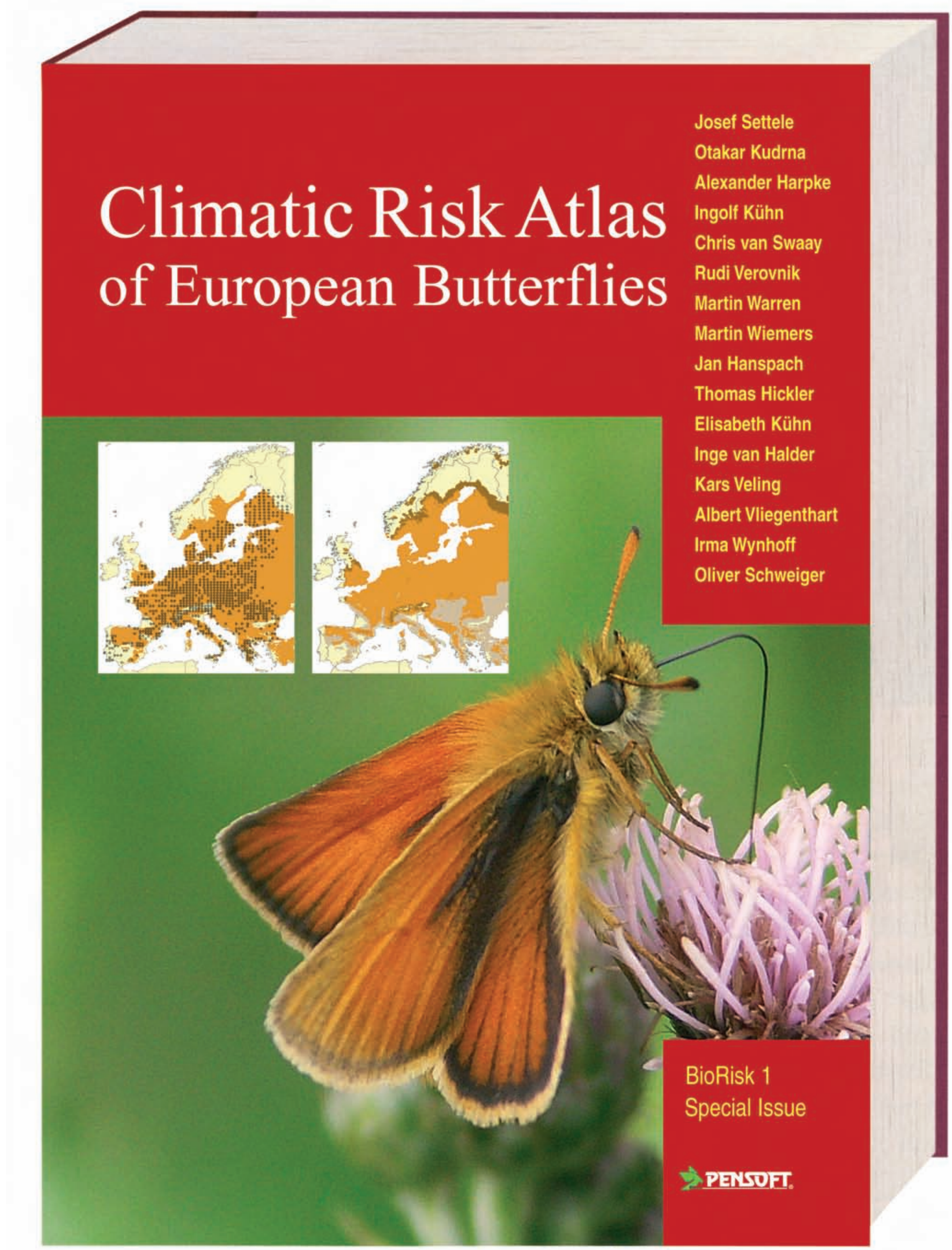
SUMMARY



Butterfly Conservation Europe

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

Introduction

Climate change is a new and potent risk to biodiversity. The inevitable change in global temperature and precipitation predicted over the next 50 years is a serious threat to butterfly and moth populations and is likely to exacerbate their decline.

Butterflies are a well-known and popular group of insects that can play a valuable role as early warning indicators of environmental change. They have short life-cycles and respond rapidly to change. Butterflies have also declined rapidly in recent decades and are declining more rapidly than other well-known groups such as plants and birds (which often depend on their caterpillars for food).

This Atlas is an early attempt to investigate the possible effects of climate change on the majority of European butterflies by modelling the impact of various future climate scenarios. The results are important because butterflies are one of the few groups of insects for which such comprehensive data are available at a European level. As insects comprise over two-thirds of all known species, the results are valuable to help understand the possible impacts of climate change on biodiversity as a whole.

Methods and future scenarios

The analysis is based on a comprehensive dataset on butterfly distributions in Europe, derived from the Mapping European Butterflies (MEB) project, coordinated by Otakar Kudrna - with contributions of hundreds of volunteers. Current distributions were transposed to 50 x 50 km resolution, aggregated to the UTM grid, and the climatic niche of each species was modelled against 22 climate variables. The model allowed an assessment of 293 of the c 450 European species.

Three scenarios of future climate were used to assess how the climate niche of each species might change in the future:

- SEDG (Sustainable Europe Development Goal) – a storyline for moderate change where the mean expected temperature increase in Europe by 2080 is 2.4°C.
- BAMBU (Business As Might Be Usual) – a storyline for intermediate change where the mean expected increase in temperature by 2080 is 3.1°C.
- GRAS (GRowth Applied Strategy) – a storyline for maximum change where the mean expected increase in temperature by 2080 is 4.1°C.

Based on the storylines, projections of future changes in climate were developed on a 10 x 10 min grid of Europe assuming full and no dispersal of butterflies into the new climate space. Monthly projected climate data were averaged for the two periods 2021–2050 and 2051–2080.

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Key overall results

Number of species at risk

The study shows clearly that climate change poses a considerable additional risk to European butterflies. However, the risk varies considerably under the three scenarios:

- Under the extreme, no dispersal, GRAS scenario, 24% of the modelled species lose more than 95% of their present climatic niche by 2080 and 78% lose more than 50%. Only 6% of species are rated as being at lower risk.
- Under the moderate, no dispersal, SEDG scenario, only 3% lose more than 95% of their climatic niche and 48% lose more than 50%, while 43% are rated as being at lower risk.

Time lag effects

The results also show that there is a considerable time lag in the effects of climate change:

- Until 2050, the effects across different scenarios are still moderate. Under the no dispersal GRAS scenario, around 60% of species are still rated as experiencing a lower risk until 2050, while in 2080 these are a mere 6 %.
- Under the moderate SEDG scenario with full dispersal, 33% of species could experience a net increase in climate niche space until 2050, while until 2080 this option is still potentially available for 30% of the species.
- Thus, until 2050, there are periods of intermediate better conditions for many warmth-loving species, but these subsequently get worse.

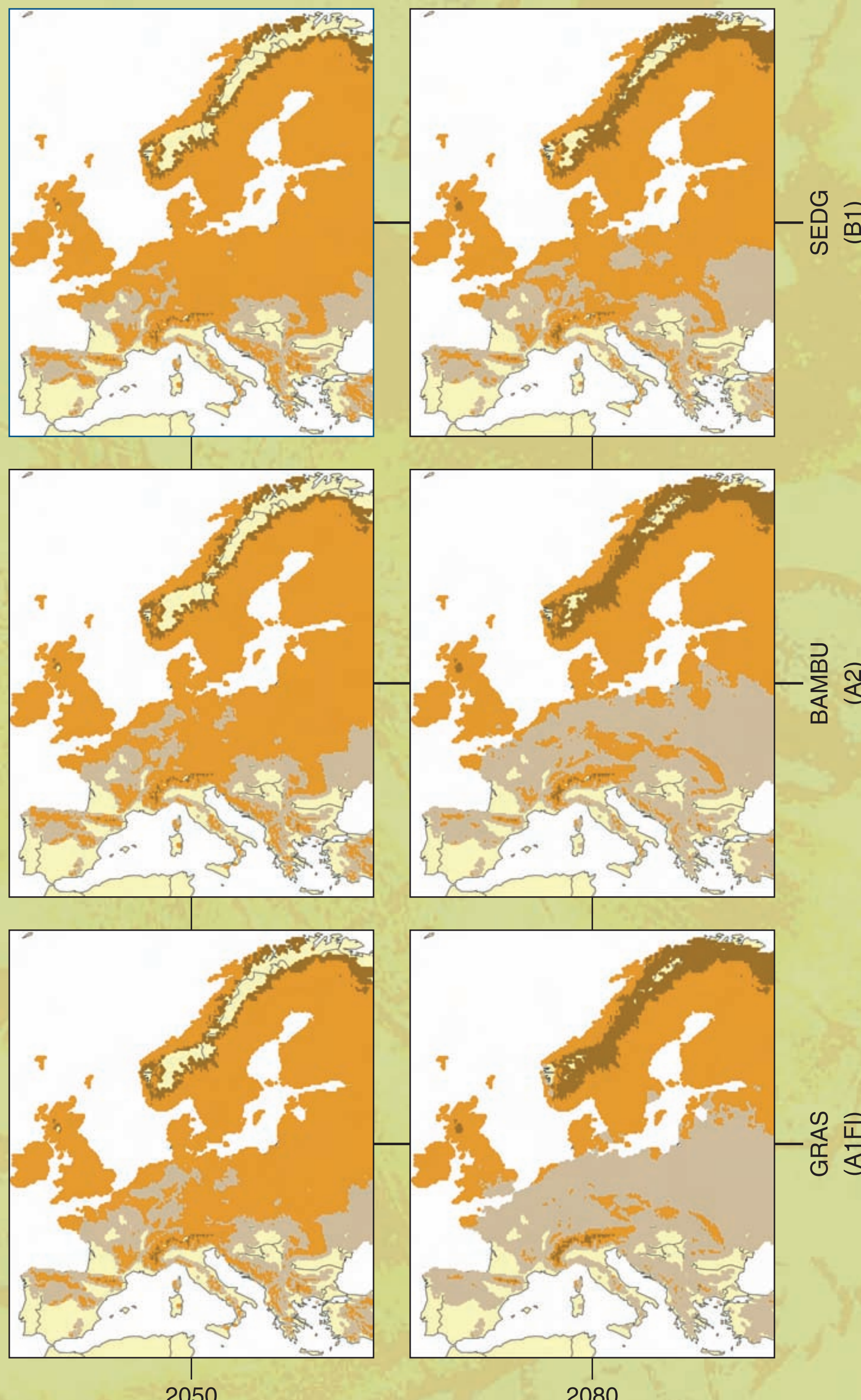
Dispersal ability

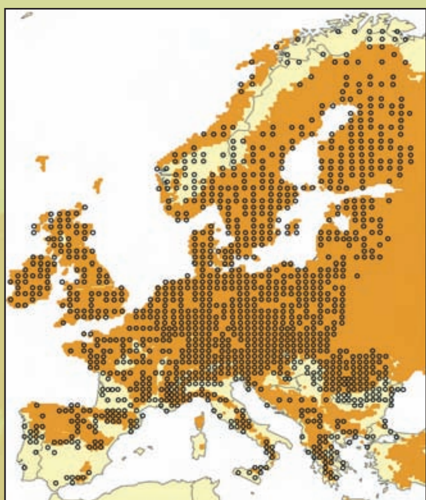
Dispersal is one of the major factors that will affect a species' ability to survive under future climatic conditions. It is likely that many species will not be able to track climate change because their habitats are now highly fragmented or because their caterpillar food-plants are unable or slow to respond. These factors are partially assessed by examining climate niche availability under full or no dispersal, but further research is needed in this area.

Example species

Aglais urticae (Linnaeus, 1758) – Small Tortoiseshell

Future distribution of climate niche space under three scenarios. Orange areas show space that remains suitable, grey areas space that gets lost and dark brown areas show space that could be gained under full dispersal.





Observed species distribution (black circles) and modelled actual distribution of climatic niche (orange areas). The model describes the species distribution moderately well (AUC = 0.8)

Northern parts of Europe are expected to remain suitable for the Small Tortoiseshell under all scenarios, but large areas of central Europe would become unsuitable. The worst case loss is 55% of its climatic niche by 2080 assuming no dispersal, but even if it can disperse fully it could lose 46% of its niche.

CONSERVATION RECOMMENDATIONS

The Atlas shows that climate change is likely to have a profound effect on European butterflies. Although some aspects may seem unstoppable, there are still ways to mitigate some of the negative impacts.

1) Maintain large populations in diverse habitats

We need to ensure effective conservation of existing protected areas and important habitats and manage them to maintain large, diverse populations that may allow species to adapt and disperse. The deliberate creation of habitat heterogeneity within such sites may also give species scope to shift within their habitats and move to cooler microclimatic conditions.

2) Encourage mobility across the landscape

More effort should be placed on habitat restoration and improving the links between habitat patches to give butterflies a chance to move and respond to climate change. We need to place far more emphasis on the conservation of whole landscapes and to build ecosystem resilience and connectivity.

3) Reduce emissions of greenhouse gasses

The vast majority of species will have a more sustainable future under the lower emission scenario (SEDG) compared to the future under the higher emission scenario GRAS.

4) Allow maximum time for species adaptation

Climate change risks for butterflies increase much faster after a lag phase and if we take immediate action we may be able to avoid some of the worst effects.

5) Conduct further research on climate change and its impacts on biodiversity

The Atlas is a first step in improving our understanding of the impacts of climate change on butterflies. The challenge now is to link climate and distribution data with habitat and land management knowledge to design effective adaptation strategies.

POLICY RECOMMENDATIONS

The results have important implications for conservation and for EU and national policies, their funding and implementation. We have the chance to mitigate some of the worst effects of climate change if we act now.

Specifically, we need:

- **A big shift** in the spending of Common Agricultural Policy (CAP) funds to reward the delivery of public goods such as biodiversity.
- **More funding** of schemes that deliver environmental out-comes, including: better resourced and targeted agri-environ-ment schemes; use of more CAP funds to enhance biodiver-sity; and targeting of Less Favoured Areas (LFA) payments to sustain High Nature Value (HNV) farming.
- **Full implementation** of the EU Habitats and Species Directives with proper protection and sustainable management of Natural 2000 sites across Europe.
- **New initiatives** to resource the creation of habitat net-works and mosaics that support biodiversity and help mitigate the adverse effect of climate change.
- **International** commitment and action to reduce greenhouse gas emission significantly

The climate change fortunes of three European swallowtail butterflies

The Apollo may lose up to 76% of its climatic niche by 2080 if it cannot disperse, but may still lose 63% even if it can.

The Eastern Festoon may gain space under climate change if it can disperse quickly enough, otherwise it may only lose 12% of its climatic niche.

The Spanish Festoon may lose up to 97% of its climatic niche by 2080 but may lose only 56% if it can track climate change.

The Atlas has been produced by an international team of scientists working within the framework of projects funded by the European Commission. It is published as a special issue of BioRisk, a new open-access journal of biodiversity and environmental sciences. Copies of the book cost €59 paperback and €89 hardback. An online version can be viewed at **www.pensoftonline.net/biorisk**

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