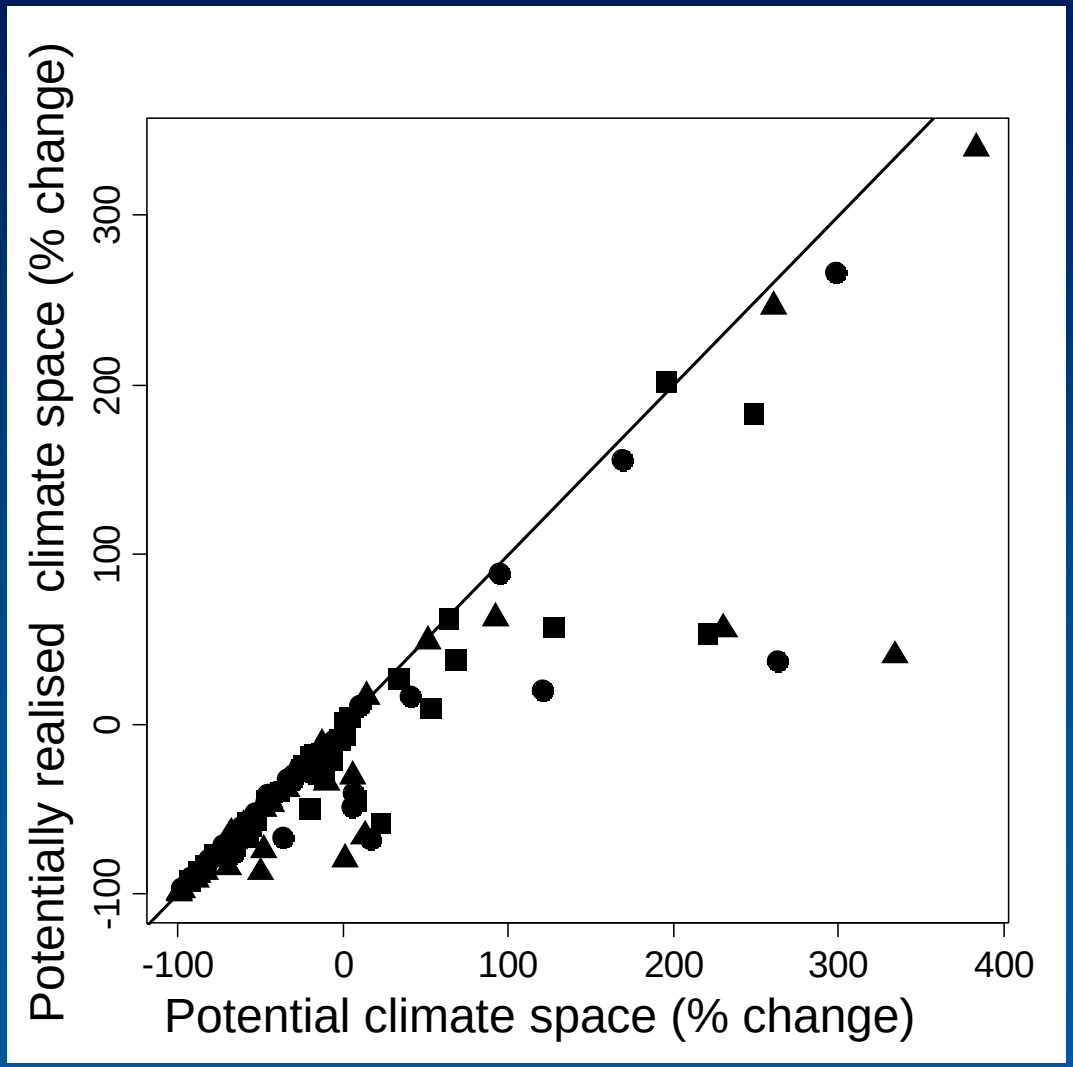
Spatial mismatching



- Most changes are unaffected by host plant
- Butterflies with hosts having small ranges seriously suffer from mismatch

Schweiger et al. in press, *GEB*

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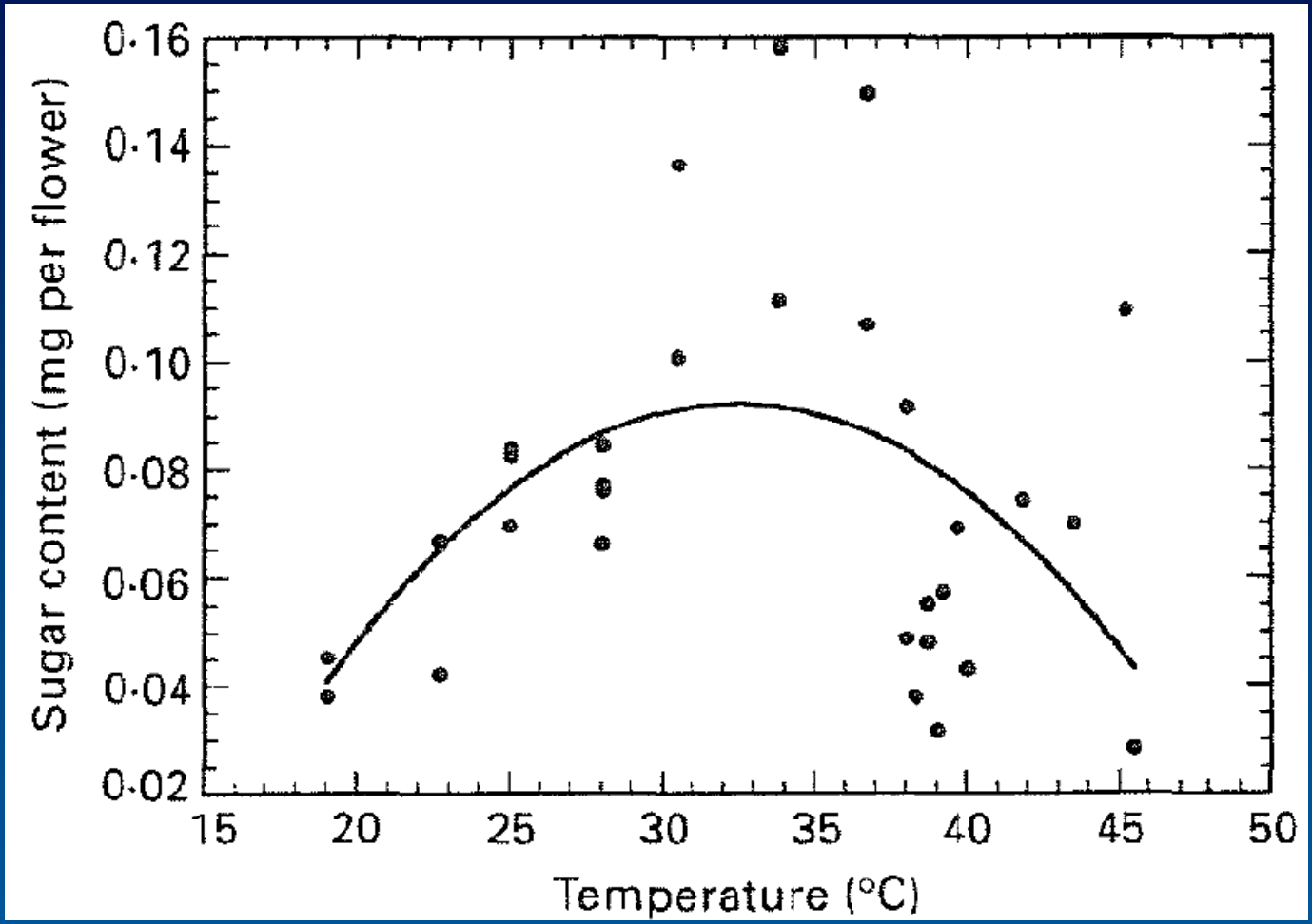
Ecophysiological mismatching



Petanidou & Smets 1996, New Phtol

- Sugar content of *Thumus capitatus* depends on temperature
- Pollinator behaviour is affected by sugar content

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