CLIMATIC RISK ATLAS OF EUROPEAN BUTTERFLIES

Josef Settele, Otakar Kudrna, Alexander Harpke,
Ingolf Kühn, Chris van Swaay, Rudi Verovnik, Martin Warren,
Martin Wiemers, Jan Hanspach, Thomas Hickler, Elisabeth Kühn,
Inge van Halder, Kars Veling, Albert Vliegenthart,
Irma Wynhoff & Oliver Schweiger

Climatic Risk Atlas of European Butterflies

by

Josef Settele, Otakar Kudrna, Alexander Harpke,
Ingolf Kühn, Chris van Swaay, Rudi Verovnik, Martin Warren,
Martin Wiemers, Jan Hanspach, Thomas Hickler,
Elisabeth Kühn, Inge van Halder, Kars Veling, Albert
Vliegenthart, Irma Wynhoff & Oliver Schweiger

Biorisk 1 (Special Issue)

PENSOFT

Sofia–Moscow
2008

Climatic Risk Atlas of European Butterflies

Josef Settele [1], Otakar Kudrna [2], Alexander Harpke [1], Ingolf Kühn [1], Chris van Swaay [3], Rudi Verovnik [4], Martin Warren [5], Martin Wiemers [6], Jan Hanspach [1], Thomas Hickler [7], Elisabeth Kühn [1], Inge van Halder [3], Kars Veling [3], Albert Vliegenthart [3], Irma Wynhoff [3] & Oliver Schweiger [1]

1 UFZ, Helmholtz Centre for Environmental Research, Department of Community Ecology, Theodor-Lieser-Str. 4, D-06120 Halle, Germany **2** Naturmuseum Südtirol, Bindergasse 1, I-39100 Bozen (Südtirol), Italy **3** De Vlinderstichting – Dutch Butterfly Conservation, P.O. Box 506, 6700 AM Wageningen, The Netherlands **4** Društvo za proučevanje in ohranjanje metuljev Slovenije (DPOMS) , Stara Dečkova cesta 14, 3000 Celje, Slovenia **5** Butterfly Conservation, Manor Yard, East Lulworth, Wareham, Dorset BH20 5QP, United Kingdom **6** Department of Population Ecology, Faculty of Life Sciences, University of Vienna, Rennweg 14, A-1030 Wien, Austria **7** Department of Physical Geography & Ecosystems Analysis, University of Lund, Sölvegatan 13, 223 62 Lund, Sweden

Biorisk 1 (*Special Issue*)
ISSN 1313-2652 (online), ISSN 1313-2644 (print)
doi: 10.3897/biorisk.1

First published 2008
ISBN 978-954-642-454-9 (paperback)
ISBN 978-954-642-455-6 (HB)
ISBN 978-954-642-456-3 (e-book)

Cover and book design: *Zheko Aleksiev*

Pensoft Publishers
Geo Milev Str. 13a, Sofia 1111, Bulgaria
info@pensoft.net
www.pensoft.net

Printed in Bulgaria, November 2008

CONTENTS

D. DISCUSSION OF METHODOLOGICAL LIMITATIONS

E. OUTLOOK: CLIMATE CHANGE AND BUTTERFLY CONSERVATION

F. APPENDICES, REFERENCES AND INDEX

Acknowledgements

For the provision of pictures of species (or the readiness to provide them), we are indebted to Bernard Fransen, Eddie John, Heiner Ziegler, Helmut Höttinger, Henk Bosma, Hermann Haas, Jean Delacre, Joe Belicek, Josef Pennerstorfer, Jostein Engdal, Karl Heyde, Matt Rowlings, Michel Tarrier, Neil Thompson, Peter Ginzinger, Philippe Mothiron, Thomas Kissling, and Zdravko Kolev.

For diverse discussions of modelling methodology we thank Risto Heikkinen and for provision of basic species texts thanks go to Claire Hengeveld. For help in the scenario chapters we acknowledge Joachim H. Spangenberg and Martin T. Sykes.

Zsolt Balint has contributed through the discussion of taxonomic questions.

We acknowledge the support of

- Helmholtz Centre for Environmental Research - UFZ
- MEB Mapping European Butterflies Project – in particular the many colleagues who provided distribution data;
- European Commission (FP 6) Scientific Support to Policy project MACIS (Minimization of and Adaptation to Climate change impacts on biodiverSity; 044399 (SSPI); Kühn et al. 2008c);
- European Commission (FP 6) Integrated Project ALARM (Assessing LArge scale environmental Risks with tested Methods; GOCE-CT-2003-506675; www.alarmproject.net; Settele et al. 2005);
- Gesellschaft für Schmetterlingsschutz (GfS; www.european-butterflies.eu);
- Butterfly Conservation Europe (BCE; www.bc-europe.eu);
- Helmholtz Association of German Research Centres funding the Virtual Institute for Macroecology (VH-VI-153; www.macroecology.org; Kühn et al. 2008b);
- EEA - European Environment Agency (www.eea.europa.eu).

Special thanks are due to Pensoft Publishers (especially Teodor Georgiev and Lyubomir Penev), who managed to design, layout, proofread and publish this book in less than six weeks time.

Foreword by Butterfly Conservation Europe

Climate change is a new and potent risk to biodiversity. The inevitable rise in global temperatures predicted over the next decades and century 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 and moths have 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 butterflies by modelling the impact of various future climate scenarios. The research is based on a unique and comprehensive dataset on butterfly distributions in Europe, derived from the Mapping European Butterflies (MEB) project. We believe that 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.

The results are alarming. The models suggest that the vast majority of European butterflies will be badly affected by climate change. Most species will have to shift their distributions considerably northwards and will lose a large amount of their suitable climate space. Furthermore, many butterflies live in discrete colonies and have limited powers of dispersal. Such species are restricted by available habitat and may not be able to alter their distribution to keep in step with climate change.

The results have important implications for conservation and for EU and national policies and for their funding and implementation. We have the chance to mitigate some of the worst effects of climate change, including those on biodiversity, 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 outcomes, including: better resourced and targeted agri-environment schemes; use of CAP "Envelope" funding to enhance biodiversity; 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 Natura 2000 sites across Europe.
- New initiatives to resource the creation of habitat networks and mosaics that support biodiversity and help mitigate the adverse effects of climate change.

Together with international commitment to reduce greenhouse gas emissions, this programme of action will help to halt the loss of biodiversity and support the recovery needed. We want our children and grand-children to inherit a Europe where our ecosystems are thriving and butterflies enrich the experience of their every day lives.

Martin Warren
Chair, Butterfly Conservation Europe

Context and objectives of a climatic risk atlas of European butterflies

Insect species contribute more than 60% of all plant and animal species in Europe. They have also declined far more rapidly than other taxa in modern European landscapes (Thomas & Morris 1994, Van Swaay & Warren 1999, Thomas et al. 2004, Van Swaay et al. 2006). Butterflies have proven to be excellent indicators for changes in other insect populations, alerting ecologists to functional and spatial changes in ecosystems and landscapes that will eventually affect multiple species (Erhardt 1985, Erhardt & Thomas 1991, Thomas 2005, Van Swaay & Van Strien 2005). They are easily detected in the field and their habitat requirements are relatively well known. Moreover butterflies have an extremely positive image amongst the public. Butterflies are a symbol for pleasure and beauty of life; they stand for intact and healthy nature. Their decline makes the dimension of biodiversity loss personally relevant to everyone. The publication of this atlas on the possible impact of climate change on a well known group of animals is both timely and important.

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:

a) 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;
b) present crucial data on a large group of species which could help to prioritise conservation efforts in the face of climatic change;
c) 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 atlas does not aim to be a guide to species identification or provide a comprehensive treatment of the species' ecology and taxonomy which are covered in detail in many other publications. The strict methodological requirements also mean that the analysis excludes highly localized species and therefore covers only 294 of the approx. 450 European species.

A

CLIMATE CHANGE, BIODIVERSITY, BUTTERFLIES, AND RISK ASSESSMENT

A.1 Introduction: Butterflies as indicators

Halting the process of biodiversity decline, or at least significant reduction of its rate, is at present one of the global challenges facing humankind. It has been addressed by several fundamental international agreements, including the EU Sustainable Development Strategy adopted at the 2001 Gothenburg summit (European Commission 2001) as well as the 2002 Johannesburg Convention on Biological Diversity (Balmford et al. 2005a). In order to assess if the ambitious targets of these agreements are being met, comprehensive biodiversity monitoring, especially at species, community, and habitat levels, is essential (Balmford et al. 2005b, Dobson 2005).

Butterflies, together with birds and vascular plants, represent the most frequently monitored taxonomic groups (de Heer et al. 2005, Thomas 2005), which is mostly due to their extreme popularity among amateur naturalists. Apart from this, several ecological characteristics make butterflies promising biodiversity indicators: (i) due to short (typically annual) life cycles they are more sensitive than other groups to changes in their habitats (Thomas 1994, Van Swaay & Warren 1999, Thomas et al. 2004); (ii) due to breeding even in small habitat patches they are likely to reflect changes occurring at a fine scale (Van Swaay et al. 2006); (iii) they may be expected to be representative for a wide range of terrestrial habitats (Van Swaay et al. 2006), and more importantly to be adequate indicators for many groups of terrestrial insects (Thomas & Clarke 2004, Thomas 2005), which themselves constitute the predominant fraction of biodiversity. Consequently, monitoring the change in abundance and assessing the distribution of butterflies have been suggested as a potential tool for assessing large-scale biodiversity trends (Thomas 2005, Van Swaay & Van Strien 2005, Van Swaay et al. 2006).

Compared to many vertebrates, butterfly populations are subject to considerable annual fluctuations induced by both inherent population dynamics and environmental variation, e.g. weather patterns (Pollard 1988, Roy et al. 2001). As a consequence, longer time-series are typically required to distinguish between such fluctuations and actual temporal trends (Van Strien et al. 1997, Thomas 2005), but the effects of global change should be visible within a rather short period.

A.2 Scenarios and biodiversity

Biodiversity can be affected by a wide variety of different and interacting pressures. The EEA (European Environment Agency, Copenhagen), in the Environment Outlook 2005 report (EEA 2005), identifies as determinants of the state of the environment: the socio-economic context, demography, macro-economy, technological developments, consumption patterns, energy and transport; agriculture, waste and material flows. In the Pan-European environment report EEA (2007b), they add geo-politics and international cooperation, globalisation and trade, migration, and natural resources. Thus to assess future risks for biodiversity, different policy options have to be analysed in the broad context of the parameters identified by the EEA.

Scenarios developed within the project ALARM (Assessing LArge-scale Environmental Risks for biodiversity with tested methods; Settele *et al.* 2005) cover all these issues; they are broad pictures of possible futures trying to derive information on the overall biodiversity risks from a broad range of factors through plausible reasoning rather than by quantitative modelling.

Biodiversity scenarios in general aim at analysing the driving forces and pressures causing the loss of biodiversity with the help of model simulations based on research data and case studies. They can serve as the basis for developing and testing European policy strategies to halt the loss of biodiversity in Europe. To this end, three policy scenarios have been developed representing three archetypical policy approaches (liberal, pragmatic and sustainable) and assessing the implications for climate change, land use, chemicals use and pollinator loss and their cumulative impact on biodiversity.

The ALARM scenarios provide decision makers and stakeholders with the picture of possible futures under the assumptions of the three policy options. Besides environmental trends and impacts on biodiversity, other relevant trends in different policy fields, from economic growth to social policies, demographic change and foreign trade and policy relations are part of the scenario storylines. Thus the scenarios represent semi-quantitative multi-factor trend assessments for different policy options currently virulent in the EU, based on the best available analyses and models.

The scenarios analysed cover a broad range of social, economic, political and geo-biosphere parameters. There are three core scenarios, in the IPCC terminology a policy driven one, a back-casting scenario (inverse projection) of regional mitigation, and a more or less resilience driven one. The following three storylines used in this atlas are based on scenarios developed within the ALARM project (see Spangenberg 2007 for further details):

1) *SEDG* scenario: *S*ustainable *E*urope *D*evelopment *G*oal scenario. A policy primacy scenario focused on the achievement of a socially, environmentally and economically sustainable development. It includes attempts to enhance the sustainability of societal developments by integrating economic, social and environment policies. Aims actively pursued include a competitive economy, a healthy environment, social justice, gender equity and international cooperation. As a normative back-casting scenario, policies are derived from the imperative of stabilising atmospheric Greenhouse gas concentrations and ending biodiversity loss.

2) *BAMBU* scenario: *B*usiness-*A*s-*M*ight-*B*e-*U*sual scenario. A continuation into the future of currently known and foreseeable socio-economic and policy trajectories. Policy decisions already made are implemented and enforced. At the national level, deregulation and privatisation continue except in "strategic areas". Internationally, there is free trade. Environmental policy is perceived as another technological challenge, tackled by innovation, market incentives and some legal regulation. The result is a rather mixed bag of market liberalism and socio-environmental sustainability policy.

3) *GRAS* scenario: *GR*owth *A*pplied *S*trategy scenario. A future world based on economic imperatives like primacy of the market, free trade, and globalisation. Deregulation (with certain limits) is a key means, and economic growth a key objective of politics actively pursued by governments. Environmental policy will focus on damage repair (supported by liability legislation) and some preventive action. The latter are designed based on cost-benefit calculations and thus limited in scale and scope.

A.3 Biodiversity Risk Assessment for butterflies and climate change

Risk analysis can be defined as "*a multi-stage process that includes the identification/ characterization of a hazard or risk factor, assessment of the likelihood of occurrence, evaluation of impacts associated with that hazard, evaluation of mitigation measures (risk management), and communication of risks*" (OIE, 2000). A risk assessment comprises hazard identification, hazard characterization, exposure assessment and risk characterization. A hazard is the potential of a risk source to cause an adverse effect. The sequential steps in risk assessment of climate change (as well as other environmental pressures) are to identify characteristics that may cause adverse effects, evaluate their potential consequence and assess the likelihood of occurrence.

Risk assessment may follow 4 stages (as elaborated e.g. by the International Standard for Pest Management; Fig. A.3.1), which can be translated for our case of butterflies and climate change as follows:

1. Hazard identification: The aim is to identify the main climatic factors which impact butterflies and which should be considered for risk analysis in relation to the identified risk area (here climatic factors which represent climate as a whole on a European; which is equally applicable to other geographic scales like biogeographic areas, nations, or counties). In our case the hazard identification is represented by the climatic niche models developed for each species and shown on the bottom right of the left side of each species' treatment.

2. Risk assessment: This is the characterisation of risk based on an evaluation of the evidence to estimate the likelihood and consequences of an adverse event, and the associated uncertainty. The "adverse event" in this case is the distribution change (expansion, retraction or a combination of both) of a butterfly species. Risk assessment can be split into three interrelated steps:

- assessment of the probability of distributional change. In the atlas this is replaced by the application of the three different scenarios, showing 3 potential future worlds, each of which may be influenced by human action that could make them more or less extreme;
- assessment of potential consequences. The atlas shows these as differences in distribution changes under the three scenarios. Consequences are shown as statistics and maps for two time steps 2050 and 2080 for all the approx. 300 species which could reasonably be modelled (species with a distribution of 20+ UTM grid cells of 50x50 km^2);
- species categorization. The atlas categorizes all European butterfly species into climate change risk classes that are explained further below. Summary risk statistics are also presented for certain methodologically or ecologically defined butterfly species groups.

3. Risk management*:* refers to the analytical process used to identify risk mitigation options and evaluate these for efficacy, feasibility and impacts. The aim is to decide on the most appropriate means to mitigate risks that are found to be unacceptable. The uncertainty noted in the assessments of potential consequences and probability of distributional change are also considered and included in the selection of options for conservation and/or management. A first attempt to a climate change risk management for butterflies is made in the chapter "Climate Change and Butterfly conservation" (page 651).

4. Risk communication: The final step is to communicate findings in terms that are clear to all stakeholders. The whole process from hazard identification to climate risk management should be sufficiently documented so that when a review or a dispute arises, the sources of information and rationale used in reaching the management decision can be clearly demonstrated. This final step is a critical one as it ensures that all parties understand the scientific, regulatory (e.g., legal), and other bases for the recommendations.

This sequential listing of steps does not imply chronology. Risk communication, in particular is a process that should occur from the beginning of the process. Whatever the method used, the results of a risk analysis must be understandable, useful, credible, and tailored to the problem in hand. This is exemplified in the present butterfly atlas, which is an integral part of risk communication, while also presenting all the other 3 steps.

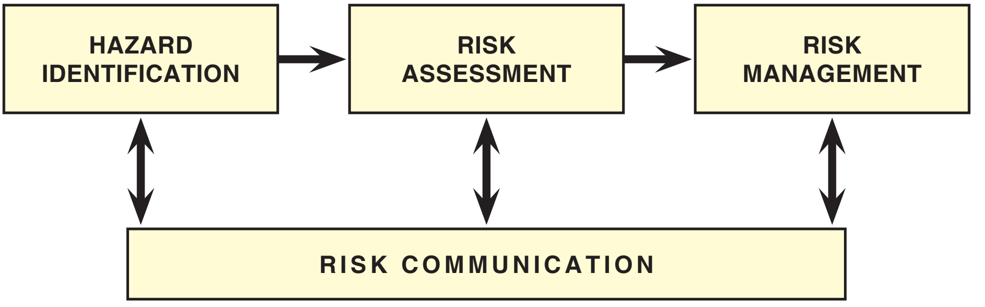


Figure A.3.1: Steps in risk analysis (OIE, 2000)

In order to be able to compare risks associated with single and combined drivers of change, we herewith present as a first step the potential climate risks for nearly 300 European butterfly species, where risk classifications of species is based on modelling approaches, while the remaining approx. 150 species (species with distribution in 20 or less UTM grid cells of 50x50 km²) are listed to raise the awareness for this group where due to their very limited distribution we have to expect a very large portion of species to belong to the highest climate change risk categories.

B

METHODOLOGY

B.1 The MEB project data as basis for the atlas

The distribution data used in this atlas originated exclusively from the 'Mapping European Butterflies' project (MEB; www.european-butterflies.eu). Within MEB butterfly occurrences were assigned to more than 9000 reference localities, which were distributed evenly across Europe and identified by their geographical coordinates. These data formed the basis of 'The Distribution Atlas of European Butterflies' (Kudrna 2002), which was the first systematic compilation of butterfly distribution data on a European scale. At present the atlas is being updated within the MEB2 project, which is run by the German Society for Lepidoptera Conservation (GfS: "Gesellschaft für Schmetterlingsschutz").

Although national distribution data are available at a finer resolution in many countries, we used the MEB database in order to have the same standard in terms of quality control and coverage throughout this atlas. The availability of such a database is a tribute to Otakar Kudrna, the approx. 250 recorders contributing directly, and many thousands of recorders who contributed to numerous data bases which have been used as well.

To construct climate envelopes which mirror the conditions at the end of the second millennium, only the most recent distribution data have been used for the period from 1981 until the publication of Kudrna (2002). Data from previous periods (which also had larger gaps) as well as newer data have not been included.

To account for local differences in sampling effort and to obtain reliable absence data, the distributional data where aggregated to the Universal Transverse Mercator (UTM) coordinate system at a 50 x 50 km² resolution (Fig. B.1.1). Due to low levels of recording and very uneven coverage, Belarus, Ukraine, Moldova, and Russia were excluded from data used for the model development. However, these countries are shown on maps of present species distribution as well as the scenarios the potential niche spaces. Excluded were also data from the Atlantic islands under European administration (the Azores, Madeira and Canary Islands) and from Cyprus. Iceland has no resident butterfly species.

B.2 Scenarios used to assess climate change risks for European Butterflies

Within the framework described above, we have restricted the analyses used in this atlas to the climate aspect of three global change scenarios. These are based on storylines developed within the EU funded project ALARM (Settele et al. 2005, Spangenberg 2007) which integrated the Intergovernmental Panel on Climate Change (IPCC 2001) Special Report on Emission Scenarios (SRES).

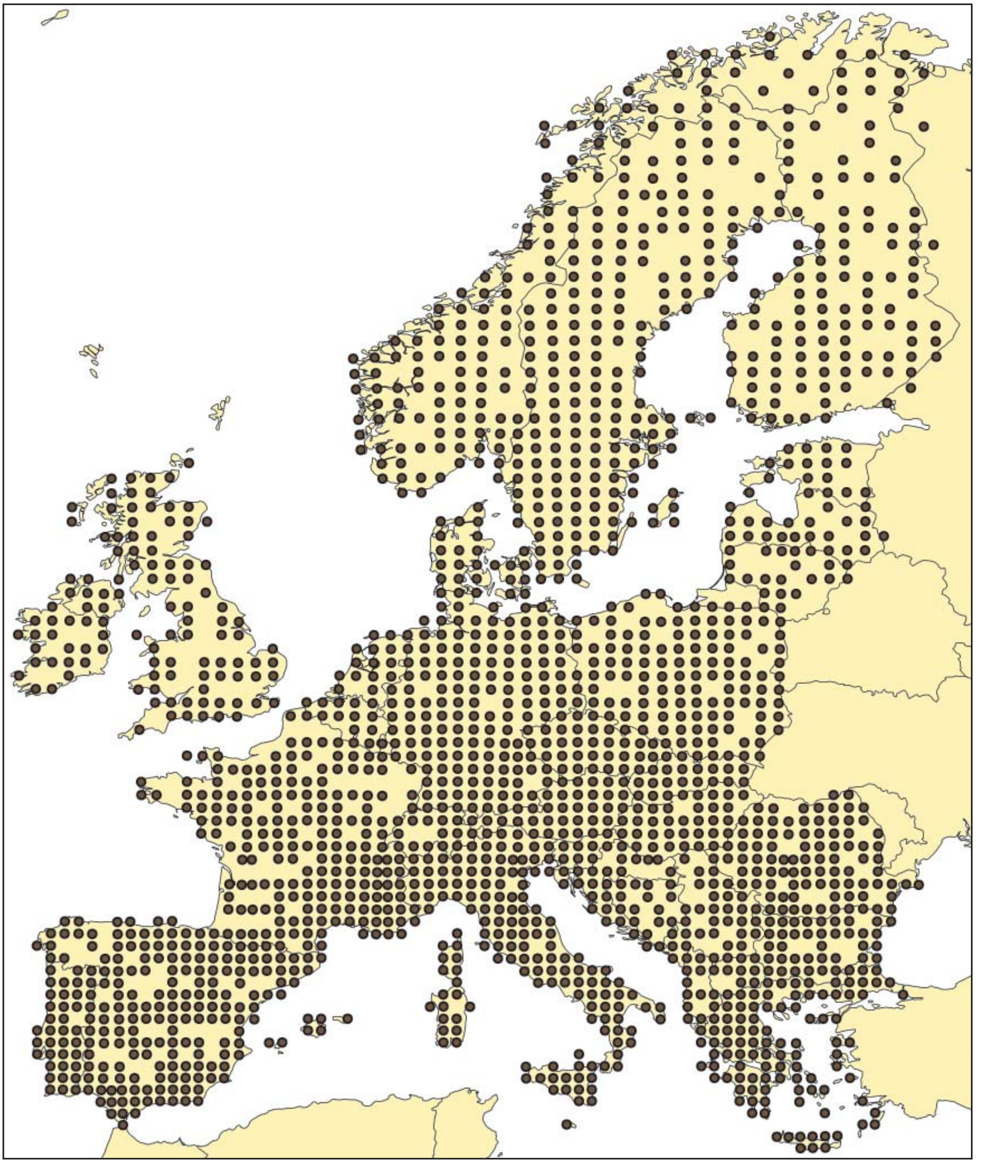


Fig. B.1.1. Geographical coverage and distribution of reference localities aggregated to 50 x 50 km² UTM grid (derived from the database which also was used for Kudrna, 2002).

The main source for future climate scenarios was a coupled Atmosphere-Ocean General Circulation Model (HadCM3; New et al. 2000). The complete ALARM scenarios as explained in chapter A.2 cover a broad range of potential developments in demography, socio-economics and technology during the 21st century. Specifically for climate the following frame conditions apply in addition to the more general aspect mentioned above:

- SEDG (Sustainable Europe Development Goal) – a storyline for moderate change:

The scenario of moderate change approximates the IPCC B1 climate change scenario. Mean expected temperature increase in Europe until 2080 is 2.4°C.

- BAMBU (Business As Might Be Usual) – a storyline for intermediate change:

The scenario of intermediate change approximates the IPCC A2 climate change scenario. Mean expected increase in temperature is 3.1°C.

- GRAS (GRowth Applied Strategy) – a storyline for maximum change:

The scenario of maximum change approximates the IPCC A1FI climate change scenario. Mean expected increase in temperature 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. Monthly projected climate data (see chapter B.3) were averaged for the two periods 2021-2050 and 2051-2080.

B.3 Climate niche modeling

Climatic factors of butterfly distribution

The climatic requirements of butterflies were modelled using monthly interpolated climate data at the same 50 x 50 km² UTM grid (New et al. 2000, Mitchell et al. 2004) that was used to present the distribution of the species (see chapter B.1). Mean values of the following 22 climate variables (absolute values and annual variations) for the period 1971-2000 were considered for the analysis of climate requirements of the butterflies:

- annual temperature (°C);
- range in annual temperature (°C);
- quarterly temperature (e.g. March - May = spring; °C);
- range in quarterly temperature (°C);
- diurnal temperature range per year (°C);
- diurnal temperature range per quarter (°C);
- annual summed precipitation (mm);
- range in annual precipitation (mm);
- quarterly summed precipitation (mm);
- range in quarterly precipitation (mm);
- annual water deficiency (annual equilibrium evapotranspiration minus annual precipitation; Sykes et al. 1996);
- range in annual water deficiency;
- soil water content for both upper and lower horizon retrieved from a dynamic vegetation model (LPJ-GUESS; Smith et al. 2001, Rickebusch et al. 2008);

- annual cloudiness (%);
- quarterly cloudiness (%);
- accumulated growing degree days with a base temperature of five degrees until February, April, June, and August.

Many of these variables are partly redundant in their effects. Thus, to avoid statistical problems due to high levels of collinearity between climate variables we selected ecological relevant and least correlated variables by means of cluster analysis. The threshold for variable selection was a Pearson correlation coefficient lower than 0.3 (Graham 2003).

The remaining variables which have been used for the climate niche models of all species within this atlas were

- accumulated growing degree days until August, which is highly representative for general temperature gradients across Europe (Fig B.3.1);
- soil water content for the upper horizon, which is a realistic measure of water availability and near surface microclimate (Fig B.3.2);
- ranges in annual precipitation (Fig B.3.3) and
- ranges in annual temperature (Fig B.3.4); with the two last ones reflecting continentality and oceanity.

Modelling procedure

To assess species response to climate change, we first need to identify the ecological niche that each species occupies with respect to key climatic variables. Climatic niche models relating such variables to presence and absence data were developed using generalized linear models (GLM) with a binomial error distribution and a logit link function. We allowed for additive and curvilinear effects by incorporating second order polynomials. Models were checked for spatial autocorrelation with Moran's I correlograms of model residuals, but none was detected. Initial models were simplified by stepwise regression, while minimizing Akaike´s information criterion (AIC; Sakamoto et al. 1986). Models were calibrated on an 80% random sample of the initial data set and model accuracy was evaluated on the remaining 20%. Agreements between observed presences and absences and projected distributions were evaluated by the Area Under the Curve (AUC) of a Receiver Operating Characteristic (ROC) plot which is independent of thresholds (Fielding & Bell 1997). Thresholds for calculating presence-absence projections were obtained by a maximizing Kappa approach (Manel et al. 2001). While the climatic niche models were developed at the 50 × 50 km² UTM grid, the future projections were downscaled to 10 × 10 min grid cells. Both were mapped within the geographical range of -10.417° to 31.917° (longitude) and 34.083° to 71.083° (latitude). All maps based on the WGS1984 coordinate system were projected in the Miller cylindrical projection using ArcGIS software (ESRI 2006).

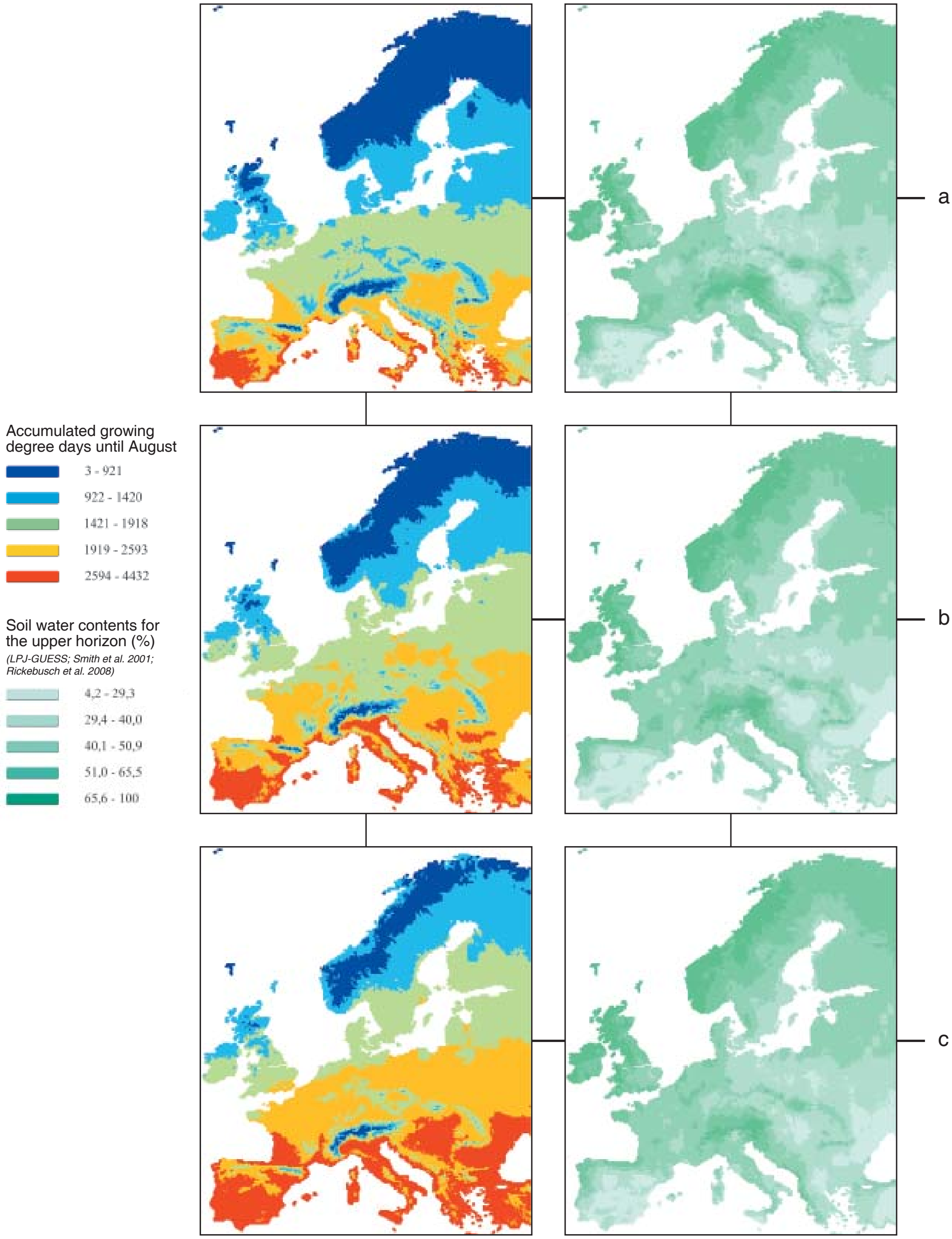


Fig. B.3.1 Accumulated growing degree days until August. (a) Current conditions (1971-2000); (b) future conditions for 2050 under the intermediate scenario (BAMBU); (c) future conditions for 2080 under the intermediate scenario (BAMBU).

Fig. B.3.2 Soil water content. (a) Current conditions (1971-2000); (b) future conditions for 2050 under the intermediate scenario (BAMBU); (c) future conditions for 2080 under the intermediate scenario (BAMBU).

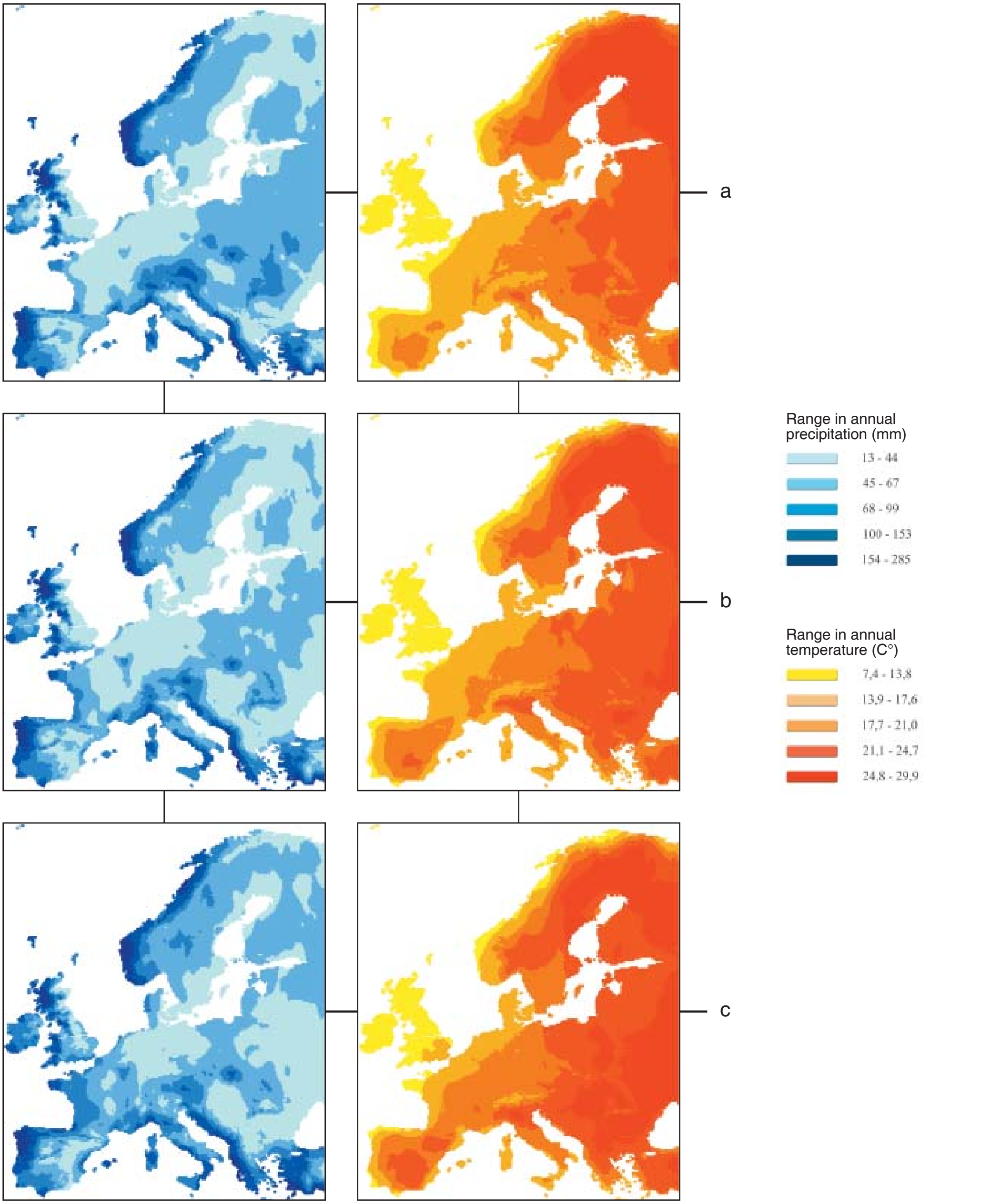


Fig. B.3.3 Range in annual precipitation. (a) Current conditions (1971-2000); (b) future conditions for 2050 under the intermediate scenario (BAMBU); (c) future conditions for 2080 under the intermediate scenario (BAMBU).

Fig. B.3.4 Range in annual temperature. (a) Current conditions (1971-2000); (b) future conditions for 2050 under the intermediate scenario (BAMBU); (c) future conditions for 2080 under the intermediate scenario (BAMBU).

Assumptions for species dispersal

The next key factor we need to incorporate is the ability of a species to colonise new potentially suitable areas in the course of climate change. For butterflies, this depends closely on a species' dispersal ability. However, detailed dispersal distances are not available for most species and we thus examined two extreme assumptions:

1. Unlimited dispersal, such that the entire projected niche space denotes the actual future distribution.
2. No dispersal, in which the future distribution results solely from the overlap between current and future niche space.

Visualisation of the multi-dimensional climatic niche

To visualise the multi-dimensional climatic niche independent from the species' geographic distribution, we provide a 4 x 4 panel of graphs. In each graph the occurrence probability surface is presented, according to the climatic niche model and the threshold beyond which occurrence is most likely, considering accumulated growing degree days until August (Gdd; x-axis) and soil water content (Swc; y-axis). Additionally, for most species the relationship between occurrence probability, Gdd and Swc varies with the other two considered variables annual temperature range and annual precipitation range. Since a continuous visualisation of this four-dimensional niche would be outside the scope of human perception, we provide 4 × 4 discrete combinations of the latter two variables. Therefore, we depict the relationship between occurrence probability, Gdd and Swc for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range.

B.4 Climate change risk assessment for butterflies

Definitions of climate change risk categories for European butterflies

Each butterfly species assessed was placed in a risk category (see below) according to the loss of grid cells in each scenario. Categories were only assigned for species whose distributions were modelled reasonably accurately by the model (AUC > 0.75, see chapter B.3). Species whose distributions were not modelled reasonable accurately were assigned the category "PR – Potential climate change risk".

The categories of model quality are as follows:

AUC: > 0.95:	Present distribution can be very well explained by climatic variables
AUC: > 0.85 – 0.95:	Present distribution can be well explained by climatic variables
AUC: > 0.75 – 0.85:	Present distribution can be explained by climatic variables to a moderate extent
AUC: ≤ 0.75:	Present distribution can be explained by climatic variables to only a limited extent

The climate risk categories which have been derived from the analysis and which are used throughout the atlas are as follows:

Category		**% loss of grid cells**	**AUC**
HHHR	extremely high climate change risk	> 95	> 0.75
HHR	very high climate change risk	> 85 – 95	> 0.75
HR	high climate change risk	> 70 – 85	> 0.75
R	climate change risk	> 50 – 70	> 0.75
LR	lower climate change risk	≤ 50	> 0.75
PR	potential climate change risk	0 - 100	≤ 0.75

Integrated overall risk categories for European species – integrating all scenarios and time steps

In the short description of the ecology of each species in chapter C.2, each species was given an overall risk category. These are defined as follows:

HHHR (extremely high climate change risk): Climate change poses a very high risk to the species because more than 95% of the grids with currently suitable climate may no longer be suitable in 2080 under at least one scenario (under the "no dispersal" assumption). Present distribution can be explained by climatic variables at least to a moderate extent (AUC > 0.75).

HHR (very high climate change risk): Climate change poses a very high risk to the species because more than 85% of the grids with currently suitable climate may no longer be suitable in 2080 under at least one scenario (under the "no dispersal" assumption). Present distribution can be explained by climatic variables at least to a moderate extent (AUC > 0.75).

HR (high climate change risk): Climate change poses a high risk to the species because more than 70% of the grids with currently suitable climate may no longer be suitable in 2080 under at least one scenario (under the "no dispersal" assumption). Present distribution can be explained by climatic variables at least to a moderate extent (AUC > 0.75).

R (climate change risk): Climate change poses a risk to the species because more than 50% of the grids with currently suitable climate may no longer be suitable in 2080 under at least one scenario (under the "no dispersal" assumption). Present distribution can be explained by climatic variables at least to a moderate extent (AUC > 0.75).

LR (lower climate change risk): Climate change poses a lower risk to the species because 50% or less of the grids with currently suitable climate may no longer be suitable in 2080 under at least one scenario (under the "no dispersal" assumption). Present distribution can be explained by climatic variables at least to a moderate extent (AUC > 0.75).

PR (potential climate change risk): At the moment, climate change can only be regarded as a potential risk for the species' long-term survival in Europe. All species whose present distribution can be explained by climatic variables to only a limited extent (AUC: ≤ 0.75) have been categorised as PR, independent of the rate of decline of their climatic niche distribution.

C

CLIMATE RISKS OF EUROPEAN BUTTERFLY SPECIES

C.1 Species inventory and taxonomy of European butterflies

Depending on different authors, the state-of-the-art in taxonomy and its interpretation, Europe is thought to support around 450 butterfly species. For this atlas we have modelled 294 species (in some cases only species complexes). The results on individual species are shown in chapter C.2, with complete lists in Appendices 1 and 2. A further 149 species (a number which might change depending on the results of taxonomic research) are listed in chapter C.3. Species covered in C.2 and C.3 only include those from the geographical area of Europe, including the Azores, Madeira, the Canary Islands, all Greek islands, Cyprus and the European part of Turkey, but excluding territories of Belarus, Ukraine, Moldova, and Russia.

Generally, the classification of butterfly genera and species in the present work is based on that utilized in 'The distribution atlas of European butterflies' (Kudrna 2002). Recent progress in systematic research (incorporating biological, genetic and molecular aspects, but not ignoring traditional morphology) has led to changes in the classification of many taxa. One always has to be aware, that taxonomic categories are in principle scientific concepts and nominate taxa, here genera and species, are scientific hypotheses. Their authors may employ different views on the status of the same taxon and their views may change as time goes by, subject to the application of new methods and new research results.

Therefore the classification of European butterflies is bound to remain fluid – not only if one considers that according to Descimon & Mallet (in press) around 16% of European butterfly species are known to hybridize in the wild. About half or more of these hybrids are fertile, and show evidence of backcrossing. An example for the need of reclassification on the genus level is the heterogeneity of the genus *Plebejus* KLUK, 1802, where new molecular data by Wiemers (2003) indicate that it is not monophyletic and possibly consists of a few closely related genera).

The first draft of the original checklist used by Kudrna (2002) dates back to 1995; it contained a number of questionable (micro)species in order to facilitate research about their ranges and, perhaps, their overlapping zones. This helped, for instance, to establish, that *Euphydryas glaciegenita* is a high alpine ecological race of *E. aurinia*, not a distinct species (Pelz, unpubl.).

The nomenclature utilized here follows the International Code on Zoological Nomenclature. Unfortunately the International Commission on Zoological Nomenclature does little at present to help stabilize zoological nomenclature by using its plenary powers, the means created in the past for this purpose by the Commission. Thus, for instance, the well established generic name *Maculinea* van ECKE, 1915, must be 'sacrificed', as it is a junior subjective synonym of *Phengaris* DOHERTY, 1891 (e.g. Pech et al. 2004).

The main changes or adjustments for the present atlas are telegraphically reviewed here, starting with general aspects and followed by a family-wise treatment:

General:

- The authorship of all names proposed in the 'Wiener Verzeichnis' was erroneously attributed to DENIS & SCHIFFERMÜLLER by most of the past authors. It has been demonstrated by Kudrna & Belicek (2005) that the sole author of the work was I. SCHIFFERMÜLLER. It has been shown that many names proposed therein are nomina nuda, but except in one case they have been made available by subsequent authors.

Hesperiidae:

- *Pyrgus malvoides* is being treated as a distinct species by some and as a subspecies by other authors (e.g. Higgins 1976, de Jong 1972). Following recent recording (Kudrna 2002) and thus for technical reasons, it appears more appropriate to treat both *Pyrgus malvae* and *Pyrgus malvoides* under the *Pyrgus malvae* complex.

Pieridae:

- Following Braby (2005) and contrary to Klots (1933), *Pontia* FABRICIUS, 1807, is provisionally recognized as a genus distinct from *Pieris* SCHRANK, 1801.
- *Pontia daplidice* was divided into two species by Geiger & Scholl (1982) due to strong differences in allozyme pattern, but Porter et al. (1997) questioned their specific distinctness after proving extensive hybridization in a contact zone in Liguria, Italy. Because of these results and lack of information on the distribution of both taxa in Central Europe, both taxa are treated as a complex in the present atlas. Work on the identity and distribution of both *P. edusa* and *P. daplidice* (including molecular work with DNA markers) is in progress. It seems that *P. edusa* is more widespread in Central Europe and currently the more active migrant, while *P. daplidice* is restricted to the Western and Southern Mediterranean region (Wiemers, unpubl. data).
- *Leptidea reali* and *L. sinapis* have proven to be sibling species rather recently, but they cannot be always reliably distinguished and most of old data often cannot be referred to either species. This makes their treatment as *L. sinapis* complex unavoidable.

Lycaenidae:

- *Favonius quercus* (LINNAEUS, 1758): Shirozu & Yamamoto (1956) have shown in their taxonomic revision that *Favonius* SIBATANI & ITO, 1942, and *Quercusia* VERITY, 1943, are very closely related, whereas *Neozephyrus* is morphologically and phylogenetically very distinct. Since Shirozu & Yamamoto (1956) following the 'fashion' of their time afforded every species-group the status of a genus, *Quercusia* is best treated as a junior subjective synonym of *Favonius*.

- *Polyommatus eroides* is a subspecies of *P. eros* (Wiemers unpubl., Vodolazhsky & Stradomsyk 2008a, 2008b).
- *Polyommatus caelestissimus* is treated as a subspecies of *P. coridon*, because there is no evidence for genetic differentiation (Descimon & Mallet in press, Wiemers 2003), therefore the UTM data points of both species have been combined into one map.
- *Plebejus glandon* and *P. aquilo* are treated as separate allopatric species in this atlas. However, many authors (e.g. Tolman & Lewington 2008) consider the latter only as a subspecies of *P. glandon*, often also including the local endemic *P. zuellichi* from Sierra Nevada (which has not been modelled due to the few data points).
- *Cyaniris semiargus* is provisionally removed from the genus *Polyommatus* Latreille, 1804. New molecular results indicate a closer relationship to *Plebejus* than to *Polyommatus* (Wiemers 2003).
- Some species of the genus *Scolitantides* Hübner, 1819, used to be placed in *Pseudophilotes* Beuret, 1958, which here is regarded as a junior subjective synonym of the former. The use of these genera however keeps changing and underlines the necessity of a revision.

Nymphalidae:

- The genus *Nymphalis* is divided into two genera: *Aglais* Dalman, 1816, and *Nymphalis* Kluk, 1802. (Wahlberg & Nylin 2003, Wahlberg pers. comm.).
- *Argyronome* Hübner, [1819] is a junior subjective synonym of *Argynnis* Fabricius, 1807 (Simonsen 2006); thus: *Argynnis laodice*.
- *Coenonympha iphioides* is a subspecies of *C. glycerion*. (Wiemers 2007).
- *Coenonympha darwiniana* is a subspecies of *C. gardetta* (Wiemers 1998, 2007, Porter et al. 1995).
- Although *Erebia arvernensis* and *E. carmenta* are probably distinct species (Albre, et al. 2008); at present their distribution data cannot be separated from *E. cassioides* for technical reasons and thus they have to be treated as a "complex" together with the "western" *E. cassioides*.
- Kudrna (2002) followed Miller (1968) and treated his 'series' as monophyletic genera *Hipparchia* Fabricius, 1807, *Maniola* Schrank, 1801, *Pararge* Hübner [1819] and *Kirinia* Moore, 1893. Current research however shows, that Miller's (1968) 'series' are not monophyletic (Pena et al. 2006). Thus the provisional classification employed here follows Pena et al. (2006); at present there is no comprehensive revision or phylogenetic study of the higher classification of the subfamily Satyrinae. The (provisionally?) resurrected genera are: *Lasiommata* Westwood, 1841, *Lopinga* Moore, 1893, *Hyponephele* Muschamp, 1915, *Pyronia* Hübner [1819], *Brintesia* Fruhstorfer, [1911], *Chazara* Moore, 1893, *Pseudochazara* Lesse, 1951, *Satyrus* Latreille, 1810, *Arethusana* Lesse, 1951, *Minois* Hübner, [1819]. Whereas some of these genera (e.g. *Hyponephele, Lasiommata, Maniola, Pararge*) are 'strong', some other genera remain 'weak'

and their taxonomic status may change in the course of new research results becoming available. It is to be remembered that only an incomplete selection of potentially congeneric species has been examined (by molecular and other studies) so far.

- *Hipparchia alcyone* is a junior subjective synonym of *H. hermione* (Verity 1913) (Kudrna 1977, 1984, Honey & Scoble 2001), based upon the lectotype of the latter, designated by Kudrna (1977).
- *Pseudochazara amalthea* (Friwaldszky, 1845), placed by Kudrna (2002) provisionally in the genus *Hipparchia*, is a subspecies of *Pseudochazara anthelea* (Lefebvre, 1831), as it is already treated by many authors.

In general we agree with Descimon & Mallet (in press), that "there is justification for reviving the rather neglected (and misused) rank of subspecies, with the trend among lepidopterists to consider only more strongly distinct forms (in morphology, ecology, or genetics) as subspecies, and to lump dubious geographic forms as synonyms." This provides "a useful compromise between descriptions of geographic variation, the needs of modern butterfly taxonomy, and Darwin's pragmatic use of the term species in evolutionary studies."

Although the definition of species will always be difficult, species will continue to function as useful tools in biology. "Studies of gene exchange in the many hierarchical layers of phenotype, genotype and genome in "bad" species of butterflies will illuminate the nature of speciation and evolution at the species level more than discussions on the "essence" of species." (citations from Descimon & Mallet, in press).

C.2 Climatic fate of individual species

The present chapter is the core part of this atlas. It encompasses the largest part of the book from page 32 to page 619. Here all species will be shown as pictures taken in natural settings. Their ecology and biology is very briefly characterized, based on general field guides and text books like Tolman & Lewington (2008), but also own field experience. Information on ant-lycaenid relationships were largely drawn from Fiedler (2006). For each species we give the statistics of changes in the climatic niche distribution, the observed and modelled present distribution, the multidimensional climatic niche, and the projected climatic niche space distribution under the different scenarios SEDG, BAMBU, and GRAS for the years 2050 and 2080. On each of these maps the distribution of climatic niche space is shown that a) remains stable (orange), b) gets lost (grey), and c) is gained (dark brown). Thus it is possible to optically deduct the changes under the no and the full dispersal assumption (see chapter B.3 on page 20ff for further details on methodology).

Erynnis tages (Linnaeus, 1758) – Dingy Skipper

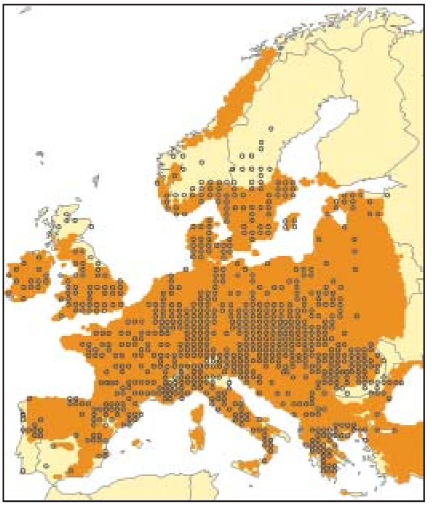
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-1786 (-10.09%)	-3203 (-18.09%)
	BAMBU	-2385 (-13.47%)	-3834 (-21.65%)
	GRAS	-2873 (-16.22%)	-4268 (-24.1%)
2080	SEDG	-4695 (-26.51%)	-6615 (-37.35%)
	BAMBU	-5429 (-30.66%)	-8408 (-47.48%)
	GRAS	-7225 (-40.8%)	-10729 (-60.59%)

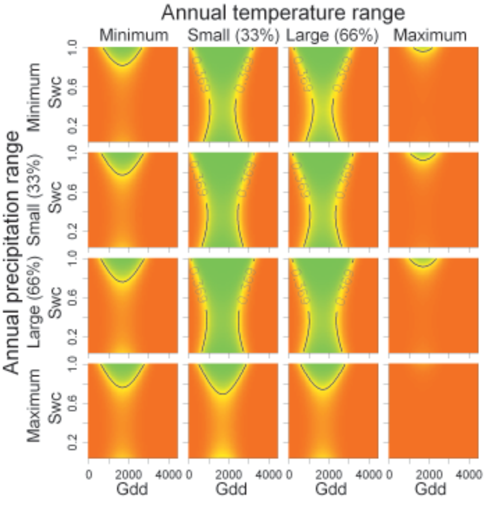
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 17709 cells)

The Dingy Skipper is a small, inconspicuous butterfly. It lays its eggs on the leaves of leguminous plants such as *Coronilla varia* (Crown Vetch), Horseshoe Vetch (*Hippocrepis comosa*) and Common Birdsfoot trefoil (*Lotus corniculatus*), usually choosing plants growing near bare patches. The caterpillar spins itself a small, tube-like shelter from leaves of the larval foodplant, living and feeding in it until fully grown. It then builds itself a sturdier shelter in which to pass the winter. In the spring, without further feeding, it pupates, either in the shelter, or in the moss layer. The adult butterfly is often found on Bugle (*Ajuga* spp.) and, while visiting flowers, is easily observed. The Dingy Skipper has one brood a year in central and northern Europe and two in the southern part.

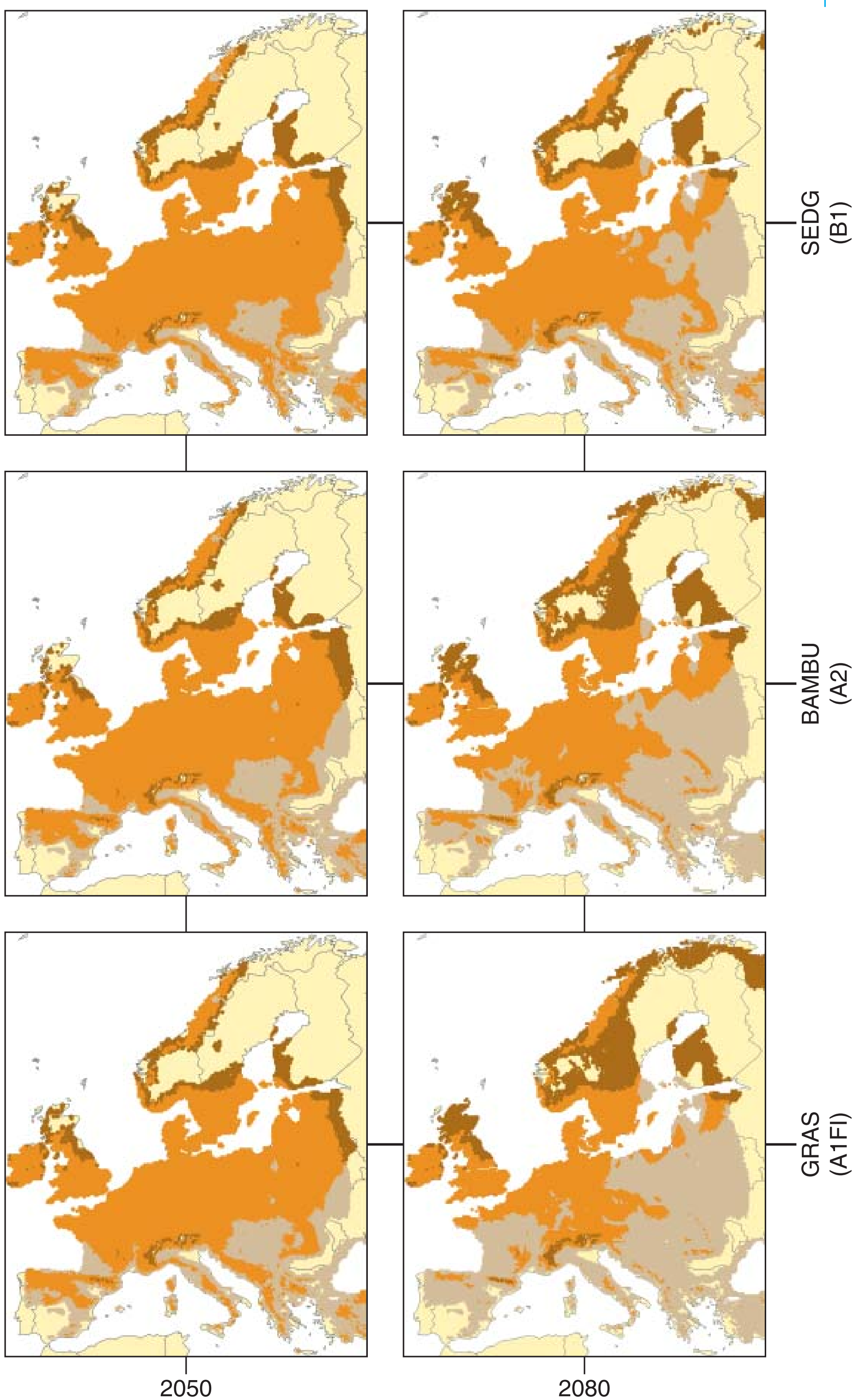
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.72).
Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erynnis marloyi (Boisduval, 1834) – Inky Skipper

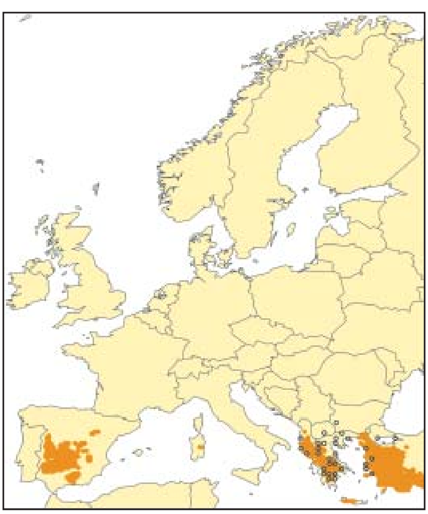
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-123 (-13.61%)	-521 (-57.63%)
	BAMBU	-240 (-26.55%)	-583 (-64.49%)
	GRAS	-222 (-24.56%)	-631 (-69.8%)
2080	SEDG	-72 (-7.96%)	-578 (-63.94%)
	BAMBU	-572 (-63.27%)	-807 (-89.27%)
	GRAS	-658 (-72.79%)	-862 (-95.35%)

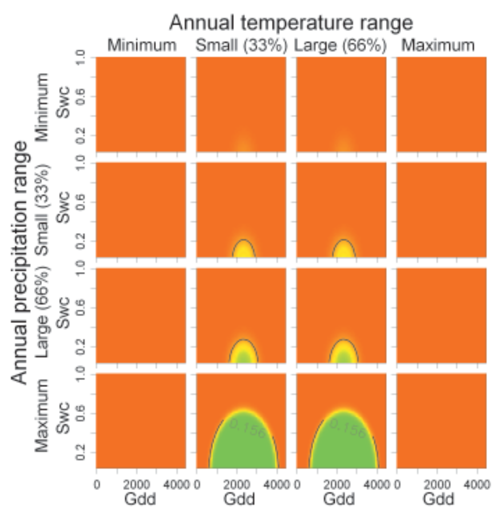
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 904 cells)

Inky Skippers are very dark little butterflies that fly rapidly, close to the ground. They are found on dry grasslands, in dried-up riverbeds, on rocky slopes, and in woodland clearings. They can often be seen basking in the sun, wings widespread, on light-coloured stones. Especially the females can also often be seen drinking nectar on thyme. The larvae feed on bushy rosaceans particularly on *Prunus spinosa* and *P. cocomilla*. The Inky Skipper has one or two broods a year.

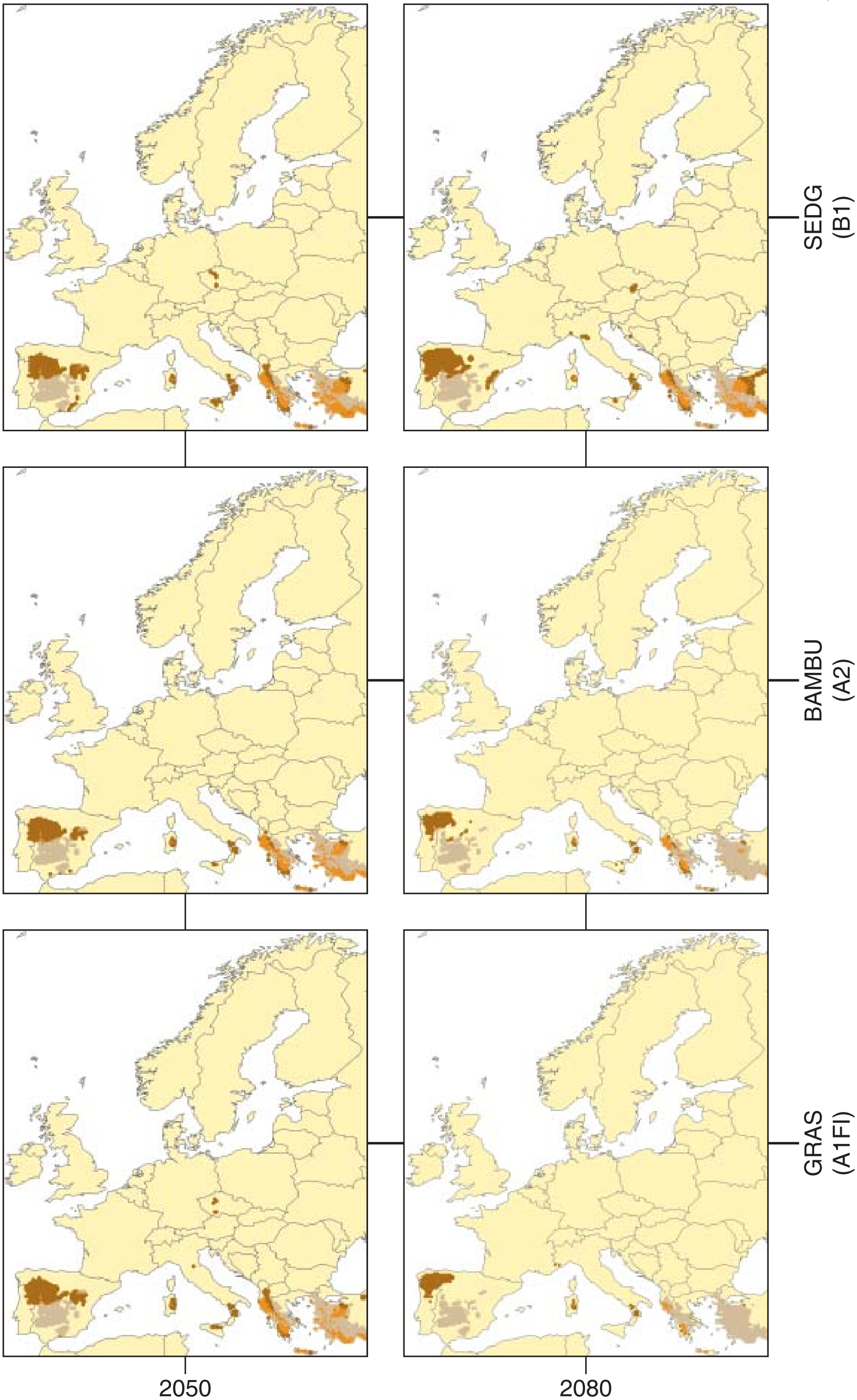
Present distribution can be very well explained by climatic variables (AUC = 0.98).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Carcharodus alceae (Esper, 1870) – Mallow Skipper

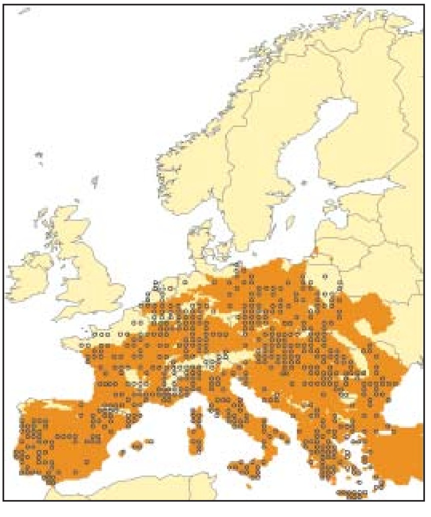
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	3884 (30.9%)	-568 (-4.52%)
	BAMBU	2554 (20.32%)	-1255 (-9.98%)
	GRAS	2940 (23.39%)	-1476 (-11.74%)
2080	SEDG	1889 (15.03%)	-2106 (-16.75%)
	BAMBU	-222 (-1.77%)	-4815 (-38.3%)
	GRAS	-1188 (-9.45%)	-6139 (-48.83%)

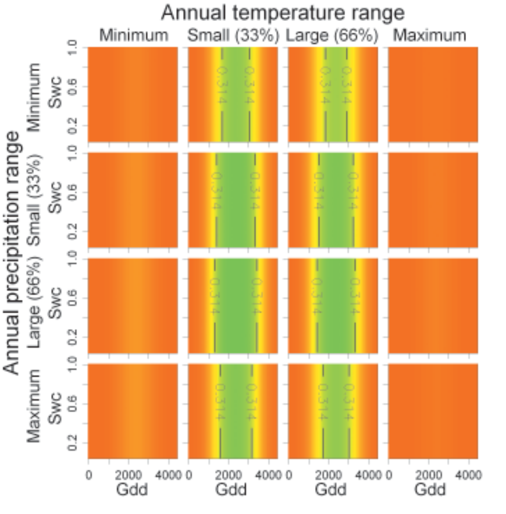
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 12571 cells)

The Mallow Skipper is a butterfly of warm, grassy places, usually with rough vegetation. It is a mobile butterfly, that strays outside its usual habitat, and thus can be met in unexpected places. In warm summers, they migrate northwards and can be seen in warm, south-facing river valleys. The resident populations are usually small. The butterflies are often seen visiting flowers for nectar. They also spend a lot of their time basking in the sun, their wings widespread, showing to full advantage their beautiful purple to olive-green metallic sheen. Eggs are laid singly on the upperside of the leaves of mallows (*Malva* ssp.). The caterpillars thrive on this food, growing very quickly. This skipper has up to three or more broods per year. As winter approaches, the fully-grown caterpillars make a cocoon in the litter layer. They pupate in the spring.

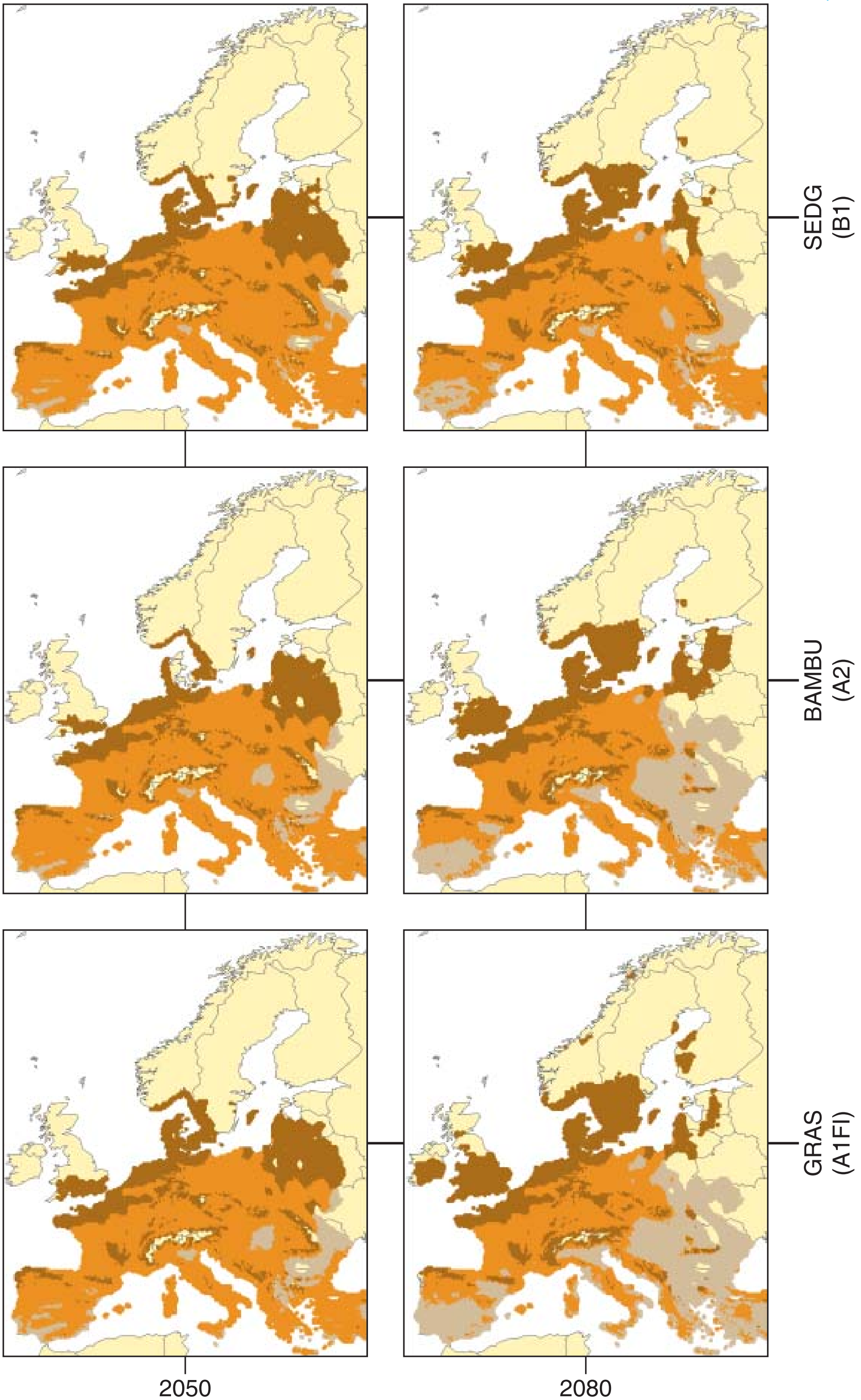
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.71). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Carcharodus lavatherae (Esper, 1783) – Marbled Skipper

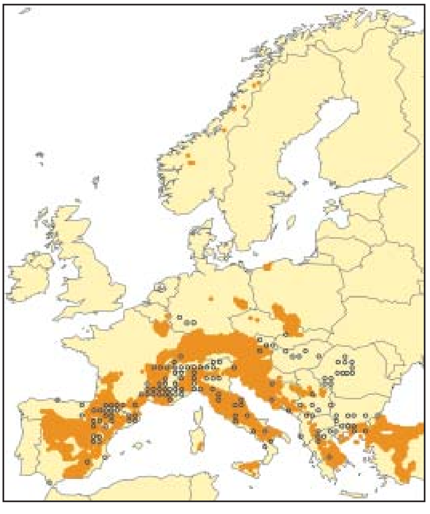
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-21 (-0.64%)	-1482 (-45.43%)
	BAMBU	-132 (-4.05%)	-1578 (-48.38%)
	GRAS	-379 (-11.62%)	-1893 (-58.03%)
2080	SEDG	1101 (33.75%)	-1978 (-60.64%)
	BAMBU	284 (8.71%)	-2409 (-73.85%)
	GRAS	-454 (-13.92%)	-2792 (-85.59%)

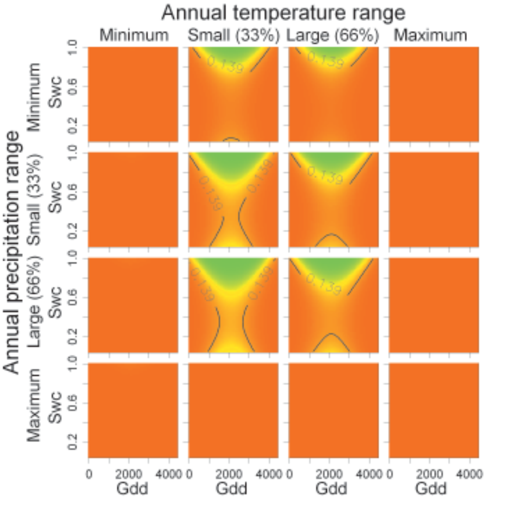
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 3262 cells)

The green sheen on the upperside of the wings and body of the Marbled Skipper distinguish it from other skippers in this genus. It lives in warm, flower-rich places. Populations are usually small, and it is exceptional to see a large number of these butterflies gathered together. On very hot days, needing to drink, they look for damp ground. The eggs are laid singly on the sepals of various woundworts (*Stachys* spp.), especially Perennial Yellow Woundwort (*S. recta*). The young caterpillars spin a loose shelter from leaves, under which they hide themselves while they feed, first eating the seeds and, later, the leaves of the plant. They hibernate in the third or fourth instar and pupate at the foot of the foodplant. The Marbled Skipper is single-brooded.

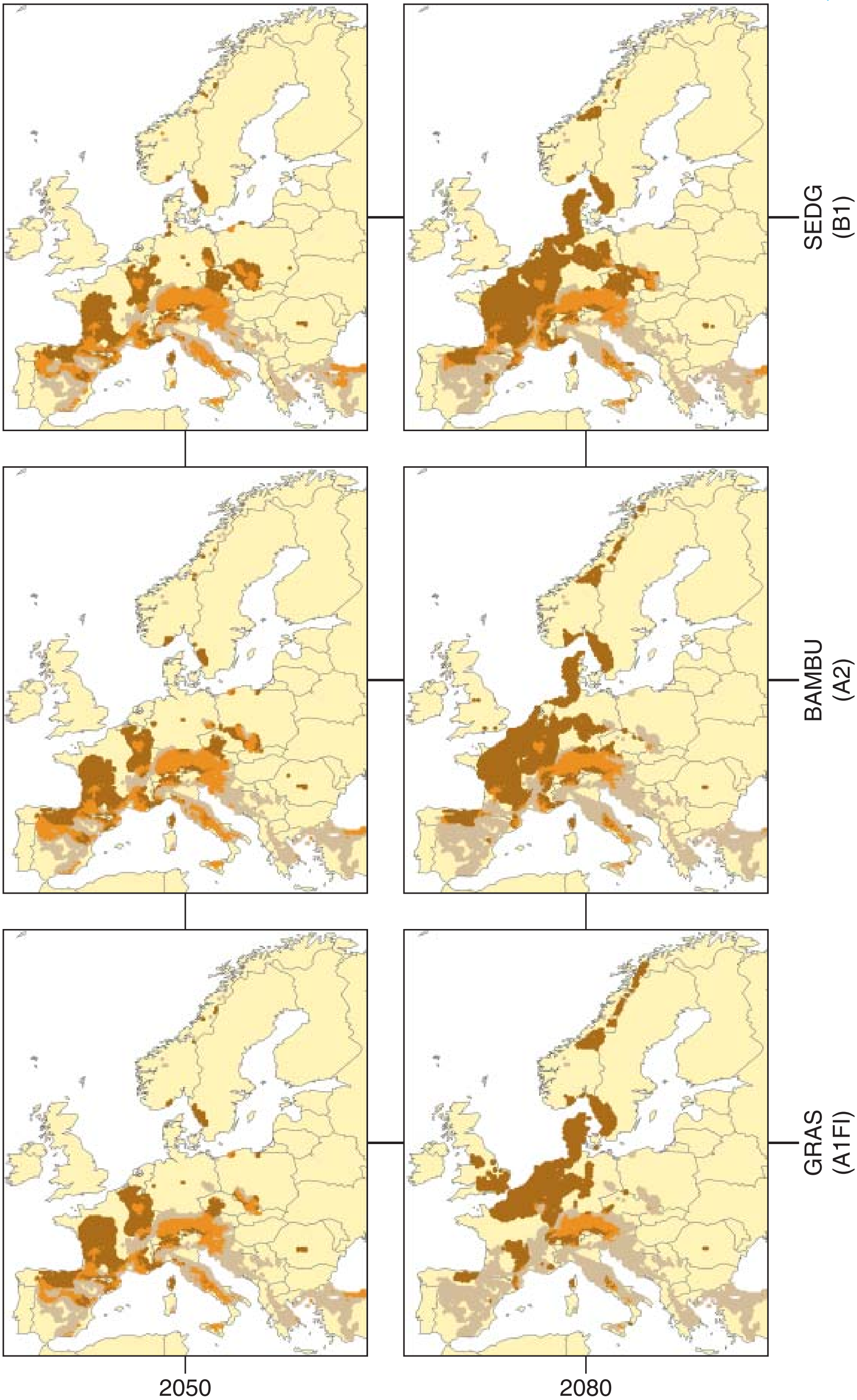
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.73). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Carcharodus flocciferus (Zeller, 1847) – Tufted Marbled Skipper

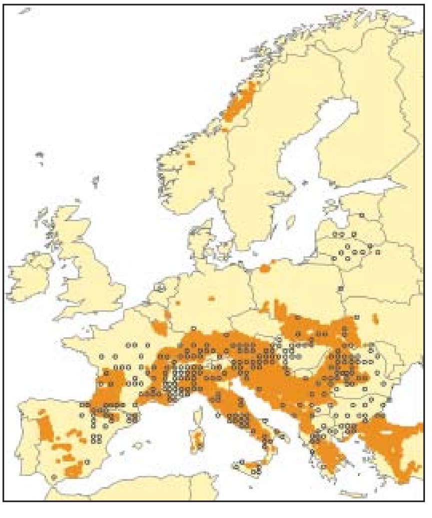
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	460 (10.92%)	-1148 (-27.25%)
	BAMBU	1228 (29.15%)	-1188 (-28.2%)
	GRAS	104 (2.47%)	-1661 (-39.43%)
2080	SEDG	2641 (62.69%)	-1670 (-39.64%)
	BAMBU	2427 (57.61%)	-2346 (-55.68%)
	GRAS	2972 (70.54%)	-2925 (-69.43%)

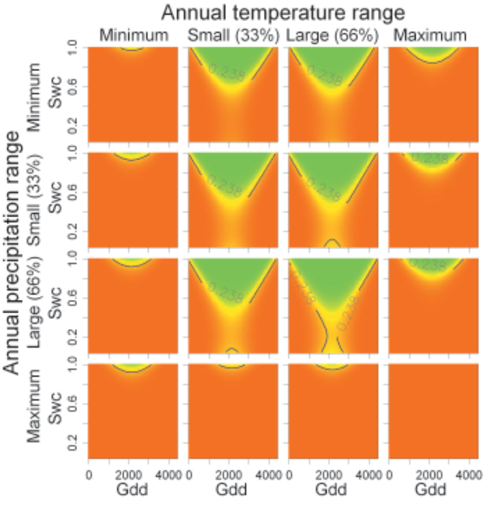
Changes in climatic niche distribution (in 10'×10' grid cells; present niche space: 4213 cells)

The Tufted Marbled Skipper can be found on flower-rich grasslands. It also occurs at the edges of woodland and in bushy vegetation. The males usually perch on a tall plant and very actively defend their territory. The female lays her eggs singly on the leaves of various woundworts (*Stachys* spp.), Betony (*S. officinalis*), but also Hedge Woundwort (*S. sylvatica*), Alpine Woundwort (*S. alpina*), and Marsh Woundwort (*S. palustris*). Species of horehounds (*Marrubium* spp.) are also considered to be larval foodplants. The young caterpillar lives in a curled-up leaf. When it is bigger, it spins two neighbouring leaves together to make a shelter where it remains during the day, coming out at night to feed on the leaves of the foodplant. It also pupates in such a shelter. This butterfly has one or two broods a year. It overwinters either as a caterpillar or a pupa.

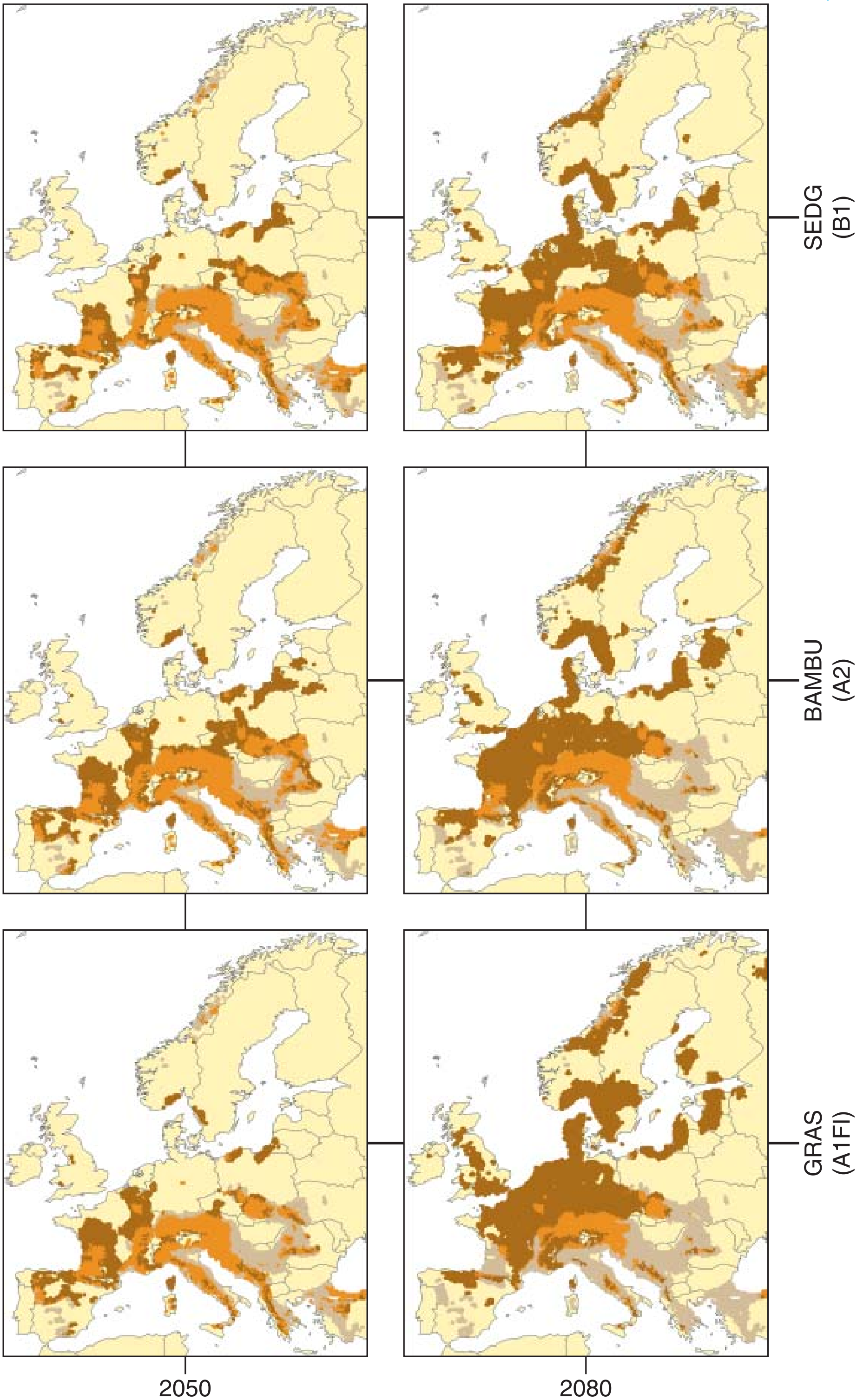
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.79).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Carcharodus orientalis (Reverdin, 1913) – Oriental Marbled Skipper

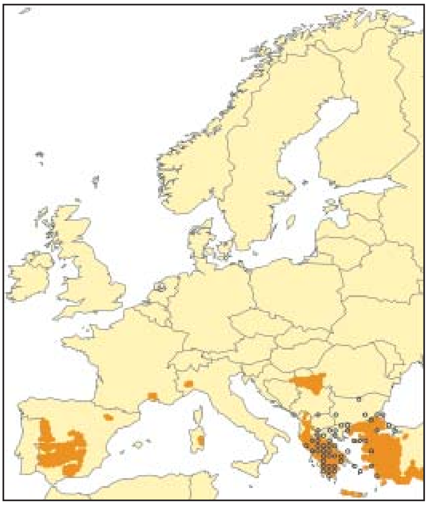
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-26 (-2.11%)	-611 (-49.59%)
	BAMBU	-119 (-9.66%)	-594 (-48.21%)
	GRAS	-94 (-7.63%)	-695 (-56.41%)
2080	SEDG	255 (20.7%)	-729 (-59.17%)
	BAMBU	-435 (-35.31%)	-972 (-78.9%)
	GRAS	-266 (-21.59%)	-1116 (-90.58%)

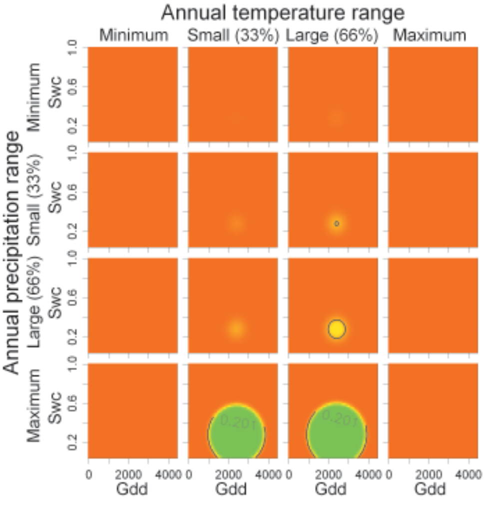
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1232 cells)

The Oriental Marbled Skipper is mostly found on grasslands, on rocky slopes with grassy vegetation, and occasionally on bushy or on low, shrubby vegetation. The butterflies fly quickly, close to the ground. When they are at rest, they usually have their wings widely spread. Males can be commonly found drinking on dump ground. The caterpillars feed on woundworts (*Stachys* spp.). It has two to three generations a year, and hibernates as a caterpillar.

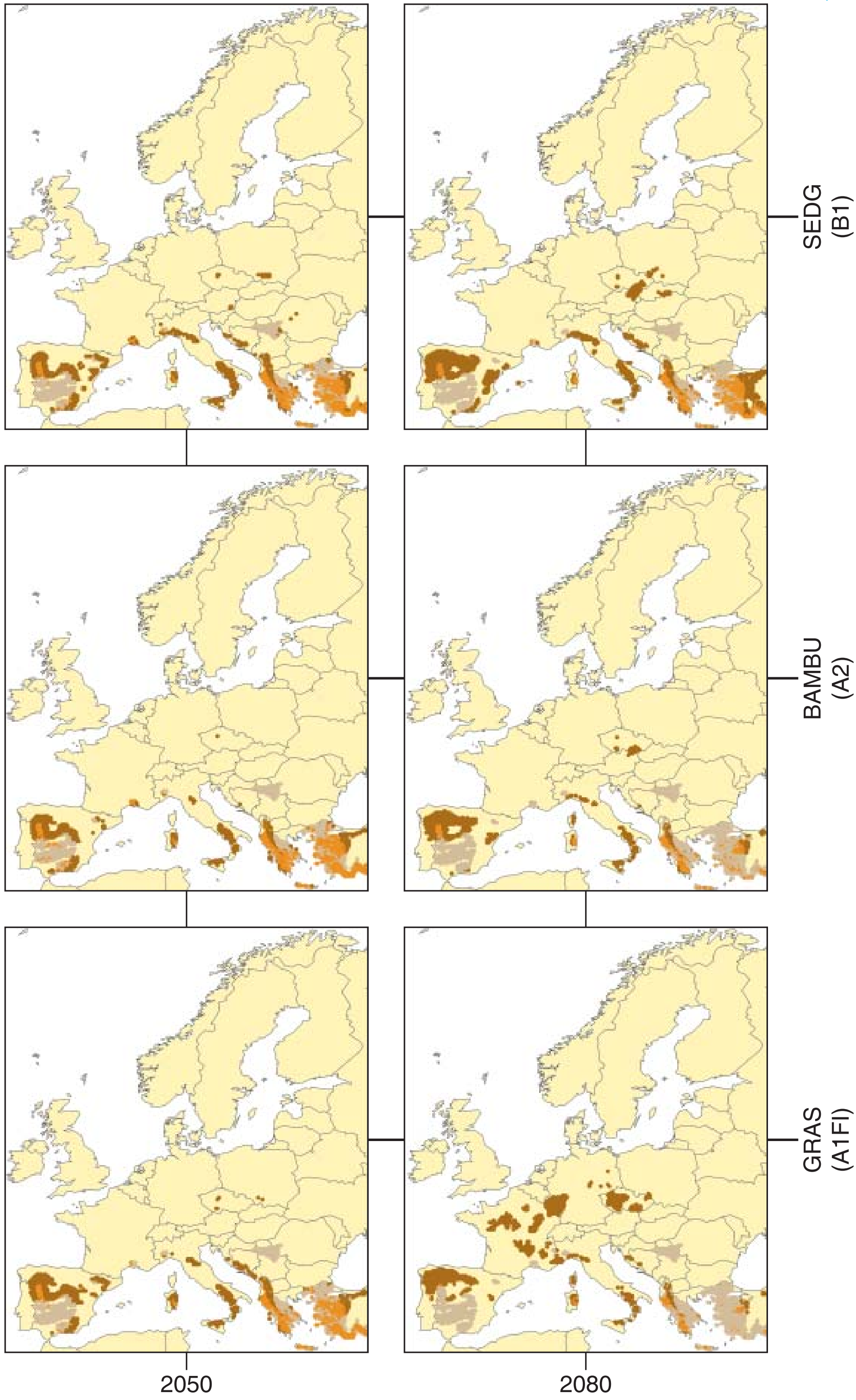
Present distribution can be well explained by climatic variables (AUC = 0.92).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold



SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Carcharodus baeticus (Rambur, 1840) – Southern Marbled Skipper

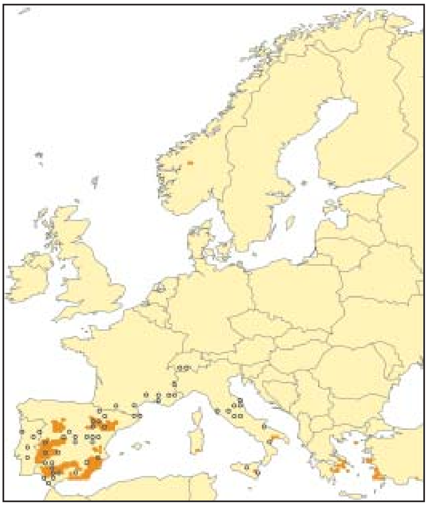
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	88 (21.26%)	-239 (-57.73%)
	BAMBU	75 (18.12%)	-233 (-56.28%)
	GRAS	168 (40.58%)	-229 (-55.31%)
2080	SEDG	106 (25.6%)	-275 (-66.43%)
	BAMBU	138 (33.33%)	-288 (-69.57%)
	GRAS	248 (59.9%)	-293 (-70.77%)

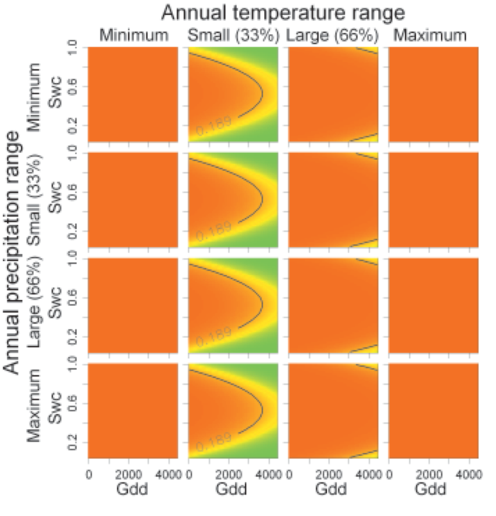
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 414 cells)

The Southern Marbled skipper occurs on dry, sparse vegetation, as found in the dunes, in dry, grassy places, and on rocky slopes. Foodplants are various horehounds, including Horehound (*Marrubium vulgare*), Black Horehound (*Ballota nigra* ssp. *foetida*), and *Ballota* spp. The female lays her eggs one by one on the leaves and shoots of the foodplant, seeming to prefer smaller plants. The small caterpillars live hidden in a spun leaf. The older, larger caterpillars spin two neighbouring leaves together to make a safe shelter. When they are fully-grown, the caterpillars go down to the foot of the foodplant, and spin a few dried leaves together in which to pupate. The species was not seen in the Alps in last 40 years, where it probably had just one generation per year, while in Spain there are two or three generations a year. It hibernates as a caterpillar.

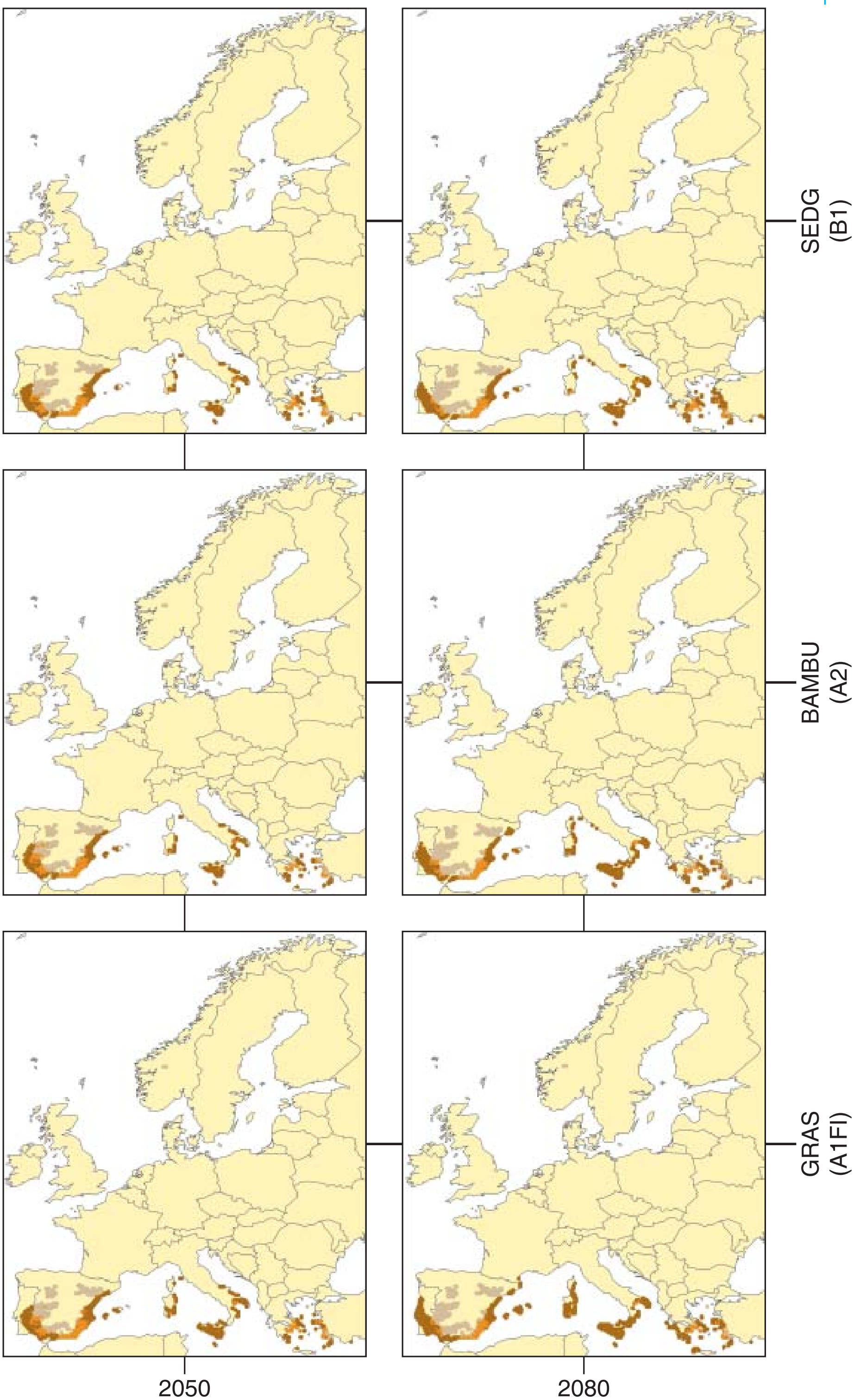
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.8).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Spialia phlomidis (Herrich-Schäffer, 1845) – Persian Skipper

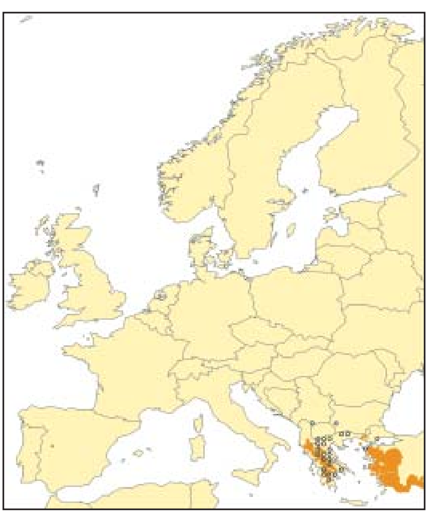
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	-59 (-15.4%)	-195 (-50.91%)
	BAMBU	-88 (-22.98%)	-228 (-59.53%)
	GRAS	-110 (-28.72%)	-260 (-67.89%)
2080	SEDG	27 (7.05%)	-229 (-59.79%)
	BAMBU	-262 (-68.41%)	-352 (-91.91%)
	GRAS	-319 (-83.29%)	-381 (-99.48%)

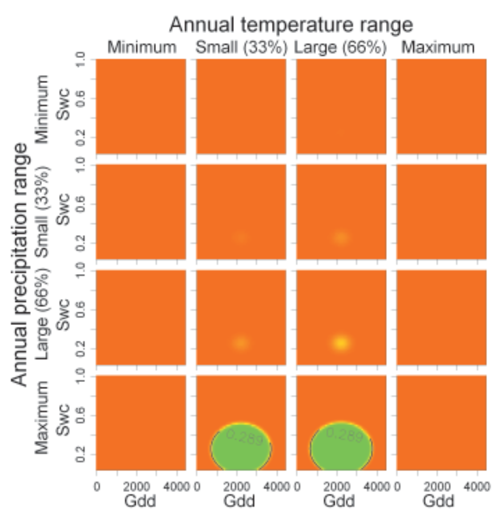
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 383 cells)

The Persian Skipper occurs on dry grasslands, on dry scrub, in rocky places and at woodland edges. On hot days males and females congregate on dump ground where they are easy to spot. Although the larval foodplant is not known for certain, probably various bindweeds (*Convolvulus* spp.) are used. Also, it is not clear how many broods it has a year, but it is probably two.

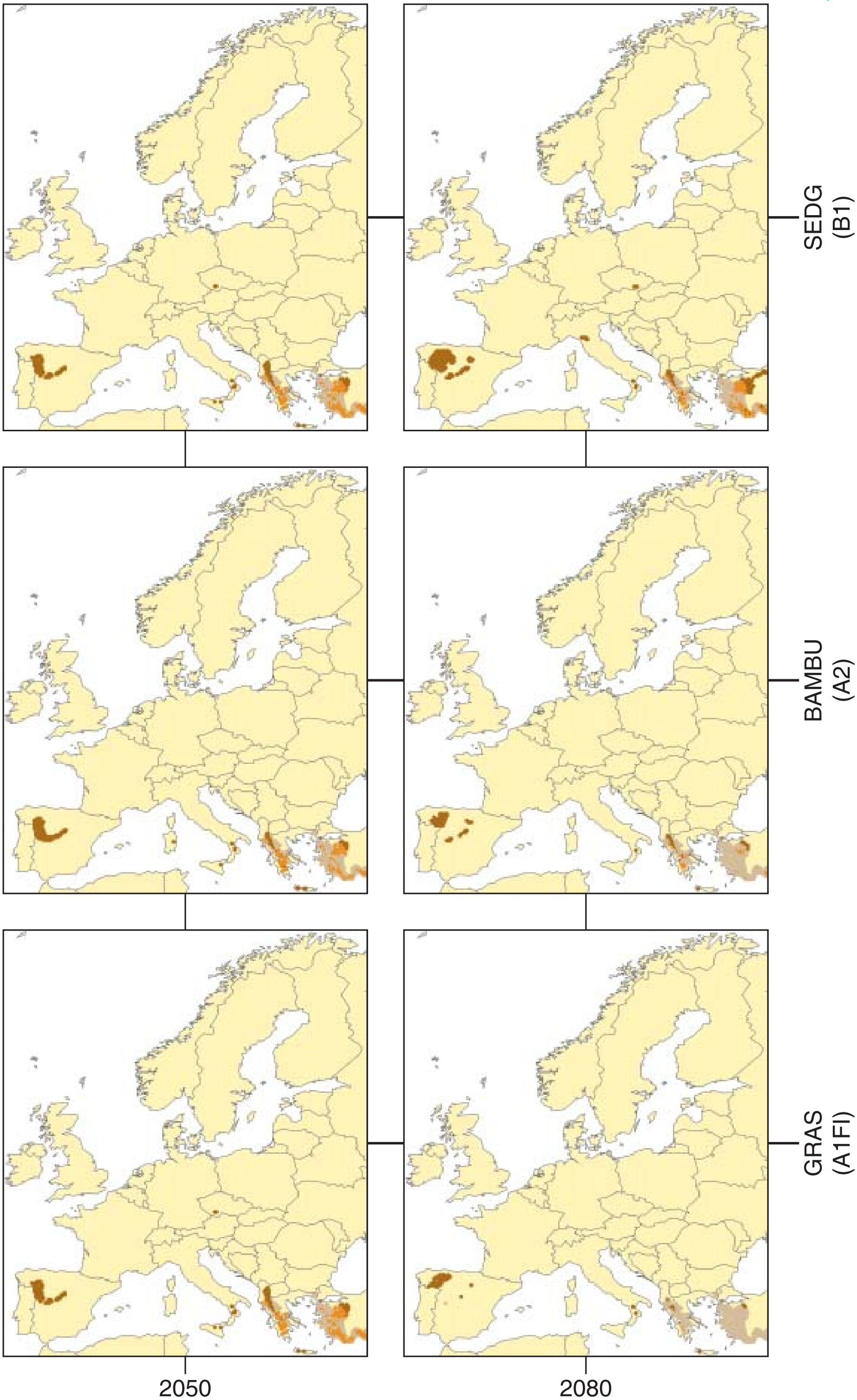
Present distribution can be well explained by climatic variables (AUC = 0.93).
Climate risk category: HHHR



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Spialia sertorius (Hoffmansegg, 1804) – Red-underwing Skipper

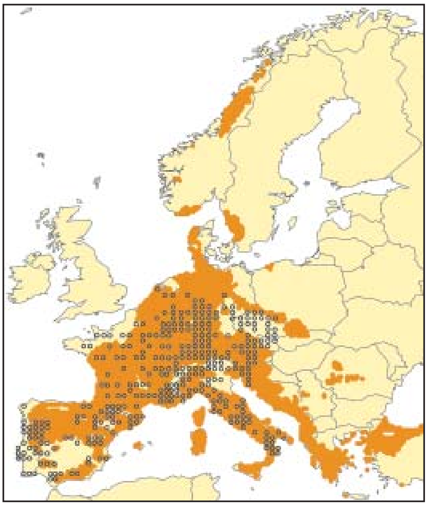
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-426 (-6.29%)	-1771 (-26.17%)
	BAMBU	-331 (-4.89%)	-1755 (-25.93%)
	GRAS	-1114 (-16.46%)	-2425 (-35.83%)
2080	SEDG	-553 (-8.17%)	-2424 (-35.82%)
	BAMBU	-1006 (-14.86%)	-3188 (-47.1%)
	GRAS	-2218 (-32.77%)	-4639 (-68.54%)

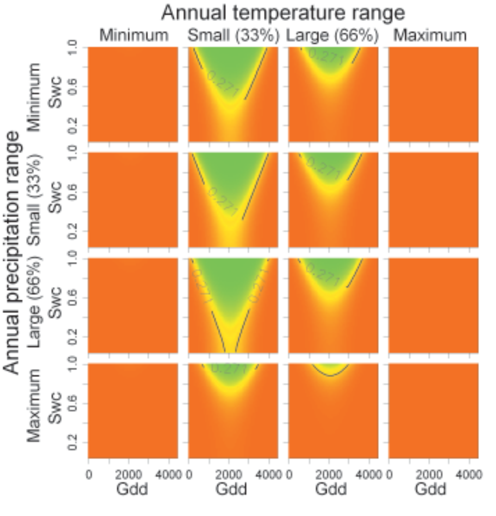
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 6768 cells)

The Red-underwing Skipper is a small butterfly that likes warm habitats. It occurs on calcareous and other dry grasslands, and also in dry, rough vegetation, as long as its larval foodplant, Salad Burnet (*Sanguisorba minor*), is present. The eggs are laid between the buds on the flowerheads of this plant and the caterpillars feed on the young leaves. Hibernation takes place as a caterpillar, in warm areas when still small, and further north when fully grown. The caterpillars pupate in the litter layer, in a sturdy cocoon made from plant remains. Because of its rapid flight and unremarkable behaviour, this small butterfly is often not even noticed. However, they are often present in large numbers over quite a small area. The butterflies like visiting flowers. It has one or two broods a year, depending on the position of the breeding ground within the range.

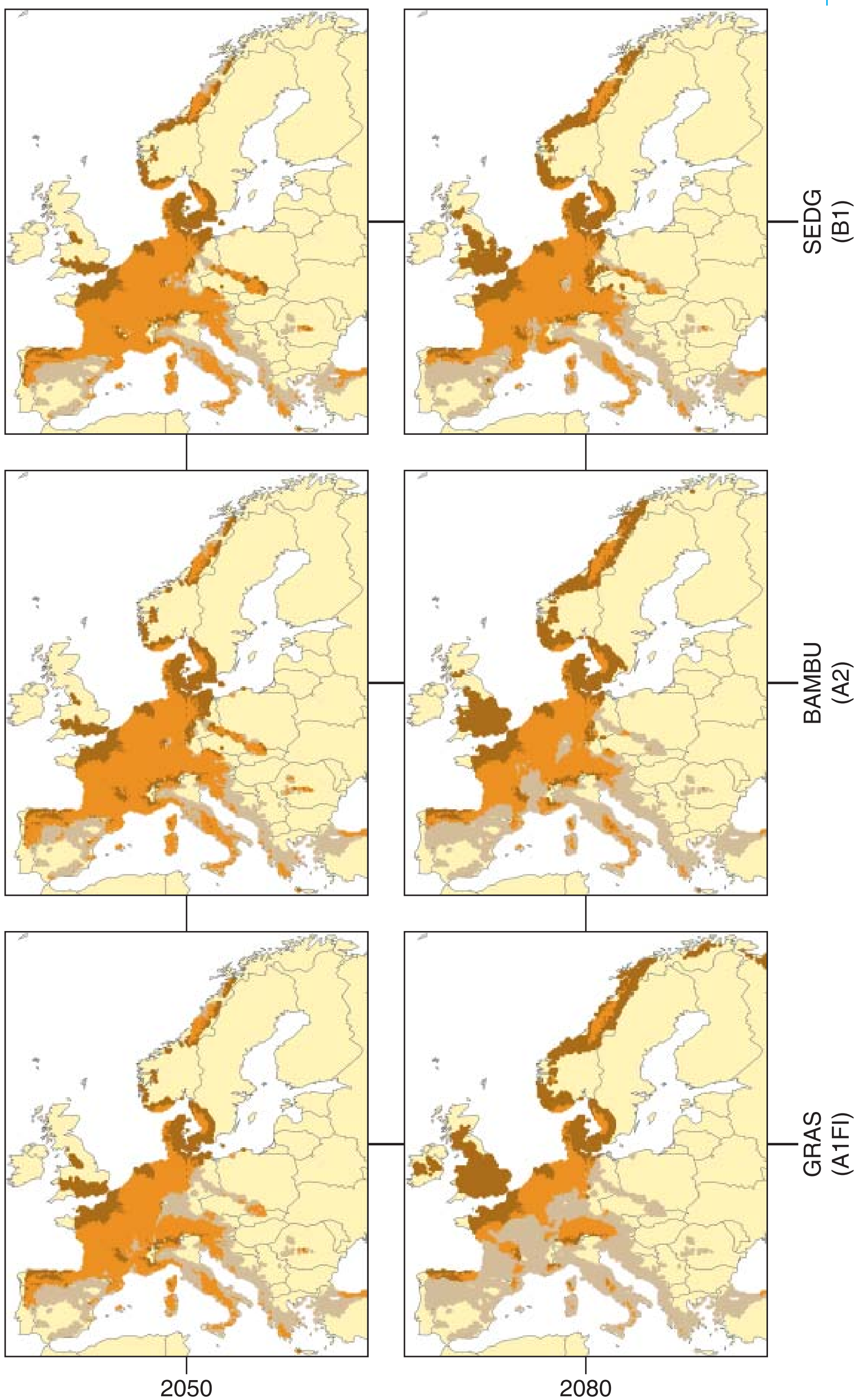
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.77)
Climate risk category: R



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Spialia orbifer (Hübner, 1823) – Orbed Red-underwing Skipper

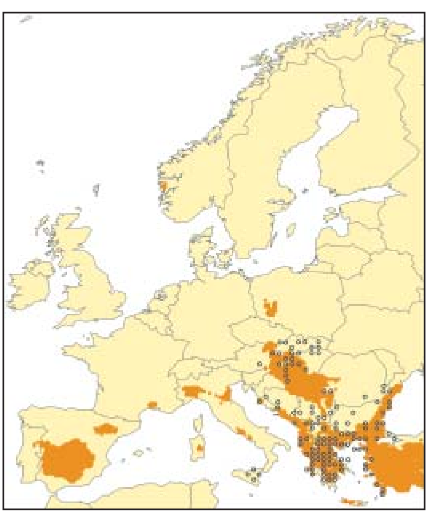
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	2229 (81.71%)	-341 (-12.5%)
	BAMBU	528 (19.35%)	-987 (-36.18%)
	GRAS	1211 (44.39%)	-976 (-35.78%)
2080	SEDG	1025 (37.57%)	-1188 (-43.55%)
	BAMBU	-59 (-2.16%)	-1848 (-67.74%)
	GRAS	1443 (52.9%)	-2000 (-73.31%)

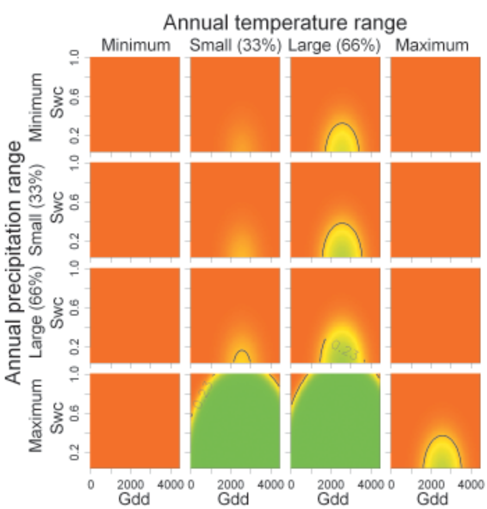
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2728 cells)

The Orbed Red-underwing Skipper occurs on dry, flower-rich grasslands, on roadside verges, at the edges of woods, on abandoned agricultural land, rocky slopes, and along dried-up river beds. The butterflies have a rapid flight, close to the ground. The eggs are laid on the flowerheads of Salad Burnet (*Sanguisorba minor*), and, in Eastern Europe, possibly also on Great Burnet (*S. officinalis*). The round flowerheads of the foodplant are the caterpillars' first food, but as they grow larger, they hide themselves between spun leaves. Hibernation takes place on the ground, in the litter layer. They also pupate in rolled-up leaves of the foodplant. This skipper is double-brooded and hibernates as a caterpillar.

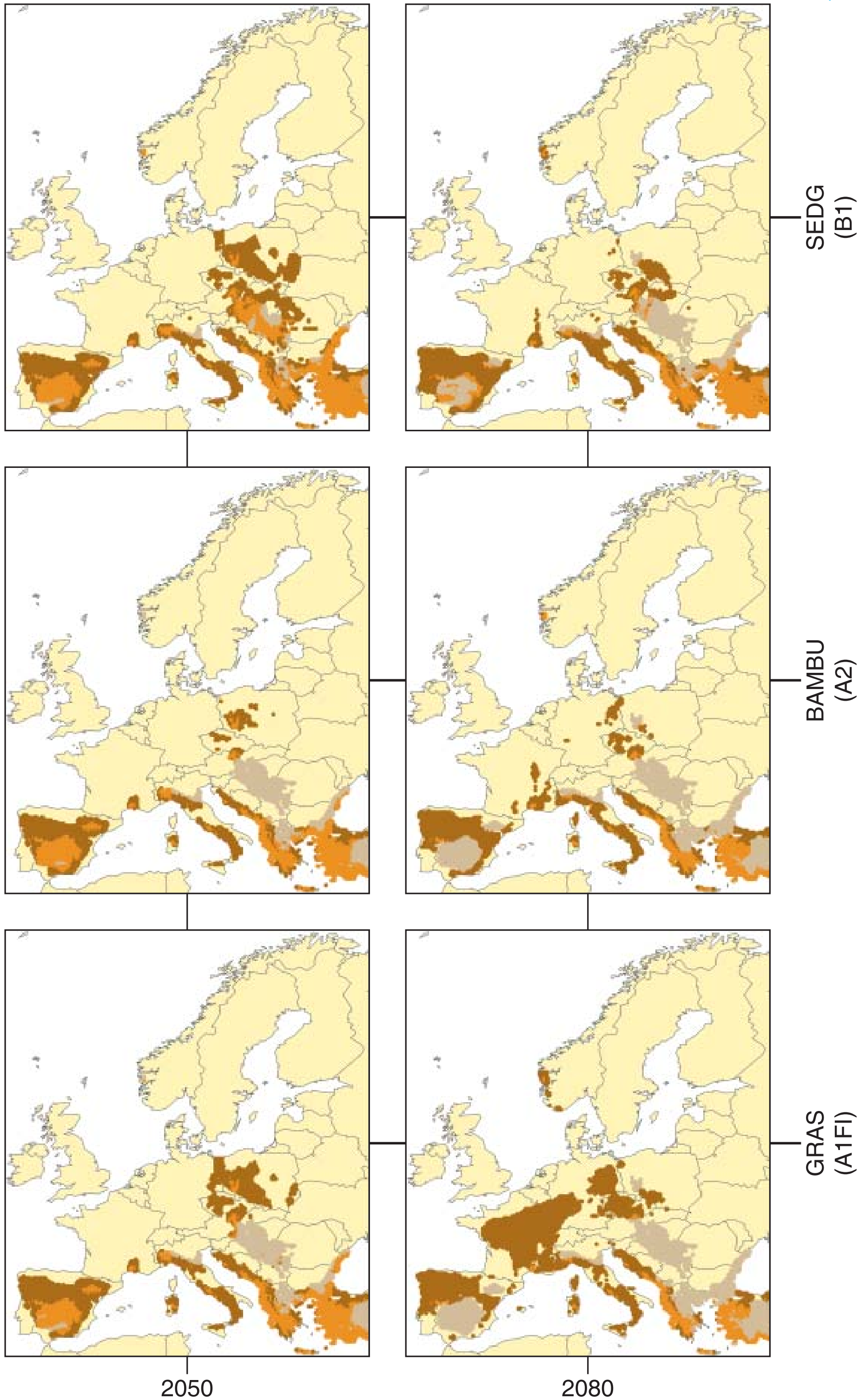
Present distribution can be well explained by climatic variables (AUC = 0.89).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Syrichtus proto (Ochsenheimer, 1808) – Sage Skipper

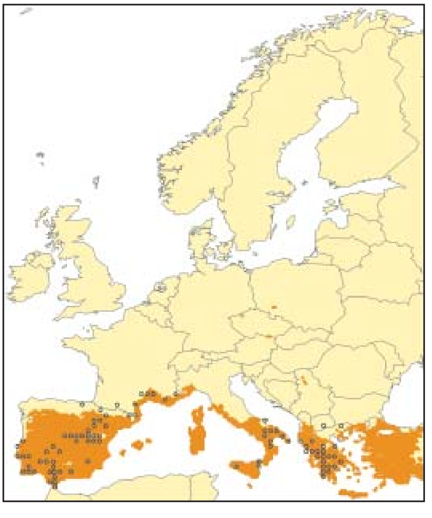
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-1328 (-36.22%)	-1802 (-49.15%)
	BAMBU	-1862 (-50.79%)	-2012 (-54.88%)
	GRAS	-1928 (-52.59%)	-2248 (-61.32%)
2080	SEDG	-1929 (-52.62%)	-2530 (-69.01%)
	BAMBU	-3014 (-82.21%)	-3242 (-88.43%)
	GRAS	-2945 (-80.33%)	-3553 (-96.92%)

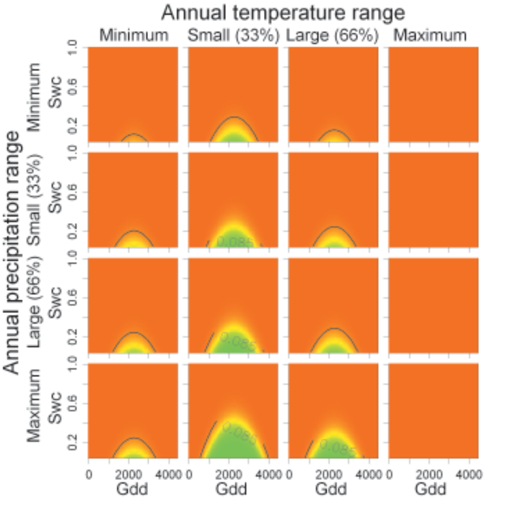
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 3666 cells)

The Sage Skipper occurs on dry, flower-rich grassland, in open scrub, on rocky ground with sparse vegetation. However, in its chosen habitat, the larval foodplants are usually abundant. Various species of *Phlomis* are used, such as Jerusalem Sage (*P. fructicosa*), *P. lychnitis*, *P. herba-venti*, and perhaps also Horehound (*Marrubium* spp.). Although there is probably only one generation a year, the butterflies of the Sage Skipper can be seen from spring until autumn, due to prolonged emergence from the pupa. This skipper passes the winter as a caterpillar inside the egg.

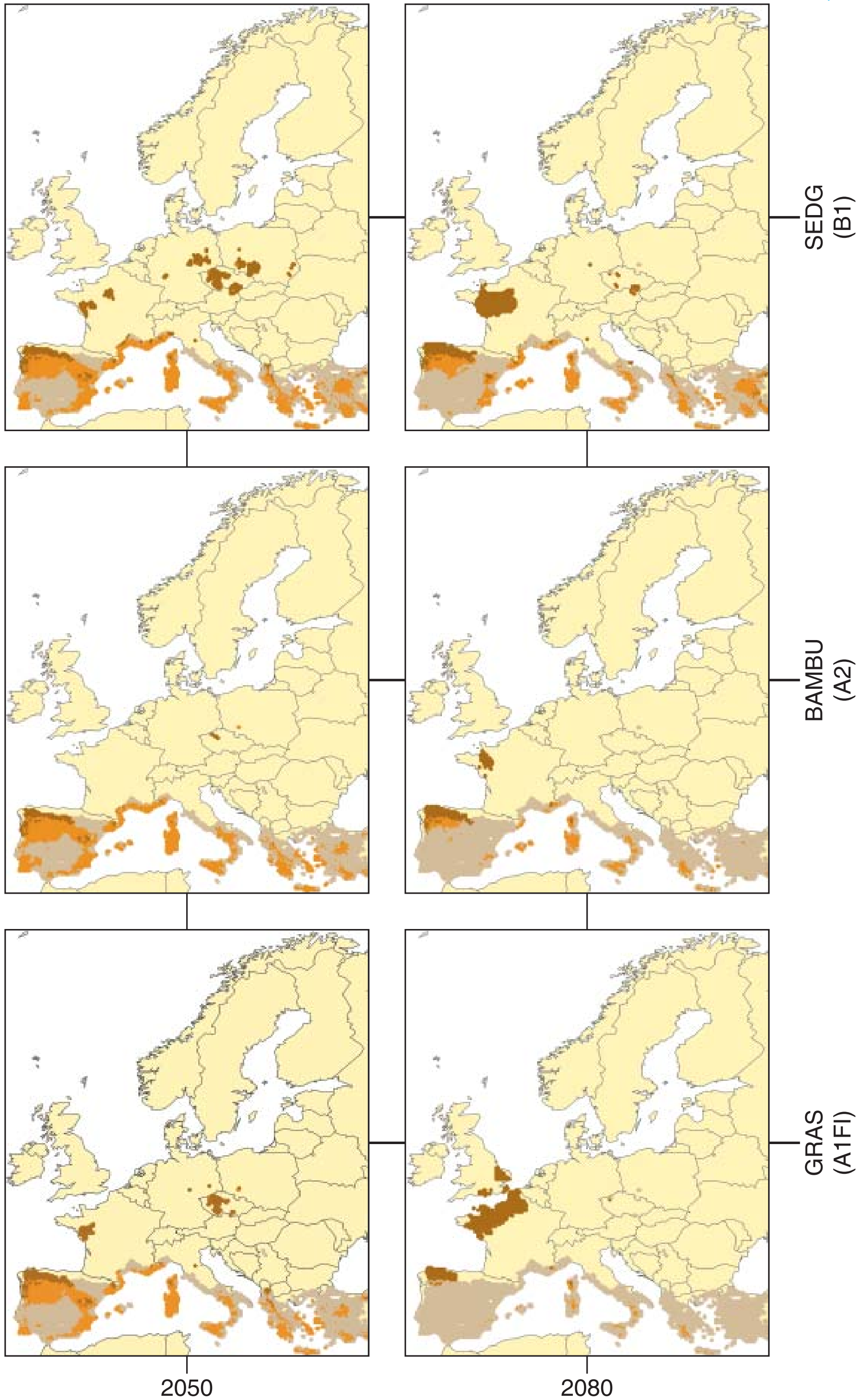
Present distribution can be well explained by climatic variables (AUC = 0.89).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Syrichtus tessellum (Hübner, 1803) – Tessellated Skipper

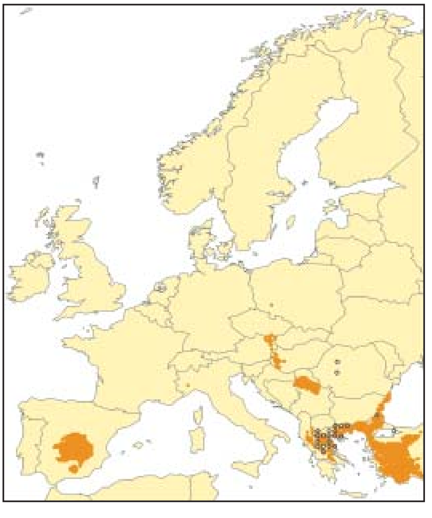
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	305 (28.8%)	-806 (-76.11%)
	BAMBU	-303 (-28.61%)	-938 (-88.57%)
	GRAS	-736 (-69.5%)	-1059 (-100%)
2080	SEDG	-270 (-25.5%)	-907 (-85.65%)
	BAMBU	-755 (-71.29%)	-1058 (-99.91%)
	GRAS	-736 (-69.5%)	-1059 (-100%)

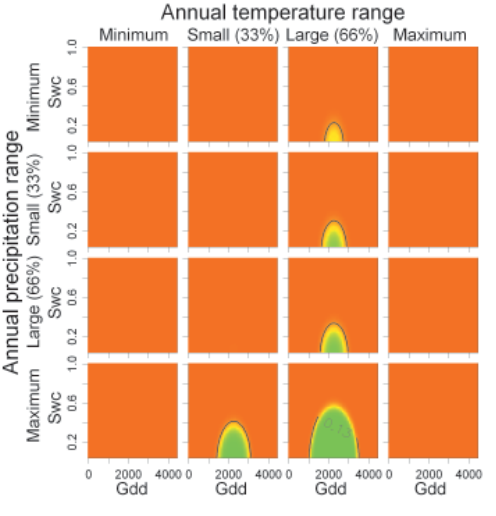
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1059 cells)

The Tessellated Skipper occurs in open grassy and flower rich places where it feeds preferably on thymes, vetches and yarrows. The butterflies have a rapid flight, often quite close to the ground. The caterpillars feed on the labiates *Phlomis tuberosa* and *P. samia,* hiding in spun leaves. The Tessellated Skipper has one or two generations a year, and passes the winter as a small caterpillar.

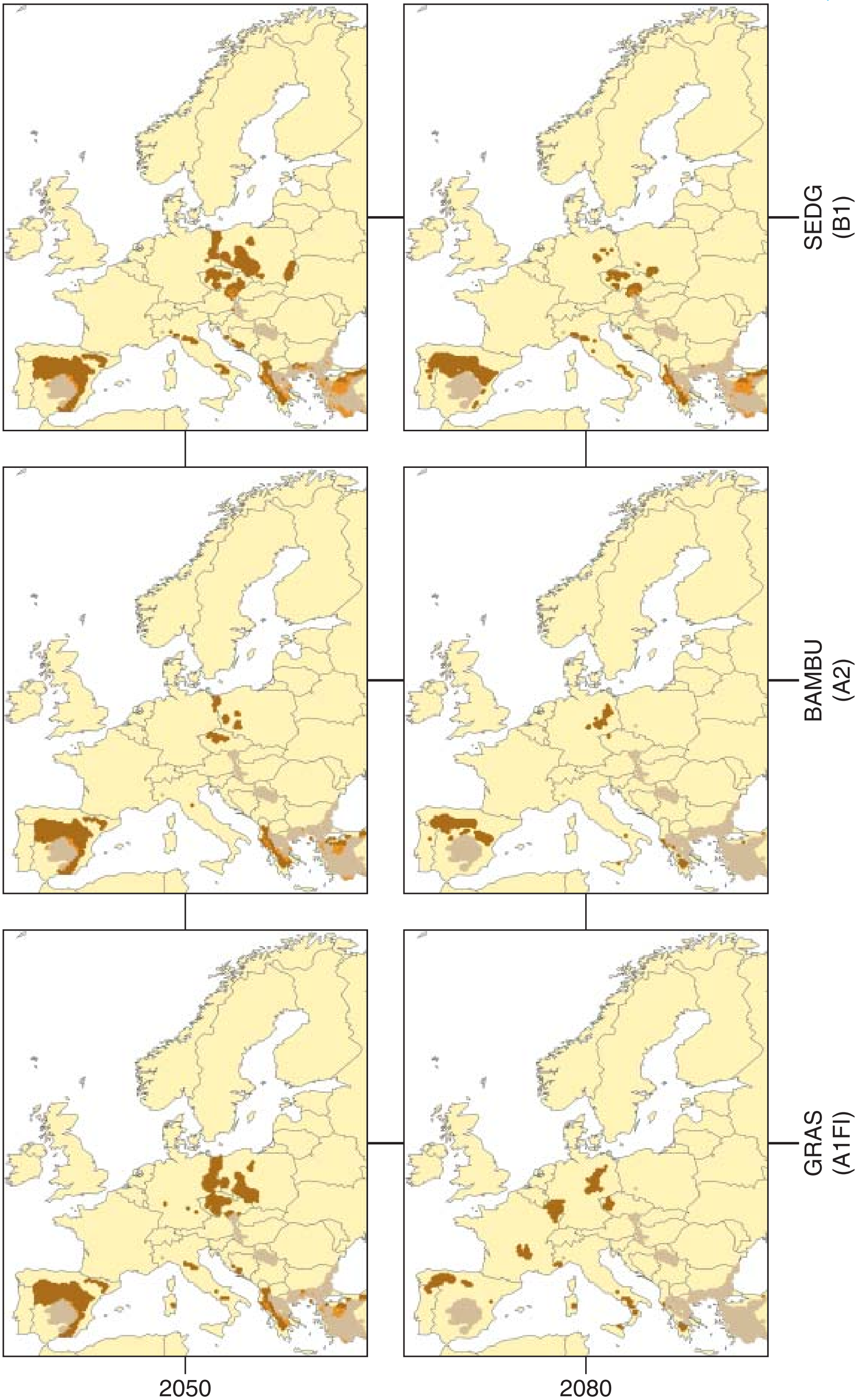
Present distribution can be well explained by climatic variables (AUC = 0.89).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pyrgus carthami (Hübner, 1813) – Safflower Skipper

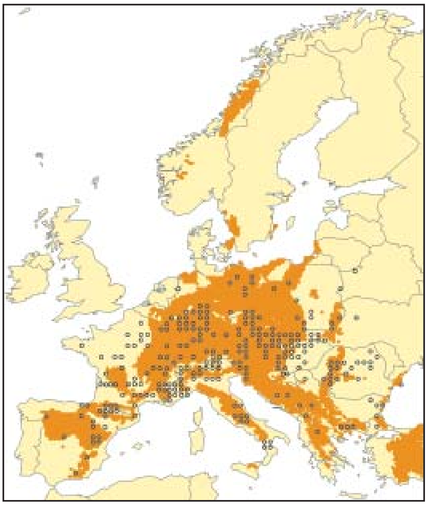
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	222 (3.38%)	1952 (-29.74%)
	BAMBU	-770 (-11.73%)	-2415 (-36.8%)
	GRAS	-761 (-11.6%)	-2712 (-41.32%)
2080	SEDG	-1051 (-16.01%)	-3471 (-52.89%)
	BAMBU	-1787 (-27.23%)	-4285 (-65.29%)
	GRAS	-3285 (-50.05%)	-5563 (-84.76%)

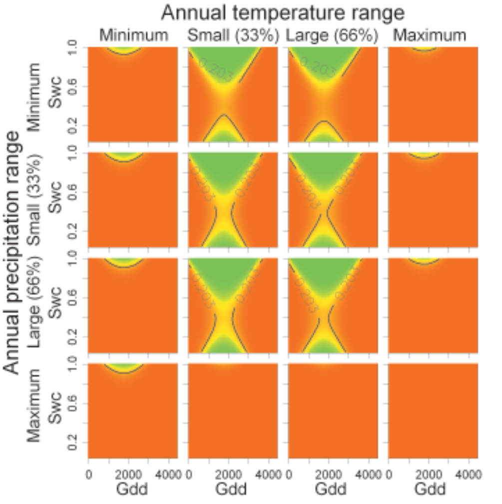
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 6563 cells)

The Safflower Skipper is the largest grizzled skipper in Central Europe. It prefers sheltered places, occurring on dry, often calcareous grasslands, and on rough vegetation in places sheltered from the wind. They often rest near bushes or at the edges of woods. They lay their eggs singly on the upperside of the leaves of cinquefoils (*Potentilla* spp.), the caterpillar later using leaves as food. However, the caterpillars are difficult to find, because they hide away in plant cushions during the day, in order to survive the summer heat. The caterpillars hibernate in spun leaves in the litter layer, probably in the last larval instar. However, in breeding experiments, each stage was found to be capable of hibernating. Before they pupate, the caterpillars make a sturdy cocoon. The Safflower Skipper is single-brooded.

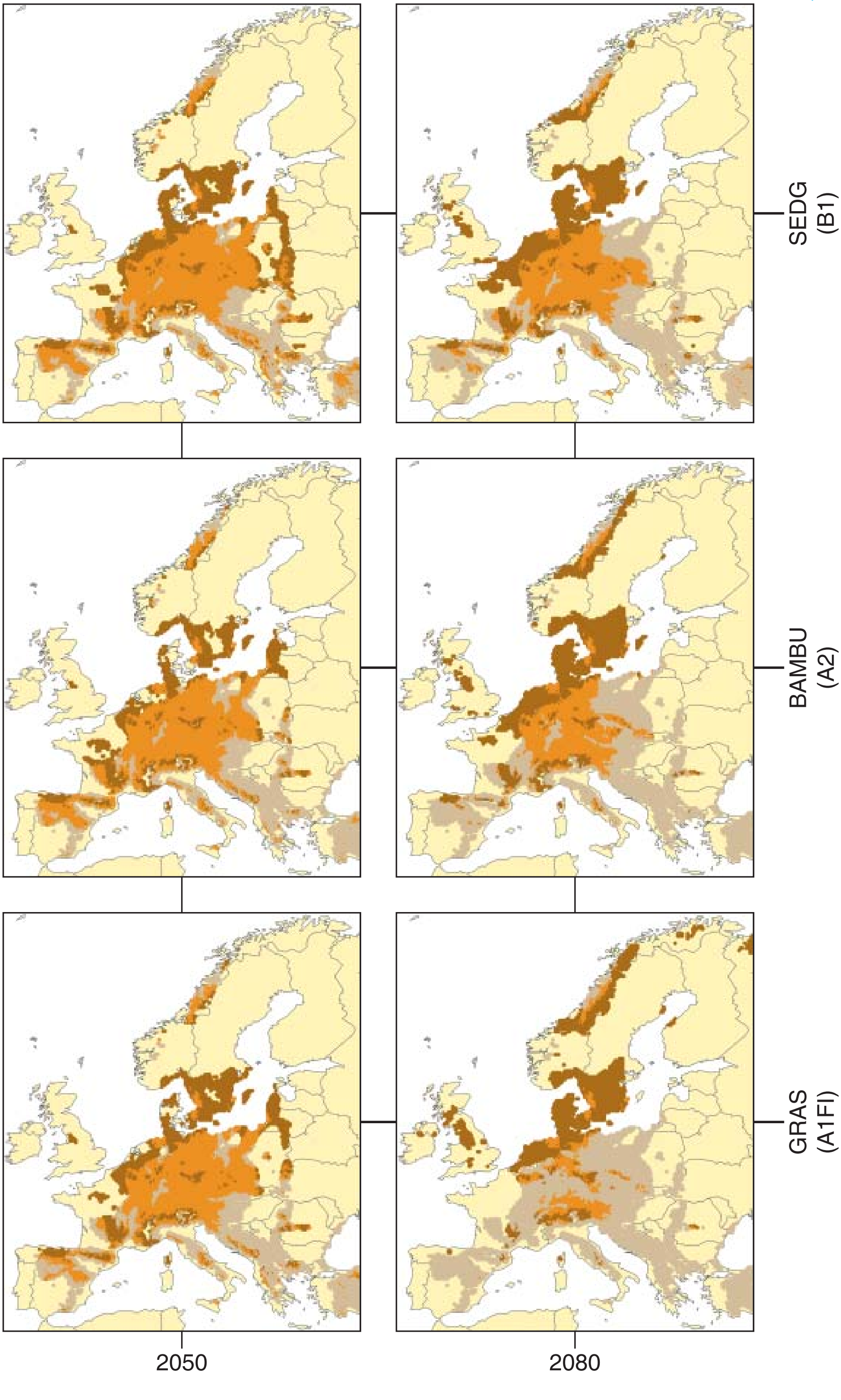
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.76). Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pyrgus sidae (Esper, 1782) – Yellow-banded Skipper

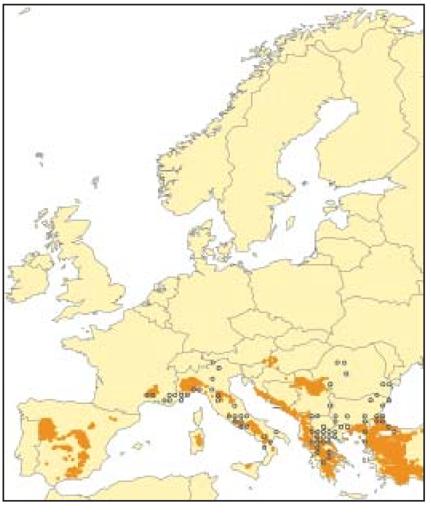
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	33 (2.46%)	-831 (-61.88%)
	BAMBU	-427 (-31.79%)	-917 (-68.28%)
	GRAS	-352 (-26.21%)	-981 (-73.05%)
2080	SEDG	-178 (-13.25%)	-1051 (-78.26%)
	BAMBU	-808 (-60.16%)	-1286 (-95.76%)
	GRAS	-384 (-28.59%)	-1328 (-98.88%)

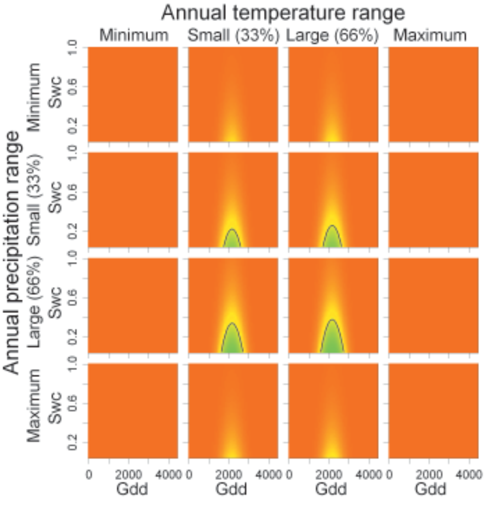
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 1343 cells)

The yellow and white bands on the underside of its hindwing make the Yellow-banded Skipper unmistakable. These skippers can be found on flower-rich grasslands, flower-rich stony slopes in gullies, and in open scrub. The butterflies fly slowly, close to the ground. Sulphur Cinquefoil (*Potentilla recta*), *Potentilla hirta*, and perhaps also *Abutilon theophrasti* are used as larval foodplants. It hibernates as a caterpillar and has one brood a year.

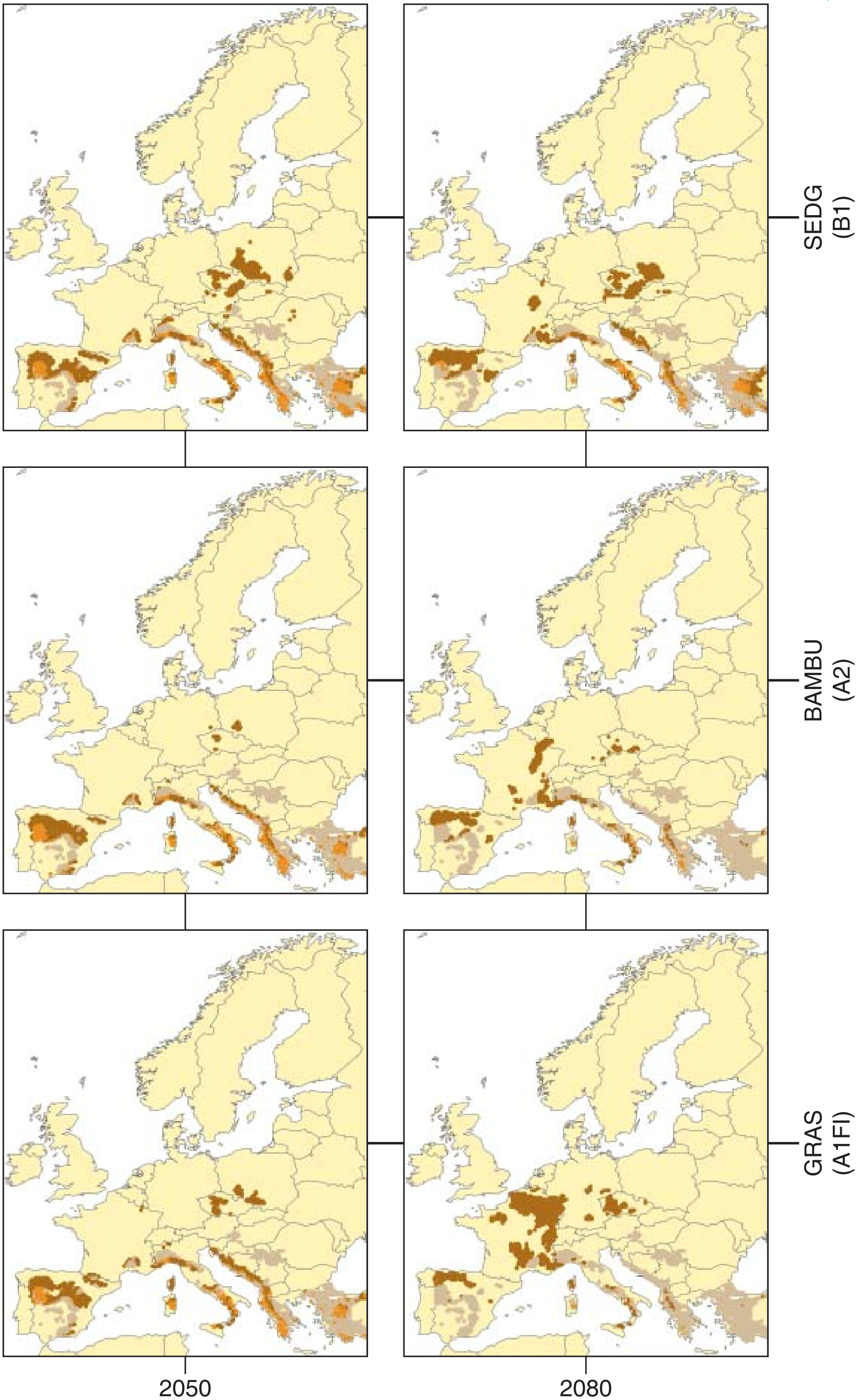
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.85).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pyrgus andromedae (Wallengren, 1853) – Alpine Grizzled Skipper

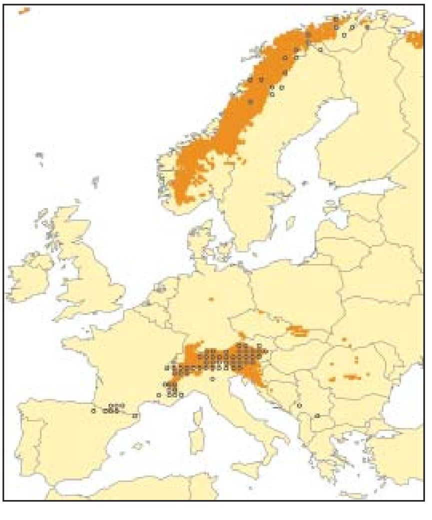
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-432 (-22.37%)	-517 (-26.77%)
	BAMBU	-280 (-14.5%)	-356 (-18.44%)
	GRAS	-511 (-26.46%)	-546 (-28.28%)
2080	SEDG	-425 (-22.01%)	-586 (-30.35%)
	BAMBU	-306 (-15.85%)	-542 (-28.07%)
	GRAS	-584 (-30.24%)	-777 (-40.24%)

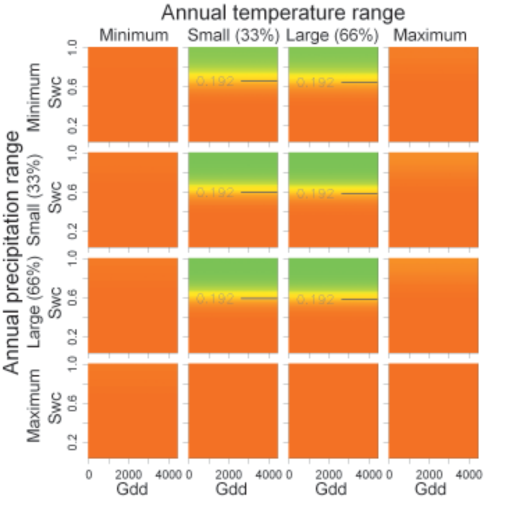
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1931 cells)

The Alpine Grizzled Skipper occurs in damp, moist, grassy places, often near streams or bogs in the Alps and Pyrenees. In Scandinavia, they are seen on dwarf scrub vegetation and also in rocky places on steep slopes. The only reported foodplant is *Dryas octopetala*. The caterpillars live in a communal shelter of spun leaves. They hibernate, pupating in a similar shelter the following spring. The species' development takes two years.

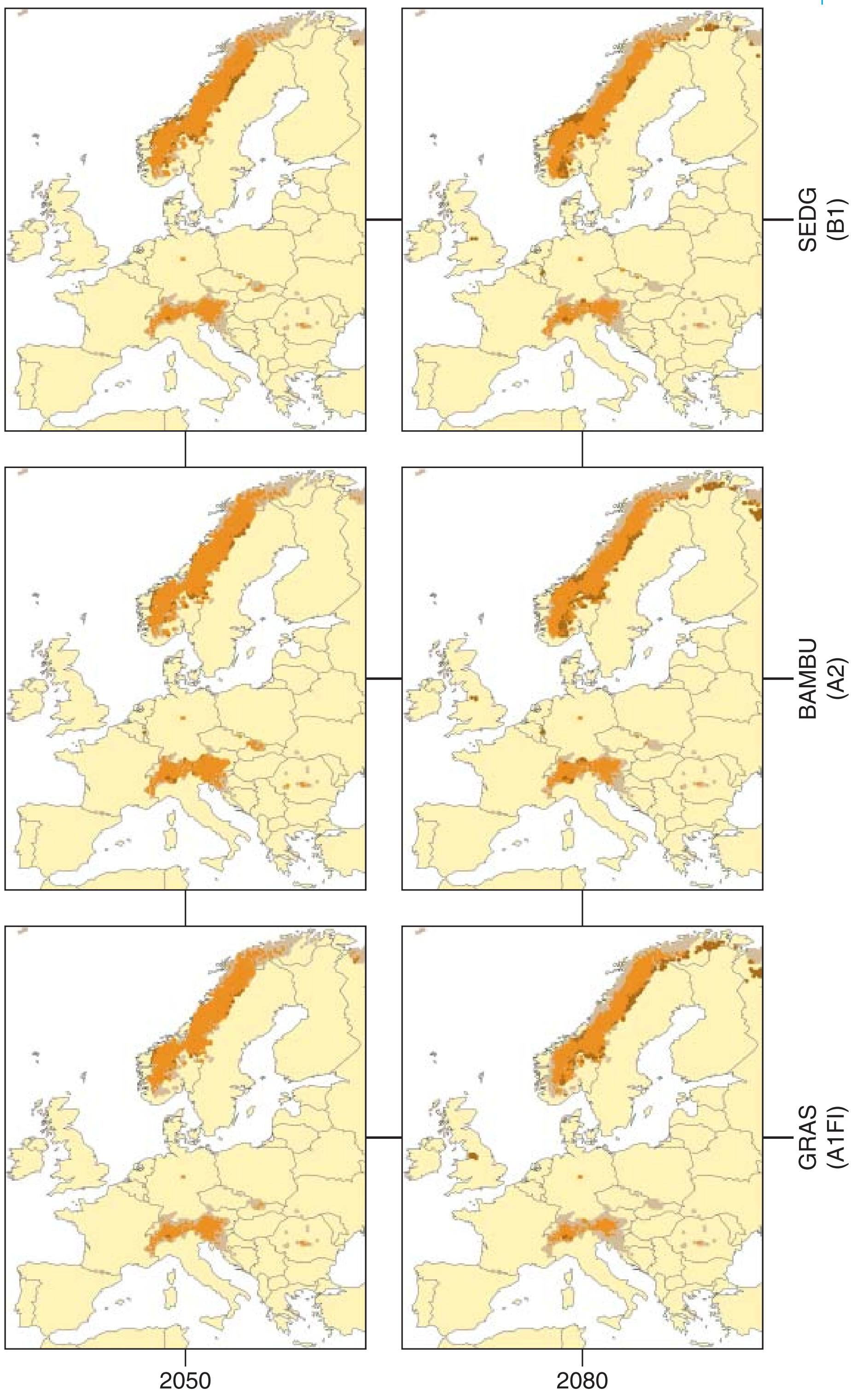
Present distribution can be well explained by climatic variables (AUC = 0.87).
Climate risk category: LR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pyrgus cacaliae (Rambur, 1840) – Dusky Grizzled Skipper

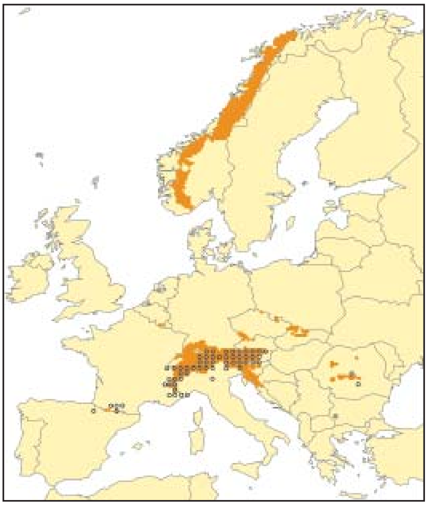
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-272 (-23.59%)	-368 (-31.92%)
	BAMBU	-207 (-17.95%)	-320 (-27.75%)
	GRAS	-312 (-27.06%)	-400 (-34.69%)
2080	SEDG	-514 (-44.58%)	-630 (-54.64%)
	BAMBU	-336 (-29.14%)	-538 (-46.66%)
	GRAS	-523 (-45.36%)	-719 (-62.36%)

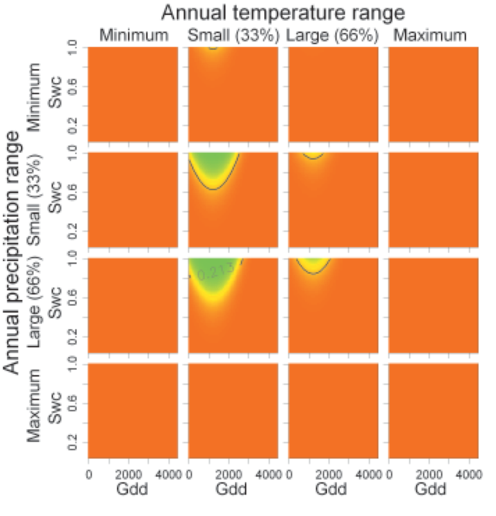
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1153 cells)

Damp grassland, at the edge of bogs or streams, is the habitat of the Dusky Grizzled Skipper, although they sometimes occur on dry grasslands. The male show marked territorial behaviour. The female lays her eggs on various species of cinquefoil (*Potentilla* spp.), such as Tormentil (*P. erecta*), and Alpine Cinquefoil (*P. crantzii*), and also on *Sibbaldia* species. She prefers plants growing on drier places, such as on hummocks in damp habitats, or at a little distance from its habitat. The caterpillars live hidden between spun leaves, and it is in this stage that the Dusky Grizzled Skipper hibernates. The development takes two years.

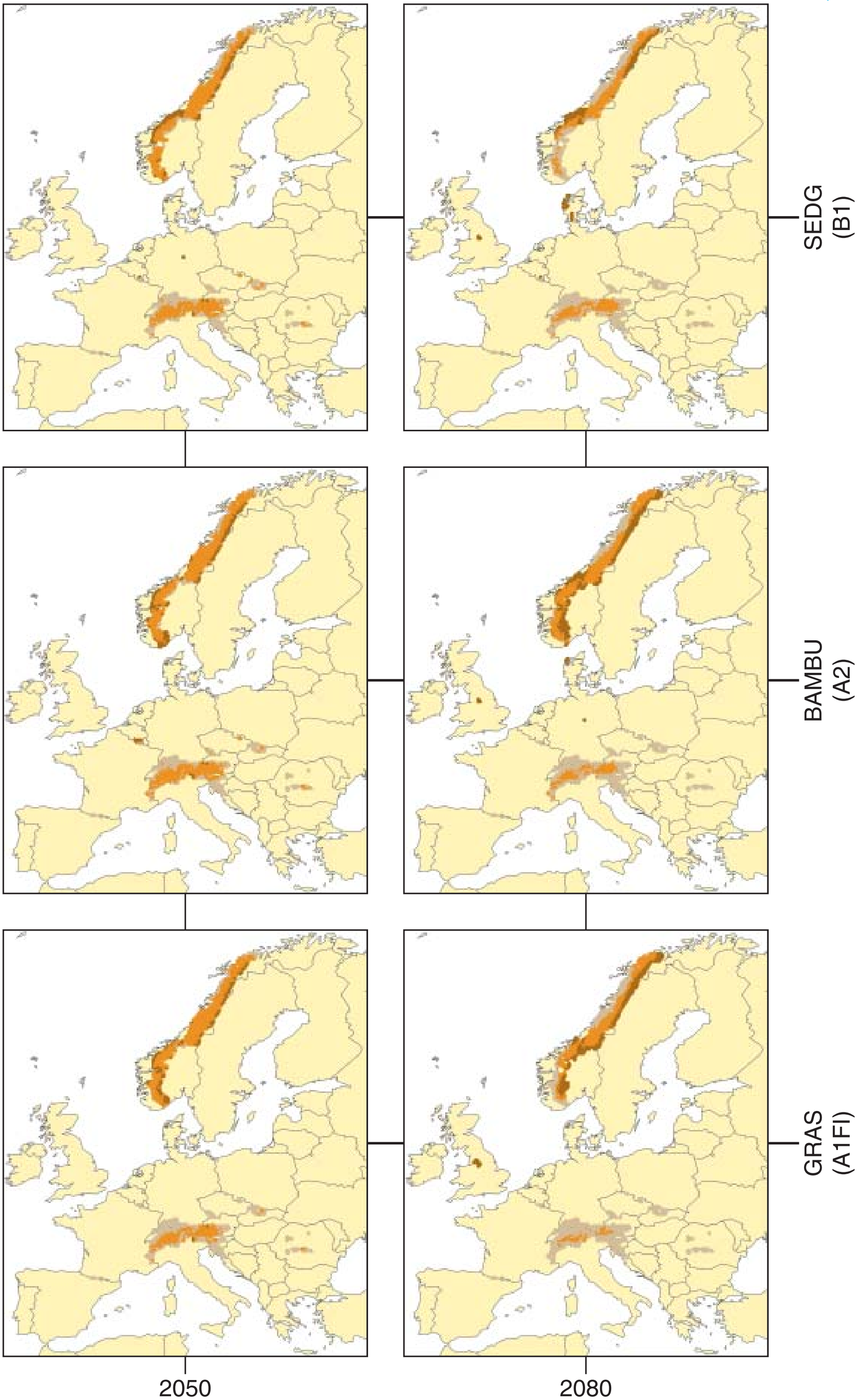
Present distribution can be well explained by climatic variables (AUC = 0.92).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pyrgus centaureae (Rambur, 1840) – Northern Grizzled Skipper

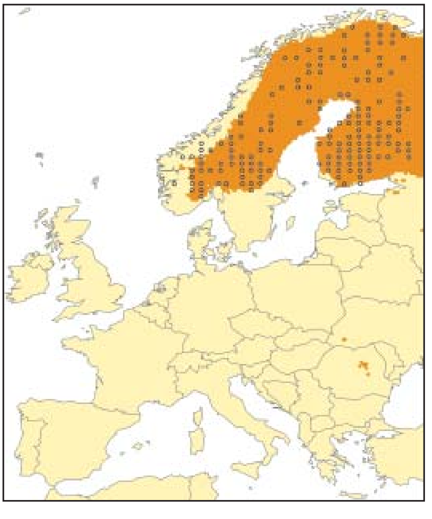
© Bernard Fransen

		Full dispersal	No dispersal
2050	SEDG	-1313 (-22.8%)	-1372 (-23.82%)
	BAMBU	-1446 (-25.1%)	-1465 (-25.43%)
	GRAS	-1565 (-27.17%)	-1588 (-27.57%)
2080	SEDG	-1836 (-31.87%)	-2073 (-35.99%)
	BAMBU	-2932 (-50.9%)	-3022 (-52.47%)
	GRAS	-3722 (-64.62%)	-3811 (-66.16%)

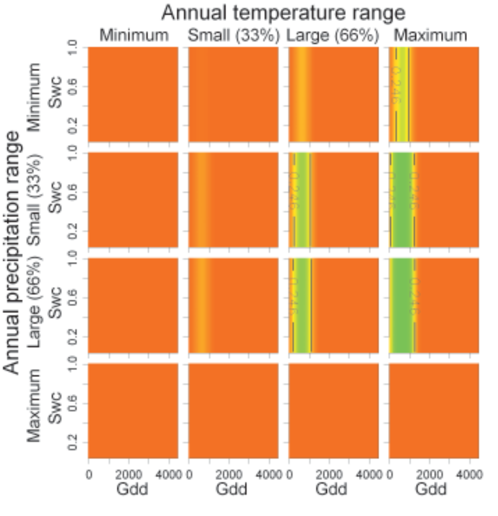
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 5760 cells)

The Northern Grizzled Skipper prefers damp, moist and wet places. It is mostly found in open areas of bogs or swamps, in scrub near swamps, and above the tree-line on stretches of wet ground with dwarf shrubs. With its inconspicuous colours and rapid flight, the butterflies of this grizzled skipper are difficult to follow. The female lays her eggs on Cloudberry (*Rubus chamaemorus*). Little is known about the way the caterpillars live. This species is single-brooded.

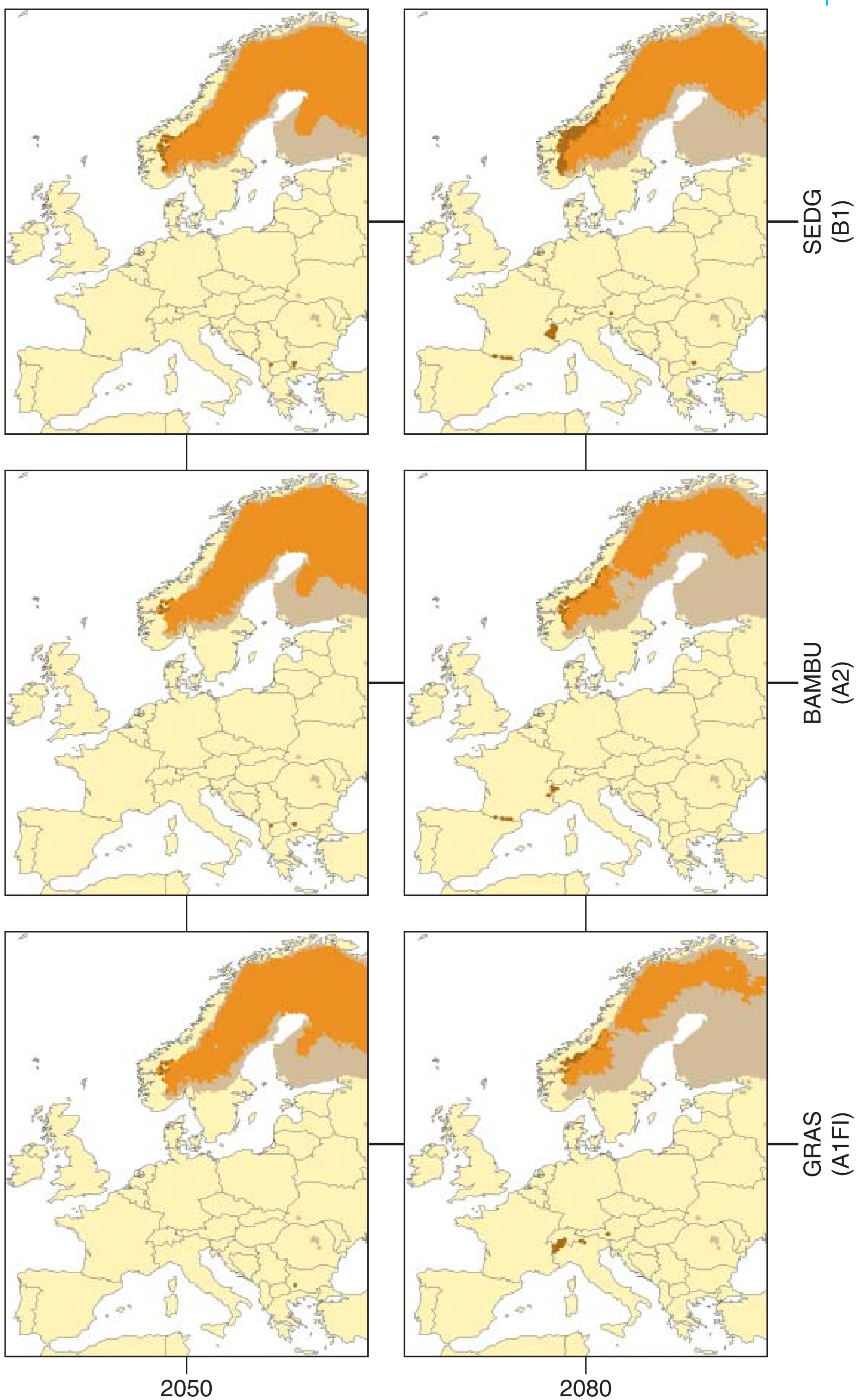
Present distribution can be very well explained by climatic variables (AUC = 0.96).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pyrgus malvae (Linnaeus, 1758) / *malvoides* (Elwes & Edwards, 1897) (complex) – Grizzled Skipper

© Rudi Verovnik

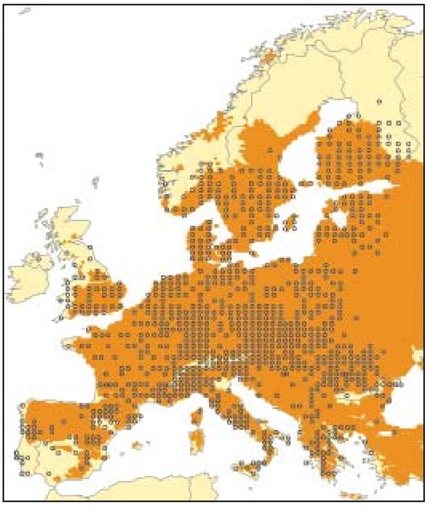
		Full dispersal	No dispersal
2050	SEDG	-2638 (-12.91%)	-4159 (-20.35%)
	BAMBU	-2324 (-11.37%)	-3586 (-17.54%)
	GRAS	-1529 (-7.48%)	-3197 (-15.64%)
2080	SEDG	-5554 (-27.17%)	-10058 (-49.21%)
	BAMBU	-4212 (-20.61%)	-7735 (-37.84%)
	GRAS	-2288 (-11.19%)	-5349 (-26.17%)

Changes in climatic niche distribution (in 10'×10' grid cells; present niche space: 20440 cells)

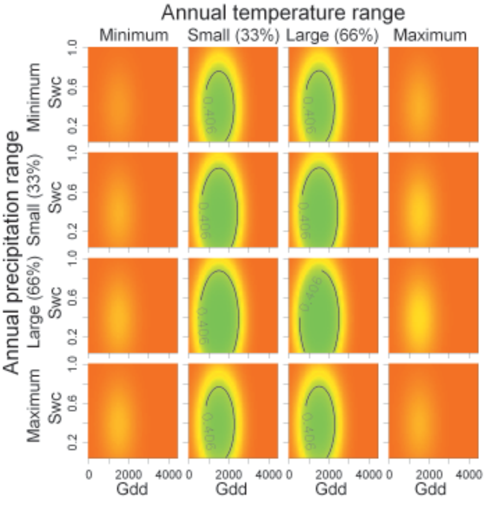
Due to data availability we here treat both *Pyrgus malvae* (Linnaeus, 1758) and *P. malvoides* (Elwes & Edwards, 1897) as the Grizzled Skipper species complex, knowing that *Pyrgus malvoides* is mostly recognised as a distinct species.

The Grizzled Skipper occurs in many different habitats, mostly on dry, as well as moist, flower-rich grasslands, and also on calcareous grasslands and heaths. The eggs are laid on the underside of the leaves of cinquefoils (*Potentilla* spp.) and strawberries (*Fragaria* spp). The caterpillar builds a small shelter from a leaf, in which it stays hidden, feeding on the leaves of the foodplant. The sturdy cocoon in which it pupates is spun from plant remains. This species has one to two broods.

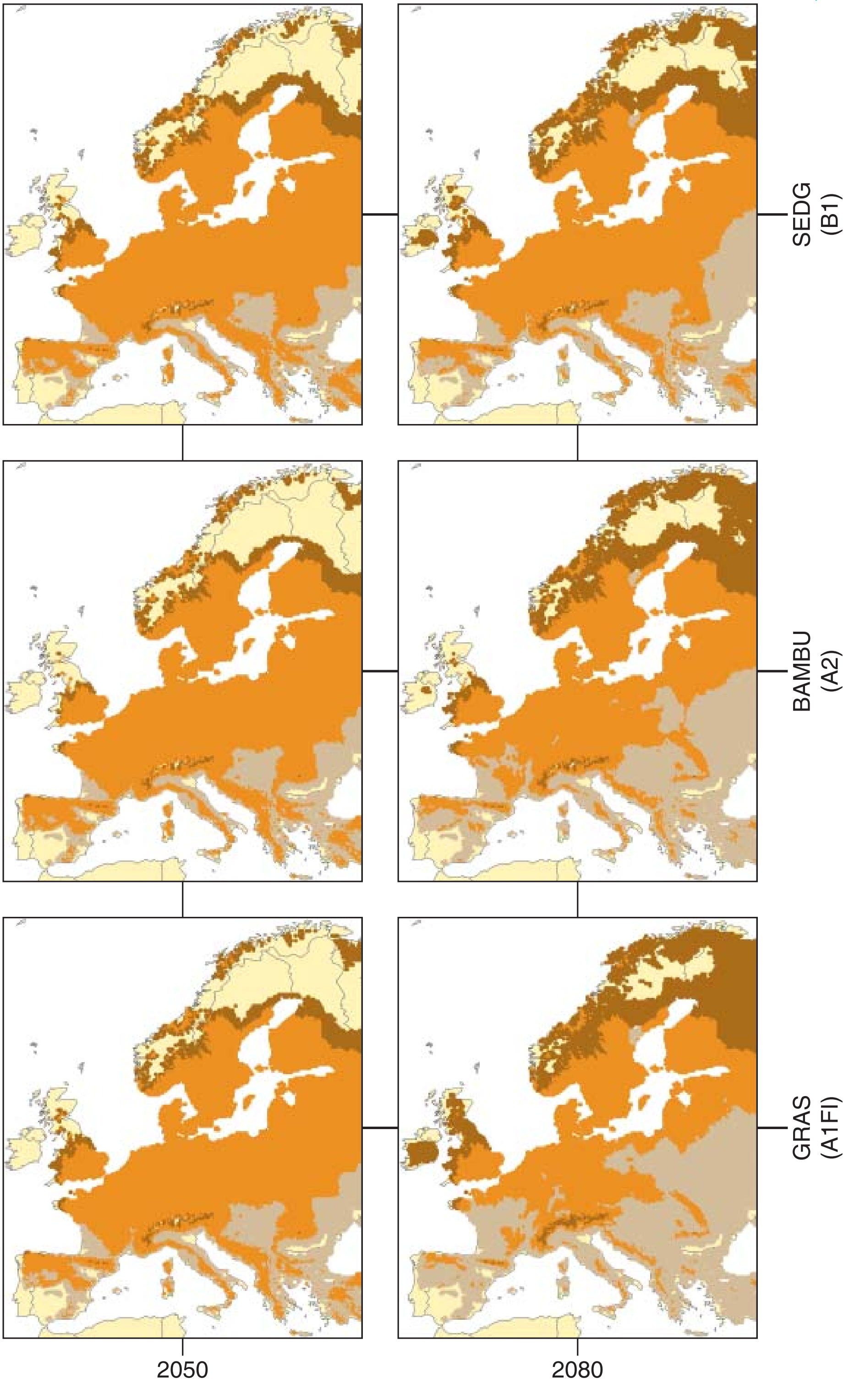
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.71).
Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pyrgus serratulae (Rambur, 1840) – Olive Skipper

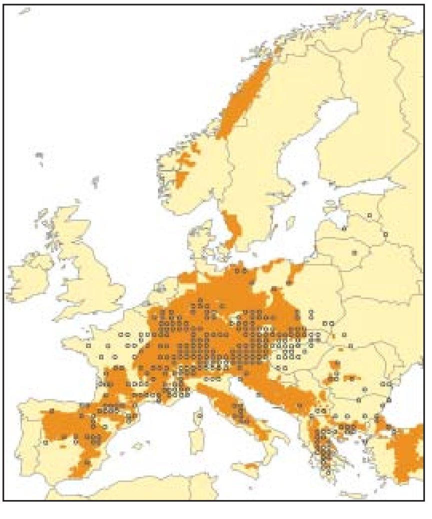
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	52 (0.84%)	-1871 (-30.1%)
	BAMBU	-450 (-7.24%)	-2061 (-33.16%)
	GRAS	-638 (-10.27%)	-2411 (-38.79%)
2080	SEDG	-759 (-12.21%)	-2952 (-47.5%)
	BAMBU	-1483 (-23.86%)	-3798 (-61.11%)
	GRAS	-3008 (-48.4%)	-4947 (-79.6%)

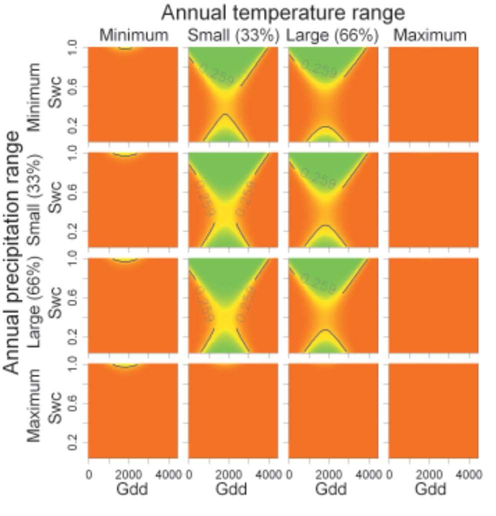
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 6215 cells)

The Olive Skipper occurs in areas that do not become too hot in the summer, on poor to rough, flower-rich grasslands, which are either open or surrounded by woodland. The butterfly of the Olive Skipper is quite mobile, and may be seen in unexpected places. The eggs are deposited on the underside of the leaves of cinquefoils (*Potentilla* spp.), and master-worts (*Astrantia* spp.). The caterpillar lives in a small shelter, spun from a rolled-up leaf, feeding on the leaves of the foodplant. It passes the winter in a cocoon, and pupates the following spring at the base of the foodplant. This skipper is single-brooded.

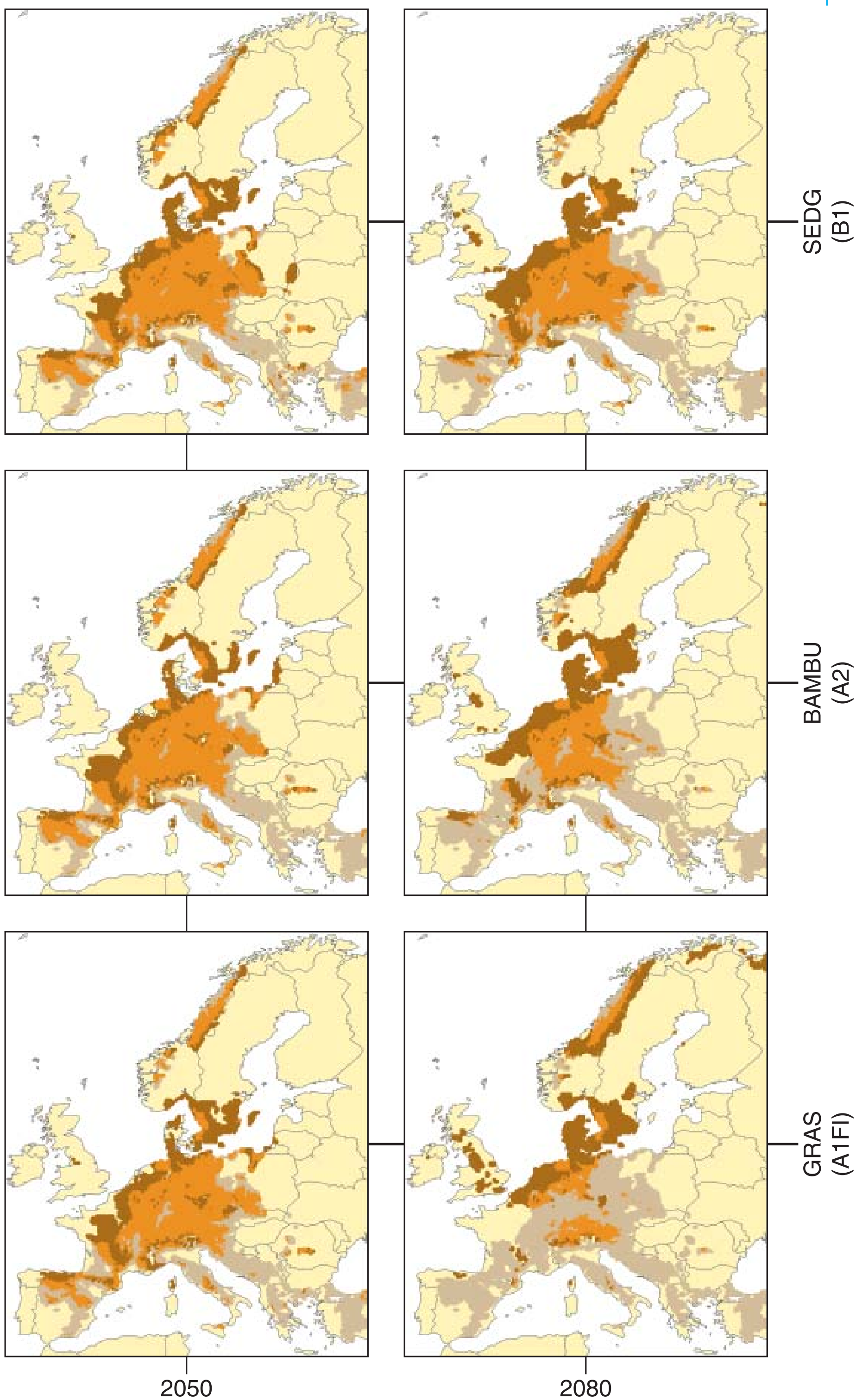
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.82). Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pyrgus onopordi (Rambur, 1840) – Rosy Grizzled Skipper

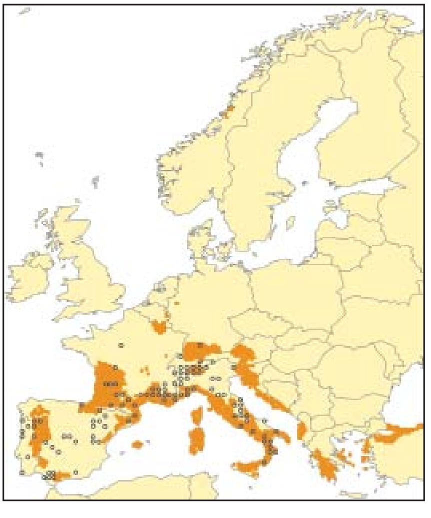
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	279 (-12.86%)	-1032 (-47.58%)
	BAMBU	-306 (-14.11%)	-1069 (-49.29%)
	GRAS	-449 (-20.7%)	-1312 (-60.49%)
2080	SEDG	88 (4.06%)	-1395 (-64.32%)
	BAMBU	-98 (-4.52%)	-1602 (-73.86%)
	GRAS	-373 (-17.2%)	-2079 (-95.85%)

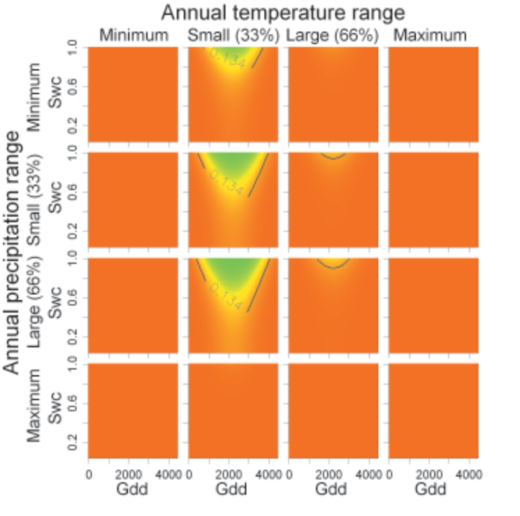
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2169 cells)

The Rosy Grizzled Skipper has a characteristic anvil-shaped spot on the underside of its hindwing. These butterflies can be seen on different types of grassy vegetation and on rocky slopes. Different foodplants are used in different parts of its range. In Switzerland the eggs are laid on rockroses (*Helianthemum* spp.) and cinquefoils (*Potentilla* spp.), in Spain, mallows (*Malva* spp.) are used. In most places, the Rosy Grizzled Skipper has two broods a year and in some places three. It hibernates as a caterpillar.

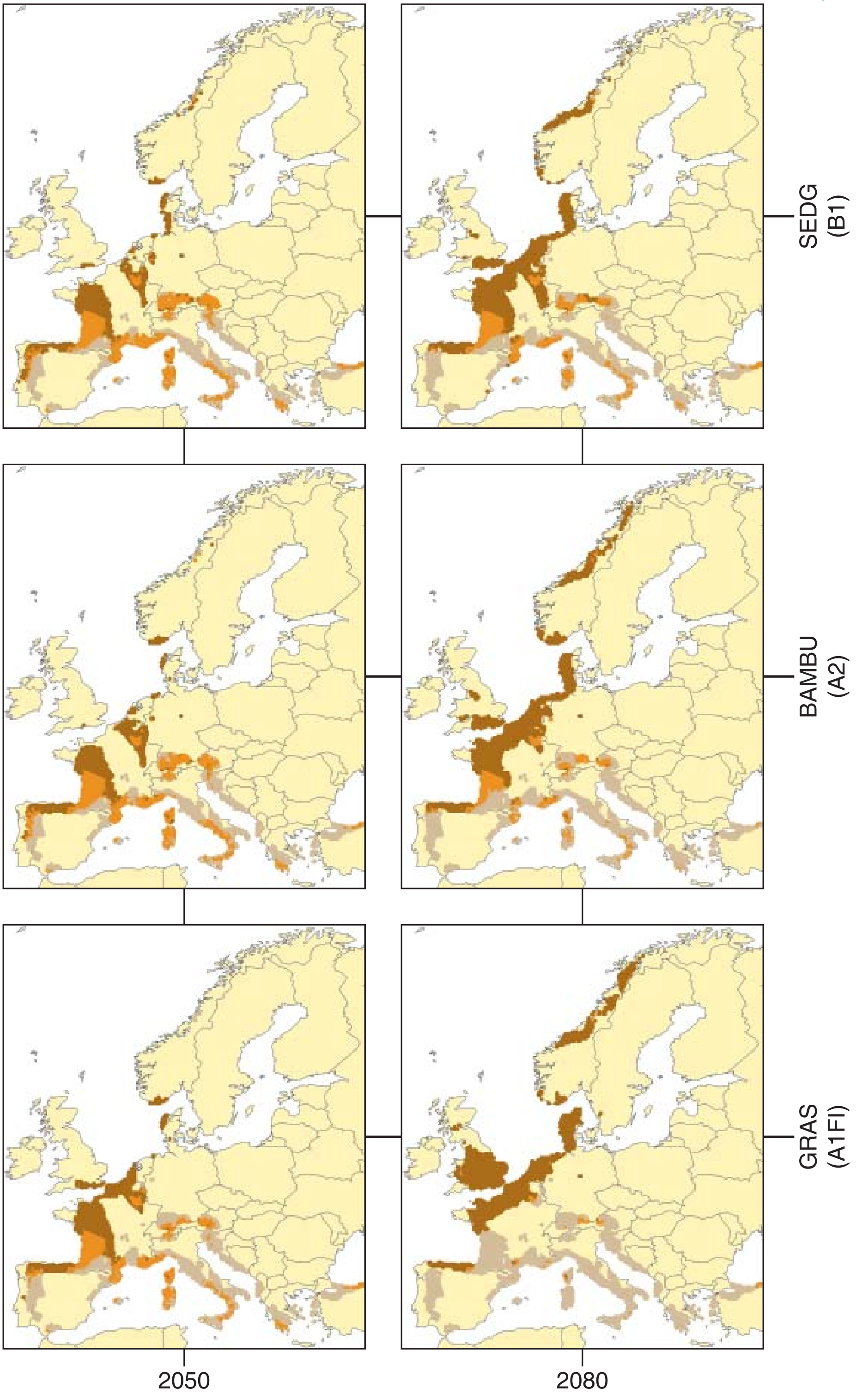
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.78).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pyrgus carlinae (Rambur, 1840) – Carline Skipper

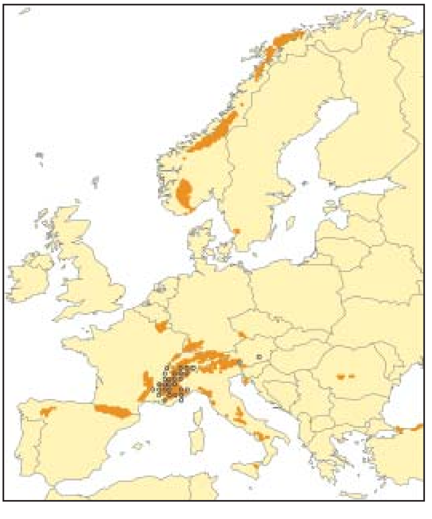
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-100 (-12.22%)	-481 (-58.8%)
	BAMBU	22 (2.69%)	-419 (-51.22%)
	GRAS	-133 (-16.26%)	-506 (-61.86%)
2080	SEDG	-231 (-28.24%)	-714 (-87.29%)
	BAMBU	-197 (-24.08%)	-614 (-75.06%)
	GRAS	-362 (-44.25%)	-703 (-85.94%)

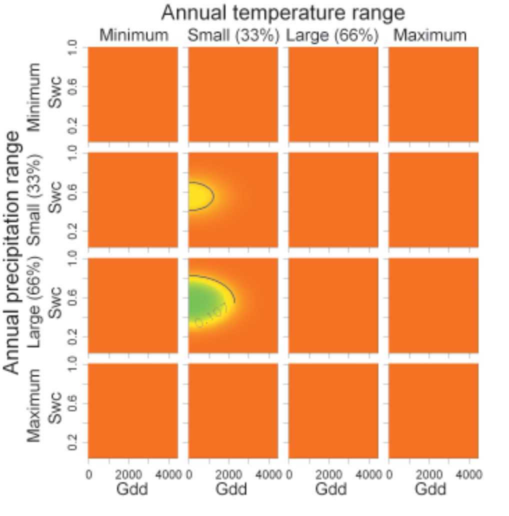
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 818 cells)

The Carline Skipper prefers dry, south-facing slopes with quite short vegetation. However, they can also be seen on damp grasslands, and in very open larch woods. Large numbers can sometimes occur locally. The female lays her eggs singly on the underside of the leaves of various cinquefoils (*Potentilla* spp.). The caterpillar remains in the egg during the winter, emerging in the spring. It then spins a shelter by attaching a leaf of the foodplant to the ground, in which it lives, hidden. It pupates close to the ground, and has one generation a year.

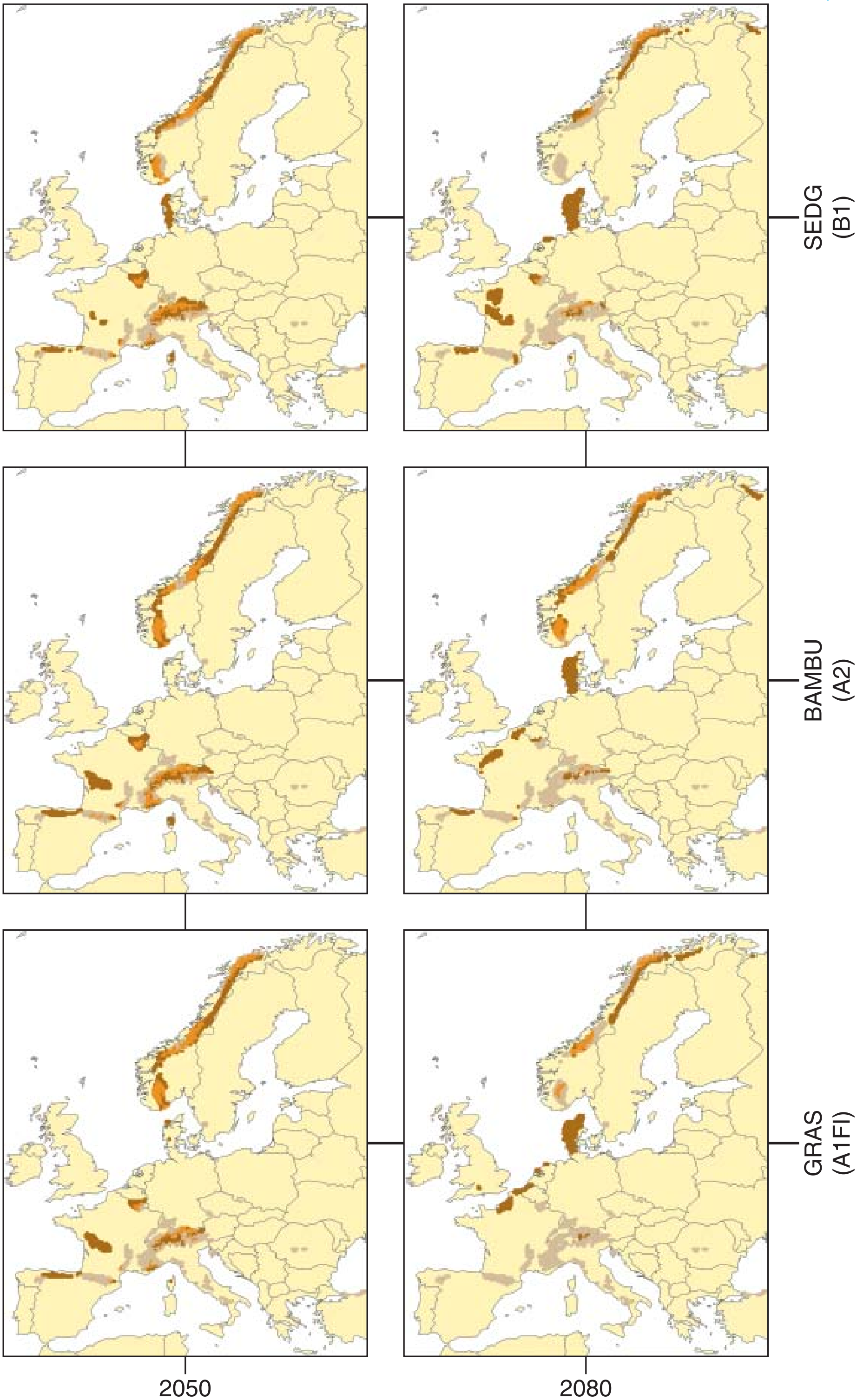
Present distribution can be well explained by climatic variables (AUC = 0.9).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pyrgus cirsii (RAMBUR, 1840)

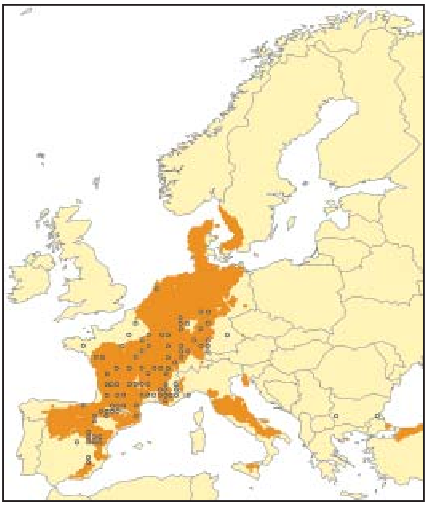
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-472 (-10.85%)	-1306 (-30.01%)
	BAMBU	-524 (-12.04%)	-1326 (-30.47%)
	GRAS	-1107 (-25.44%)	-1933 (-44.42%)
2080	SEDG	-947 (-21.76%)	-1936 (-44.49%)
	BAMBU	-1773 (-40.74%)	-2764 (-63.51%)
	GRAS	-3080 (-70.77%)	-3713 (-85.32%)

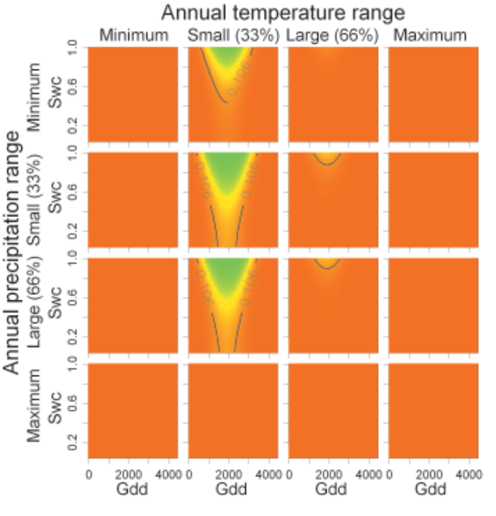
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 4352 cells)

This grizzled skipper occurs on warm, flower-rich grasslands, preferring those in sheltered situations, for example, on slopes, or near shrubs or woodland. In the northern part of its range, it is only found in very warm places. The female lays her eggs singly on the underside of the leaves of various cinquefoils (*Potentilla* spp.), choosing the smaller plants. This butterfly hibernates as a very tiny caterpillar in the egg, in which it remains until the spring. It then emerges and spins itself a small shelter from leaves. In the last larval instar, this is replaced by a parchment-like shelter. It pupates in a cocoon. It is single-brooded.

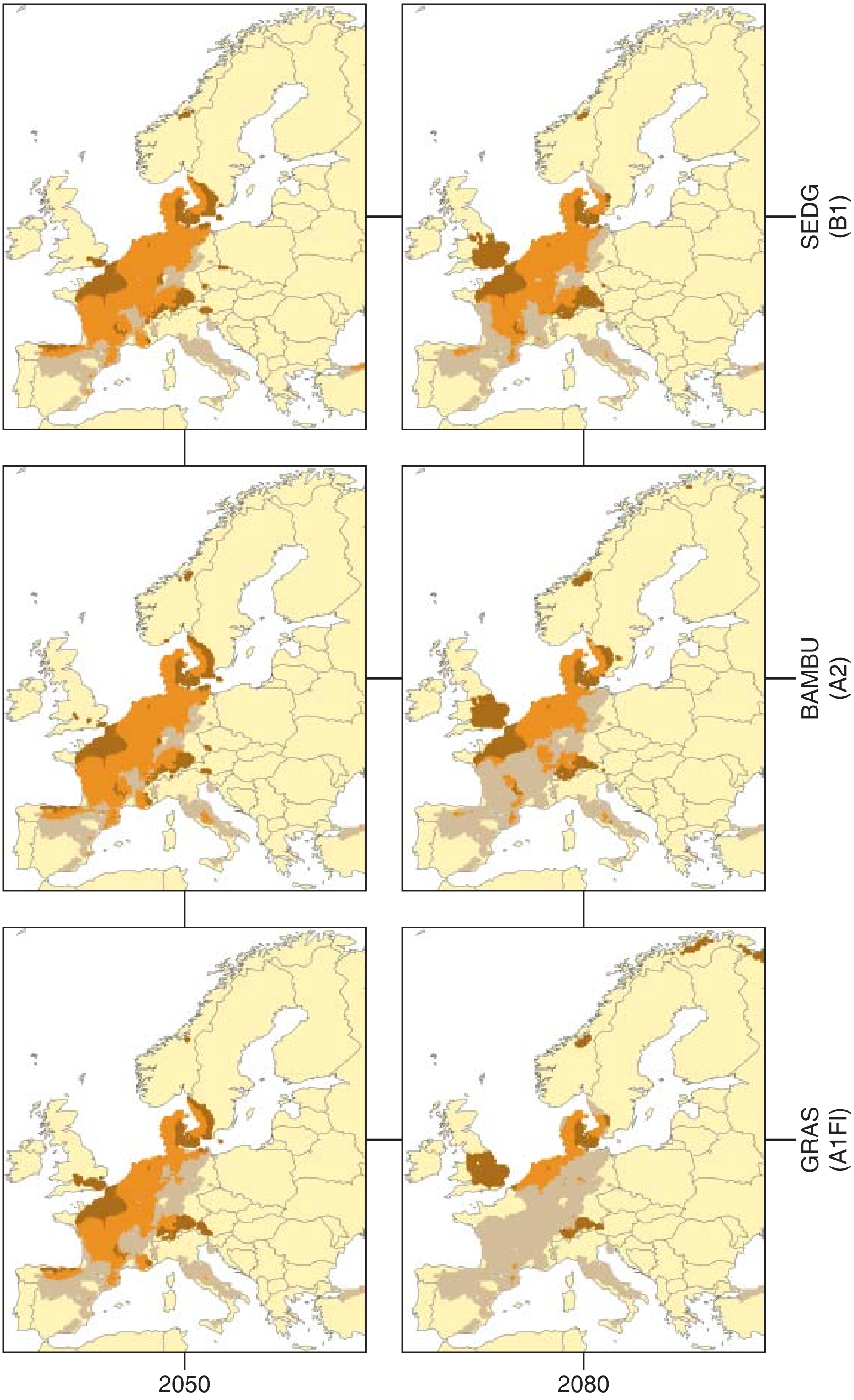
Present distribution can be well explained by climatic variables (AUC = 0.9).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pyrgus armoricanus (Oberthür, 1910) – Oberthür's Grizzled Skipper

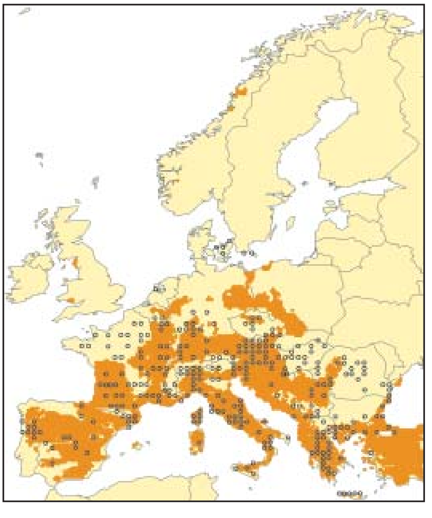
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	1076 (16.16%)	-2050 (-30.79%)
	BAMBU	362 (5.44%)	-2404 (-36.11%)
	GRAS	386 (5.8%)	-2691 (-40.42%)
2080	SEDG	987 (14.82%)	-3082 (-46.29%)
	BAMBU	67 (1.01%)	-4177 (-62.74%)
	GRAS	-402 (-6.04%)	-5276 (-79.24%)

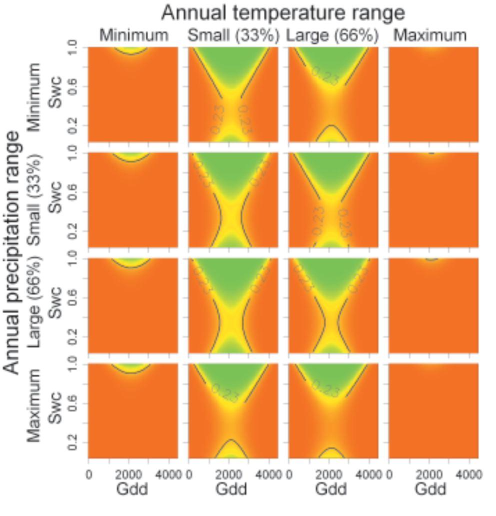
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 6658 cells)

Oberthür's Grizzled Skipper is generally limited to unimproved grasslands. In the north of its range, the populations are small, but large numbers of butterflies make up the southern populations. The butterflies can often be seen visiting flowers and seem to be especially fond of *Globularia*. The female lays her eggs singly on the underside of the leaves of cinquefoils (*Potentilla* spp.) and rockroses (*Helianthemum* spp.). The caterpillars of the first instar only eat the surface layer, leaving translucent "windows" in the leaf. The larger caterpillars eat the whole leaf, and live in a tent-like shelter, spun from one or more leaves. It is the caterpillar that hibernates. It pupates in a cocoon on the ground and there are two to three generations a year.

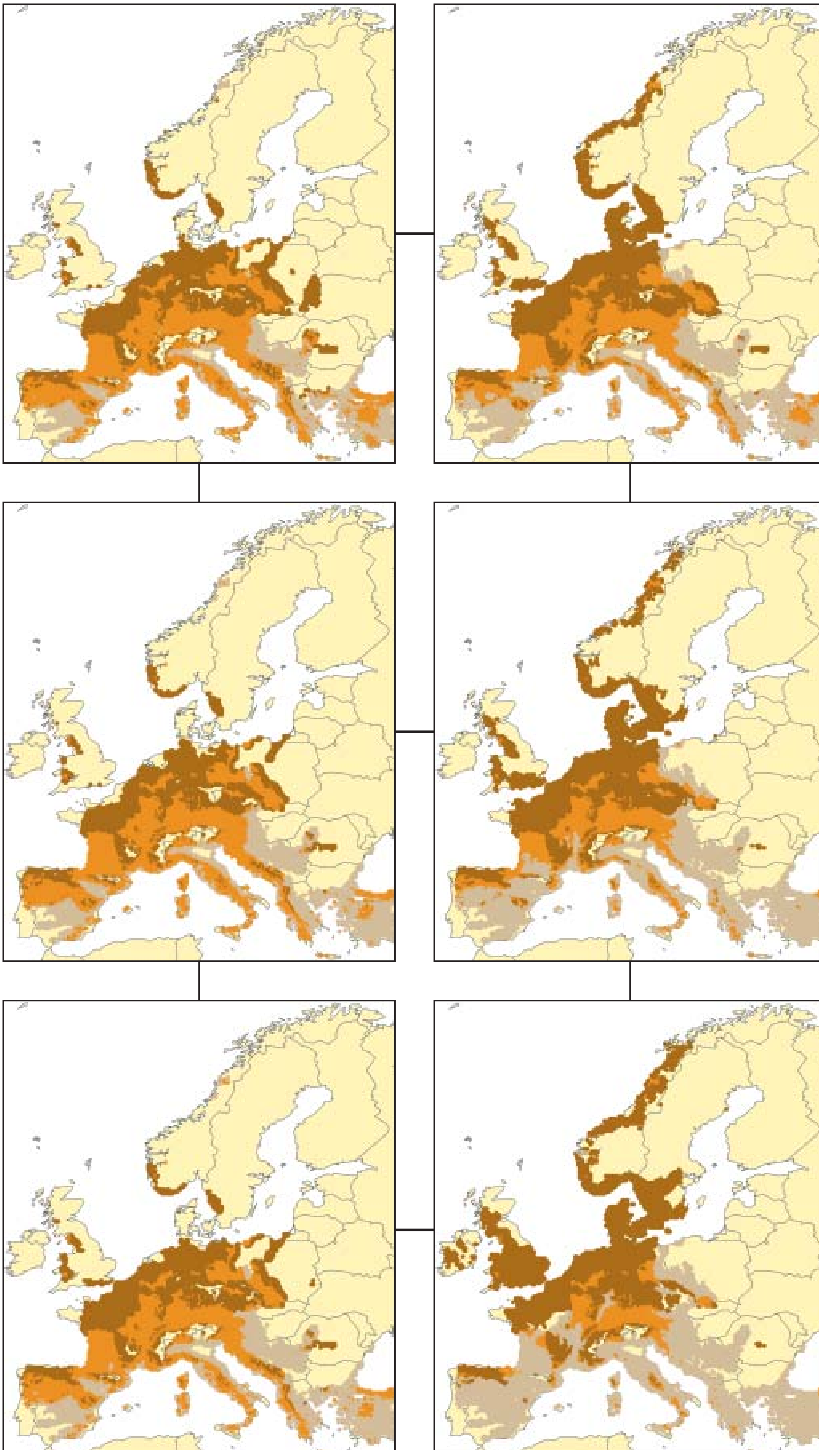
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.78).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold



SEDG (B1)

BAMBU (A2)

GRAS (A1FI)

2050

2080

Pyrgus alveus (Hübner, 1803) (complex) – Large Grizzled Skipper

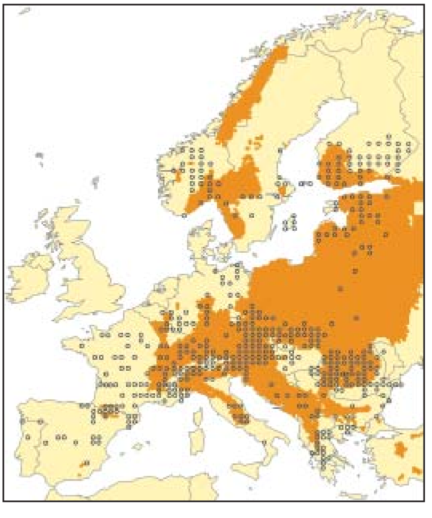
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-102 (-0.93%)	-2549 (-23.36%)
	BAMBU	580 (5.32%)	-2013 (-18.45%)
	GRAS	-1796 (-16.46%)	-3665 (-33.59%)
2080	SEDG	2539 (23.27%)	-3680 (-33.72%)
	BAMBU	1087 (9.96%)	-4815 (-44.13%)
	GRAS	246 (2.25%)	-6117 (-56.06%)

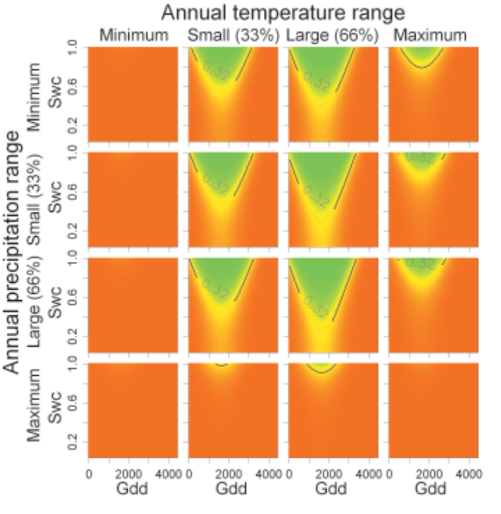
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 10912 cells)

Due to data availability and resolution we include *P. trebevicensis*, *P. accretus* and *P. alveus* in this complex, while we are aware that these taxa are often treated separately. The Large Grizzled Skipper is usually found in mountainous areas on dry, poor, flower-rich grassland, and rough vegetation. Quick-flying and alert, it also likes basking on the ground and drinking from wet mud. It is a very variable butterfly with many different subspecies and forms, making identification difficult. Choosing the smaller leaves, the female lays her eggs singly on various rock-roses (*Helianthemum* spp.). At first, the caterpillar lives between spun leaves on plants, later on it spins a tent-like shelter on the ground. It passes the winter in this stage and builds a special tube-like structure in which to pupate. There are one or two generations a year.

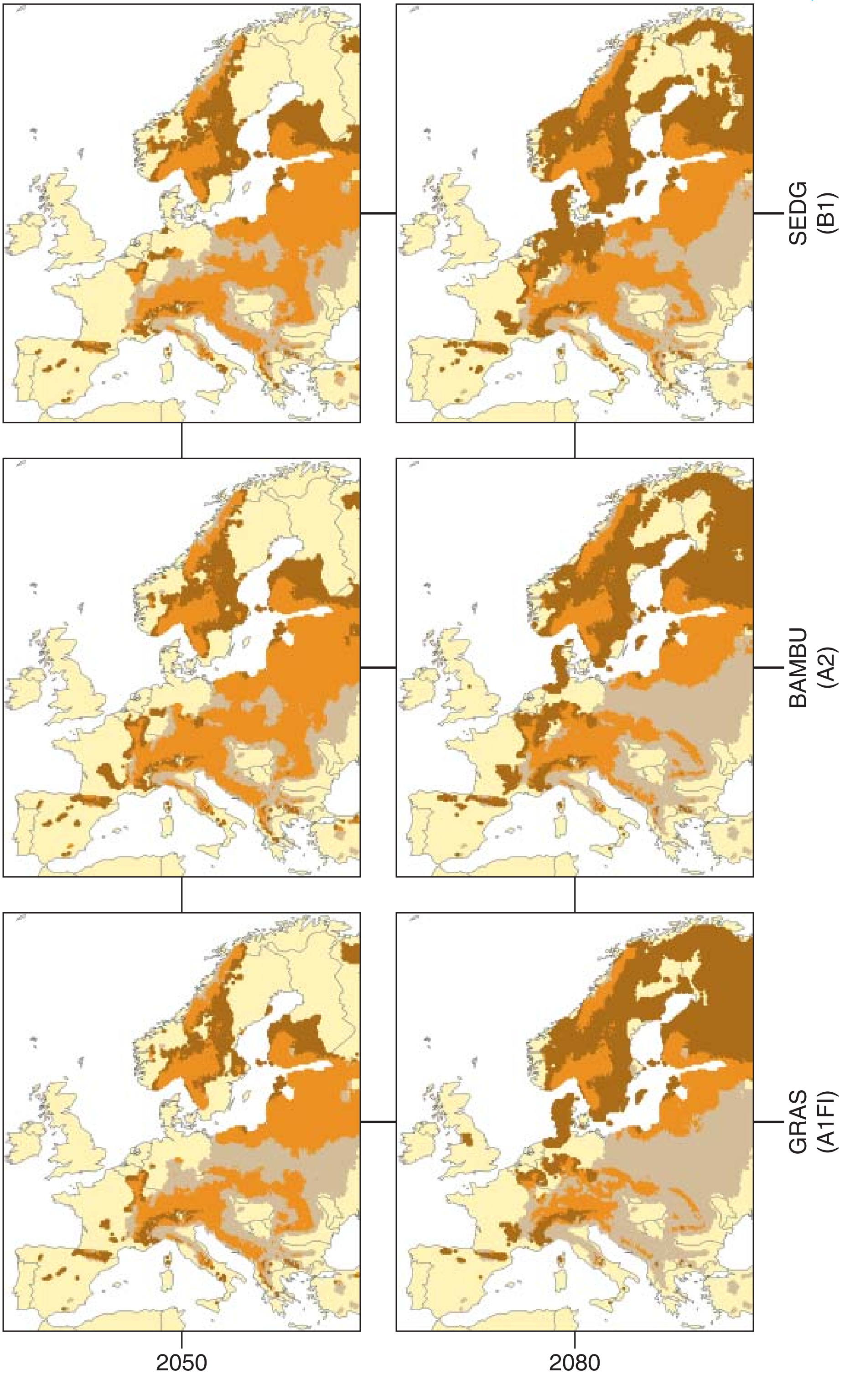
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.73). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pyrgus bellieri (Oberthür, 1910) – Foulquier's Grizzled Skipper

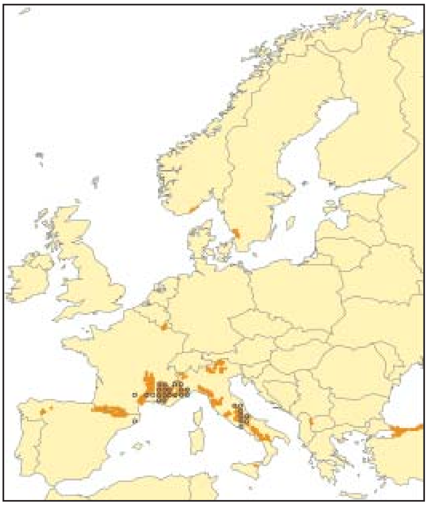
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-180 (-44.33%)	-356 (-87.68%)
	BAMBU	-172 (-42.36%)	-338 (-83.25%)
	GRAS	-109 (-26.85%)	-369 (-90.89%)
2080	SEDG	242 (59.61%)	-395 (-97.29%)
	BAMBU	-60 (-14.78%)	-404 (-99.51%)
	GRAS	-113 (-27.83%)	-406 (-100%)

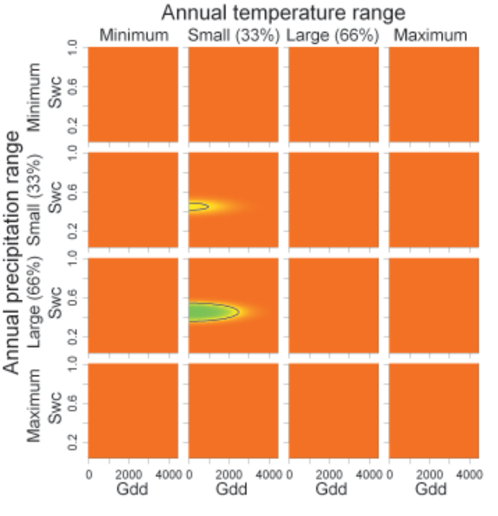
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 406 cells)

This grizzled skipper likes flower-rich, grassy vegetation. It occurs on sub-alpine and alpine grasslands as well as on damp, sometimes rough, grassy vegetation. Various cinquefoils (*Potentilla* spp.) are used as foodplant, including Tormentil (*P. erecta*), Silverweed (*P. anserina*), Spring Cinquefoil (*P. tabernaemontani*), and Creeping Cinquefoil (*P. reptans*). This butterfly hibernates in the larval stage and has one generation a year.

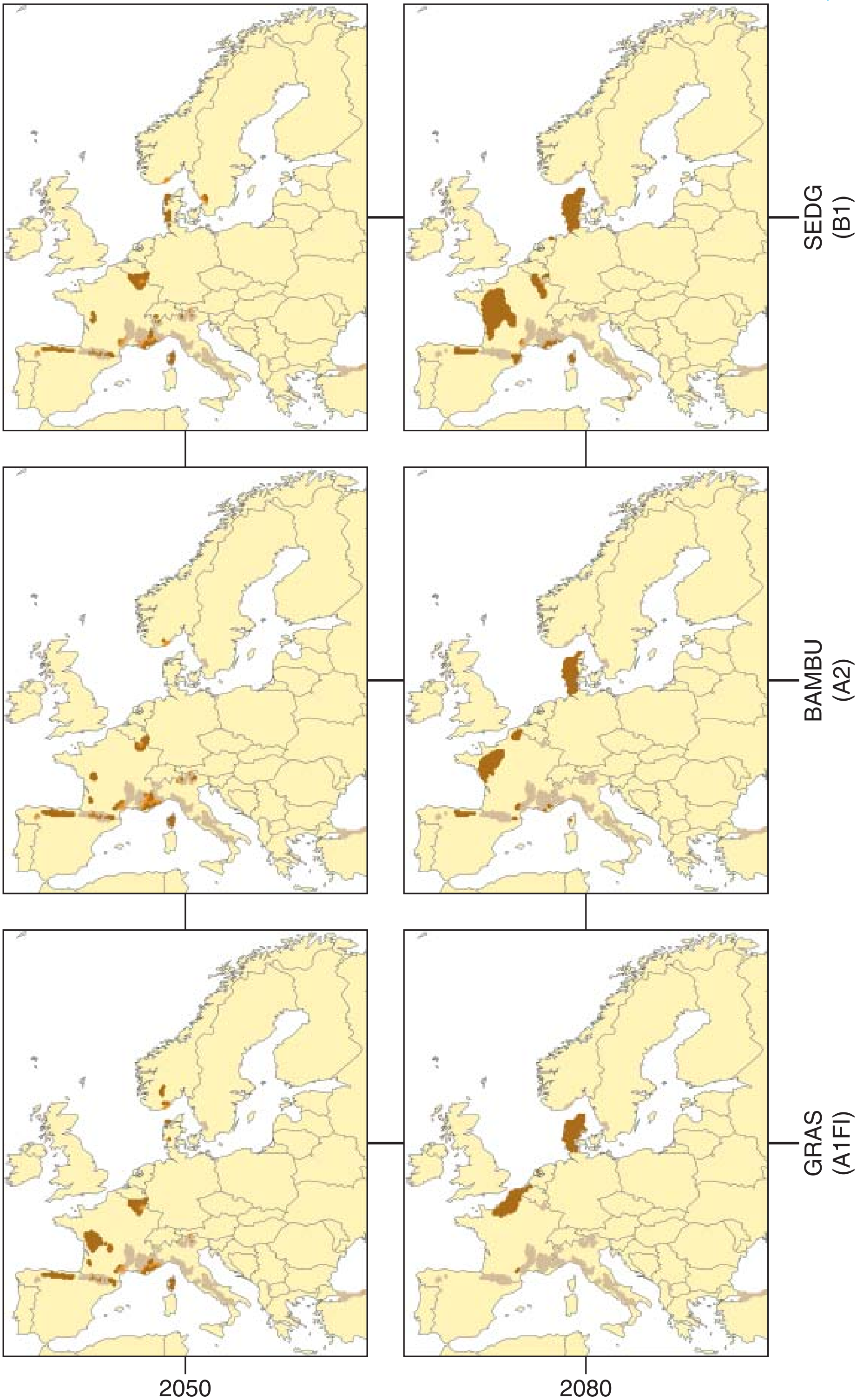
Present distribution can be well explained by climatic variables (AUC = 0.94).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pyrgus warrenensis (Verity, 1928) – Warren's Skipper

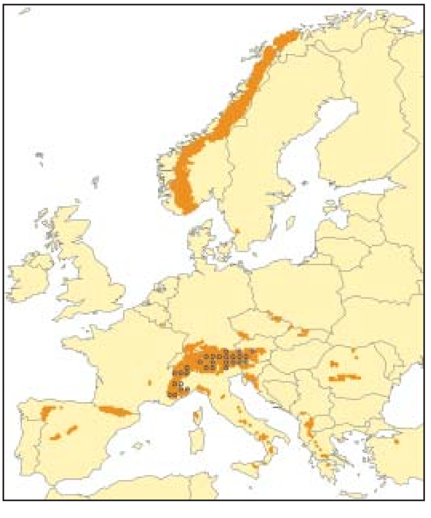
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-447 (-31.81%)	-568 (-40.43%)
	BAMBU	-437 (-31.1%)	-541 (-38.51%)
	GRAS	-537 (-38.22%)	-644 (-45.84%)
2080	SEDG	-725 (-51.6%)	-954 (-67.9%)
	BAMBU	-655 (-46.62%)	-834 (-59.36%)
	GRAS	-796 (-56.65%)	-997 (-70.96%)

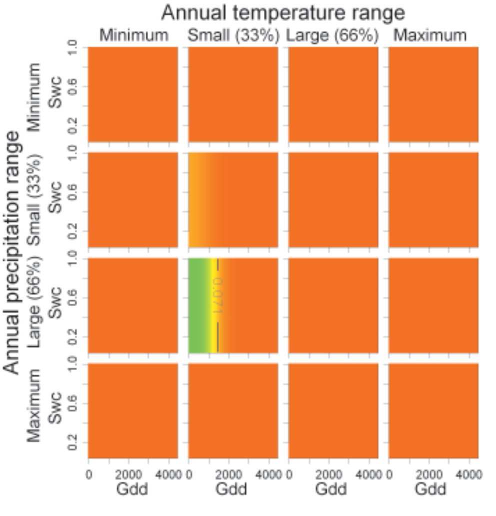
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1405 cells

Warren's Skipper occurs mostly on flower-rich alpine grasslands. The males fly where flowers are most abundant, along mountain streams, for example. From a perch on a bush or tall plant, they also defend their territory. The females meanwhile are often found on warm, dry patches near bushes, where they lay their eggs one by one on the rockrose *Helianthemum alpestre*, preferring the smaller plants. The small caterpillar lives hidden in a spun leaf, while caterpillars of later stages spin two leaves together, and finally, make a larger shelter from several leaves. The Warren's Skipper is single-brooded and passes the winter as a caterpillar.

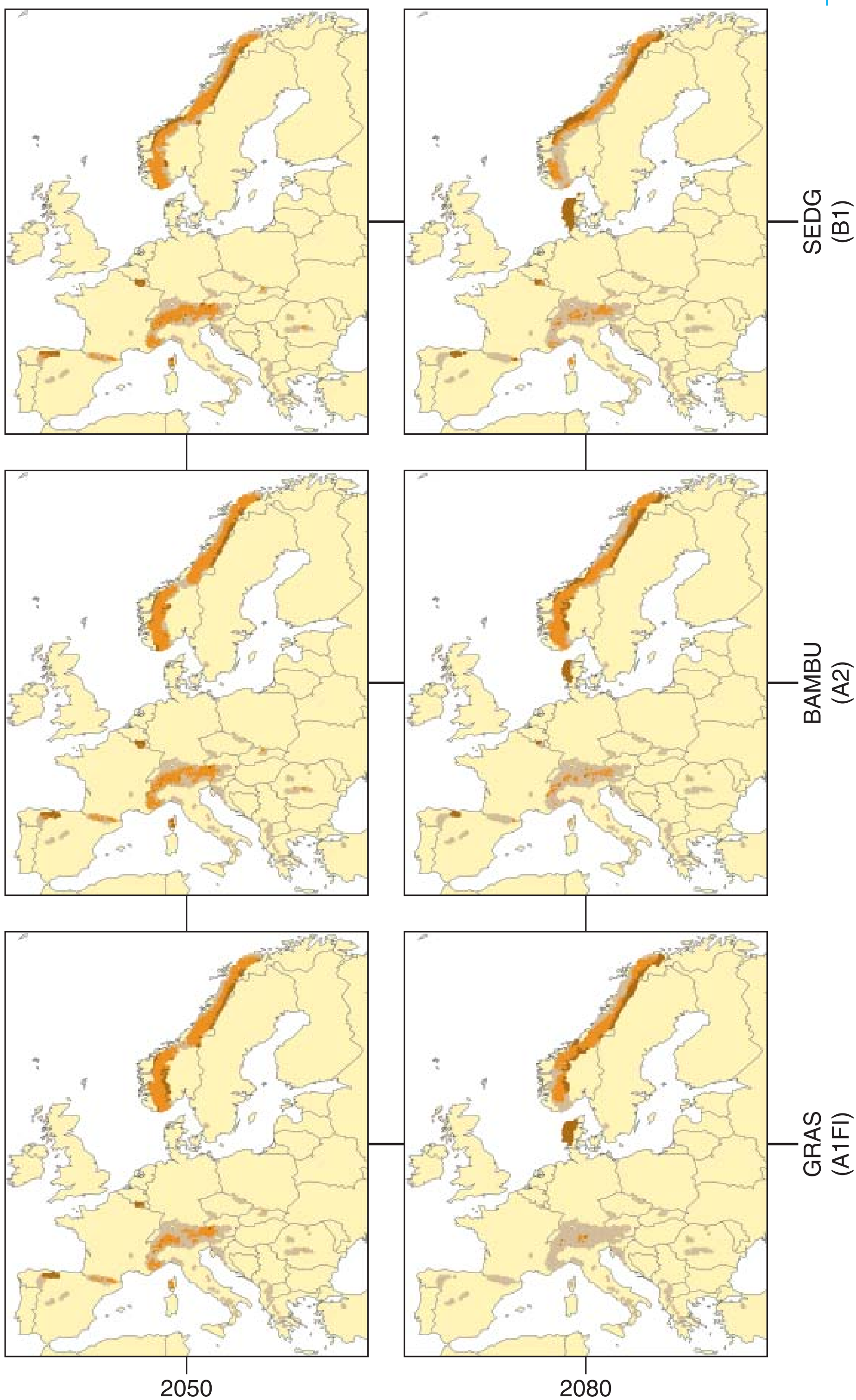
Present distribution can be very well explained by climatic variables (AUC = 0.99).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


2050
2080
SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)

Heteropterus morpheus (Pallas, 1771) – Large Chequered Skipper

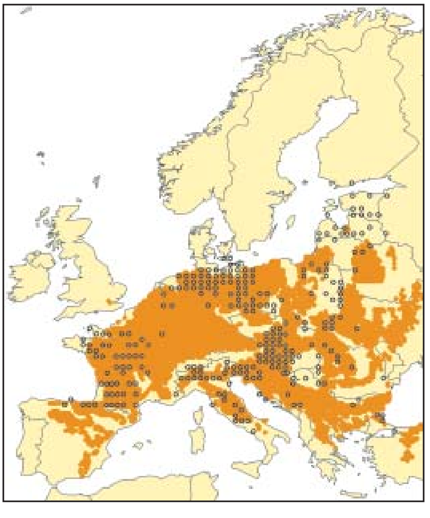
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	1974 (26.11%)	-568 (-40.43%)
	BAMBU	4028 (53.29%)	-541 (-38.51%)
	GRAS	2282 (30.19%)	-644 (-45.84%)
2080	SEDG	1760 (23.28%)	-954 (-67.9%)
	BAMBU	2305 (30.49%)	-834 (-59.36%)
	GRAS	819 (10.83%)	-997 (-70.96%)

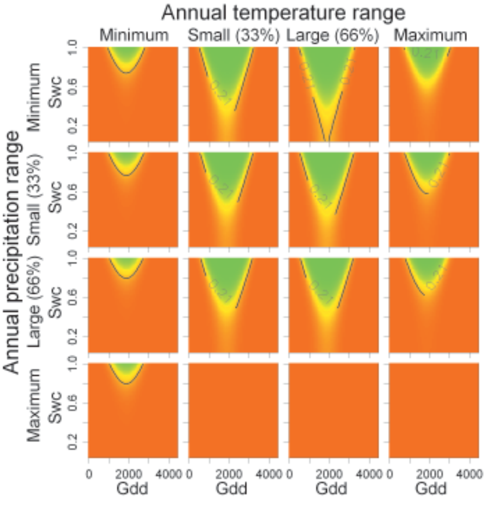
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 7559 cells)

The conspicuous pattern on the underside of the wings of the Large Chequered Skipper is unlike that of any other European butterfly. Furthermore, it has a characteristic, bouncing flight, low over the vegetation. It occurs in damp, rough, grassy places, such as grasslands, road verges, edges of streams, at the edges of raised bogs, and in woodland clearings. The eggs are laid singly or in small batches on the blades of grasses, such as Purple Moor-grass (*Molinea caerulea*) or Purple Smallreed (*Calamagrostis canescens*). The caterpillar makes a tubular shelter from grass, at first using a folded blade, and later using spun grass-blades. It leaves its shelter in search of food. The caterpillars pass the winter in the shelter. Pupation takes place in spring. The Large Chequered Skipper has one generation a year.

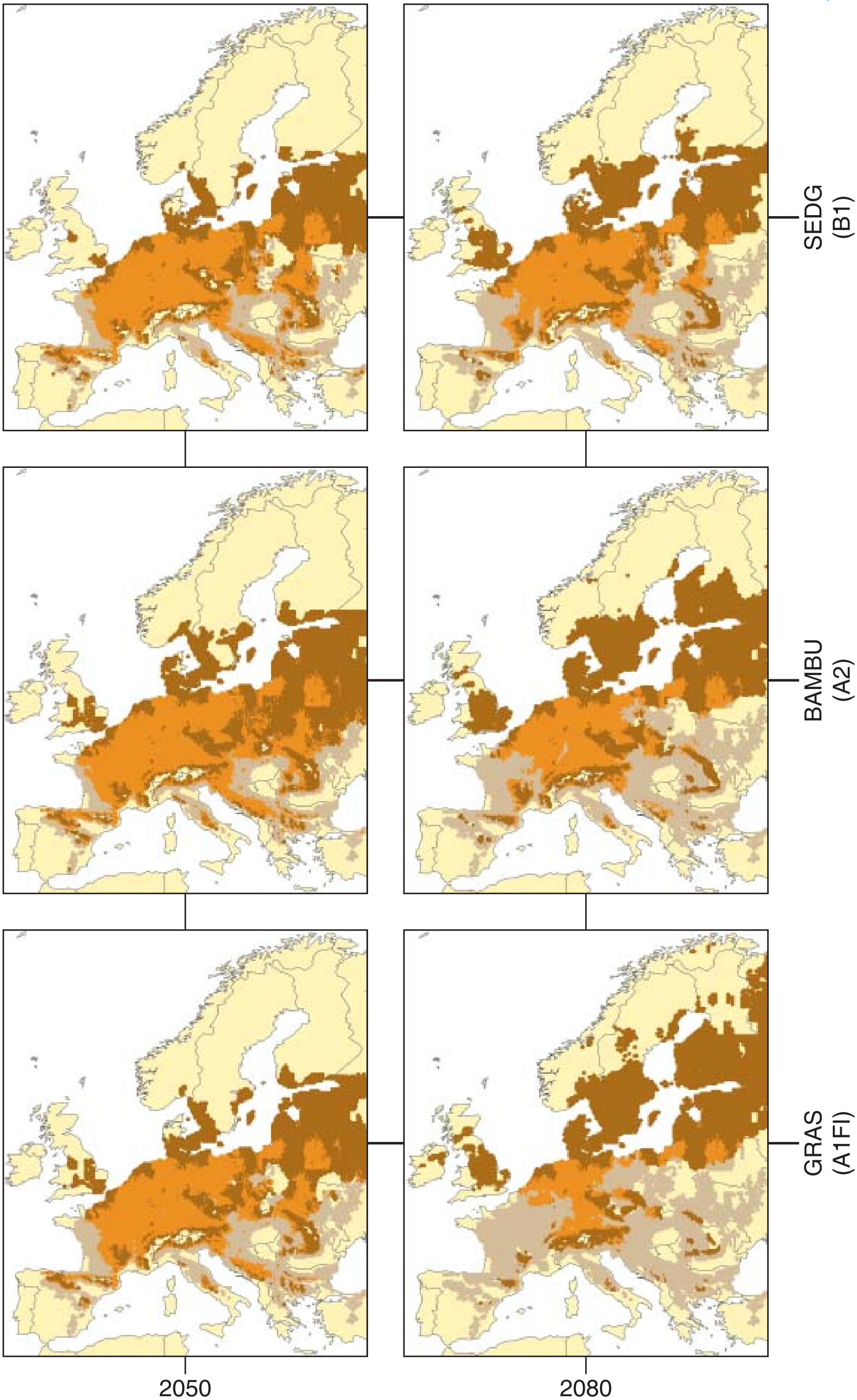
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.78).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Carterocephalus palaemon (Pallas, 1771) – Chequered Skipper

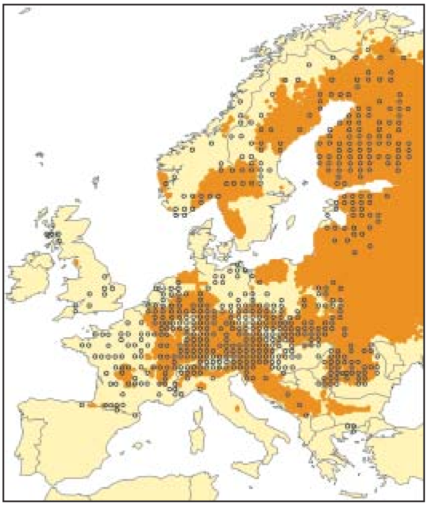
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-1722 (-15.33%)	-3397 (-30.24%)
	BAMBU	113 (1.01%)	-2117 (-18.85%)
	GRAS	-1877 (-16.71%)	-3570 (-31.78%)
2080	SEDG	696 (6.2%)	-2961 (-26.36%)
	BAMBU	41 (0.37%)	-3528 (-31.41%)
	GRAS	-748 (-6.66%)	-4725 (-42.07%)

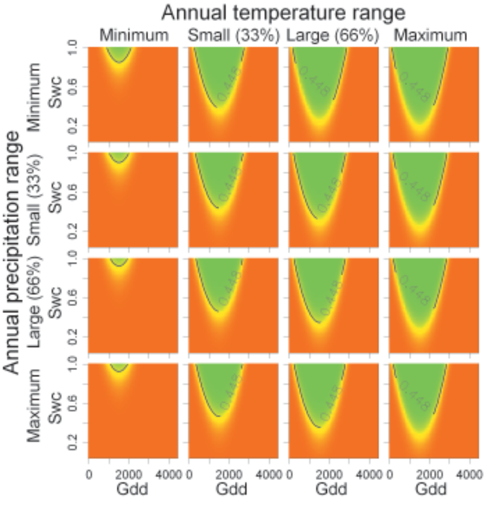
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 11232 cells)

The Chequered Skipper usually occurs on damp grassland at woodland margins, or where there is woodland nearby, including road verges, also on the drier areas of raised bogs and at their edges. Breeding grounds are also known in somewhat drier locations at higher altitudinal levels. Populations are usually small. The female lays her eggs one by one on the blades of coarse-leaved grasses. The caterpillars spin folded grass leaves together into a little tube, in which they spend most of their life, leaving it only to feed. Those who know what to look for, can find their traces, small half-moons nibbled away from the edge of the grass-blade. The caterpillars hibernate in a more substantial tube-like shelter. It pupates, its papery, pale-yellow pupa b suspended from withered grass by a silken girdle. The Chequered Skipper is single-brooded.

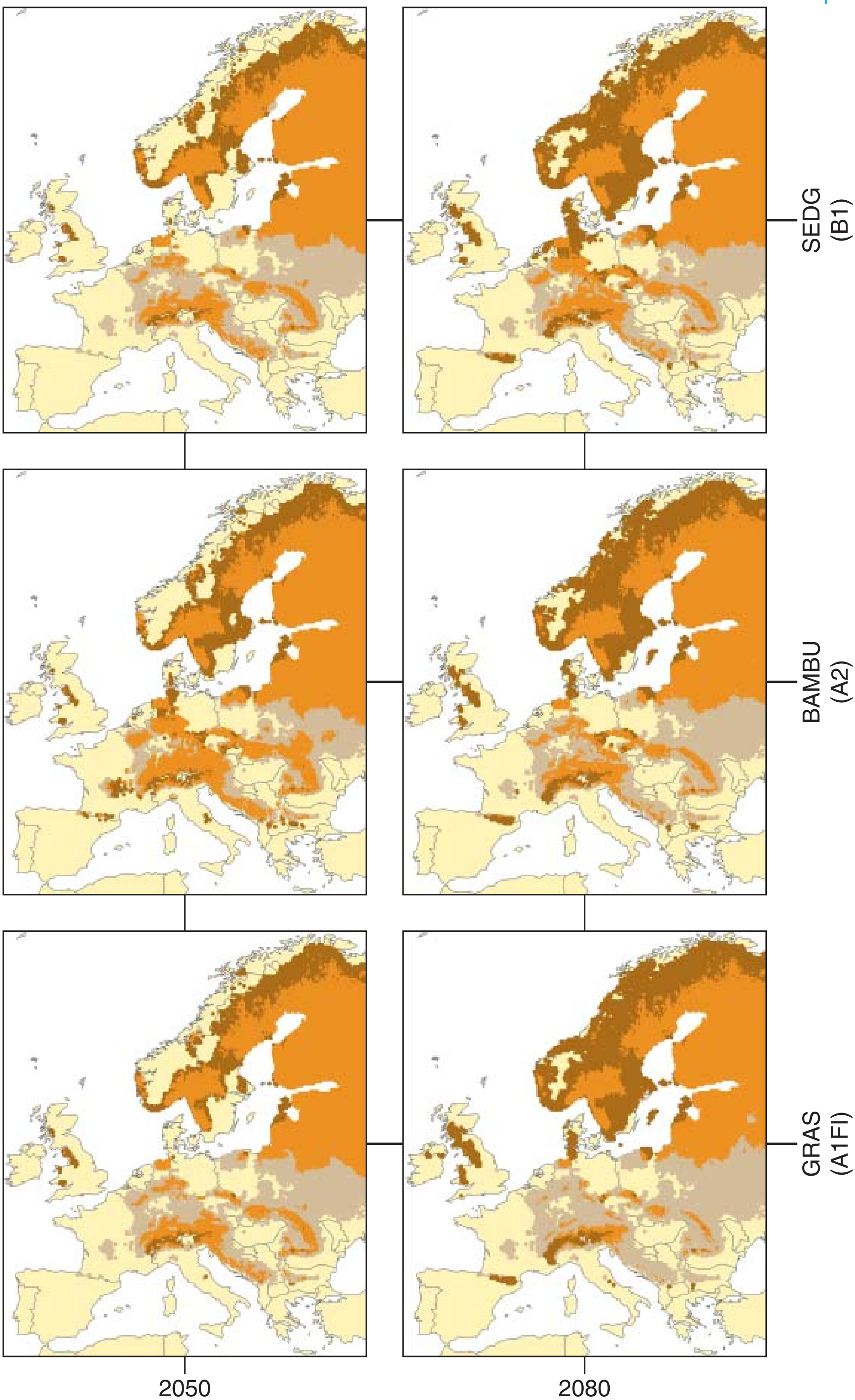
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.79).
Climate risk category: LR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Carterocephalus silvicolus (Meigen, 1829) – Northern Chequered Skipper

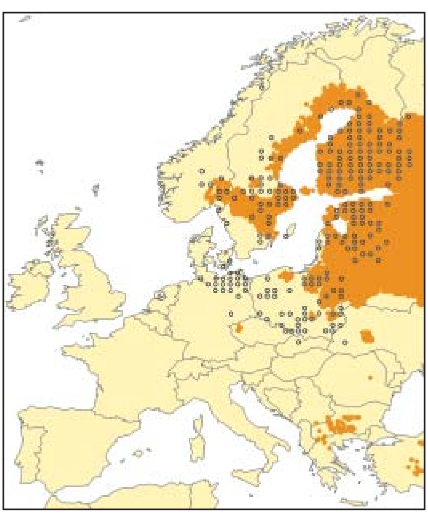
© Otakar Kudrna

		Full dispersal	No dispersal
2050	SEDG	-1008 (-18.35%)	-2364 (-43.04%)
	BAMBU	-919 (-16.73%)	-2273 (-41.38%)
	GRAS	-599 (-10.9%)	-2200 (-40.05%)
2080	SEDG	-1928 (-35.1%)	-3609 (-65.7%)
	BAMBU	-1746 (-31.79%)	-3780 (-68.81%)
	GRAS	-2565 (-46.7%)	-4642 (-84.51%)

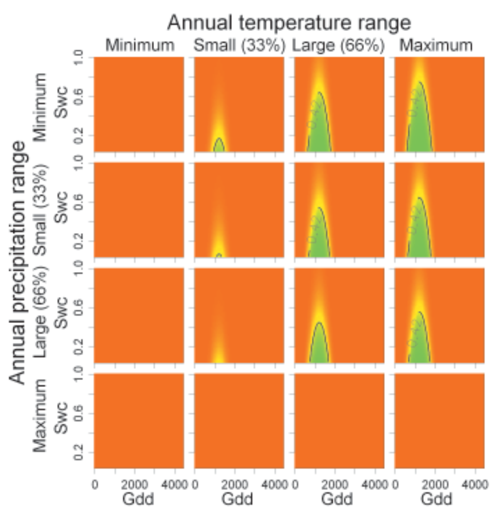
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 5493 cells)

The Northern Chequered Skipper can be found flying on the damp, flower-rich grass of woodland rides. They can often be seen drinking nectar from various speedwells (*Veronica* spp.). The eggs are laid on various coarse-leaved grasses. The caterpillar lives in a shelter spun from a blade of grass. In the last larval instar, the caterpillar makes a shelter from withered leaves in which it hibernates. The pale-yellow pupa is suspended in a silken girdle in the vegetation. It pupates in the spring. The Northern Chequered Skipper is single-brooded.

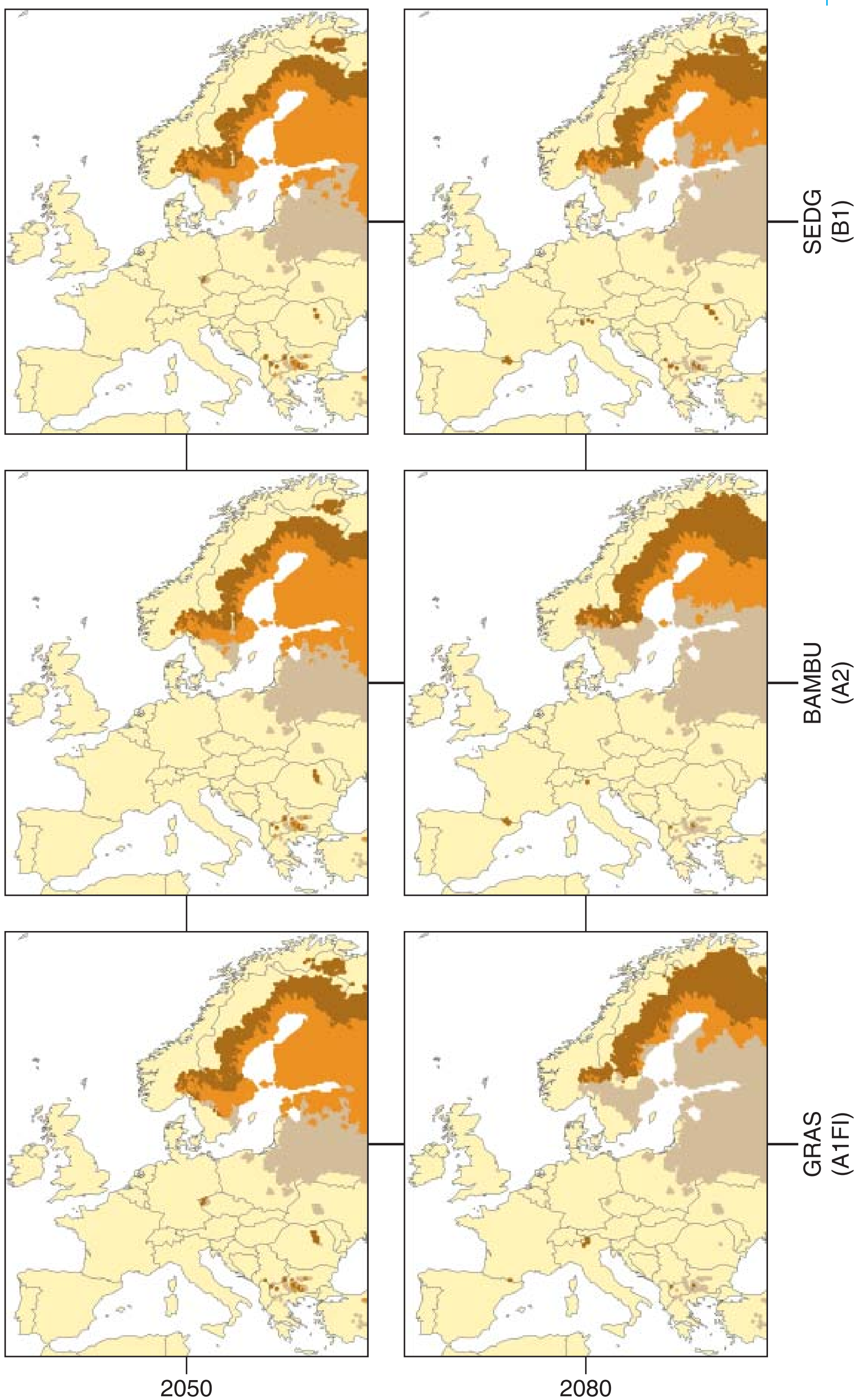
Present distribution can be well explained by climatic variables (AUC = 0.93).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Thymelicus lineola (Ochsenheimer, 1806) – Essex Skipper

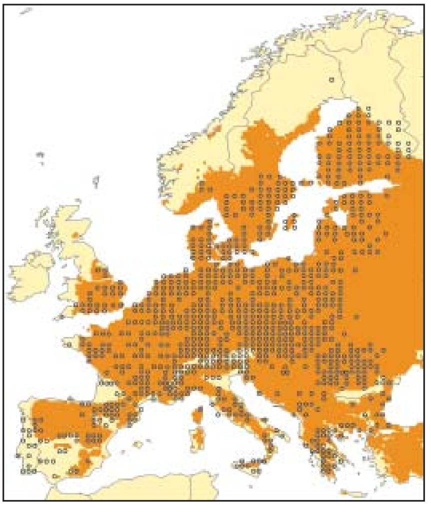
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-1906 (-9.81%)	-3176 (-16.35%)
	BAMBU	-2572 (-13.24%)	-3506 (-18.04%)
	GRAS	-2839 (-14.61%)	-4045 (-20.82%)
2080	SEDG	-3425 (-17.63%)	-5330 (-27.43%)
	BAMBU	-5580 (-28.72%)	-7891 (-40.61%)
	GRAS	-7605 (-39.14%)	-10551 (-54.3%)

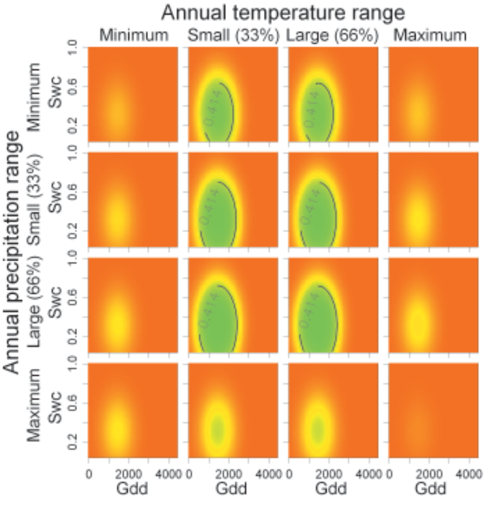
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 19431 cells)

The Essex Skipper occurs in many sorts of flower-rich places with tall grass, such as grasslands, road verges and on banks of streams. Because these butterflies need quite a lot of nectar, they can often be seen drinking on thistles, knapweeds and other purple or pink flowers rich in nectar. The female deposits her eggs in groups in the leaf-sheaths of coarse grasses, and lays them when the foodplants are already withered. It is the eggs that hibernate. The development of the caterpillar takes place the following spring. At first, the caterpillar only feeds during the day, but later also at night. They pupate in the vegetation. The pupa may be suspended from a grass blade by a silken girdle, but also just by the tip. The Essex Skipper is single-brooded.

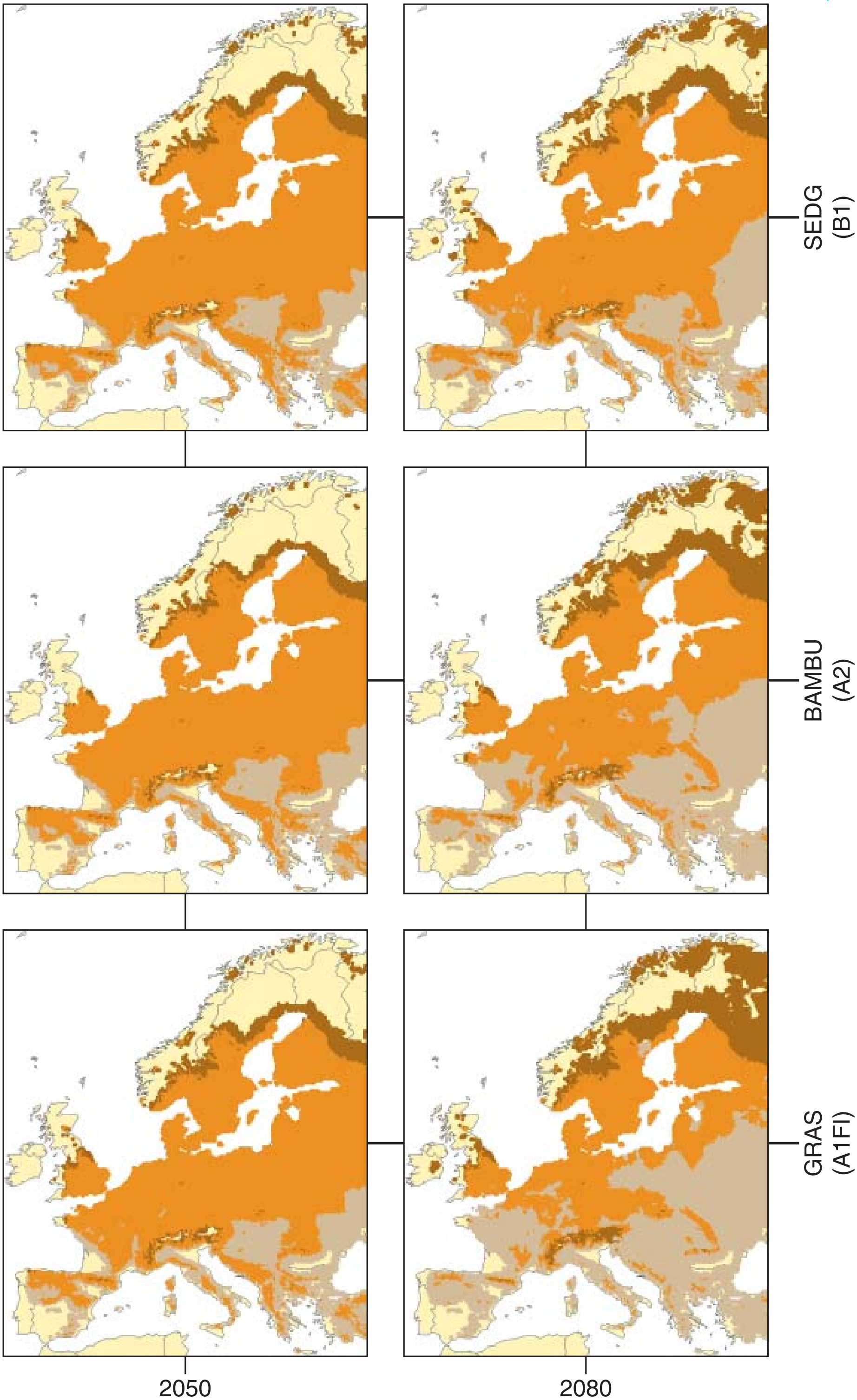
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.75). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Thymelicus sylvestris (Poda, 1761) – Small Skipper

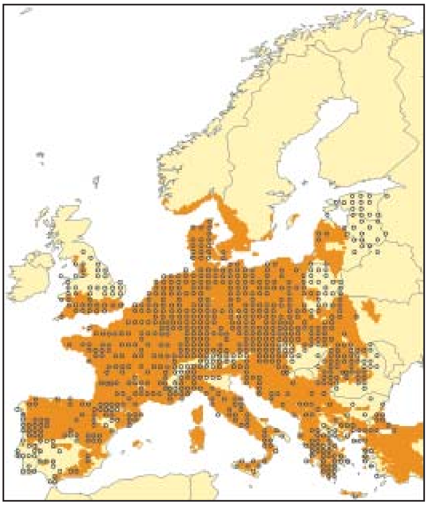
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-979 (-7.94%)	-2907 (-23.58%)
	BAMBU	-1880 (-15.25%)	-3492 (-28.32%)
	GRAS	-2283 (-18.52%)	-4097 (-33.23%)
2080	SEDG	-3060 (-24.82%)	-4995 (-40.51%)
	BAMBU	-4395 (-35.65%)	-6533 (-52.99%)
	GRAS	-5406 (-43.85%)	-8045 (-65.25%)

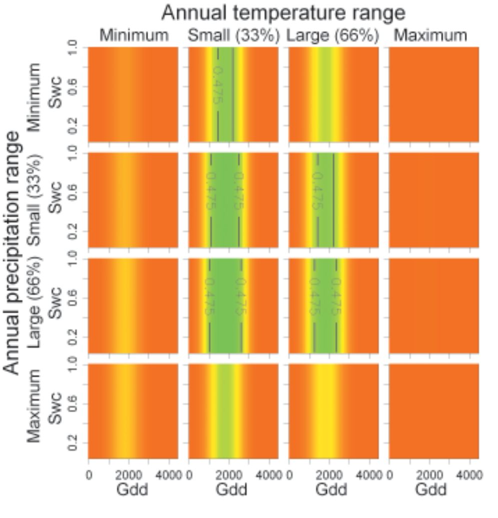
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 12329 cells)

The Small Skipper occurs in all sorts of flower-rich places with tall grass, such as grasslands, road verges and edges of streams. The butterflies are fond of visiting thistles, knapweeds and other purple or pink flowers for their nectar. The female deposits her eggs in batches of three to twenty in the leaf-sheaths of coarse-leaved grasses. Unlike the Essex Skipper, she only uses young, green leaves. After about three weeks, the eggs hatch and the small caterpillars begin spinning a shelter straightaway in which to hibernate. Only the next spring do they begin to feed and grow. At first, they only feed during the day and later also at night. They pupate in a web of loosely spun white threads. The Small Skipper is single-brooded, but the butterflies emerge over a long period.

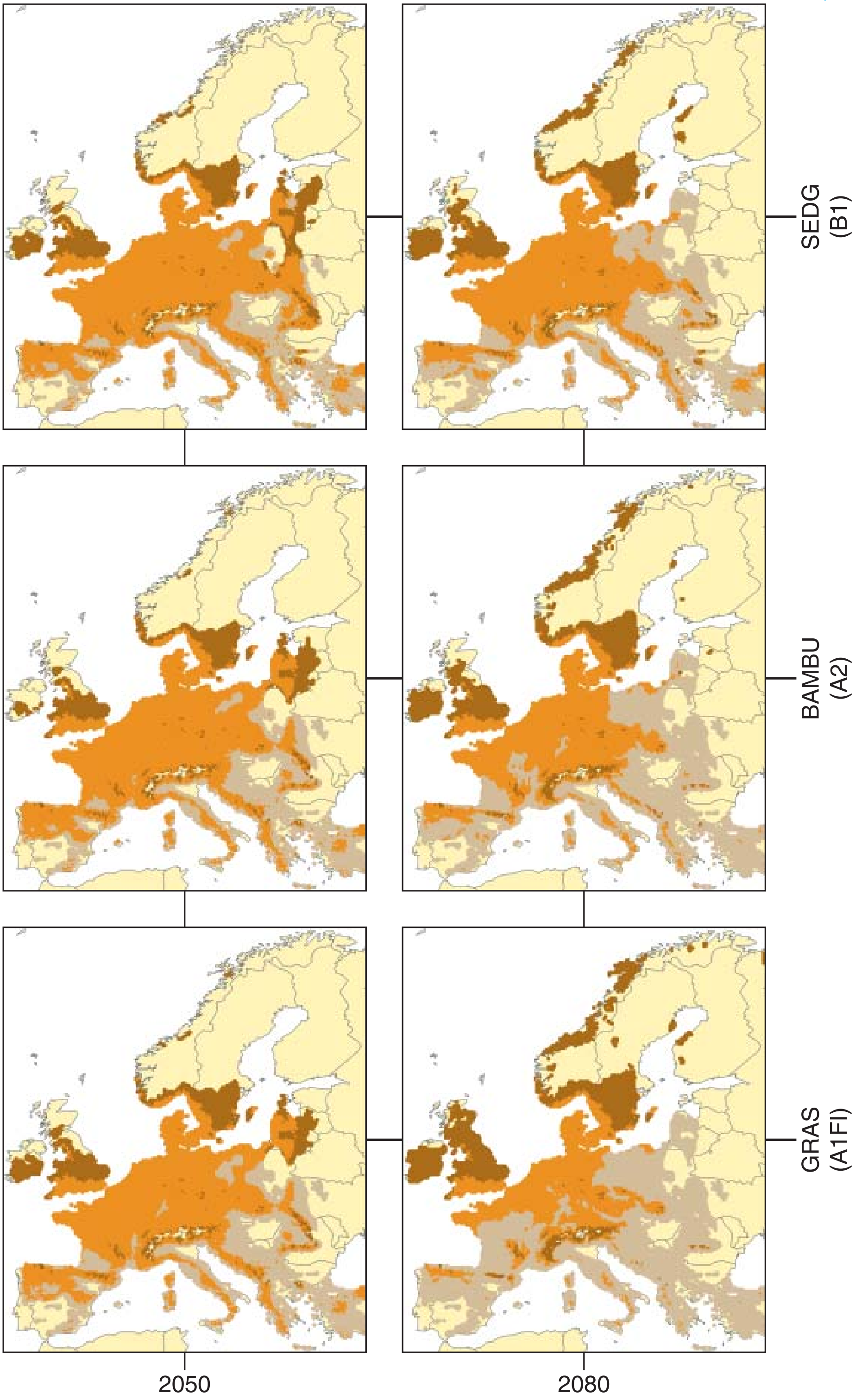
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.72).
Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Thymelicus acteon (Rottemburger, 1775) – Lulworth Skipper

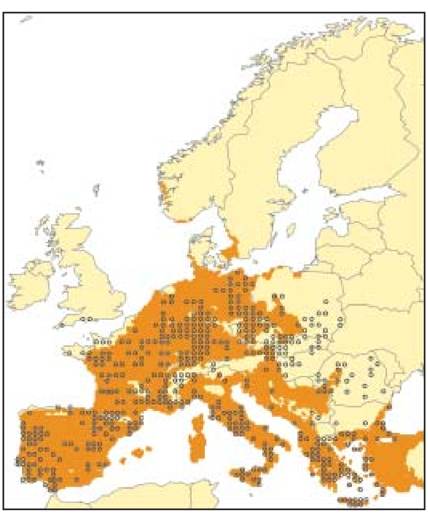
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	222 (2.27%)	-1744 (-17.79%)
	BAMBU	-456 (-4.65%)	-2089 (-21.31%)
	GRAS	-445 (-4.54%)	-2359 (-24.07%)
2080	SEDG	-827 (-8.44%)	-2875 (-29.33%)
	BAMBU	-2148 (-21.92%)	-4352 (-44.4%)
	GRAS	-2860 (-29.18%)	-5473 (-55.84%)

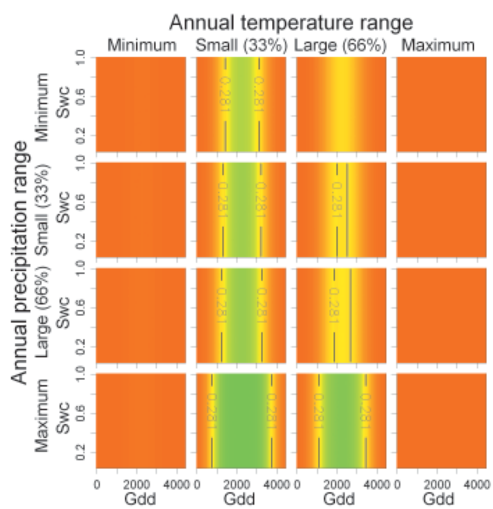
Changes in climatic niche distribution (in 10’×10’ grid cells; present niche space: 9801 cells)

The Lulworth Skipper can be found on warm, dry grassland, with bushes or scrub nearby, or at the edge of woodland. In the north of its range, it is mostly found on calcareous grassland. Eggs are laid on the withered leaves of many grasses. Directly after hatching, the small caterpillar spins itself a cocoon in which to hibernate. It does not begin to eat and grow until the following spring. It then builds itself a shelter by spinning blades of grass together, which it only leaves when looking for food. When fully grown, it pupates, changing into a green pupa suspended in the vegetation by a silken girdle. The Lulworth Skipper is mostly single-brooded.

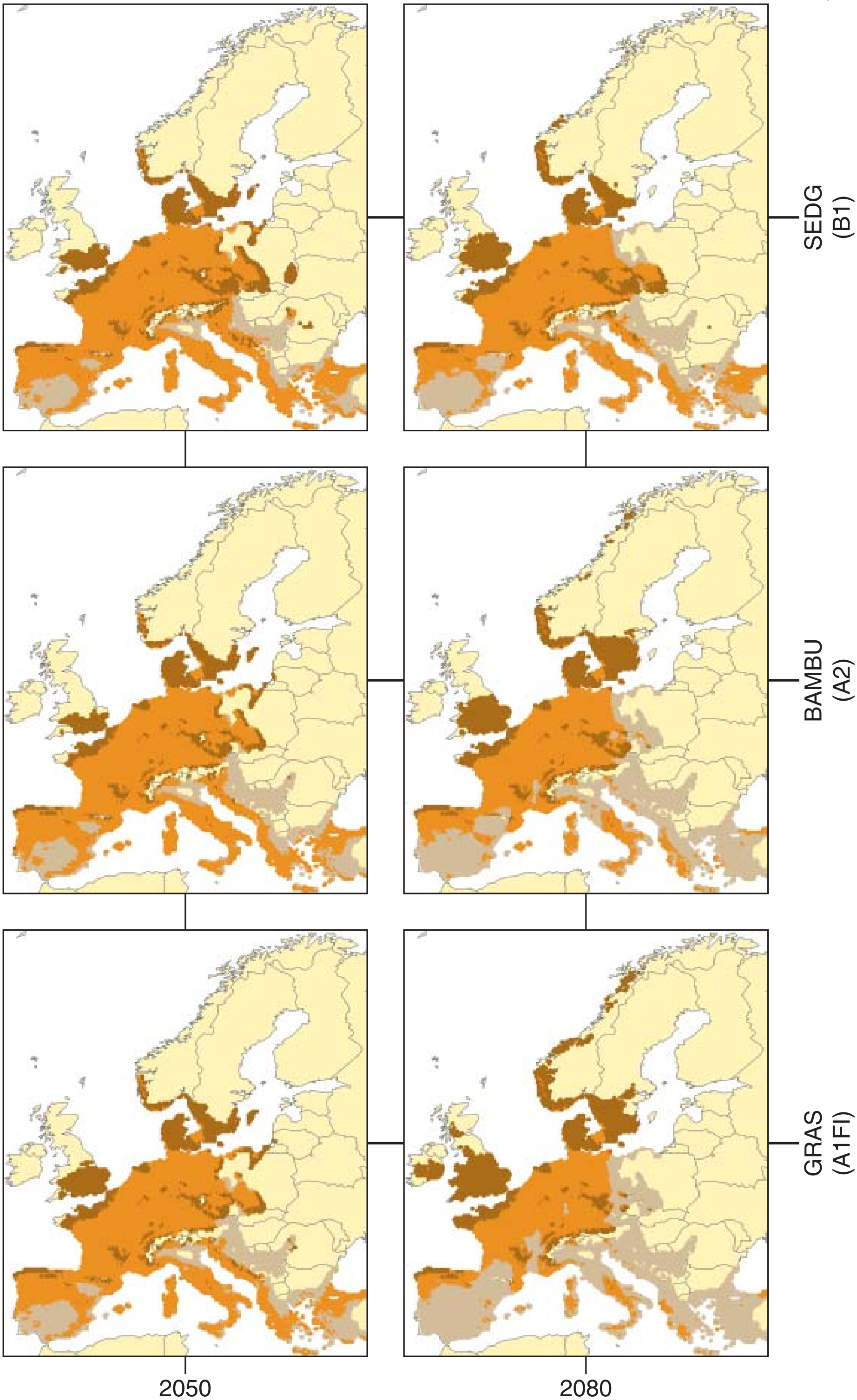
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.76). Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Hesperia comma (Linnaeus, 1758) – Silver-spotted Skipper

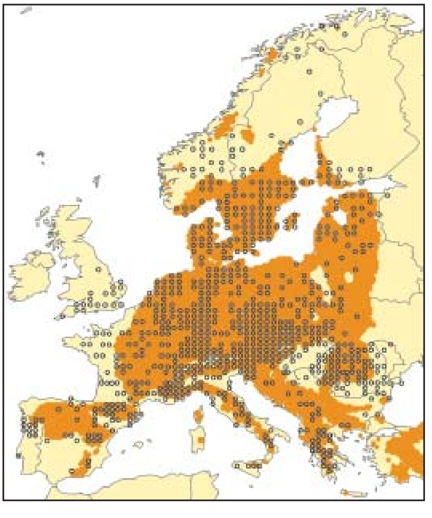
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-1980 (-16.77%)	-3034 (-25.7%)
	BAMBU	-2321 (-19.66%)	-3408 (-28.87%)
	GRAS	-2913 (-24.67%)	-4003 (-33.91%)
2080	SEDG	-4598 (-38.95%)	-6026 (-51.04%)
	BAMBU	-5466 (-46.3%)	-7294 (-61.78%)
	GRAS	-7069 (-59.88%)	-9066 (-76.79%)

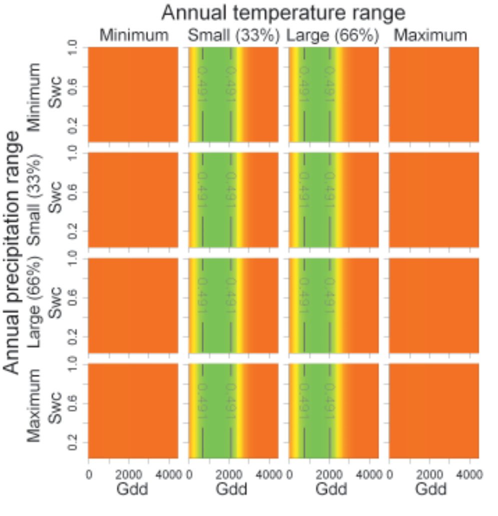
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 11806 cells)

The Silver-spotted Skipper occurs on open, poor grasslands, heathlands, and on sparsely covered blown sand. The habitat varies from dry to moist, but is never rich in nutrients. However, in their search for nectar, the skippers do visit nutrient-rich areas where flowers are growing, usually not so far from their breeding ground. Eggs are laid on various fine-leaved grasses, passing the winter in this stage. In the spring, the caterpillars emerge and spin a shelter from blades of grass in which they spend most of their time, usually coming out to feed at night. When fully-grown, the caterpillar spins a cocoon of silk and grass blades near the ground in which it pupates. The Silver-spotted Skipper has one generation a year.

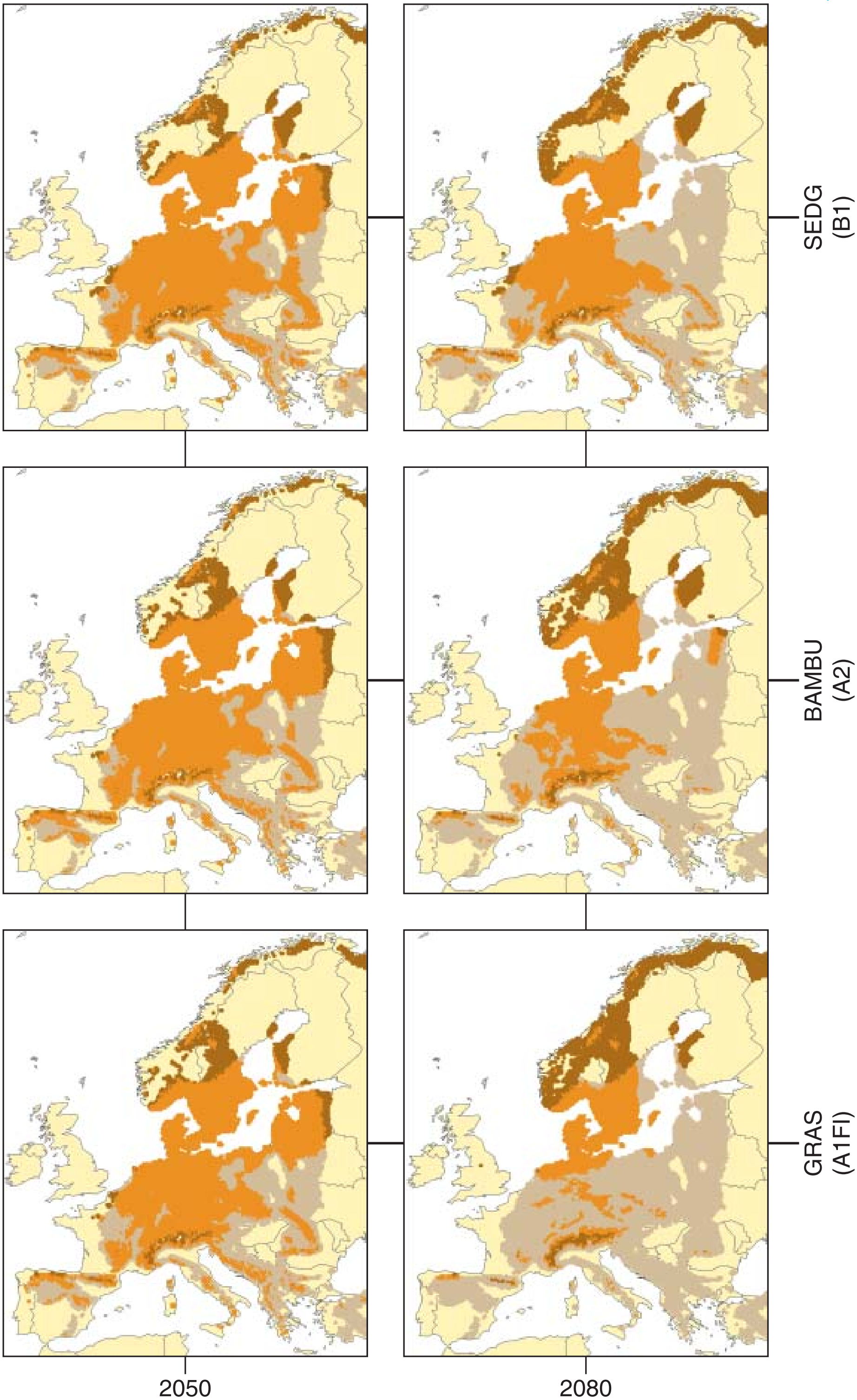
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.77).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Ochlodes sylvanus (Esper, 1777) – Large Skipper

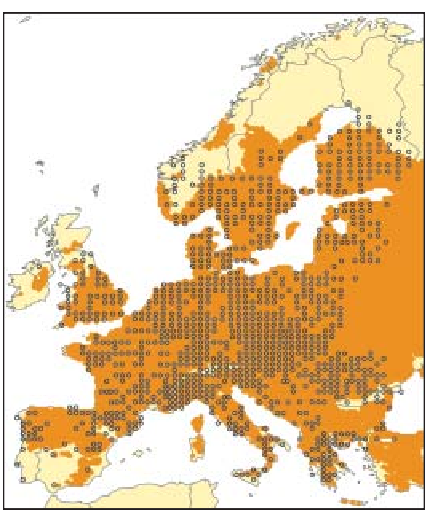
© Peter Ginzinger

		Full dispersal	No dispersal
2050	SEDG	-726 (-3.53%)	-3276 (-15.94%)
	BAMBU	-953 (-4.64%)	-3309 (-16.1%)
	GRAS	-1398 (-6.8%)	-4058 (-19.74%)
2080	SEDG	-750 (-3.65%)	-4881 (-23.75%)
	BAMBU	-2082 (-10.13%)	-6893 (-33.54%)
	GRAS	-3892 (-18.94%)	-9349 (-45.49%)

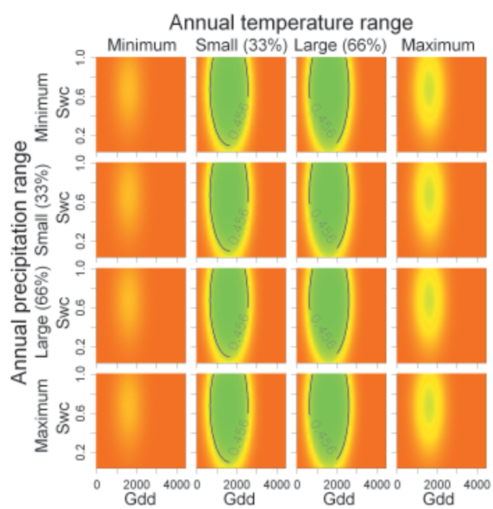
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 20554 cells)

The Large Skipper is found on sunny, grassy vegetation in or near woods and scrub. It often visits flowers, and the development of some rough vegetation close to the breeding ground is thus favourable. They are especially fond of bramble blossom for nectar. The female deposits her eggs onto the blades of coarse-leaved grasses one by one. The caterpillars make a shelter by spinning blades of grass together, and pass the winter in the third larval instar. When fully grown, they also spin leaves and silk together, to form a tube-like shelter in which to pupate. The Large Skipper is single-brooded.

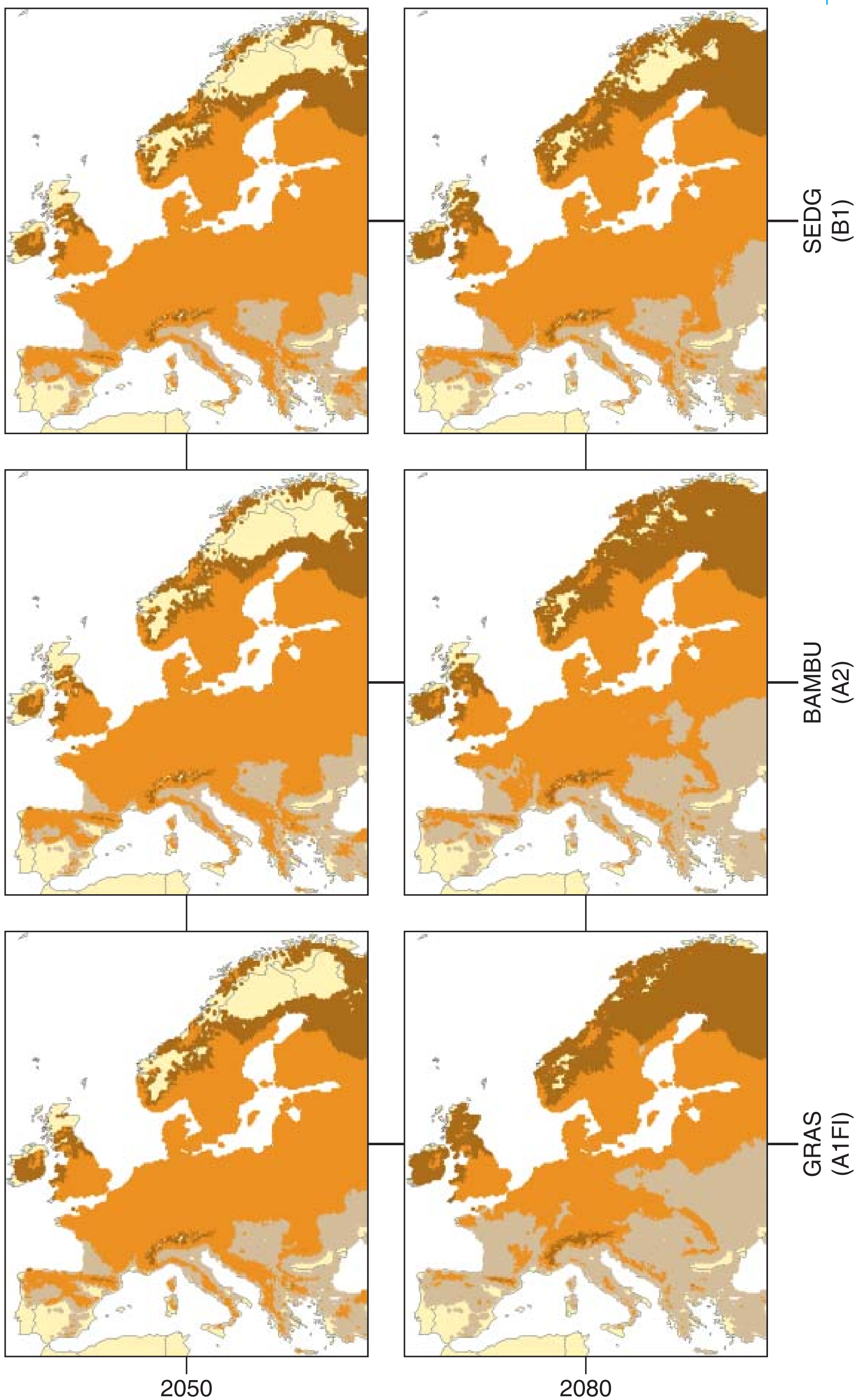
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.75). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Gegenes pumilio (Hoffmansegg, 1804) – Pigmy Skipper

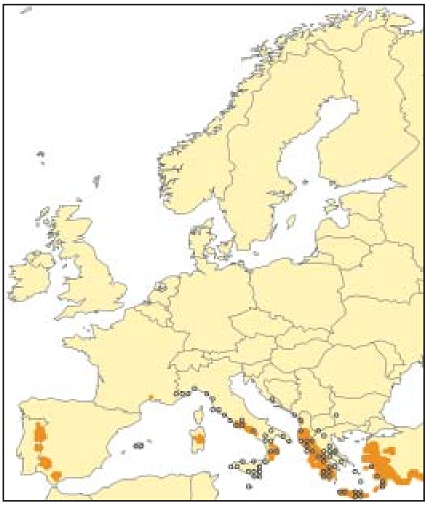
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-11 (-2.1%)	195 (-37.14%)
	BAMBU	-15 (-2.86%)	-201 (-38.29%)
	GRAS	-39 (-7.43%)	-239 (-45.52%)
2080	SEDG	90 (17.14%)	-220 (-41.9%)
	BAMBU	-123 (-23.43%)	-342 (-65.14%)
	GRAS	-223 (-42.48%)	-420 (-80%)

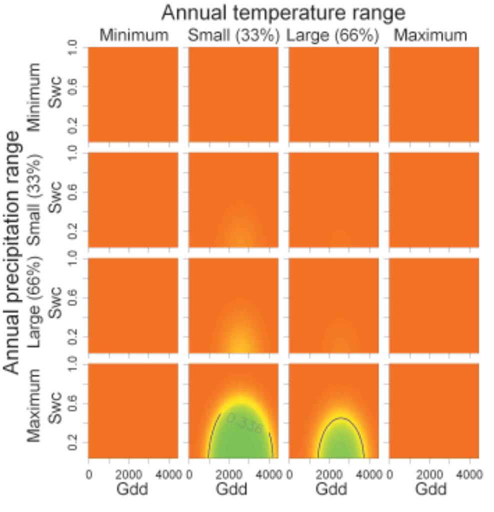
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 525 cells)

The Pigmy Skipper occurs in the same types of habitat as the Mediterranean Skipper (*Gegenes nostrodamus*). Dry gullies, rocky slopes, sandy or stony riverbanks with sparse vegetation, dry grassland and low scrub near the coast are all places where these butterflies can be seen, often basking in the sun on stones and bare soil. In spring, there are fewer butterflies than in the summer and autumn. The larvae feed on the grasses *Hyparrhenia hirta* and *Sorghum halepensis*. The Pigmy Skipper has two to three generations a year.

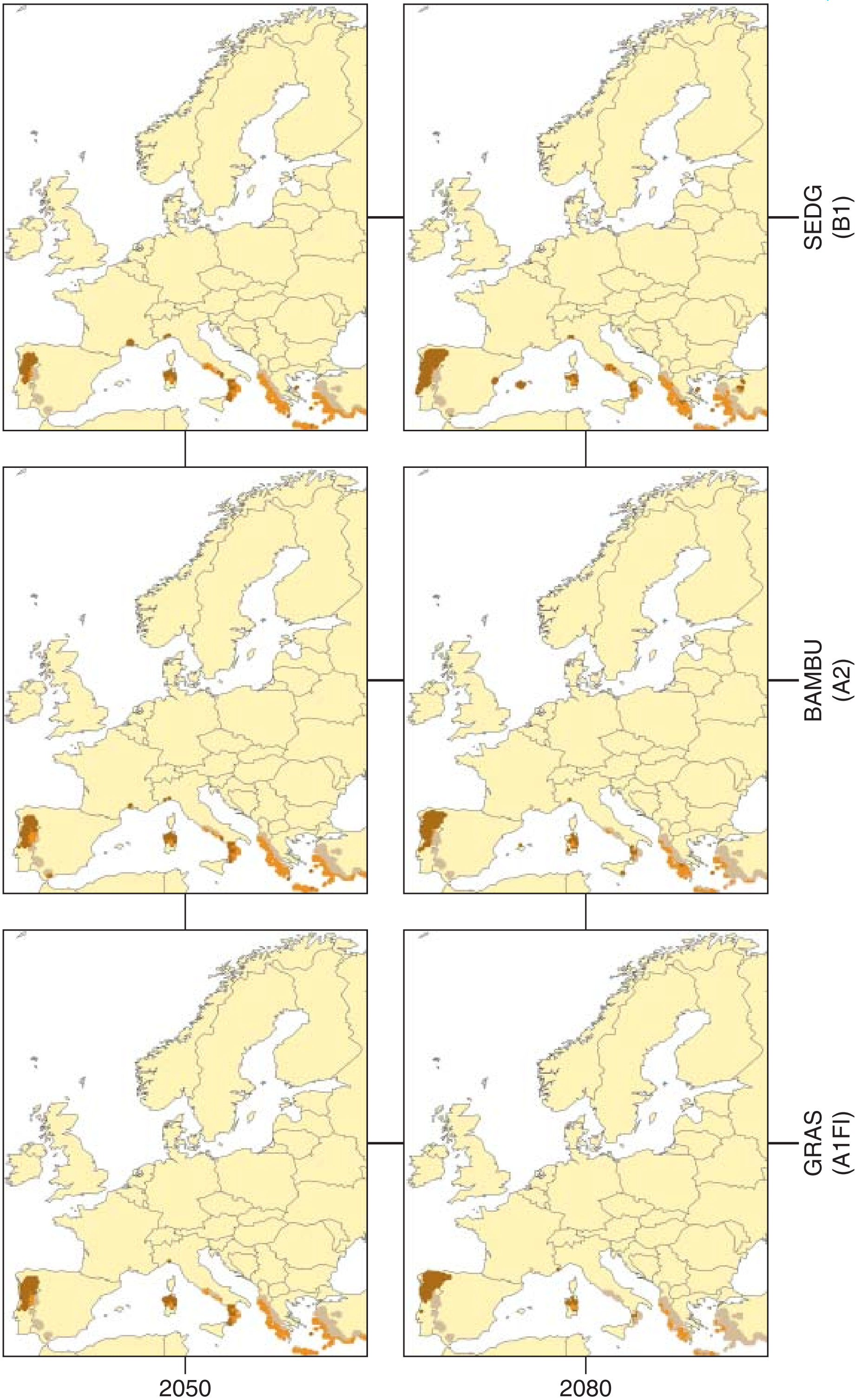
Present distribution can be very well explained by climatic variables (AUC = 0.96).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Gegenes nostrodamus (Fabricius, 1793) – Mediterranean Skipper

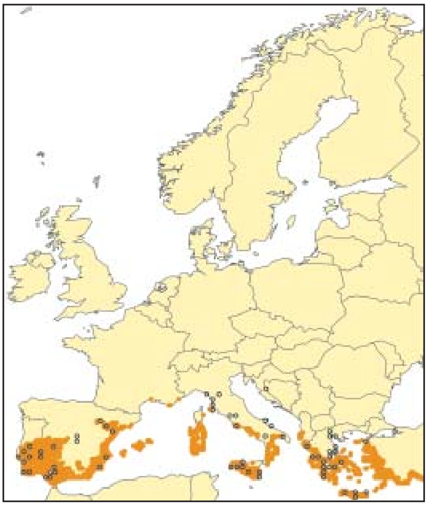
© Thomas Kissling

		Full dispersal	No dispersal
2050	SEDG	-628 (-51.27%)	-805 (-65.71%)
	BAMBU	-626 (-51.1%)	-828 (-67.59%)
	GRAS	-718 (-58.61%)	-927 (-75.67%)
2080	SEDG	-731 (-59.67%)	-1005 (-82.04%)
	BAMBU	-912 (-74.45%)	-1142 (-93.22%)
	GRAS	-1035 (-84.49%)	-1216 (-99.27%)

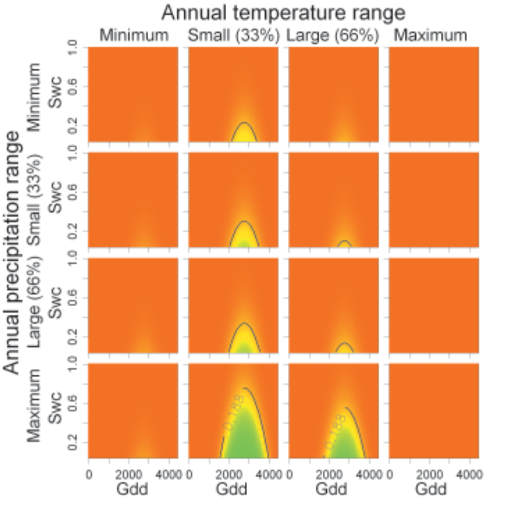
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 1225 cells)

Like the Pigmy Skipper (*G. pumilio*), the Mediterranean Skipper can be found in rocky or stony places, such as dried-up riverbeds, on dry, grassy vegetation or in thickets, and low scrub along the coast. The males defend their territory perched on a stone or on the ground, returning to the same spot if disturbed. These butterflies fly fast and close to the ground. The larvae feed on Reed (*Phragmites australis*) and the grass *Saccharum ravennae*. It has one to three generations a year. There are far fewer butterflies in the spring than in the summer or autumn.

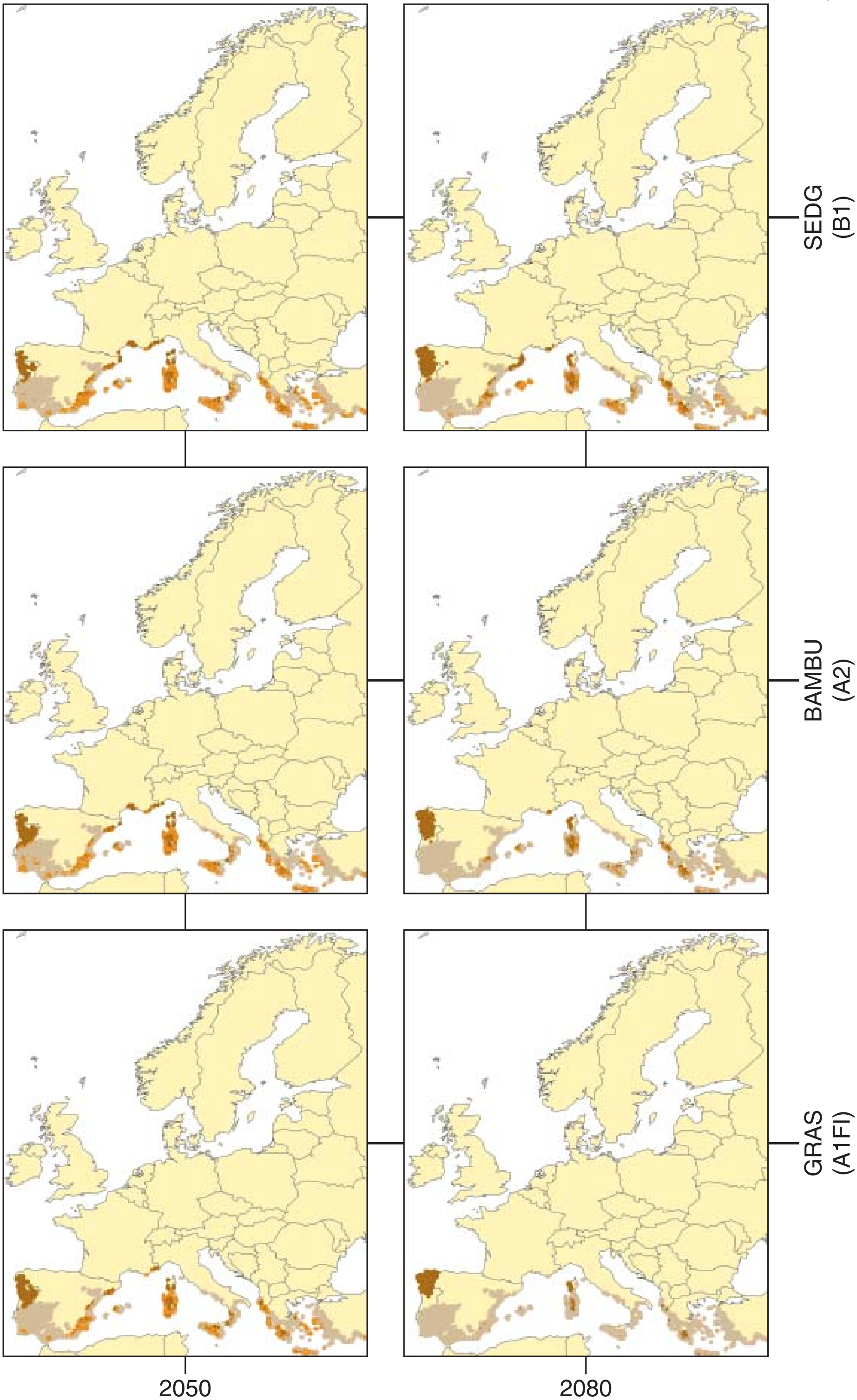
Present distribution can be well explained by climatic variables (AUC = 0.94).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Zerynthia rumina (Linnaeus, 1767) – Spanish Festoon

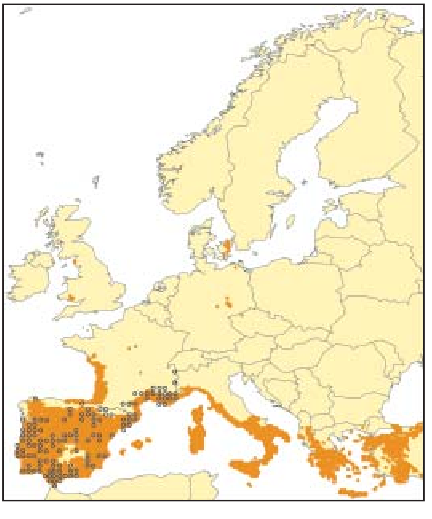
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-802 (-22.91%)	-1847 (-52.77%)
	BAMBU	-1378 (-39.37%)	-1932 (-55.2%)
	GRAS	-1187 (-33.91%)	-2196 (-62.74%)
2080	SEDG	-1574 (-44.97%)	-2617 (-74.77%)
	BAMBU	-2119 (-60.54%)	-3078 (-87.94%)
	GRAS	-1967 (-56.2%)	-3405 (-97.29%)

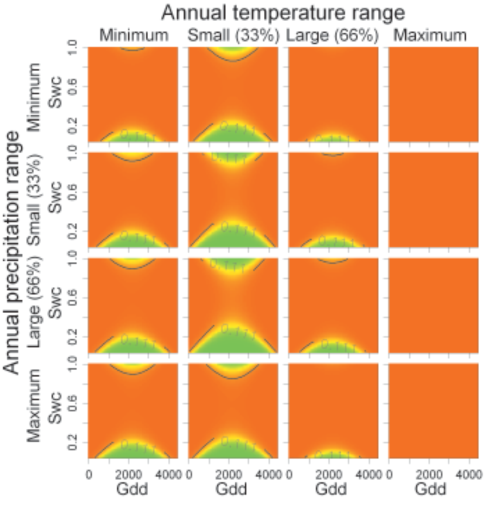
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 3500 cells)

The Spanish Festoon can be found on scrub and dry, grassy vegetation. The butterflies are often found in rocky areas, where they can be seen, wings widespread, basking on stones, warming themselves in the sun. The female lays her eggs singly or in small groups on birthworts (*Aristolochia* spp.), such as *A. longa*, *A. rotunda*, and *A. pistolochia*. The caterpillars feed on these poisonous plants, pupating for the winter. It can sometimes take two to three years before the butterfly emerges from the pupa. Apart form a few sites in southern Spain the species is single brooded.

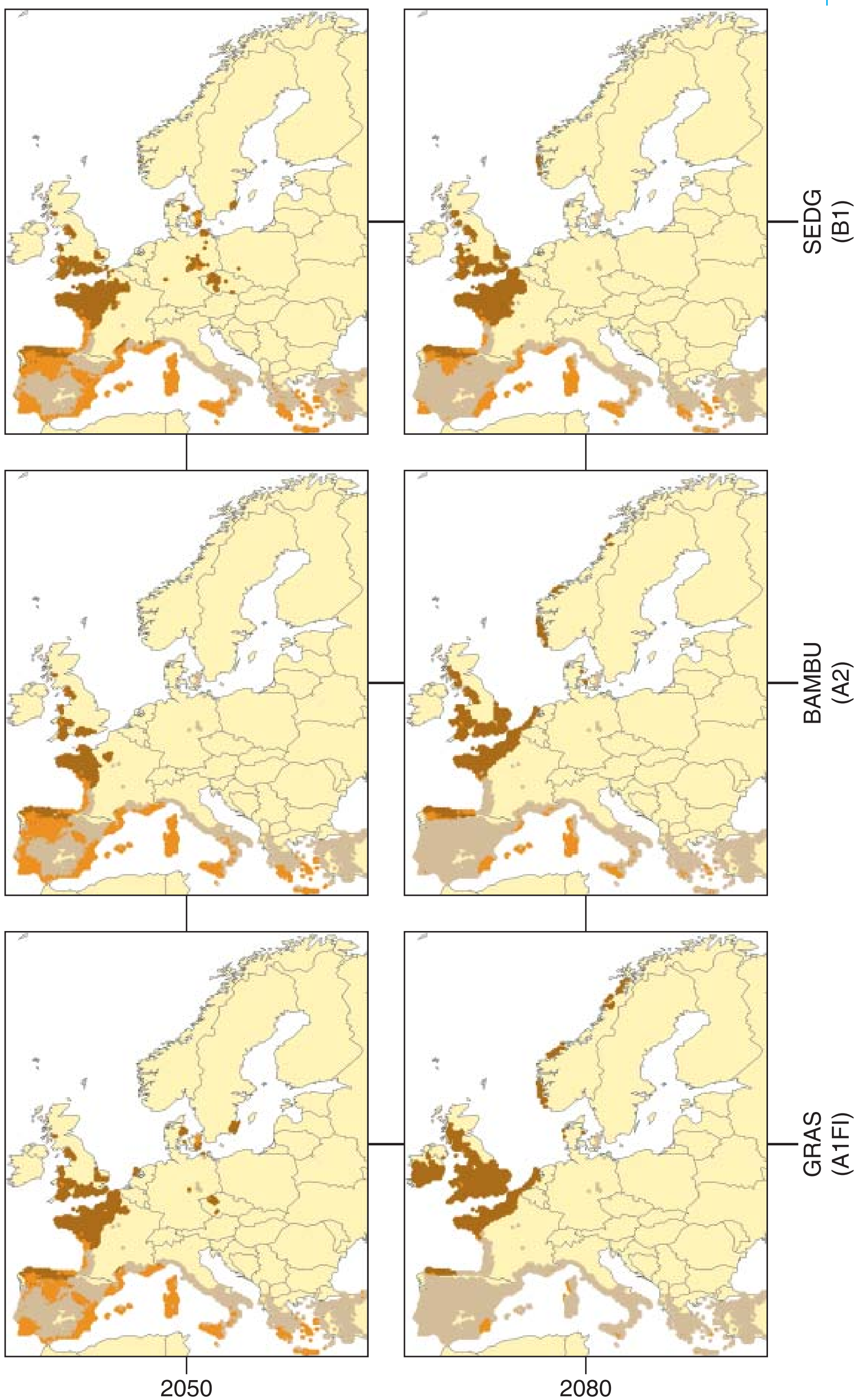
Present distribution can be well explained by climatic variables (AUC = 0.91).
Climate risk category: HHHR



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Zerynthia polyxena ([Schiffermüller], 1775) – Southern Festoon

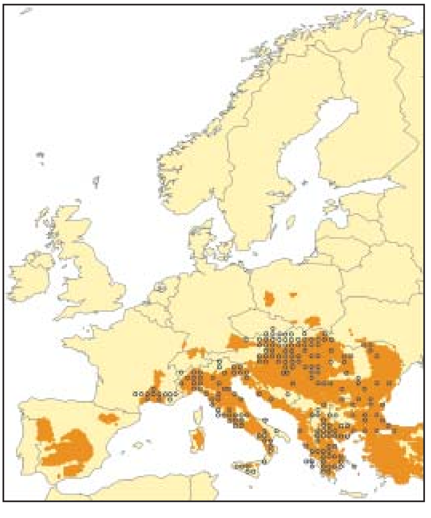
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	3753 (76.61%)	-722 (-14.74%)
	BAMBU	3218 (65.69%)	-1107 (-22.6%)
	GRAS	3098 (63.24%)	-1499 (-30.6%)
2080	SEDG	4158 (84.87%)	-1612 (-32.9%)
	BAMBU	3432 (70.06%)	-3156 (-64.42%)
	GRAS	4141 (84.53%)	-3917 (-79.96%)

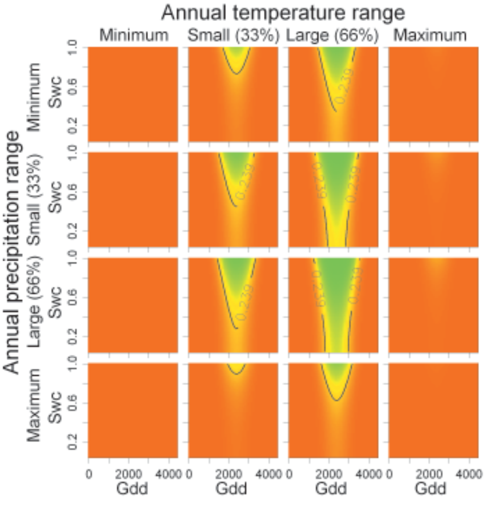
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 4899 cells)

The caterpillars of the Southern Festoon live on various birthworts, such as *Aristolochia clematitis, A. rotunda, A. pallida,* and *A. pistolochia*. Because their foodplants grow in different habitats, and because the caterpillars also have different foodplants in different areas, this spring butterfly can be found in quite different habitats. The eggs are laid singly or in small groups on the underside of the leaves, where the caterpillars are usually also found. The caterpillars have a striking appearance. Otherwise beige with black spots, it has some orange tubercles on each segment, each ending in a black, spiny tuft. The Southern Festoon is single-brooded and hibernates as pupa.
This species is listed in Annex IV of the Habitats’ Directive.

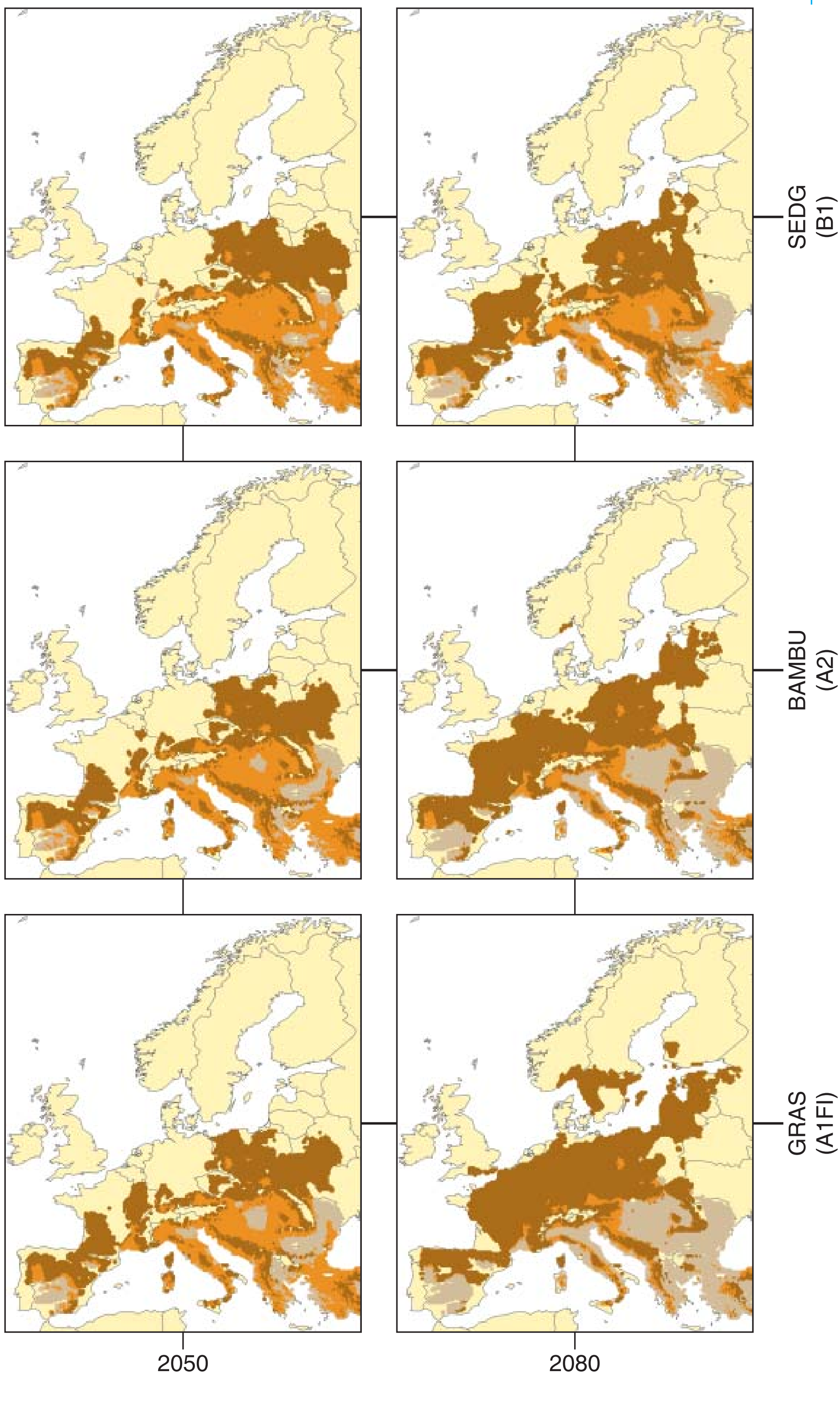
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.85).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG (B1)
BAMBU (A2)
GRAS (A1FI)
2050
2080

Zerynthia cerisyi (Godart, 1822) – Eastern Festoon

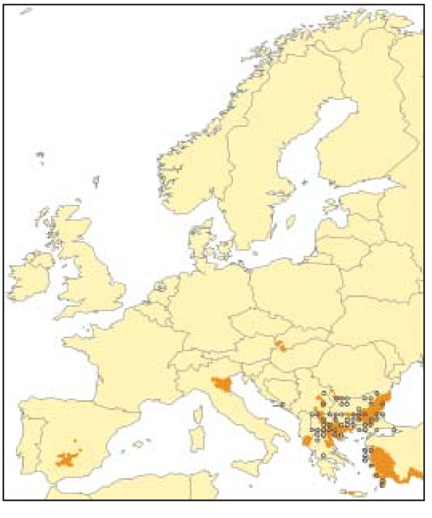
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	1685 (291.02%)	-11 (-1.9%)
	BAMBU	2079 (359.07%)	-10 (-1.73%)
	GRAS	2080 (359.24%)	-23 (-3.97%)
2080	SEDG	2970 (512.95%)	-35 (-6.04%)
	BAMBU	3022 (521.93%)	-73 (-12.61%)
	GRAS	4073 (703.45%)	-71 (-12.26%)

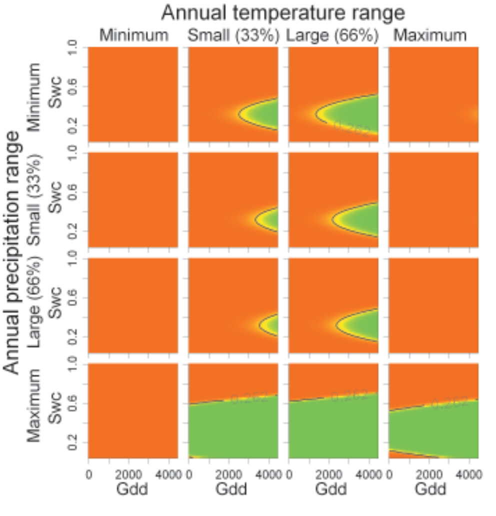
Changes in climatic niche distribution (in 10'×10' grid cells; present niche space: 579 cells)

The Eastern Festoon occurs in warm, usually dry, places such as in dry grassland with scattered bushes, in scrub, near hedges, on agricultural land, vineyards and olive groves. It is also found in river valleys. Choosing plants growing near bushes or trees, the female lays her eggs mostly on Birthwort (*Aristolochia clematitis*), but also on other birthworts. The Eastern Festoon has one generation a year and passes the winter in the pupal stage.

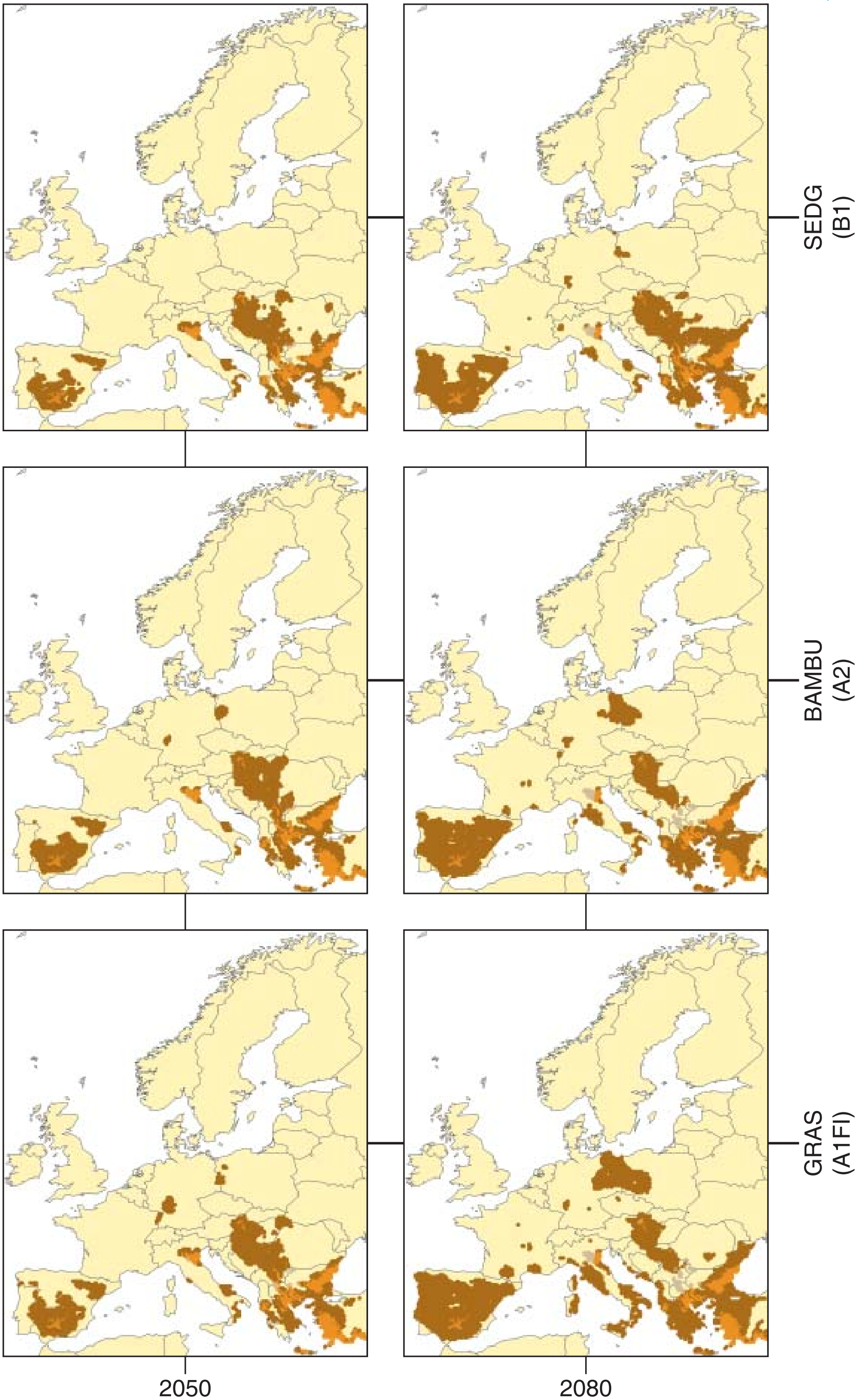
Present distribution can be well explained by climatic variables (AUC = 0.91).
Climate risk category: LR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Parnassius mnemosyne (Linnaeus, 1758) – Clouded Apollo

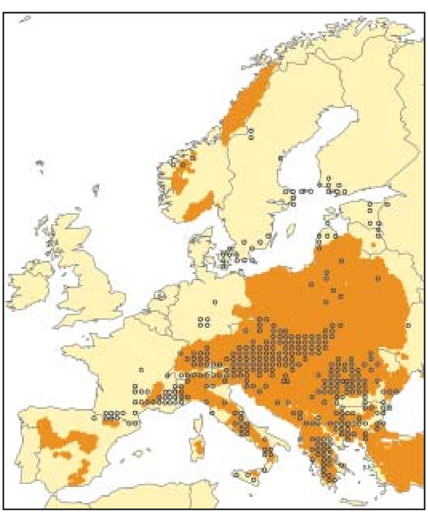
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-465 (-5.1%)	-2308 (-25.34%)
	BAMBU	-1793 (-19.68%)	-2980 (-32.71%)
	GRAS	-1983 (-21.77%)	-3222 (-35.37%)
2080	SEDG	-175 (-1.92%)	-4413 (-48.45%)
	BAMBU	-2536 (-27.84%)	-6269 (-68.82%)
	GRAS	-2163 (-23.75%)	-7025 (-77.12%)

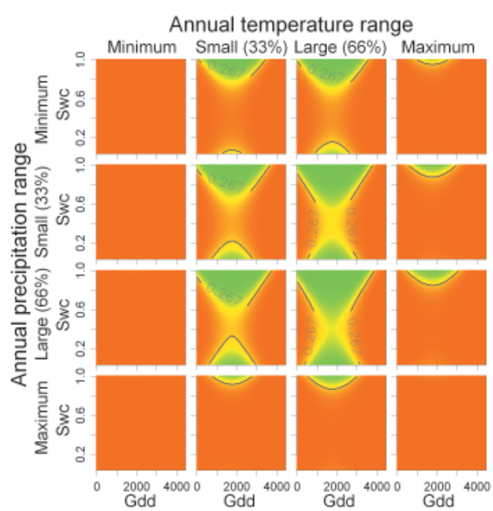
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 9109 cells)

The Clouded Apollo occurs in mountainous regions on damp to moderately dry grassland, usually with woodland or scrub in the neighbourhood. The butterflies can often be seen visiting red or purple flowers for the nectar they need. The foodplant is *Corydalis,* that at the time of egg laying is not yet above ground. The eggs are laid on its dried stems, on grass blades, or on other plants not too far from the foodplants. The egg hibernates. In the spring, as soon as it has released itself from the egg, the small caterpillar starts its search for a suitable foodplant. When fully-grown, it pupates in a closely spun cocoon of fine threads, situated above the ground in the leaves of the foodplant. The Clouded Apollo has one generation a year.
This species is listed in Annex IV of the Habitats' Directive.

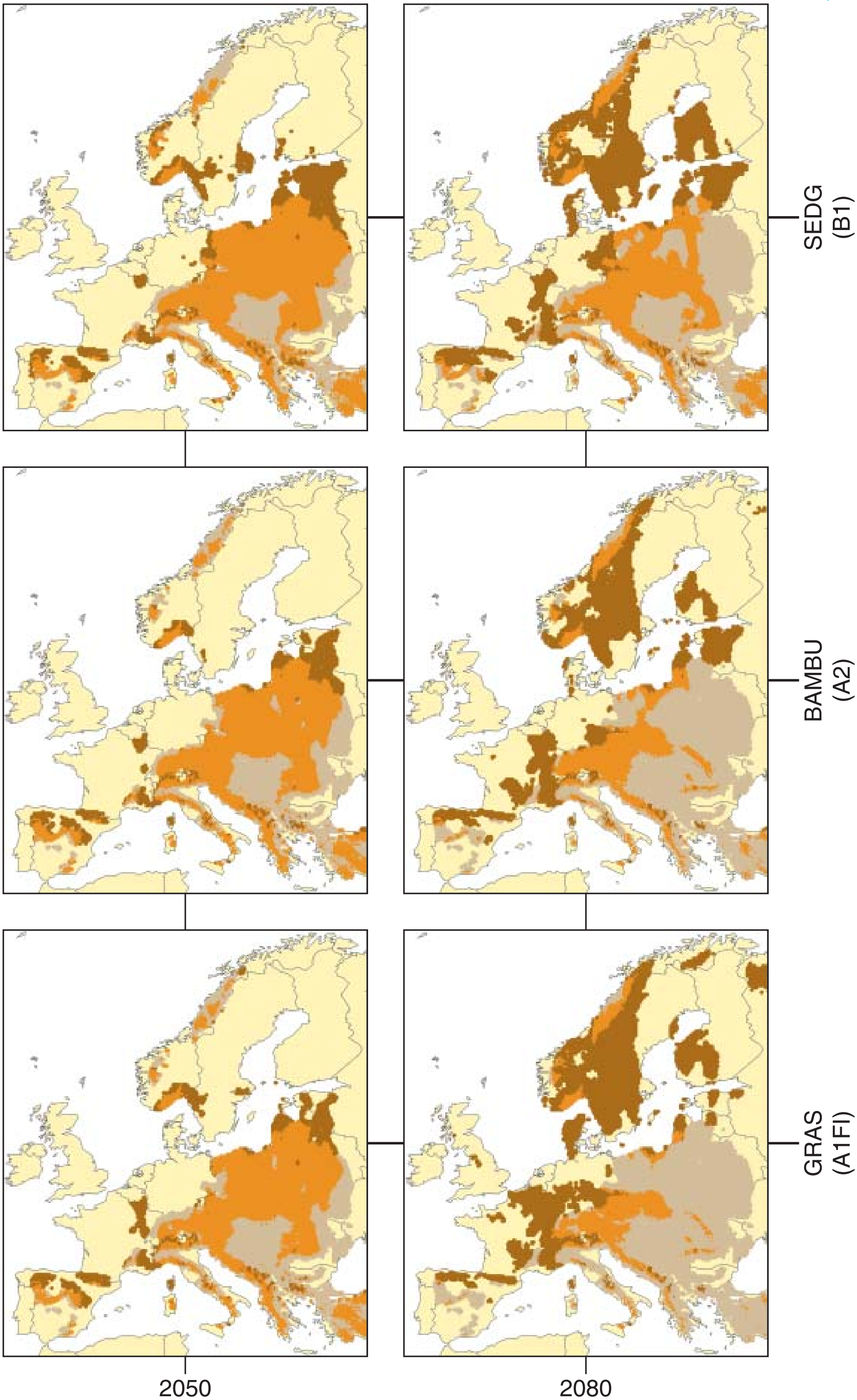
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.77).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG (B1)
BAMBU (A2)
GRAS (A1FI)
2050
2080

Parnassius phoebus (Fabricius, 1793) – Small Apollo

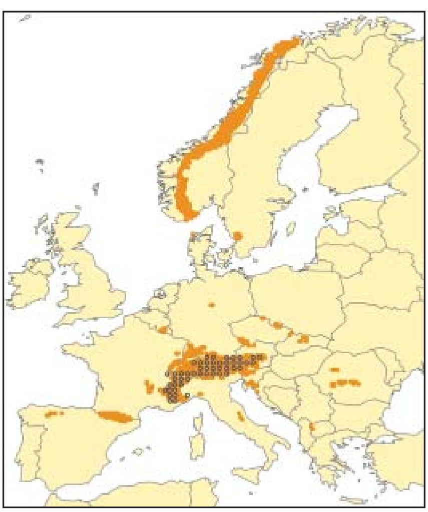
© Jostein Engdal

		Full dispersal	No dispersal
2050	SEDG	-275 (-24.71%)	-455 (-40.88%)
	BAMBU	-198 (-17.79%)	-388 (-34.86%)
	GRAS	-314 (-28.21%)	-488 (-43.85%)
2080	SEDG	-526 (-47.26%)	-755 (-67.83%)
	BAMBU	-364 (-32.7%)	-645 (-57.95%)
	GRAS	-574 (-51.57%)	-804 (-72.24%)

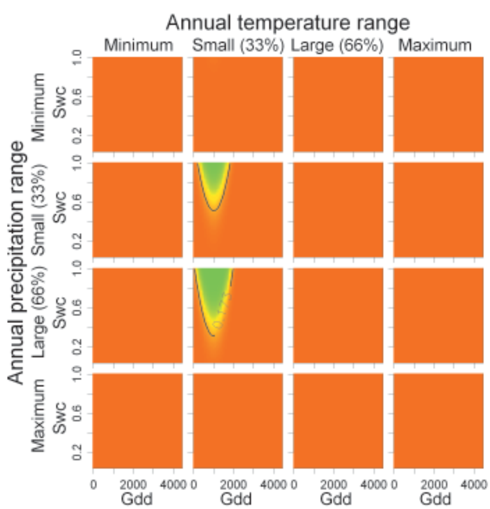
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1113 cells)

The Small Apollo occurs in the mountains, especially in damp places, such as beside streams and where it gets flooded from time to time. Such spots are the habitat of the larval food plant Yellow Mountain Saxifrage (*Saxifraga aizoides*). However, in the Mercantour in the south-west of the Alps, the foodplant is Roseroot (*Rhodiola roseum*). Although the eggs are sometimes laid on the foodplant, they are also often laid not far from it. The very small caterpillar sometimes passes the winter in the egg, sometimes outside it. The fully-grown caterpillars are black with a row of orange-red or yellow spots along each side. At the beginning of the summer, they spin a flimsy cocoon in which to pupate, either low down on the larval plant, or on the ground. The Small Apollo is single-brooded.

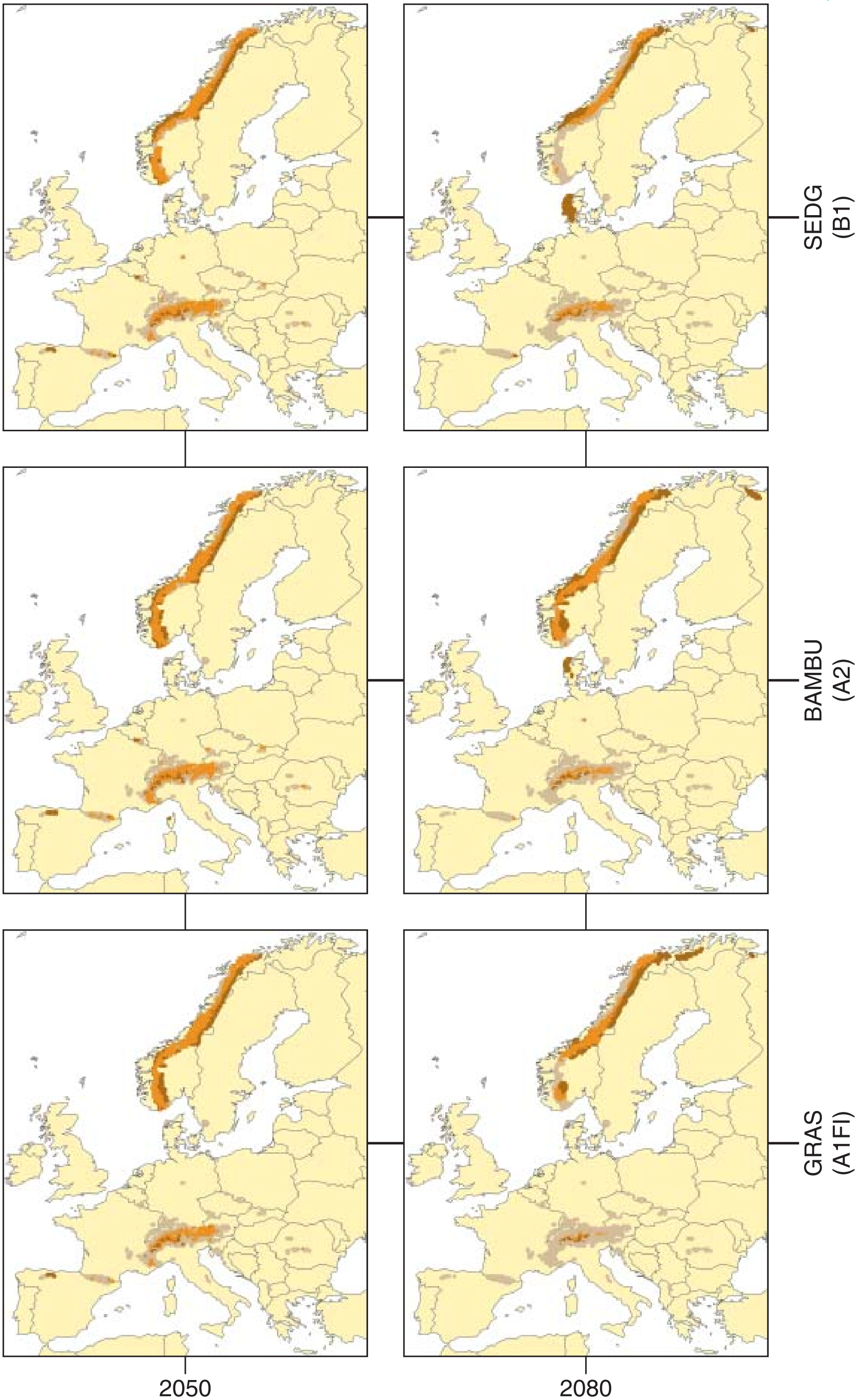
Present distribution can be very well explained by climatic variables (AUC = 0.99).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold



SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Parnassius apollo (Linnaeus, 1758) – Apollo

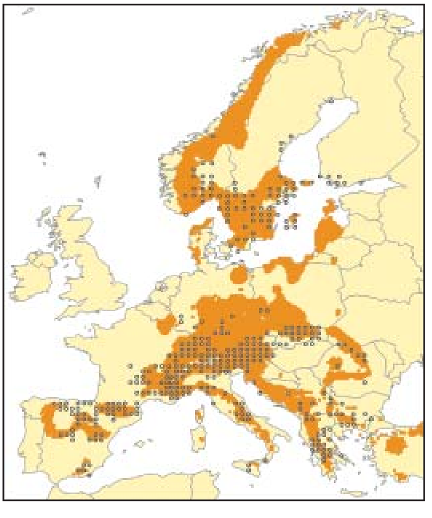
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-1887 (-30.08%)	-2568 (-40.94%)
	BAMBU	-2609 (-41.59%)	-3126 (-49.83%)
	GRAS	-2915 (-46.47%)	-3479 (-55.46%)
2080	SEDG	-2234 (-35.61%)	-3431 (-54.69%)
	BAMBU	-3319 (-52.91%)	-4177 (-66.59%)
	GRAS	-3972 (-63.32%)	-4758 (-75.85%)

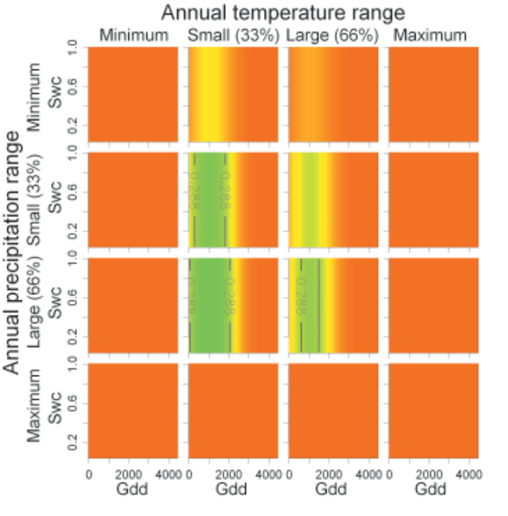
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 6273 cells)

The Apollo occurs in areas on steep, sunny slopes with sparse vegetation. In Europe, there are many different subspecies, forms and aberrations, because of the large isolation of populations. The butterflies are fond of visiting thistles and other flowering plants for their nectar. The female lays her eggs singly or in small groups on or near the foodplant stonecrop (*Sedum* spp.). The eggs develop but the tiny caterpillar hibernates inside the eggshell or as newly hatched larvae. It emerges in the spring, and starts feeding on the buds of the foodplant. The caterpillars of later instars also eat the leaves. When it is time to pupate, the caterpillars look for a safe place between the stones, where they then spin a flimsy cocoon for pupation. The Apollo is single-brooded.
This species is listed in Annex IV of the Habitats' Directive.

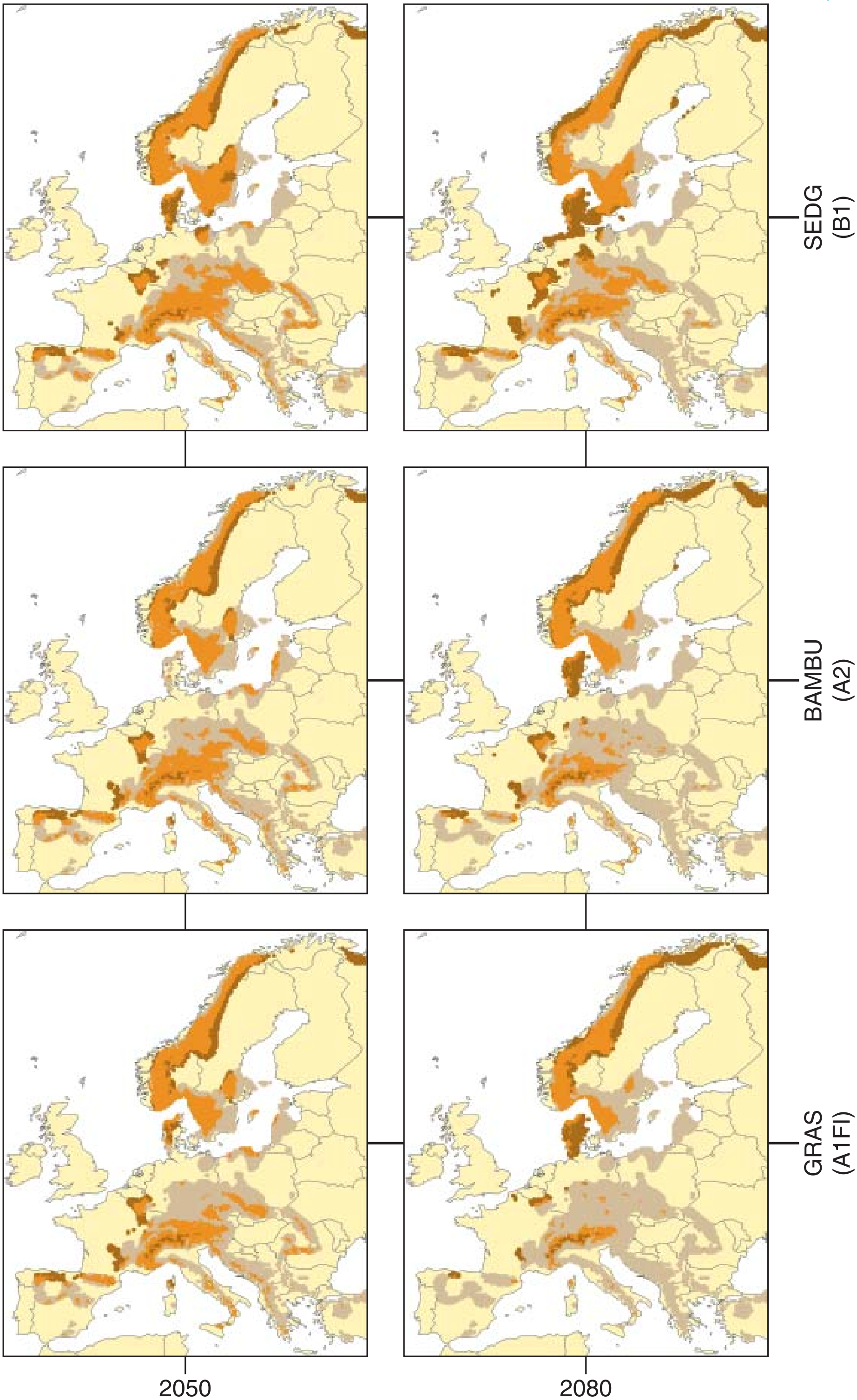
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.8).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Iphiclides podalirius (Linnaeus, 1758) – Scarce Swallowtail

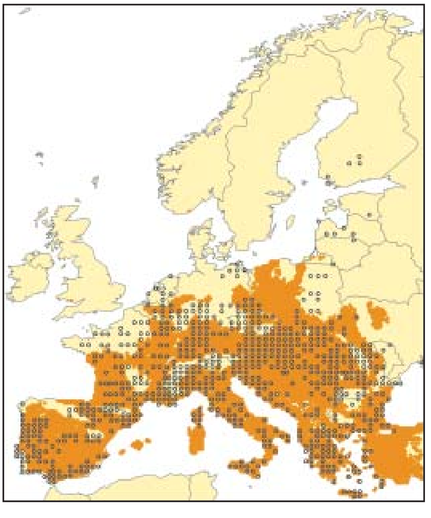
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	4099 (39.5%)	-483 (-4.65%)
	BAMBU	3818 (36.79%)	-852 (-8.21%)
	GRAS	3058 (29.47%)	-1226 (-11.81%)
2080	SEDG	4380 (42.2%)	-1186 (-11.43%)
	BAMBU	3105 (29.92%)	-3182 (-30.66%)
	GRAS	3433 (33.08%)	-4169 (-40.17%)

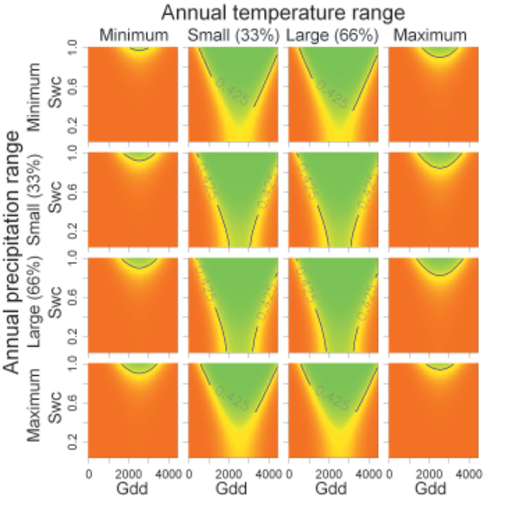
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 10378 cells)

This large, conspicuous butterfly with its elegant gliding flight, is very impressive. It occurs in warm, dry places with scrub and rough vegetation. The males of the Scarce Swallowtail congregate on hilltops, dancing in the air and waiting for the females, a type of behaviour known as "hill-topping". They visit thistles and other flowers rich in nectar. The eggs are laid on the leaves of small bushes or trees of Blackthorn (*Prunus spinosa*) and other species of *Prunus*. The caterpillars feed on the leaves. When fully-grown, they pupate, the pupa suspended in a silken girdle in the foodplant. Depending on its position in the range and on the altitude, the Scarce Swallowtail has one to three generations a year.

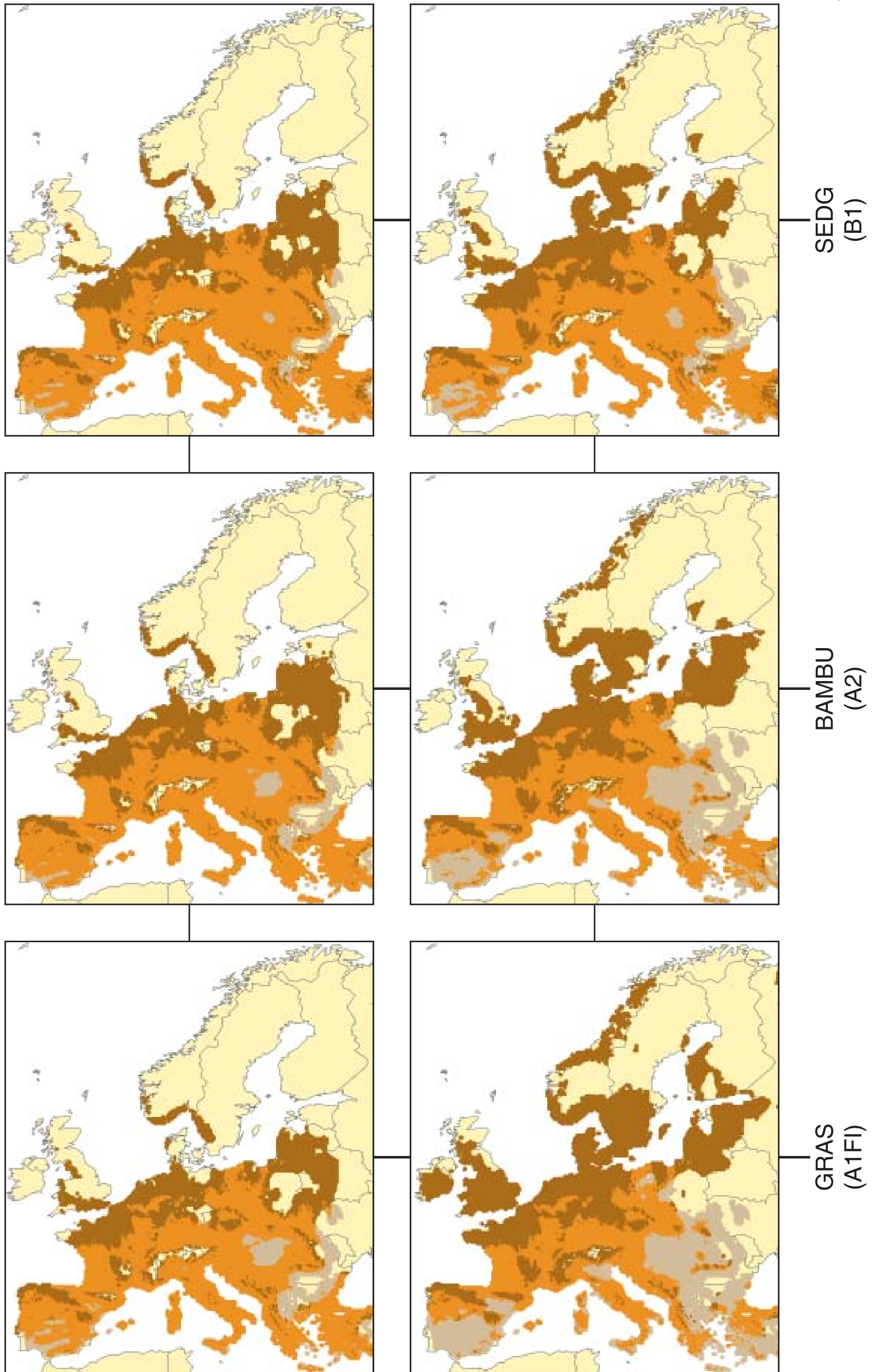
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.76).
Climate risk category: LR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Papilio machaon Linnaeus, 1758 – Swallowtail

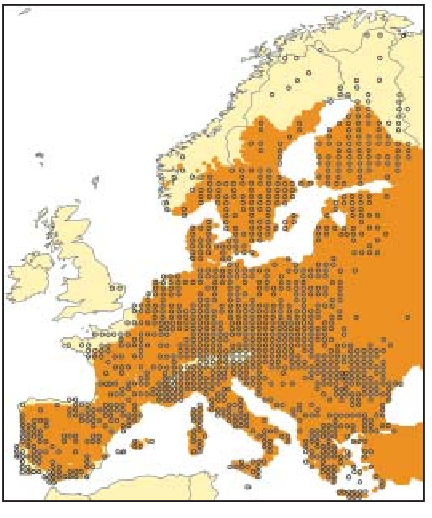
© Peter Ginzinger

		Full dispersal	No dispersal
2050	SEDG	1744 (8.18%)	-449 (-2.1%)
	BAMBU	1206 (5.65%)	-428 (-2.01%)
	GRAS	1346 (6.31%)	-742 (-3.48%)
2080	SEDG	2637 (12.36%)	-809 (-3.79%)
	BAMBU	1066 (5%)	-2547 (-11.94%)
	GRAS	227 (1.06%)	-4167 (-19.53%)

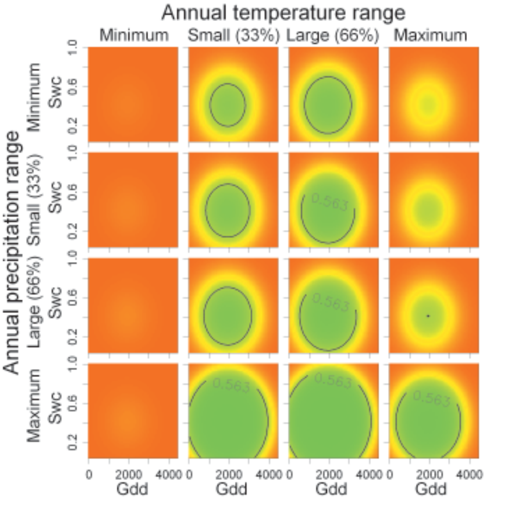
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 21332 cells)

The Swallowtail is a species of flower-rich meadows and small-scale farmland. The males and females meet at elevated places or above high trees, showing a type of behaviour known as "hill-topping". The butterfly of the Swallowtail needs a lot of nectar. Eggs are laid on various umbellifers, including Wild Carrot (*Daucus carota*). The fully-grown larvae are very conspicuous, bright green with black stripes and orange spots. Caterpillars from autumn broods leave the foodplant to pupate on the ground and hibernation takes place as a pupa. The caterpillars of the summer broods pupate low down on the larval foodplant. Depending on geographic setting, the Swallowtail produces one to three generations a year.

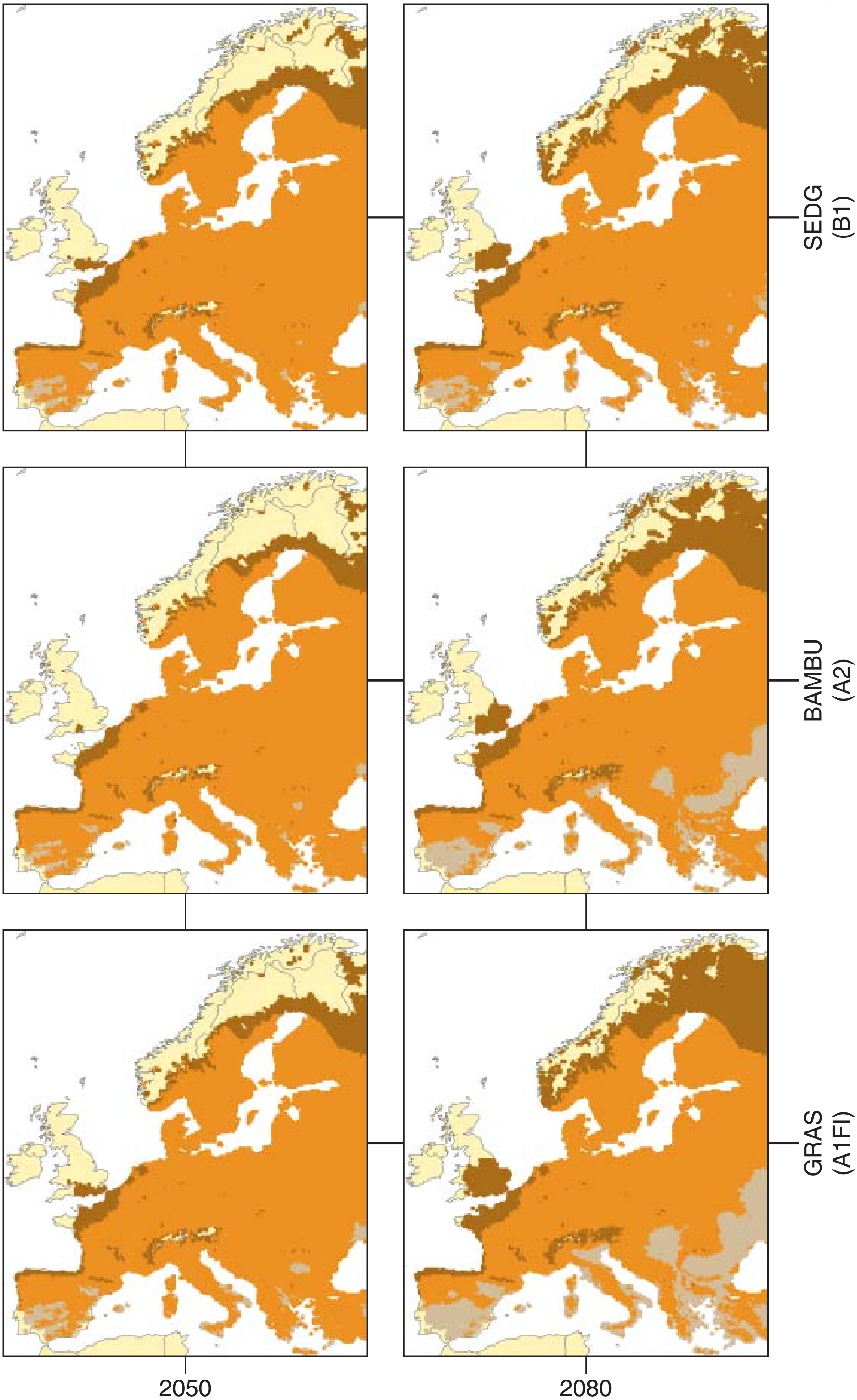
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.67). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

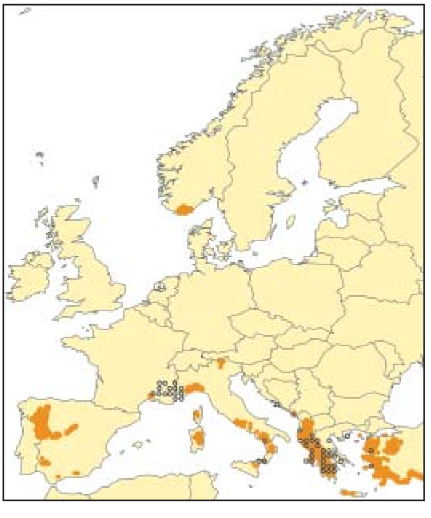
Papilio alexanor ESPER, 1799 – Southern Swallowtail

		Full dispersal	No dispersal
2050	SEDG	-224 (-32.61%)	-404 (-58.81%)
	BAMBU	-277 (-40.32%)	-436 (-63.46%)
	GRAS	-278 (-40.47%)	-454 (-66.08%)
2080	SEDG	-257 (-37.41%)	-455 (-66.23%)
	BAMBU	-380 (-55.31%)	-534 (-77.73%)
	GRAS	-462 (-67.25%)	-592 (-86.17%)

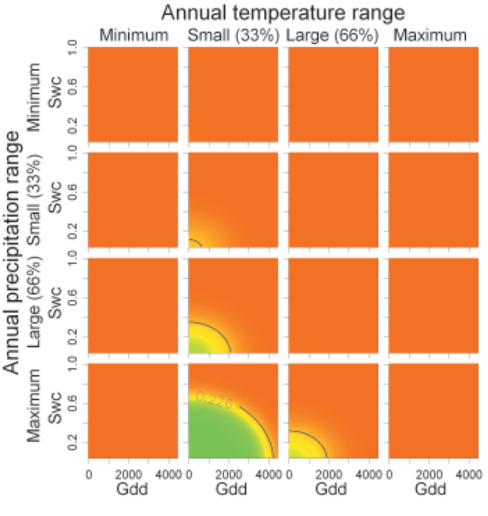
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 687 cells)

The Southern Swallowtail is mostly found on warm, dry calcareous slopes with a flower-rich vegetation and low-growing bushes. They prefer slopes that are steep and rocky. Different foodplants are known, all of them umbellifers. *Ptychotis saxifraga* is the most important one in the western part of its range, but eggs are also laid on *Opopanax chironium, Seseli montanum,* and *Trinia glauca*. In the eastern part, the caterpillars feed mostly on various of fennels (*Ferula* spp.), and also on *Opopanax hispidus*, Burnet saxifrage (*Pimpinella saxifraga*), *Scaligeria cretica*, and Wild Parsnip (*Pastinaca sativa*). The caterpillars eat the flowers and ripening seeds. The Southern Swallowtail is single-brooded and passes the winter in the pupa stage.
This species is listed in Annex IV of the Habitats’ Directive.

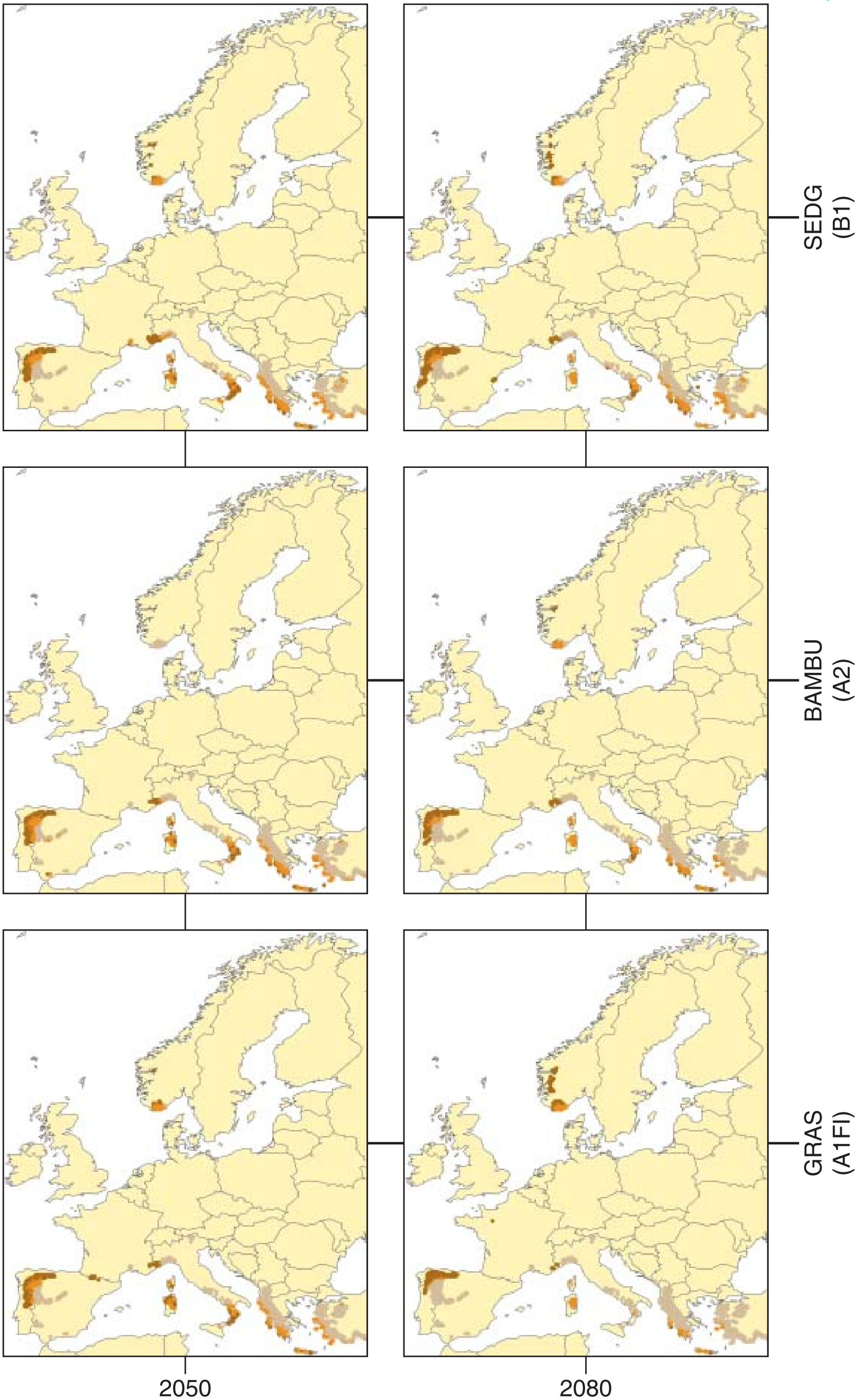
Present distribution can be well explained by climatic variables (AUC = 0.94).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Leptidea sinapis (Linnaeus, 1758) / *reali* Reissinger, 1990 (complex) – Wood White

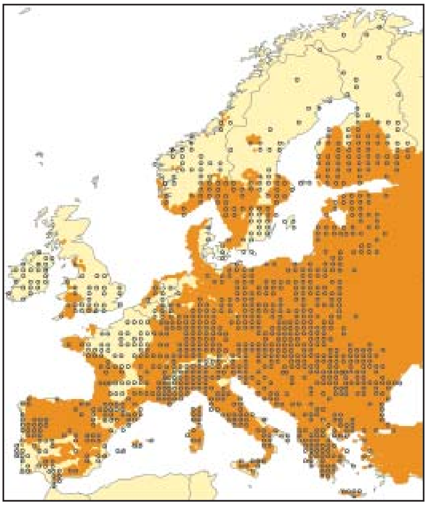
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	1829 (10.09%)	-2394 (-13.21%)
	BAMBU	236 (1.3%)	-2733 (-15.08%)
	GRAS	97 (0.54%)	-3575 (-19.72%)
2080	SEDG	2744 (15.14%)	-3709 (-20.46%)
	BAMBU	1117 (6.16%)	-5664 (-31.25%)
	GRAS	795 (4.39%)	-7192 (-39.68%)

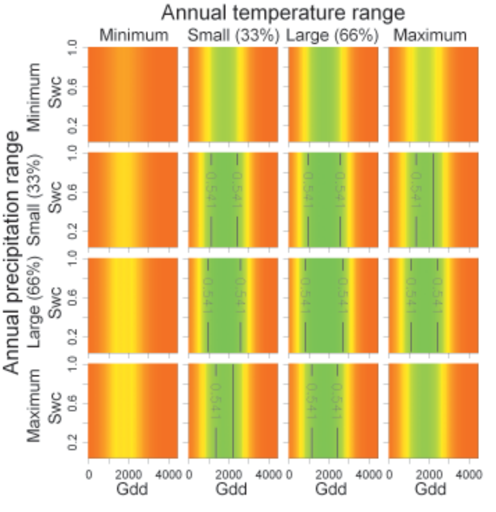
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 18126 cells)

At present, the Wood White is divided into two species, *L. sinapis* (Linnaeus, 1758) and *L. reali* Reissinger, 1990, which are indistinguishable in the field. Their distribution is not yet entirely clear. Their life cycles are similar. These fragile butterflies occur on damp, warm grassland near bushes and scrub. They lay their thin, spindle-shaped eggs on different sorts of *Lathyrus* and birdsfoot-trefoil (*Lotus* spp.). Cream, turning to bright yellow as they mature, they are easy to find. The pupa is pale-green, and the winter is spent in this stage. In the north of its range, it is single-brooded, but in the middle it has two generations a year, and in the south sometimes three.

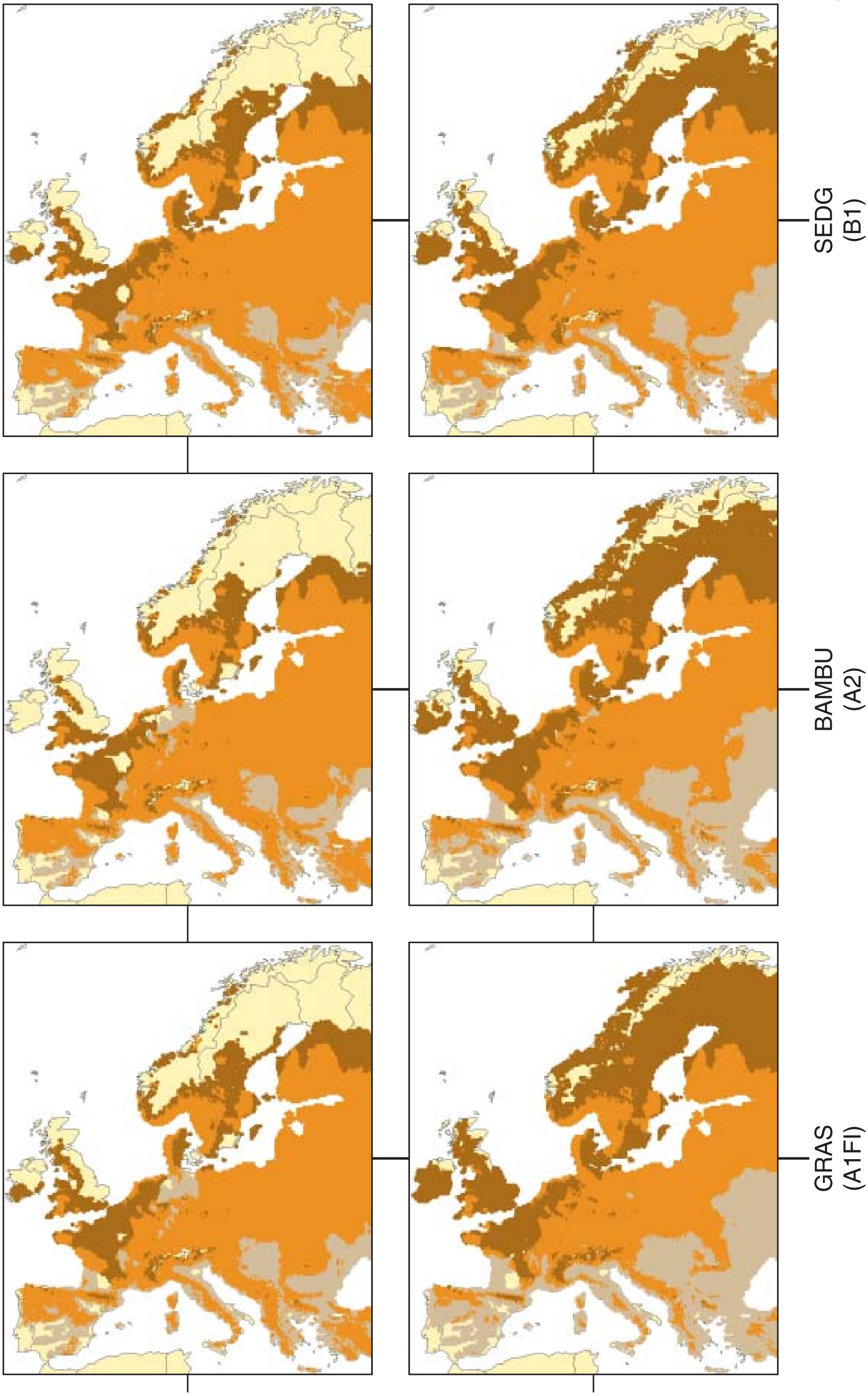
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.63). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Leptidea duponcheli (Staudinger, 1871) – Eastern Wood White

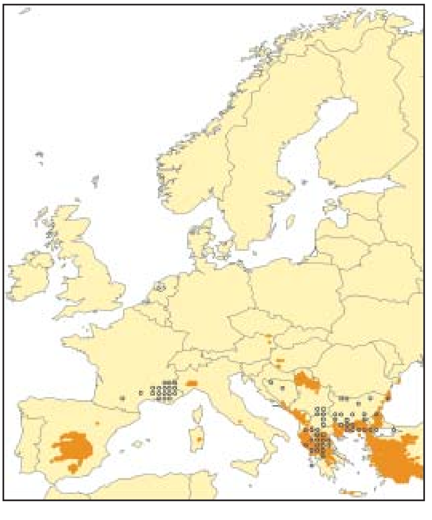
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	221 (19.79%)	-712 (-63.74%)
	BAMBU	-186 (-16.65%)	-812 (-72.69%)
	GRAS	22 (1.97%)	-856 (-76.63%)
2080	SEDG	32 (2.86%)	-782 (-70.01%)
	BAMBU	-628 (-56.22%)	-1009 (-90.33%)
	GRAS	-594 (-53.18%)	-1066 (-95.43%)

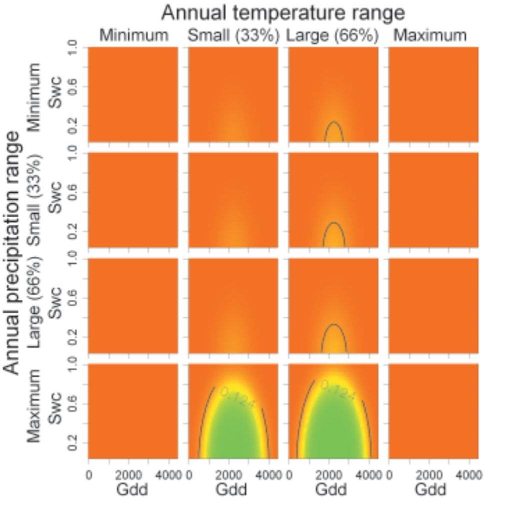
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1117 cells)

The Eastern Wood White occurs on dry grassland, often where scattered trees or bushes are growing, and also in open woods. It is found on both calcareous and non-calcareous soils. The habitats of the Eastern Wood White are drier and warmer than those of the Wood White (*L. sinapis* complex).
The eggs are laid on the leaves of Meadow Vetchling (*Lathyrus pratensis*), Yellow Vetchling (*L. aphaca*) and birdsfoot-trefoils (*Lotus* spp.), mostly on plants growing in the shade. The caterpillars feed on the leaves of the foodplant. The Eastern Wood White is double-brooded and hibernates in the pupal stage.

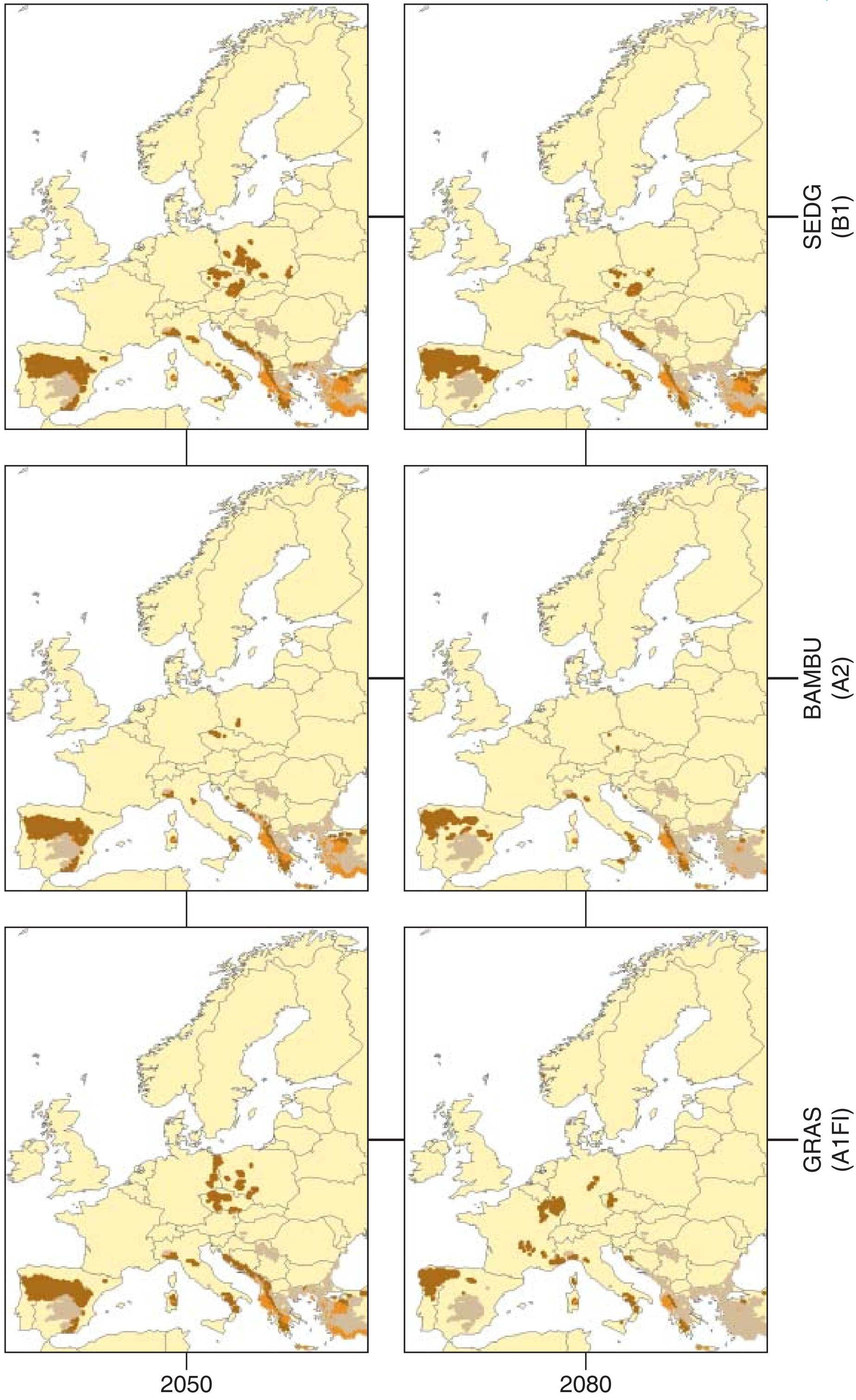
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.69). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold



SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Leptidea morsei (Fenton, 1881) – Fenton's Wood White

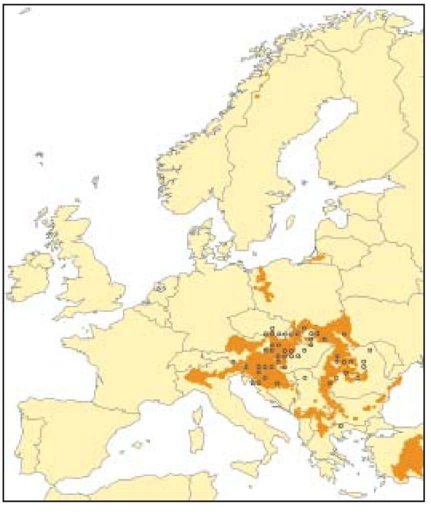
© Helmut Höttinger

		Full dispersal	No dispersal
2050	SEDG	188 (12%)	-1154 (-73.64%)
	BAMBU	761 (48.56%)	-988 (-63.05%)
	GRAS	370 (23.61%)	-893 (-56.99%)
2080	SEDG	293 (18.7%)	-1416 (-90.36%)
	BAMBU	196 (12.51%)	-1328 (-84.75%)
	GRAS	-133 (-8.49%)	-1198 (-76.45%)

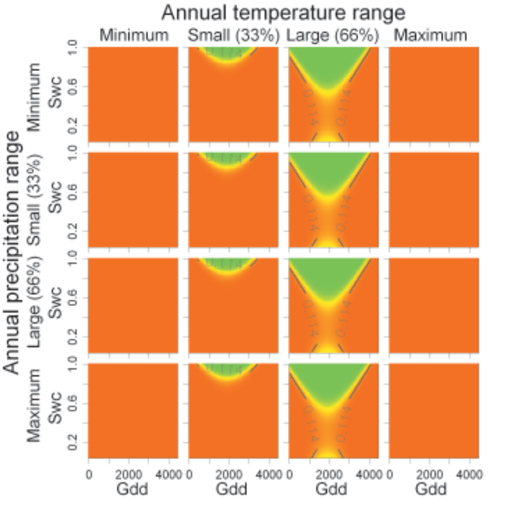
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1567 cells)

Apart from its greater size and slightly falcate forewings the species can be separated from the other Wood Whites by conspicuous gliding flight sometimes displayed by males. The habitat of Fenton's Wood White is almost exclusively highly structured deciduous woodland. The only confirmed food plant of this species in Europe is Black Pea (*Lathyrus niger*). This butterfly is double-brooded and hibernates in the pupal stage.
This species is listed in Annexes II and IV of the Habitats' Directive.

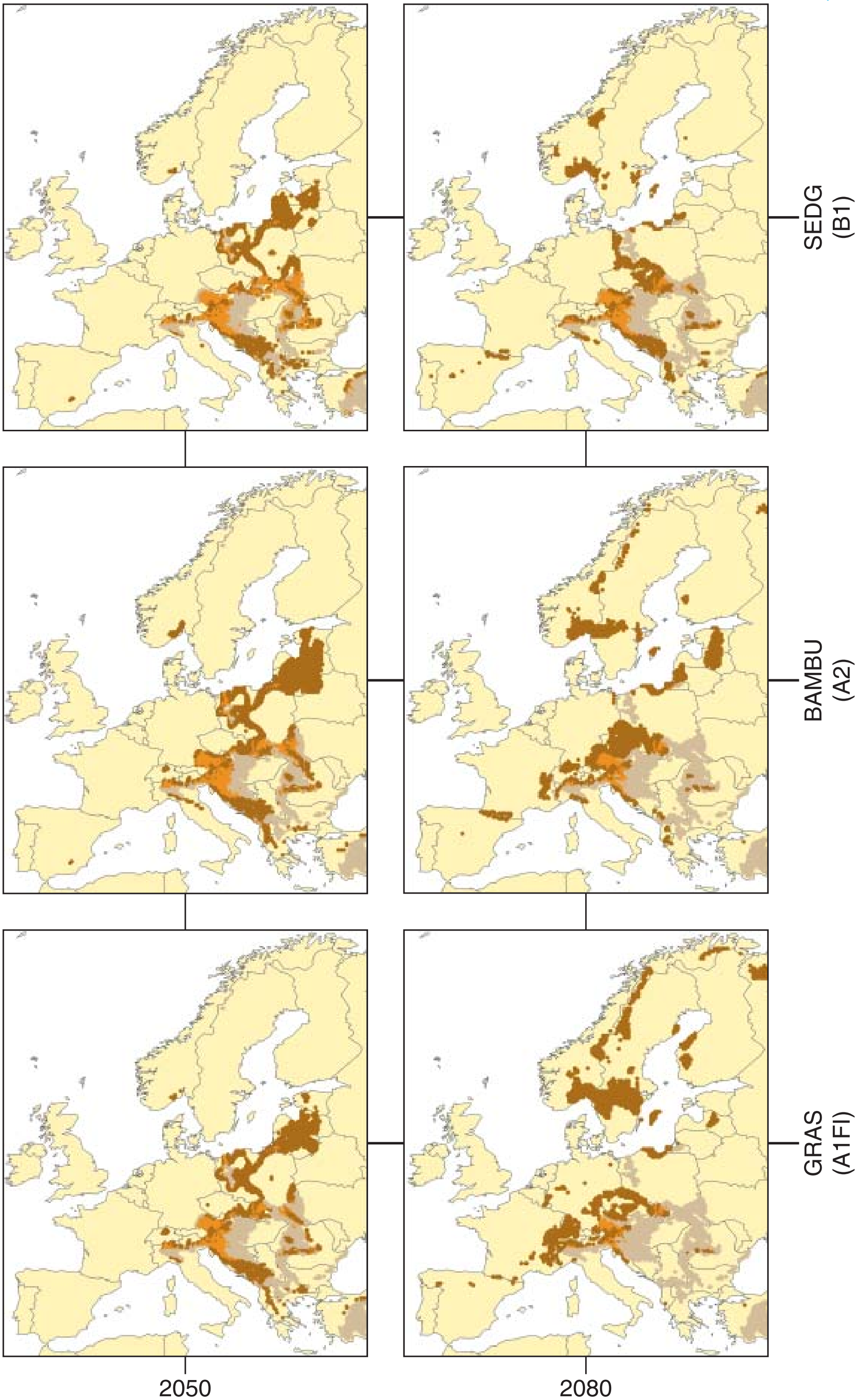
Present distribution can be well explained by climatic variables (AUC = 0.92).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG (B1)
BAMBU (A2)
GRAS (A1FI)
2050
2080

Anthocharis cardamines (Linnaeus, 1758) – Orange-tip

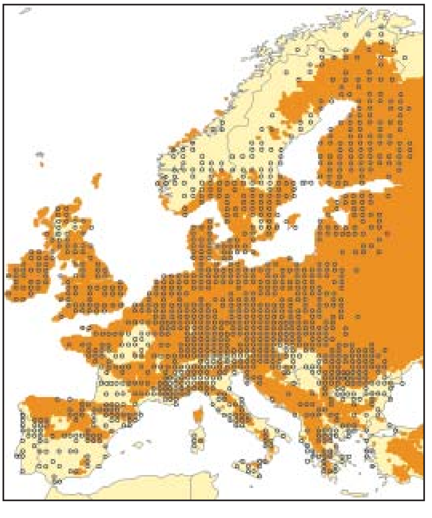
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-1416 (-7.53%)	-3168 (-16.86%)
	BAMBU	-2021 (-10.75%)	-3707 (-19.72%)
	GRAS	-2928 (-15.58%)	-4787 (-25.47%)
2080	SEDG	-2159 (-11.49%)	-4447 (-23.66%)
	BAMBU	-4765 (-25.35%)	-7476 (-39.78%)
	GRAS	-6918 (-36.81%)	-10040 (-53.42%)

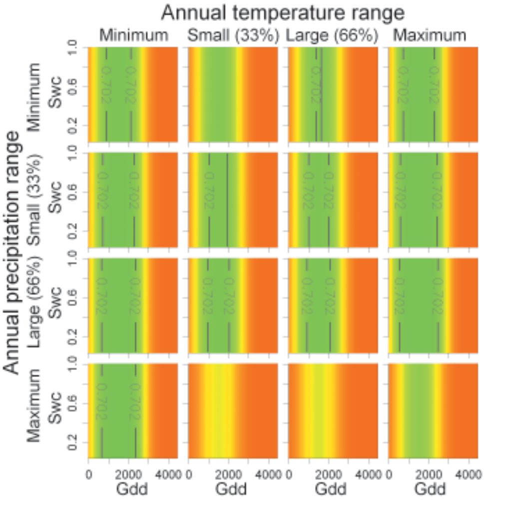
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 18795 cells)

In Western Europe, the first Orange-tip gives us the feeling that spring has arrived. However, high in the mountains, these butterflies only appear in early summer. The Orange-tip occurs in damp to quite wet grasslands at the edge of woods, or near thickets. The eggs are laid singly on flowerheads of different crucifers. At first, the caterpillars feed on the flowerbuds of the foodplant and later on the fruits. They live alone, which accords with their cannibalistic nature. When ready to pupate, they move into rough vegetation, climbing up a little twig and turning into an attractive light-brown pupa, suspended from the plant by a silken girdle. The Orange-tip hibernates in this stage and has one generation a year.

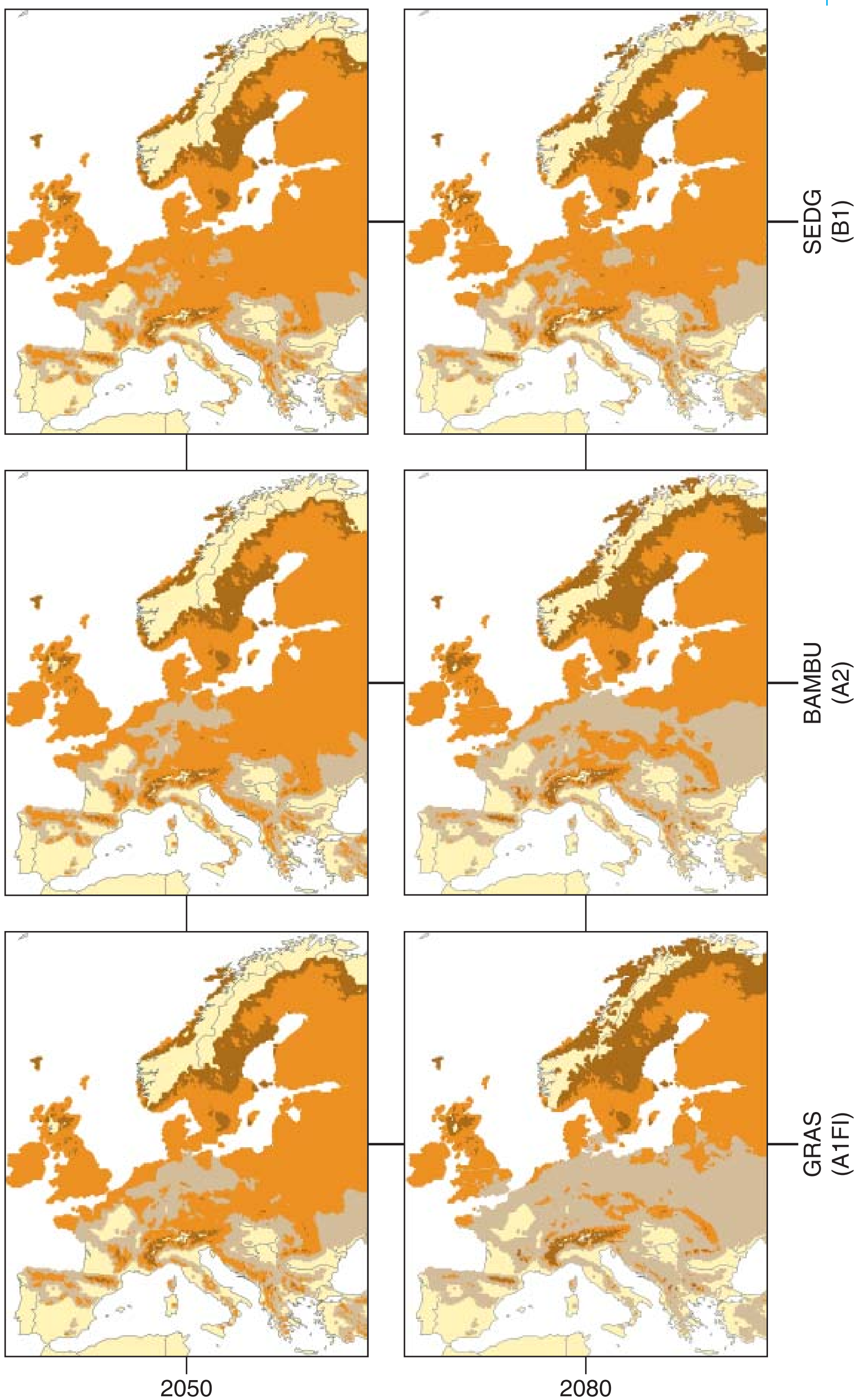
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.7).
Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Anthocharis euphenoides Staudinger, 1869

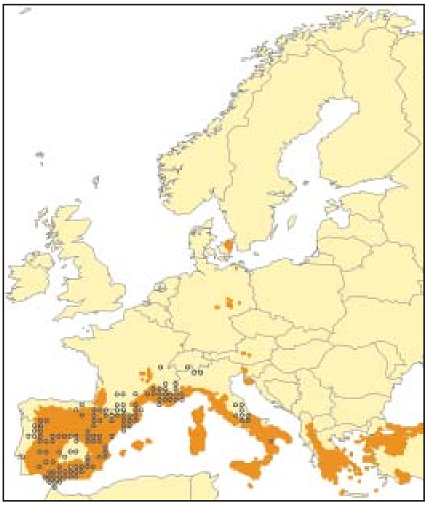
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-989 (-33.3%)	-1744 (-58.72%)
	BAMBU	-1299 (-43.74%)	-1763 (-59.36%)
	GRAS	-1374 (-46.26%)	-2012 (-67.74%)
2080	SEDG	-1313 (-44.21%)	-2309 (-77.74%)
	BAMBU	-1948 (-65.59%)	-2614 (-88.01%)
	GRAS	-1956 (-65.86%)	-2887 (-97.21%)

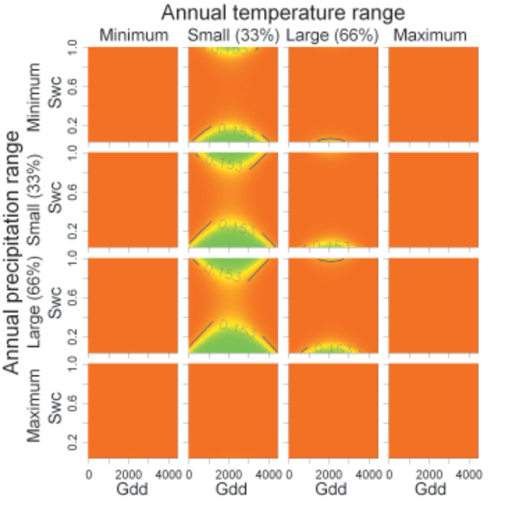
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 2970 cells)

This butterfly inhabits warm, dry places with flower-rich, grassy vegetation and scattered bushes. Eggs are laid one by one on the flowerbuds of various crucifers, such as the buckler mustards *Biscutella laevigata* and *B. auriculata,* London Rocket (*Sisymbrium irio*), and Hedge Mustard (*S. officinale*). The caterpillars feed mainly on ovaries, but at times are also cannibalistic. This species hibernates as a pupa and has one generation a year.

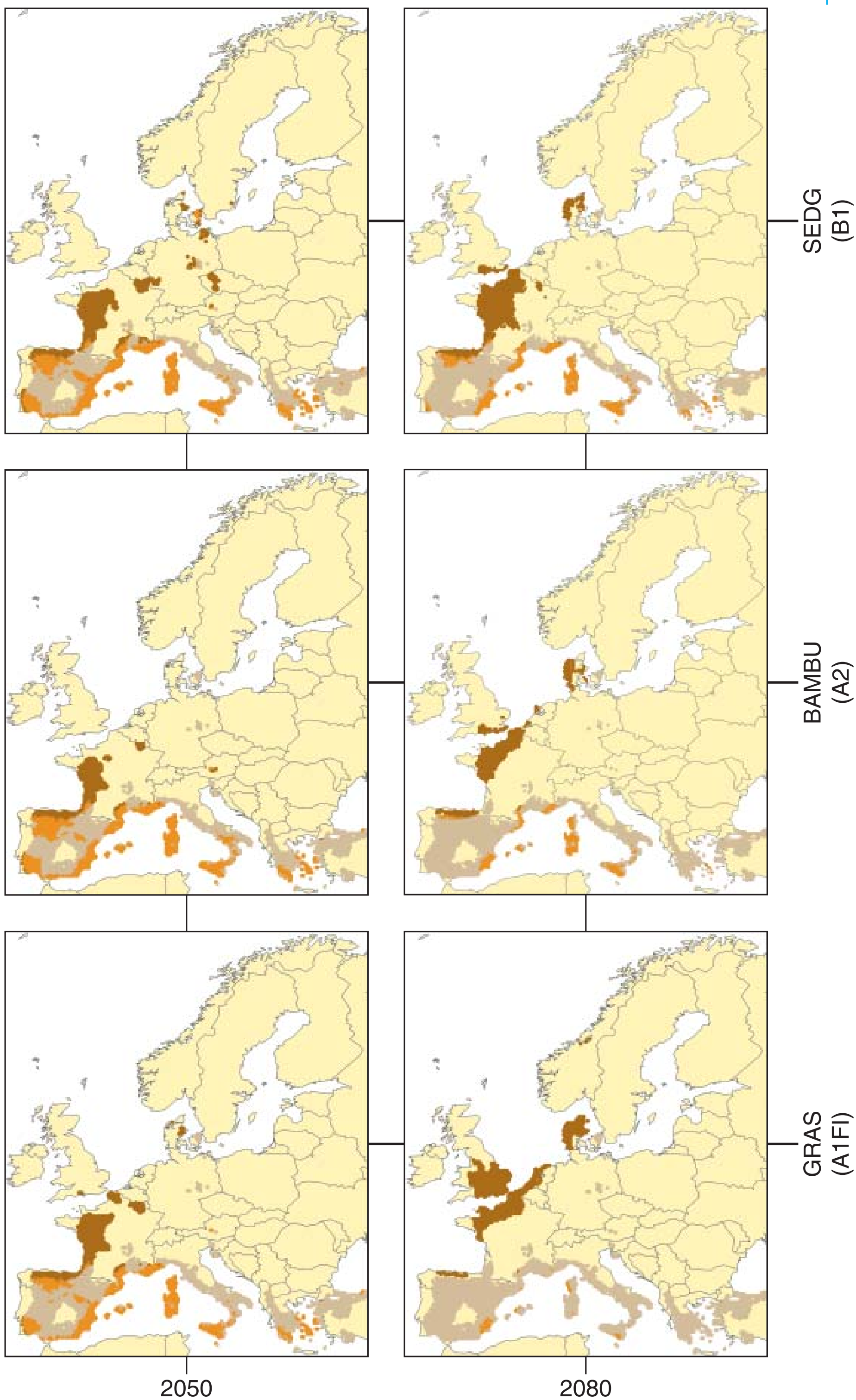
Present distribution can be well explained by climatic variables (AUC = 0.91).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

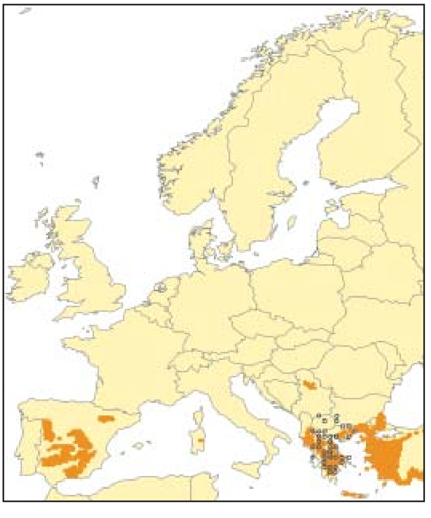
Anthocharis gruneri Herrich-Schäffer, 1851 – Gruner's Orange-tip

		Full dispersal	No dispersal
2050	SEDG	-266 (-26.68%)	-613 (-61.48%)
	BAMBU	-330 (-33.1%)	-648 (-64.99%)
	GRAS	-356 (-35.71%)	-696 (-69.81%)
2080	SEDG	-224 (-22.47%)	-695 (-69.71%)
	BAMBU	-666 (-66.8%)	-888 (-89.07%)
	GRAS	-773 (-77.53%)	-971 (-97.39%)

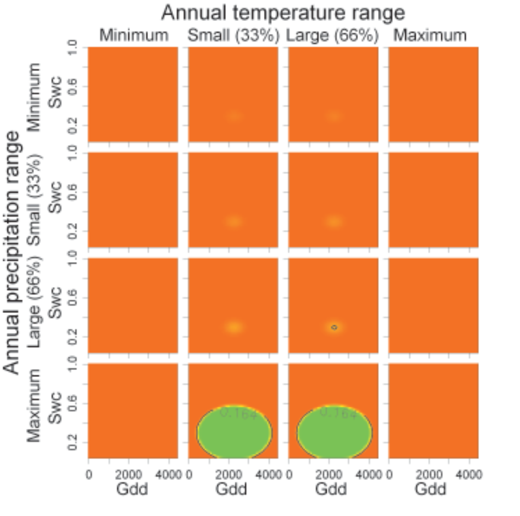
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 997 cells)

Gruner's Orange-tip lives on dry, open grasslands, on rocky, often calcareous slopes, scrub and clearings in dry woodland. The eggs are laid on *Aethionema* species, including Burnt Candytuft (*A. saxatile*) and *A. orbiculatum*, the caterpillars eating both the leaves and ripening seeds. It is single-brooded and the pupa hibernates.

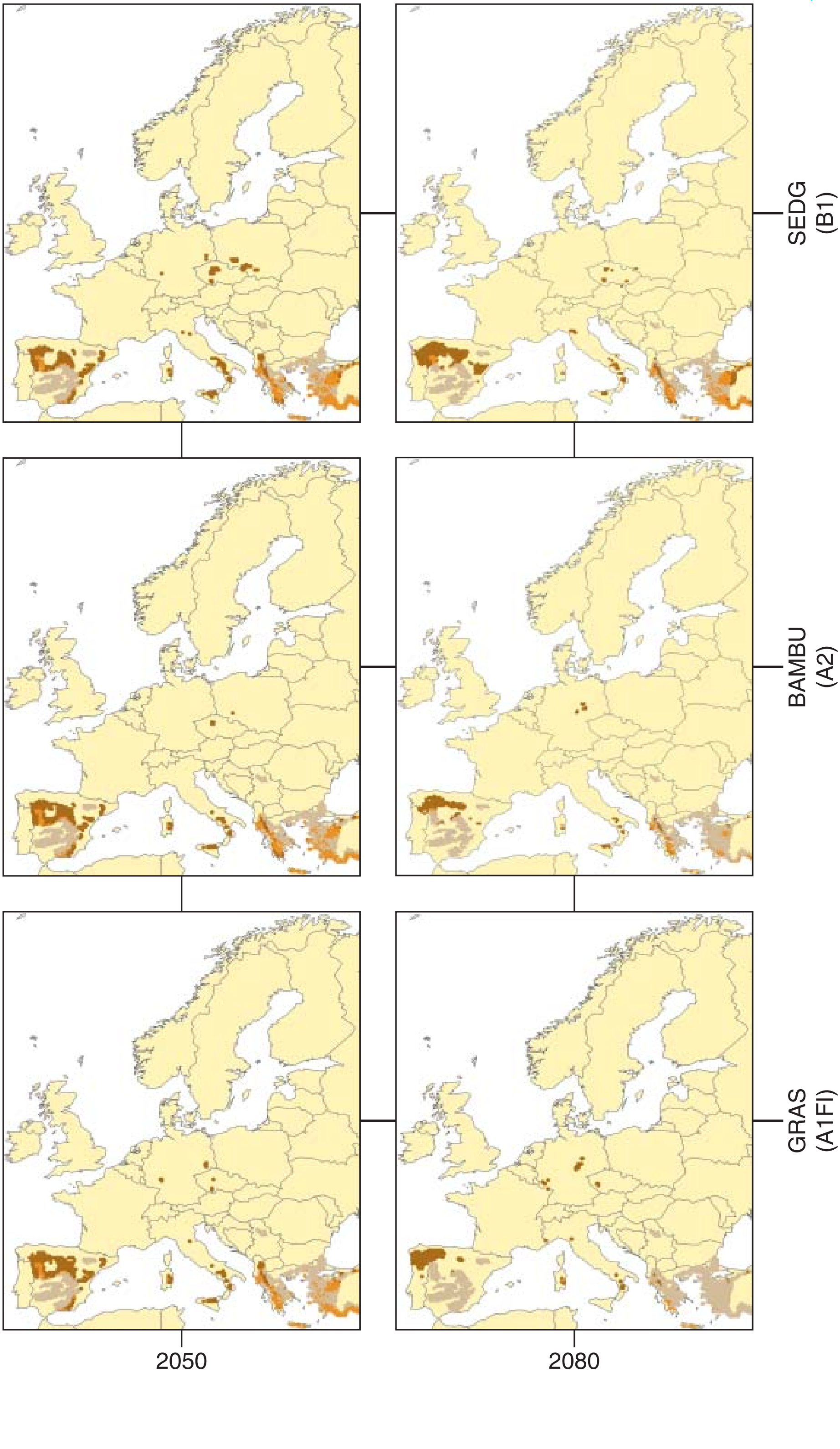
Present distribution can be well explained by climatic variables (AUC = 0.92).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Zegris eupheme (Esper, 1805) – Sooty Orange-tip

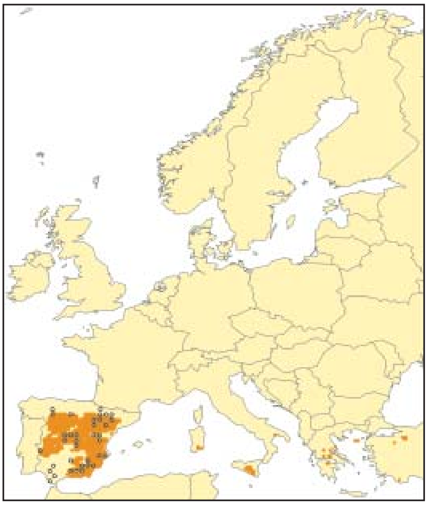
© Neil Thompson

		Full dispersal	No dispersal
2050	SEDG	-411 (-47.9%)	-520 (-60.61%)
	BAMBU	-536 (-62.47%)	-562 (-65.5%)
	GRAS	-456 (-53.15%)	-580 (-67.6%)
2080	SEDG	-765 (-89.16%)	-766 (-89.28%)
	BAMBU	-837 (-97.55%)	-837 (-97.55%)
	GRAS	-849 (-98.95%)	-849 (-98.95%)

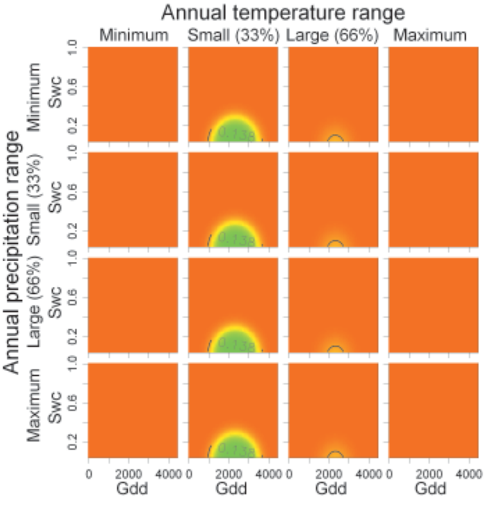
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 858 cells)

The Sooty Orange-tip is mostly seen in dry, flower-rich places, waste ground, and abandoned agricultural land. Crucifers, such as London Rocket (*Sisymbrium irio*), the buckler mustard *Biscutella auriculata*, Hoary Mustard (*Hirschfeldia incana*), and radishes (*Raphanus* spp.), are usually abundant in its habitat. They are used by the butterflies for their nectar and as larval foodplants. The butterflies have a quick, zigzagging flight. The Sooty Orange-tip hibernates as a pupa. This pupal stage may last for one, two, or three years. It is single-brooded.

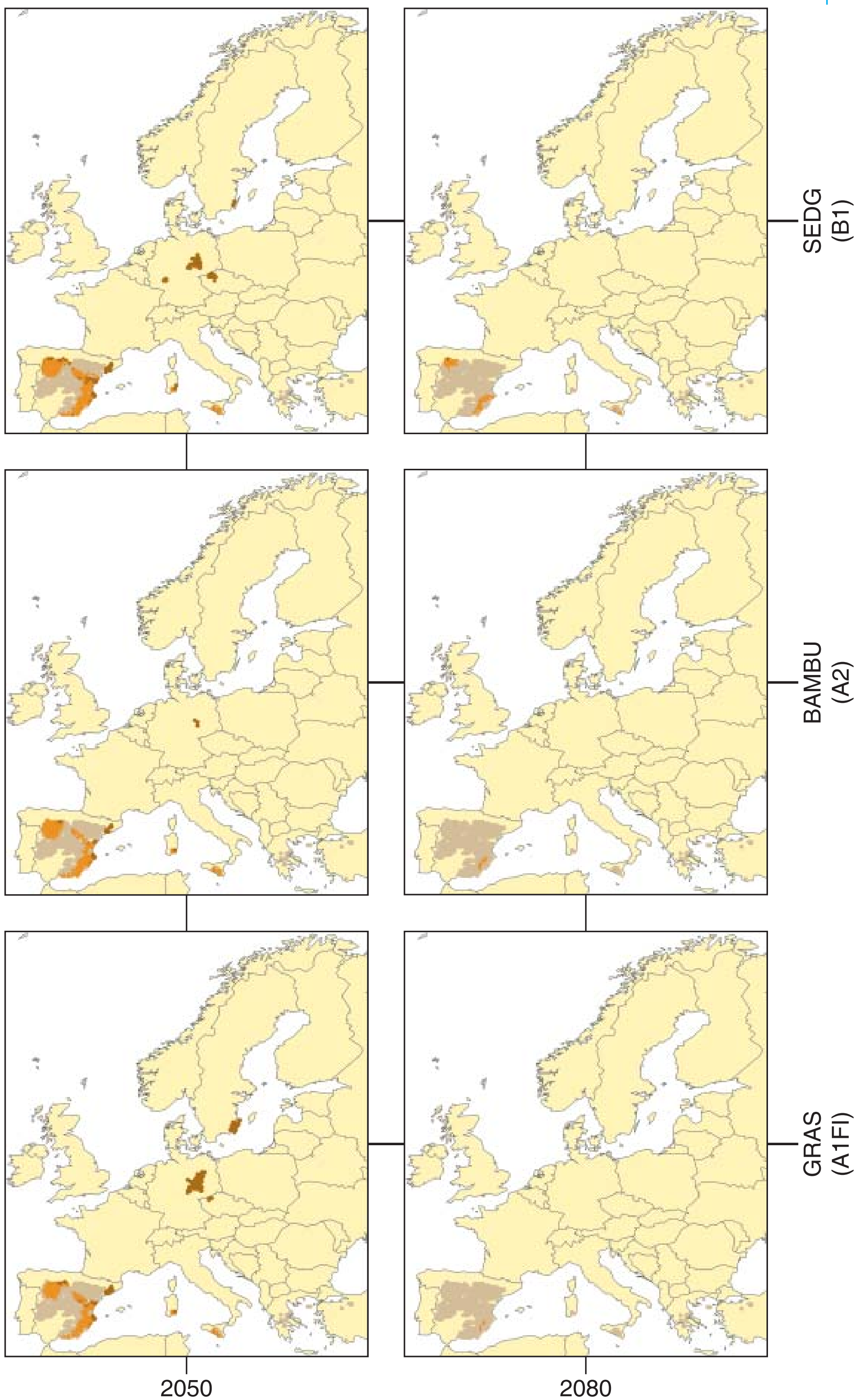
Present distribution can be very well explained by climatic variables (AUC = 0.97).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Euchloe belemia (Esper, 1798) – Green-striped White

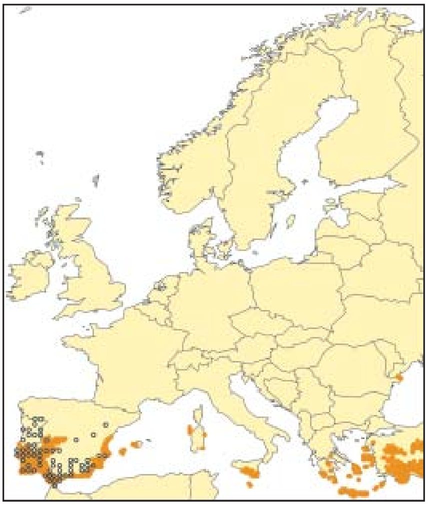
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-289 (-41.58%)	-377 (-54.24%)
	BAMBU	-424 (-61.01%)	-432 (-62.16%)
	GRAS	-400 (-57.55%)	-446 (-64.17%)
2080	SEDG	-338 (-48.63%)	-495 (-71.22%)
	BAMBU	-607 (-87.34%)	-626 (-90.07%)
	GRAS	-649 (-93.38%)	-670 (-96.4%)

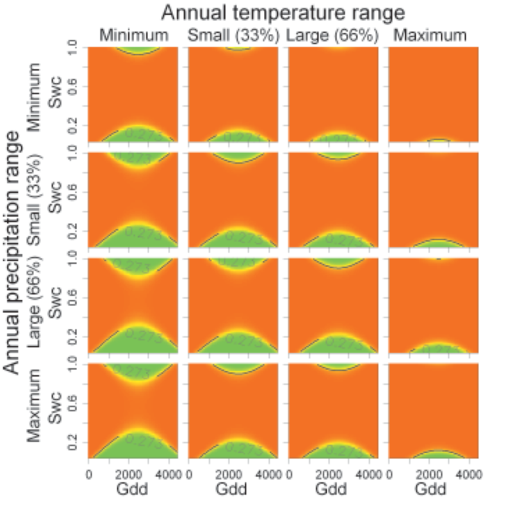
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 695 cells)

The Green-striped White occurs in flower-rich places, between bushes, on waste ground, and on abandoned agricultural land. It occurs locally, but can be numerous in its flight area. The butterfly flies quickly and close to the ground. The caterpillars eat the ripening seeds of different crucifers, such as the buckler mustard *Biscutella auriculata*, candytufts (*Iberis* spp.) including Annual Candytuft (*I. amara*), and rockets (*Sisymbrium* spp.). The Green-striped White has two broods a year in the spring, and passes the winter as a pupa.

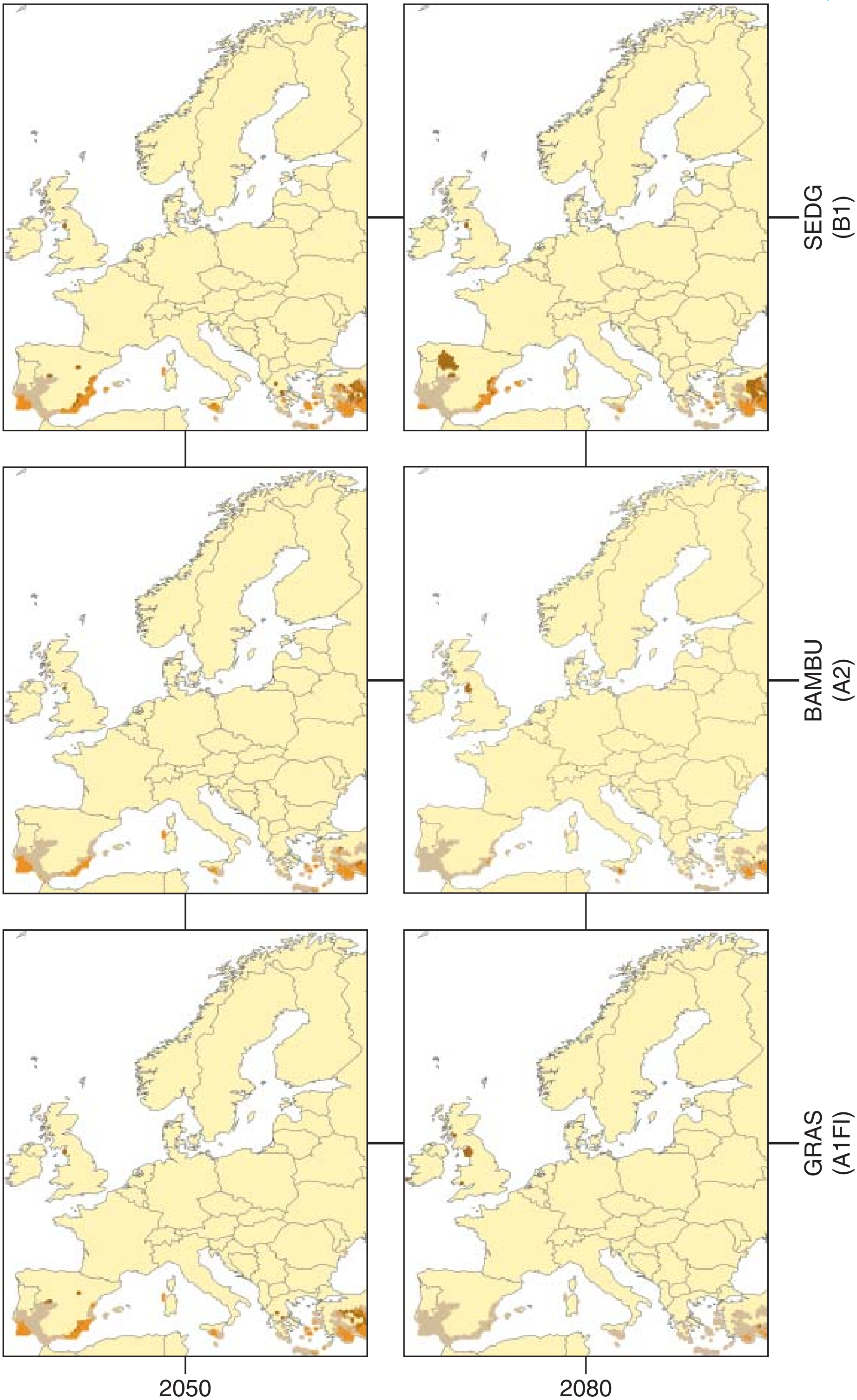
Present distribution can be very well explained by climatic variables (AUC = 0.96).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Euchloe ausonia (Hübner, 1806) (complex) – Dappled White

© Chris van Swaay

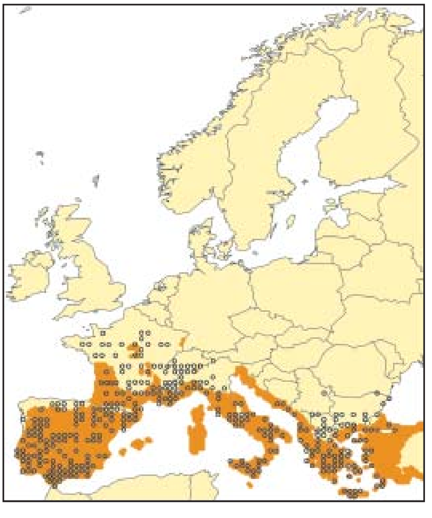
		Full dispersal	No dispersal
2050	SEDG	742 (16.55%)	-802 (-17.89%)
	BAMBU	-91 (-2.03%)	-1080 (-24.09%)
	GRAS	586 (13.07%)	-1029 (-22.95%)
2080	SEDG	338 (7.54%)	-1439 (-32.1%)
	BAMBU	-327 (-7.29%)	-2058 (-45.91%)
	GRAS	-265 (-5.91%)	-2472 (-55.14%)

Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 4483 cells)

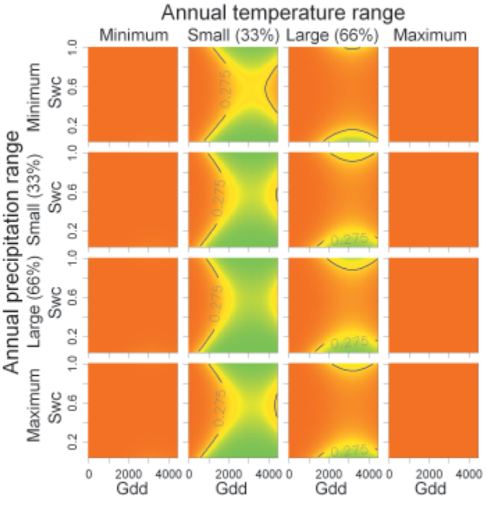
Due to data availability we here treat *Euchloe ausonia* (Hübner, 1806), *Euchloe simplonia* Freyer, 1829, and *Euchloe crameri* Butler, 1869, as the Dappled White species complex, knowing that they are normally being treated as distinct species.

The Dappled Whites are species of warm, dry places. They occur on flower-rich grasslands and waste ground, along hedges and the edges of woods. Various crucifers are used as larval foodplant, such as a Charlock (*Sisymbrium arvensis*), Woad (*Isatis tinctoria*), buckler mustards (*Biscutella* spp.), Evergreen Candytuft (*Iberis sempervirens*), and Crested Bunias (*Bunias erucago*). The caterpillars feed on the flowers and ripening seeds. They are double-brooded and hibernate as pupa.

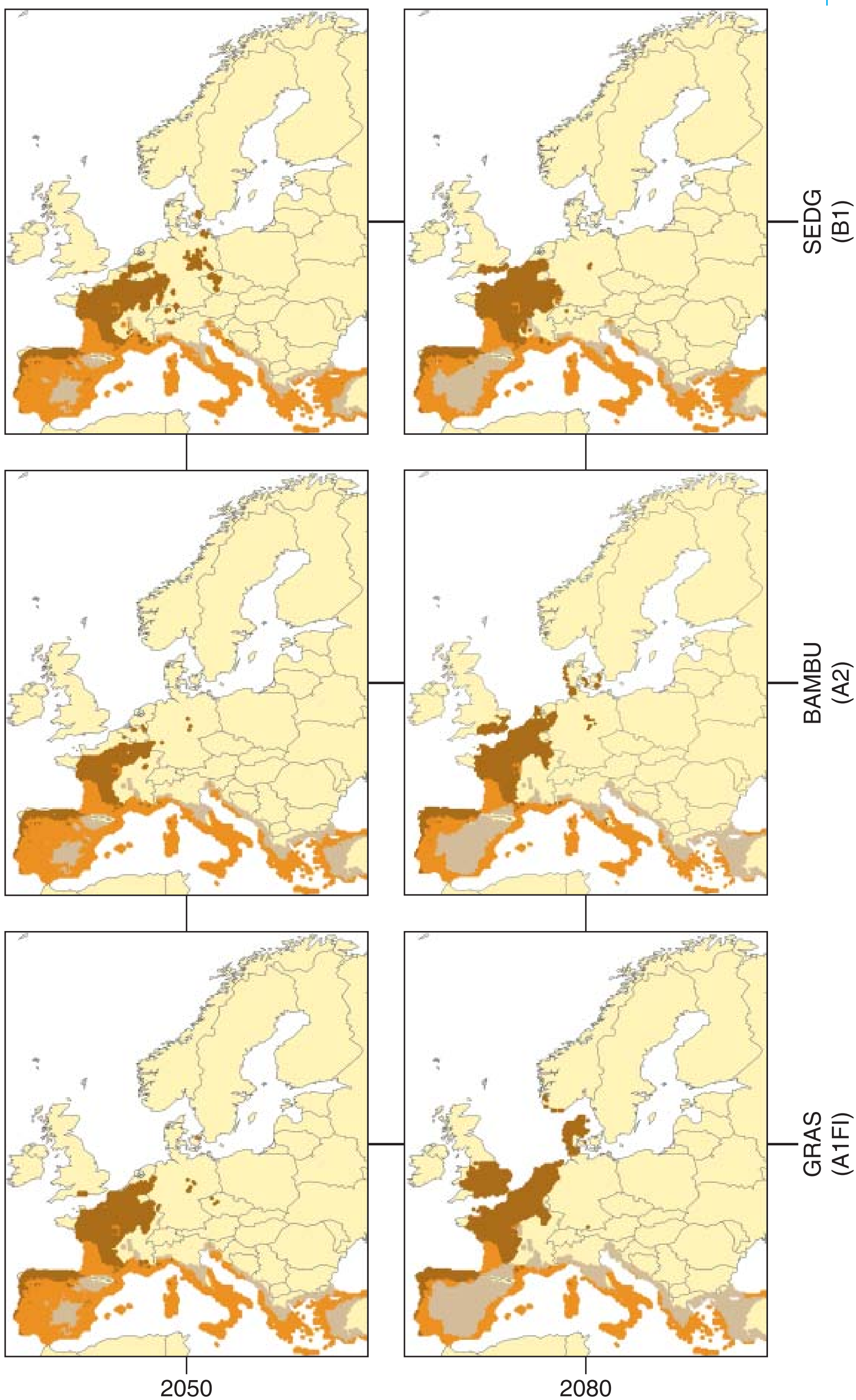
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.85).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Euchloe tagis (Hübner, 1804) – Portuguese Dappled White

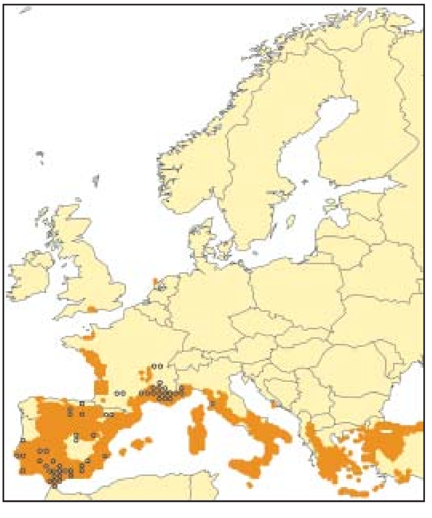
© Jean Delacre

		Full dispersal	No dispersal
2050	SEDG	-590 (-18.72%)	-1537 (-48.76%)
	BAMBU	-999 (-31.69%)	-1507 (-47.81%)
	GRAS	-794 (-25.19%)	-1692 (-53.68%)
2080	SEDG	-920 (-29.19%)	-1943 (-61.64%)
	BAMBU	-1535 (-48.7%)	-2350 (-74.56%)
	GRAS	-1749 (-55.49%)	-2743 (-87.02%)

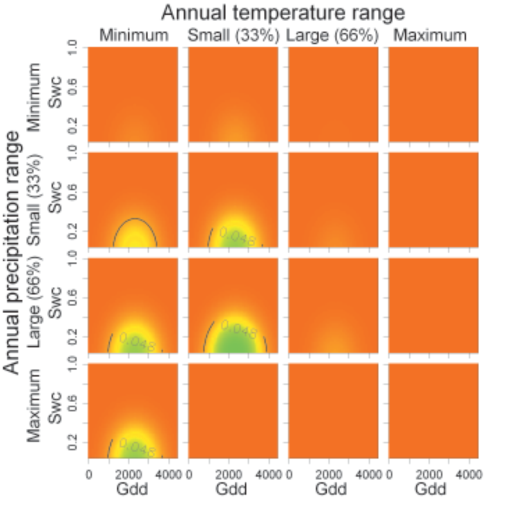
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 3152 cells)

This butterfly owes its specific name to the River Tagus in Portugal, along the banks of which it was first found. The Portuguese Dappled White is found on warm, dry rocky places with patches of flower-rich grassy vegetation, in dry scrub, and on abandoned agricultural land. Various crucifers are used as foodplant, such as candytufts (*Iberis* spp.), including *I. ciliata*, *I. saxatilis* and Annual Candytuft (*I. amara*), and buckler mustards (*Biscutella* spp.). The caterpillars eat the ovaries and flowers. It has one brood a year and hibernates as a pupa.

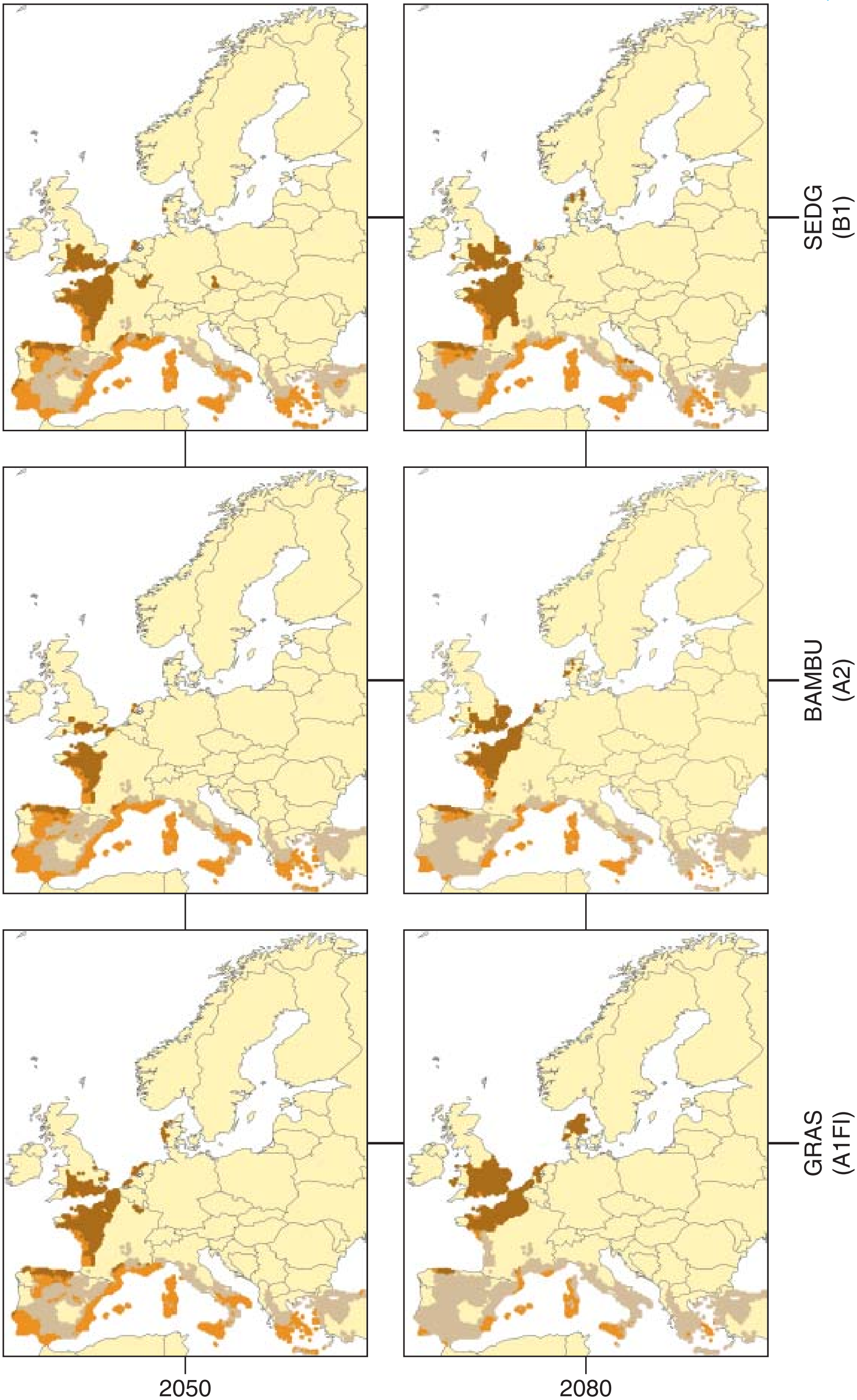
Present distribution can be well explained by climatic variables (AUC = 0.86).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Aporia crataegi (Linnaeus, 1758) – Black-veined White

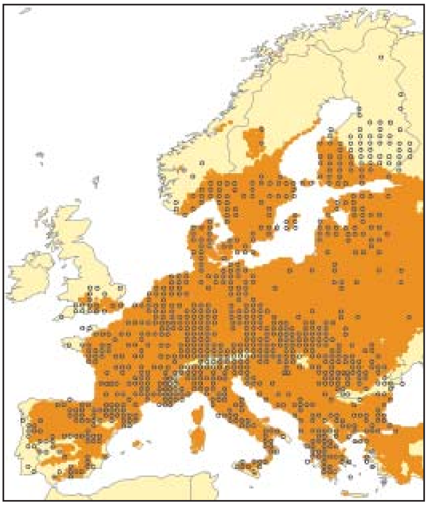
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-661 (-3.52%)	-2426 (-12.91%)
	BAMBU	-703 (-3.74%)	-2451 (-13.05%)
	GRAS	-1530 (-8.14%)	-3266 (-17.39%)
2080	SEDG	-1604 (-8.54%)	-4323 (-23.01%)
	BAMBU	-2410 (-12.83%)	-6143 (-32.7%)
	GRAS	-3323 (-17.69%)	-8101 (-43.12%)

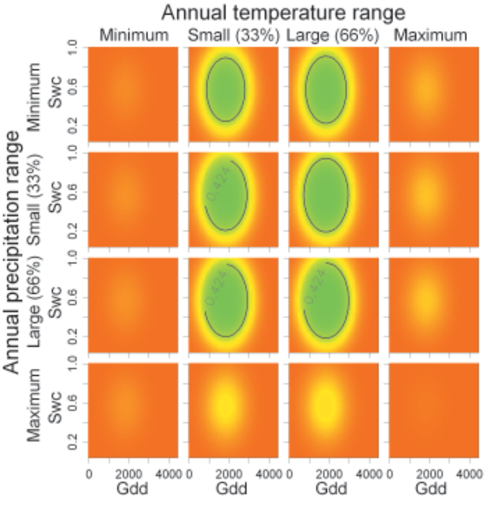
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 18785 cells)

The Black-veined White can be found on many different sorts of vegetation in a variety of landscapes, but seems to prefer habitats in the neighbourhood of woods or scrub. Numbers of this migratory species can fluctuate greatly and the reasons for this are not well understood. The species may build up huge populations at unusual places such as hedges along motorways, but also disappear from large areas for many years. The eggs are laid in large clusters of often sixty or more, on the leaves of trees and bushes of the rose family (Rosaceae), such as hawthorn (*Crataegus* spp.), Blackthorn (*Prunus spinosa*), Cherry (*Prunus* spp.), Apple (*Malus* spp.), also in orchards. The caterpillars spend their time in a communal silken nest until they pupate, the nest in which they hibernate being more substantial. When they are ready to pupate, they disperse over the foodplant. The yellow pupa with black spots suspends in a silken girdle. The Black-veined White has one brood a year.

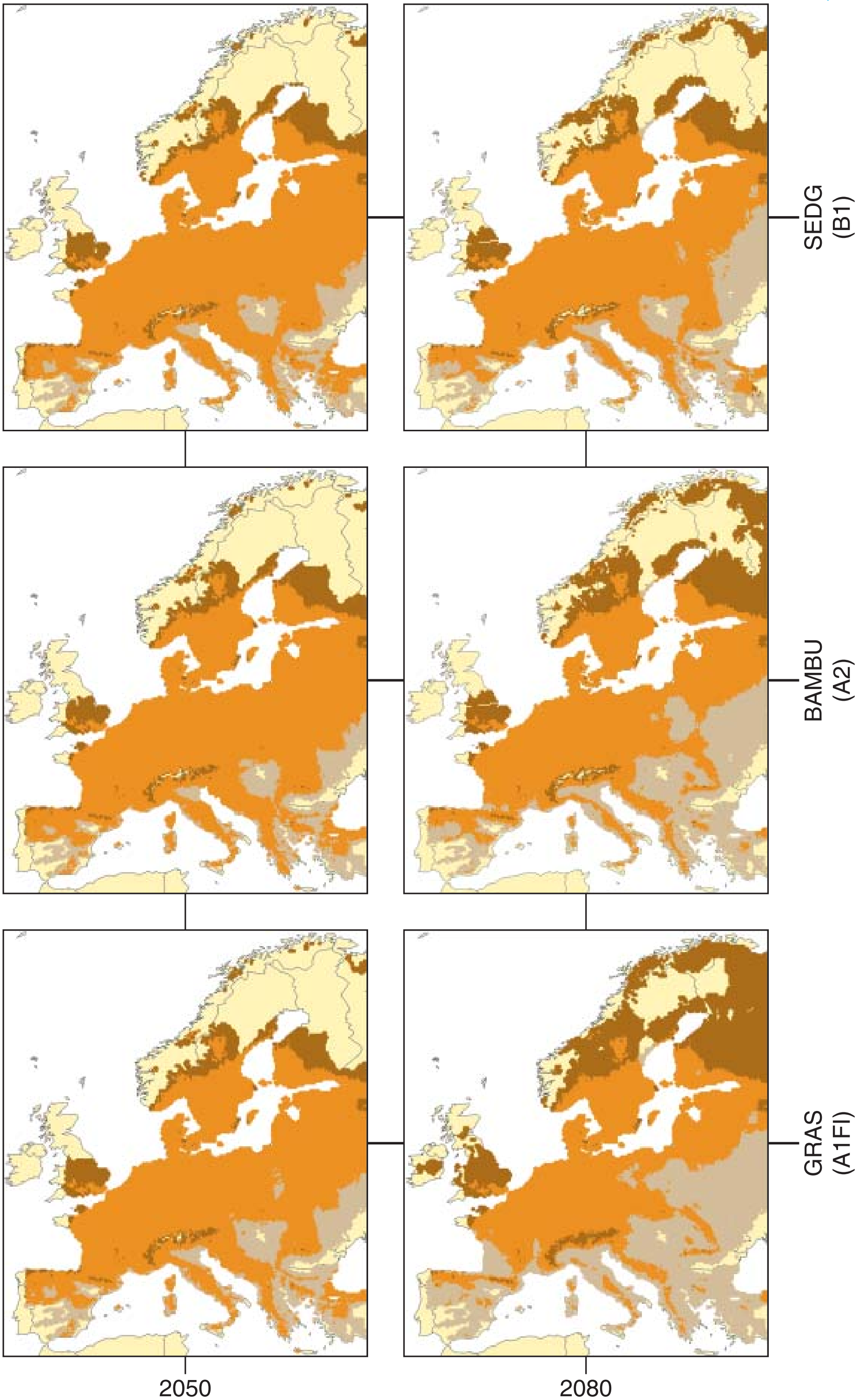
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.69). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

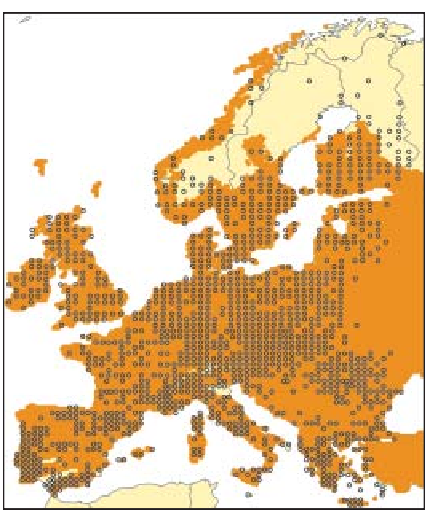
Pieris brassicae (Linnaeus, 1758) – Large White

		Full dispersal	No dispersal
2050	SEDG	-1904 (-8.11%)	-3228 (-13.75%)
	BAMBU	-3133 (-13.34%)	-4027 (-17.15%)
	GRAS	-3241 (-13.8%)	-4419 (-18.82%)
2080	SEDG	-3429 (-14.6%)	-5640 (-24.02%)
	BAMBU	-6368 (-27.12%)	-8473 (-36.08%)
	GRAS	-8906 (-37.93%)	-11751 (-50.04%)

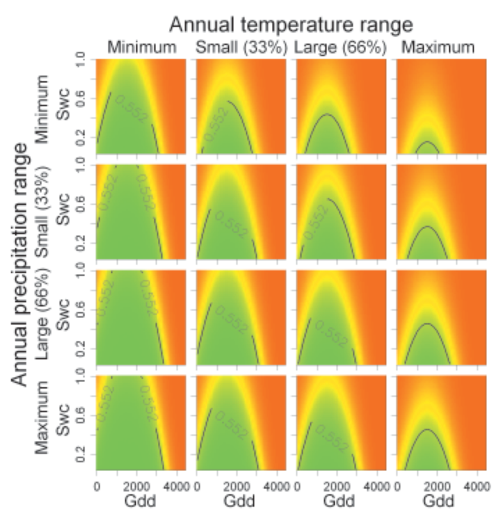
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 23482 cells)

You can come across the Large White almost everywhere. It lays its eggs singly or in small clusters on the underside of the foodplants, which are mainly broad-leaved Brassicaceae (like *Brassica*, *Crambe*, *Lunaria*, *Cakile*) that offer enough food for the gregarious caterpillars, but also species of the introduced genus *Tropaeolum* (Tropaeolaceae) which also contains glucosinolates On such a nutritious diet, the caterpillar grows very quickly, reaching the pupal stage in three to six weeks. The attractive white pupa is suspended in a silken girdle from the foodplant. The Large White has several generations a year, the number depending on the geographical location and latitude of the flight area, and the length of the summer.

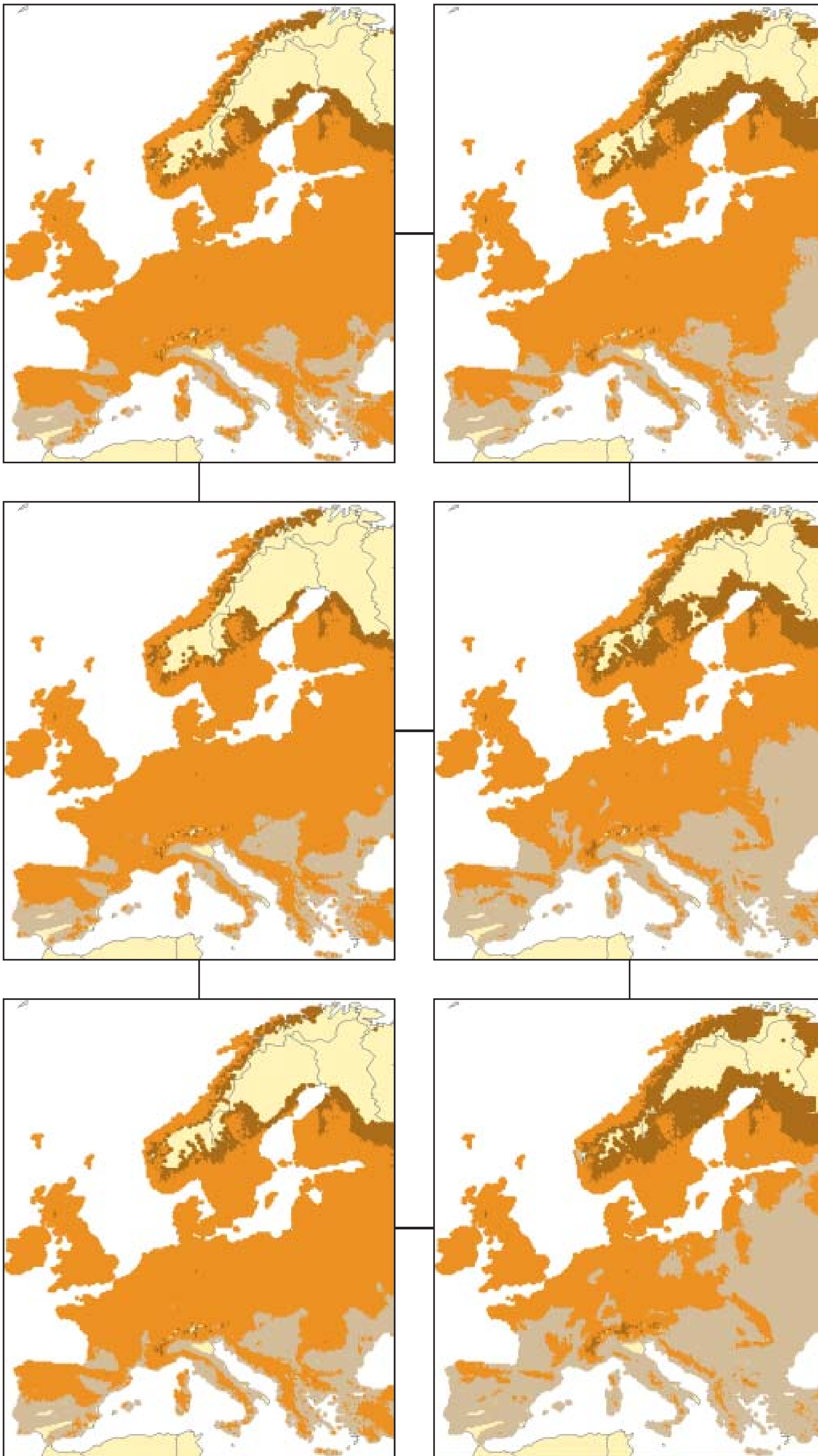
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.66).
Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold



SEDG (B1)

BAMBU (A2)

GRAS (A1FI)

2050

2080

Pieris krueperi (Staudinger, 1860) – Krüper's Small White

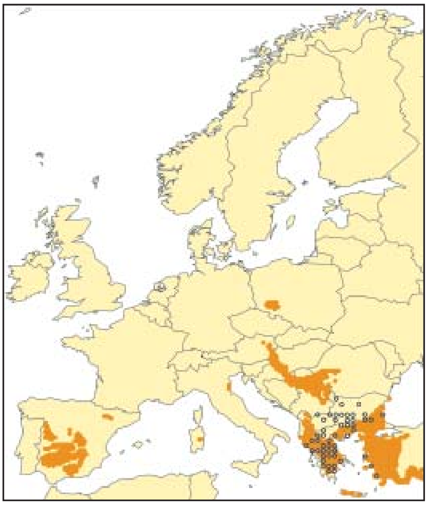
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	216 (16.44%)	-619 (-47.11%)
	BAMBU	11 (0.84%)	-604 (-45.97%)
	GRAS	-25 (-1.9%)	-698 (-53.12%)
2080	SEDG	446 (33.94%)	-748 (-56.93%)
	BAMBU	-141 (-10.73%)	-900 (-68.49%)
	GRAS	36 (2.74%)	-1033 (-78.61%)

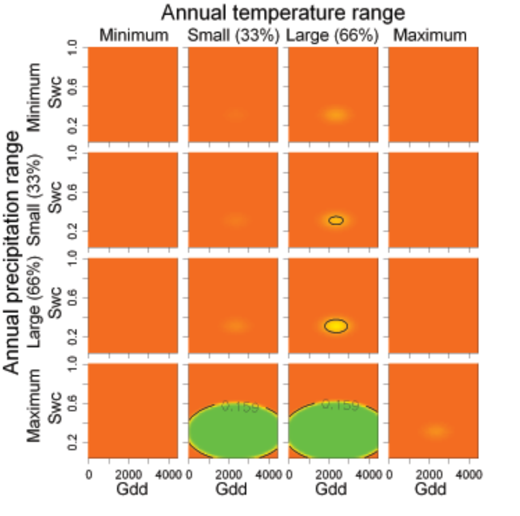
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1314 cells)

Krueper's Small White occurs in warm, dry places on calcareous, rocky slopes with scattered low, herbaceous vegetation. Eggs are laid on the sepals of Golden Alyssum (*Alyssum saxatile*), and *A. montanum*. The caterpillars feed on the ovaries. It hibernates as a pupa and has two or more generations a year.

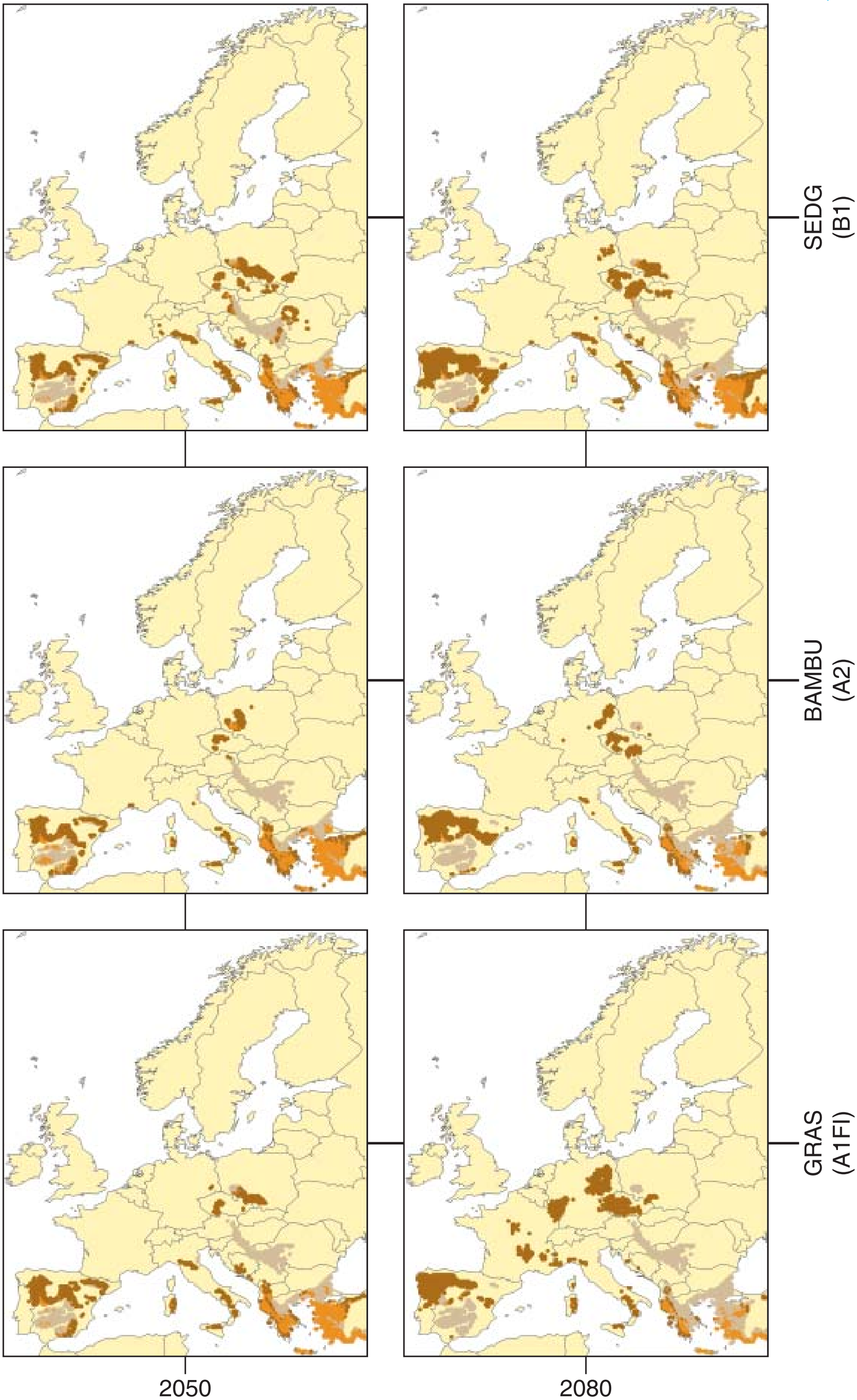
Present distribution can be well explained by climatic variables (AUC = 0.91).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pieris mannii (Mayer, 1851) – Southern Small White

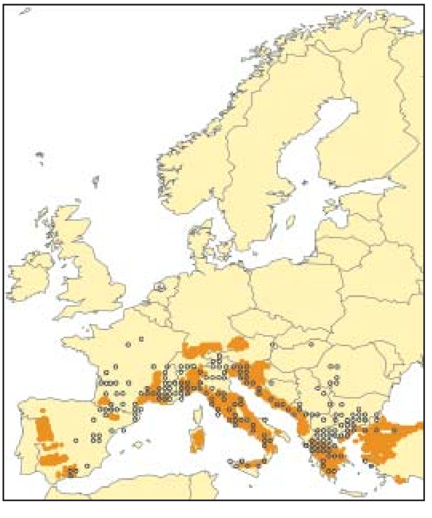
© Martin Wiemers

		Full dispersal	No dispersal
2050	SEDG	214 (12.51%)	-572 (-33.45%)
	BAMBU	221 (12.92%)	-716 (-41.87%)
	GRAS	222 (12.98%)	-803 (-46.96%)
2080	SEDG	616 (36.02%)	-968 (-56.61%)
	BAMBU	639 (37.37%)	-1318 (-77.08%)
	GRAS	711 (41.58%)	-1497 (-87.54%)

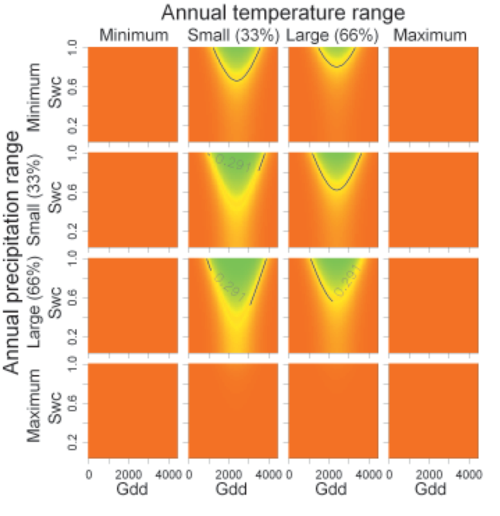
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1710 cells)

The Southern Small White, which looks very much like the Small White (*P. rapae*), occurs on both calcareous and non-calcareous dry, grassy vegetation, in open scrub and open woodland. The most important larval foodplants are the candytufts Evergreen Candytuft (*Iberis sempervirens*) and *I. saxatilsis,*.although other crucifers, such as *Alyssoides utriculata,* and mustards (*Sinapis* spp.) are also used. The eggs are laid singly or in small groups on the uppersides of the leaves. The caterpillars feed on the leaves. It has several generations a year, pupating on plant stalks and stones. It overwinters as a pupa, and the butterflies emerge in the spring.

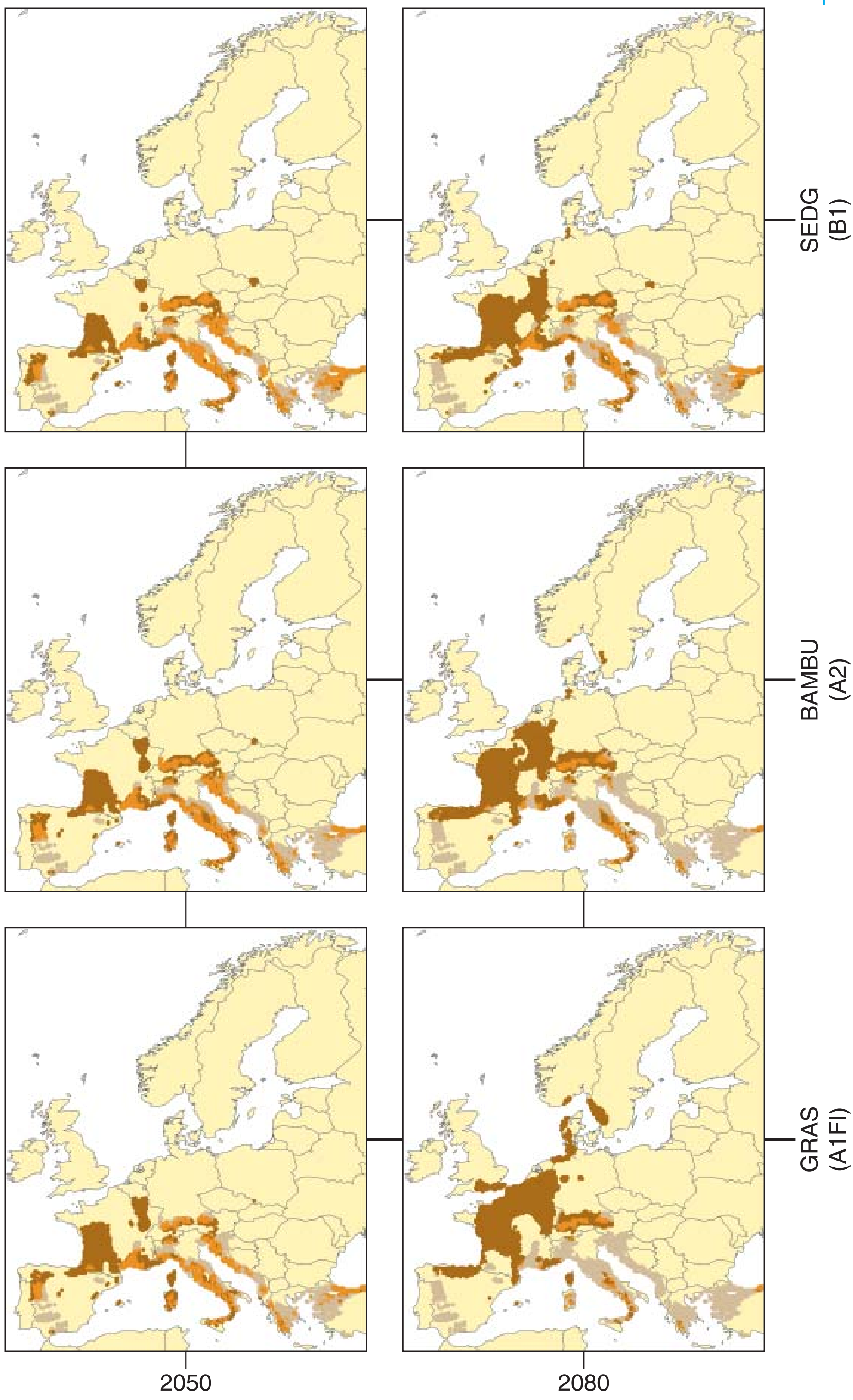
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.76).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pieris rapae (Linnaeus, 1758) – Small White

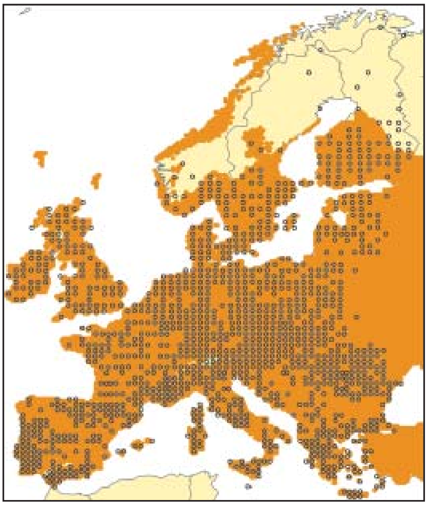
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	82 (0.34%)	-1502 (-6.22%)
	BAMBU	-690 (-2.86%)	-1742 (-7.22%)
	GRAS	-891 (-3.69%)	-2258 (-9.35%)
2080	SEDG	-670 (-2.78%)	-3296 (-13.65%)
	BAMBU	-3119 (-12.92%)	-6008 (-24.89%)
	GRAS	-4088 (-16.93%)	-8043 (-33.31%)

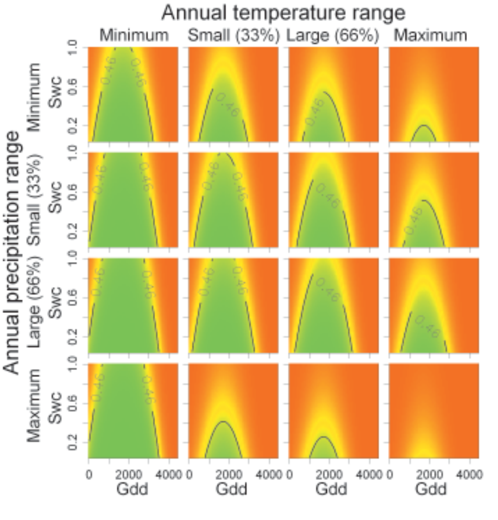
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 24143 cells)

The Small White is found in any sort of habitat where its larval foodplants grow, such as gardens, parks, grasslands, heathland and woodland. The eggs are laid on the underside of the leaves of a wide variety of crucifers, including cultivated brassicas, and also on *Reseda* species, such as Wild Mignonette (*R. lutea*). The caterpillars grow very rapidly, sometimes pupating after two weeks. The pupa hangs in a silken girdle, normally on vertical surfaces, and hibernates in this stage. The Small White has several generations a year, depending on the geographical position and altitude of the flight area, and the length of the summer.

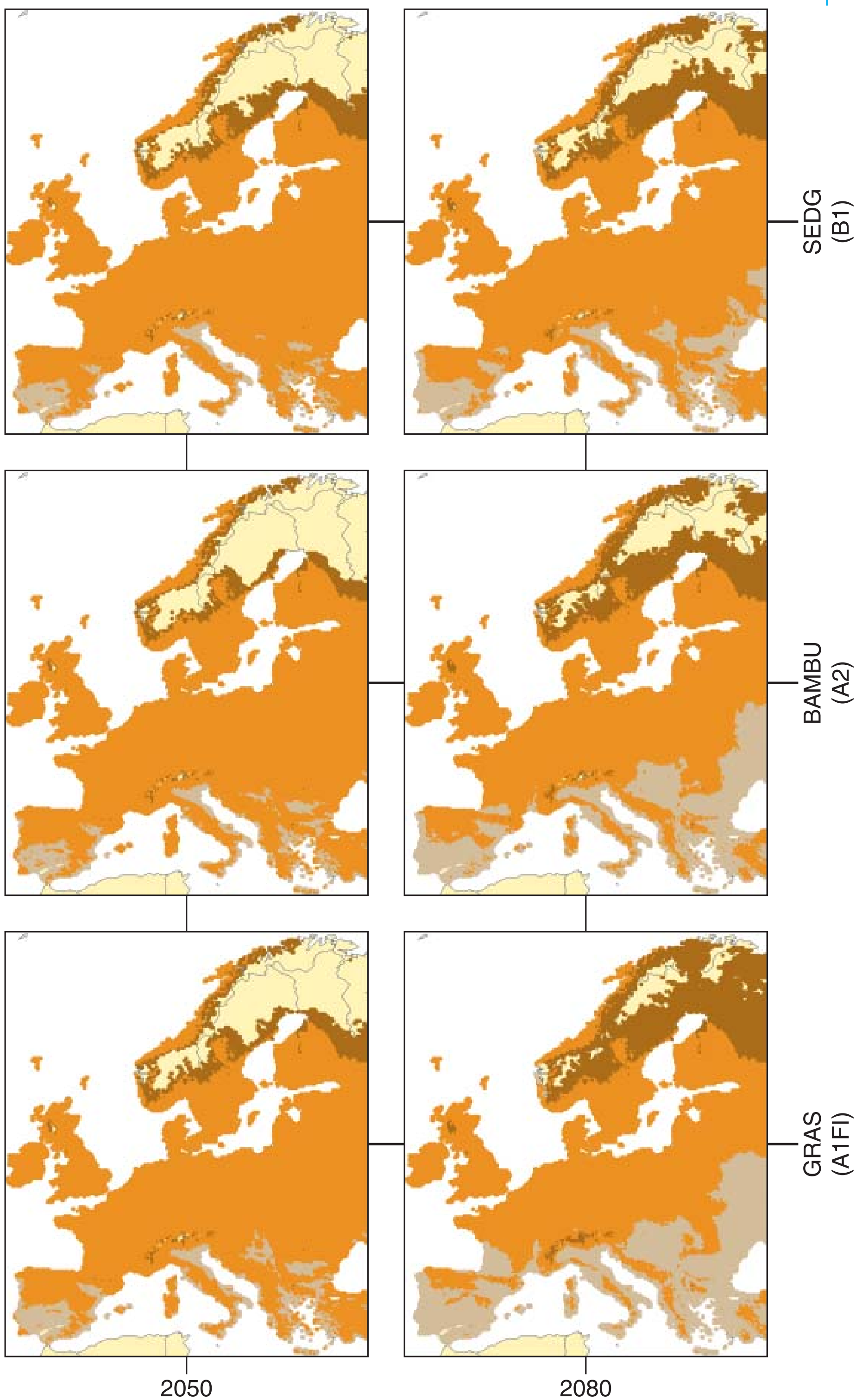
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.69). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pieris ergane (Geyer, 1828) – Mountain Small White

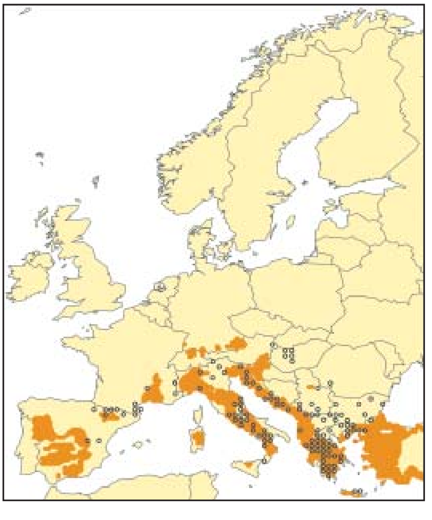
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	94 (4.38%)	-786 (-36.63%)
	BAMBU	-101 (-4.71%)	-932 (-43.43%)
	GRAS	-90 (-4.19%)	-1043 (-48.6%)
2080	SEDG	527 (24.56%)	-1157 (-53.91%)
	BAMBU	223 (10.39%)	-1684 (-78.47%)
	GRAS	519 (24.18%)	-1894 (-88.26%)

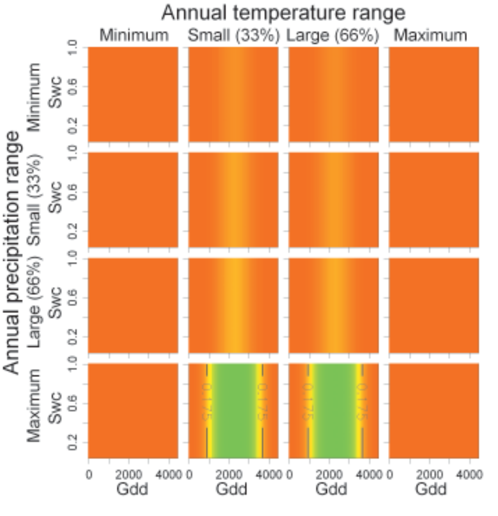
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 2146 cells)

The Mountain Small White likes warm and dry places, and is found on dry, poor grasslands, in rocky places, in open scrub and in large clearings in woods. The flight areas are usually on calcareous soil. The males can sometimes be seen in large groups on damp ground. Compared to other whites, this butterfly has a slow and measured flight. The main larval foodplant is Burnt Candytuft (*Aethionema saxatile*), but *A. orbiculatum* and Woad (*Isatis tinctoria*) are also used. The eggs are laid singly. The pupa is normally fixed to stones and rocks. There are two or three generations a year, and the pupa of the autumn generation hibernates.

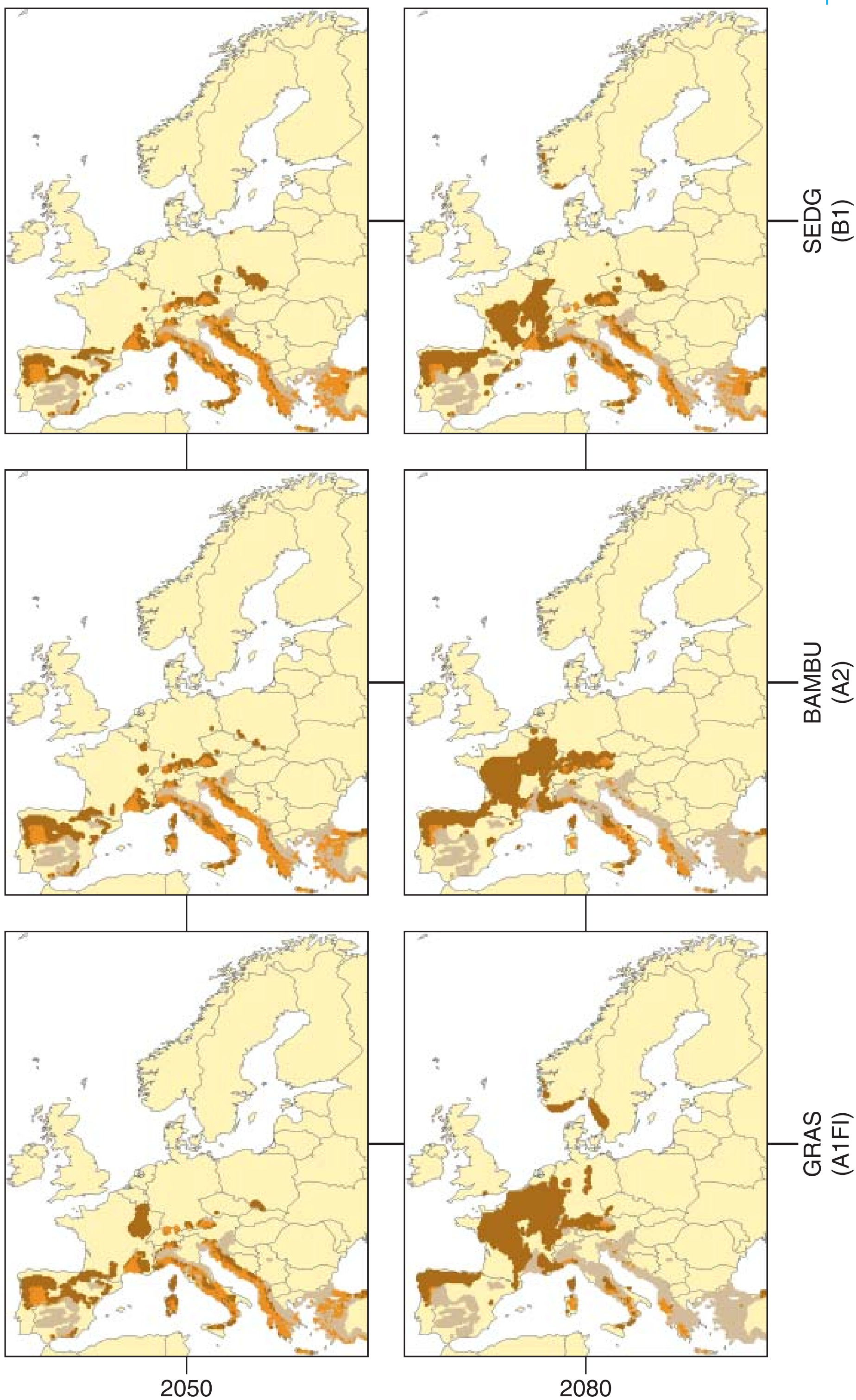
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.84). Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pieris napi (Linnaeus, 1758) – Green-veined White

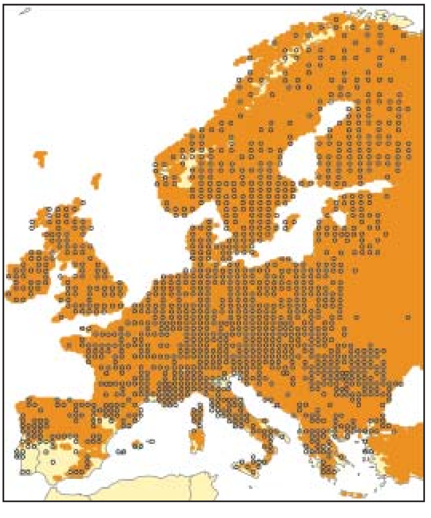
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-2543 (-9.61%)	-3045 (-11.51%)
	BAMBU	-2497 (-9.44%)	-3022 (-11.42%)
	GRAS	-3275 (-12.38%)	-3819 (-14.43%)
2080	SEDG	-3817 (-14.43%)	-4424 (-16.72%)
	BAMBU	-5386 (-20.36%)	-6063 (-22.91%)
	GRAS	-7583 (-28.66%)	-8253 (-31.19%)

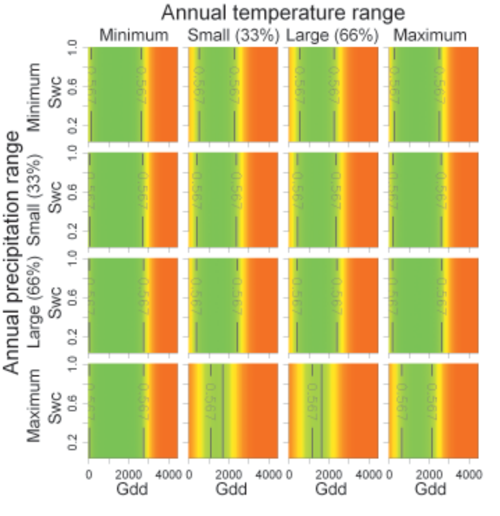
Changes in climatic niche distribution (in 10'×10' grid cells; present niche space: 26459 cells)

The Green-veined White occurs in many different habitats and landscapes with varying amounts of shelter. It can be found on all types of grasslands and heathlands in open or more closed landscapes. However, a too dry habitat is not favourable. This butterfly is very variable in appearance, having several forms and subspecies. The eggs are laid singly or in small numbers on many, mostly wild, crucifers It pupates on a stalk and overwinters in this stage. The Green-veined White has several broods a year, the number depending on the geographical location and altitude of the flight area, and the length of the summer.

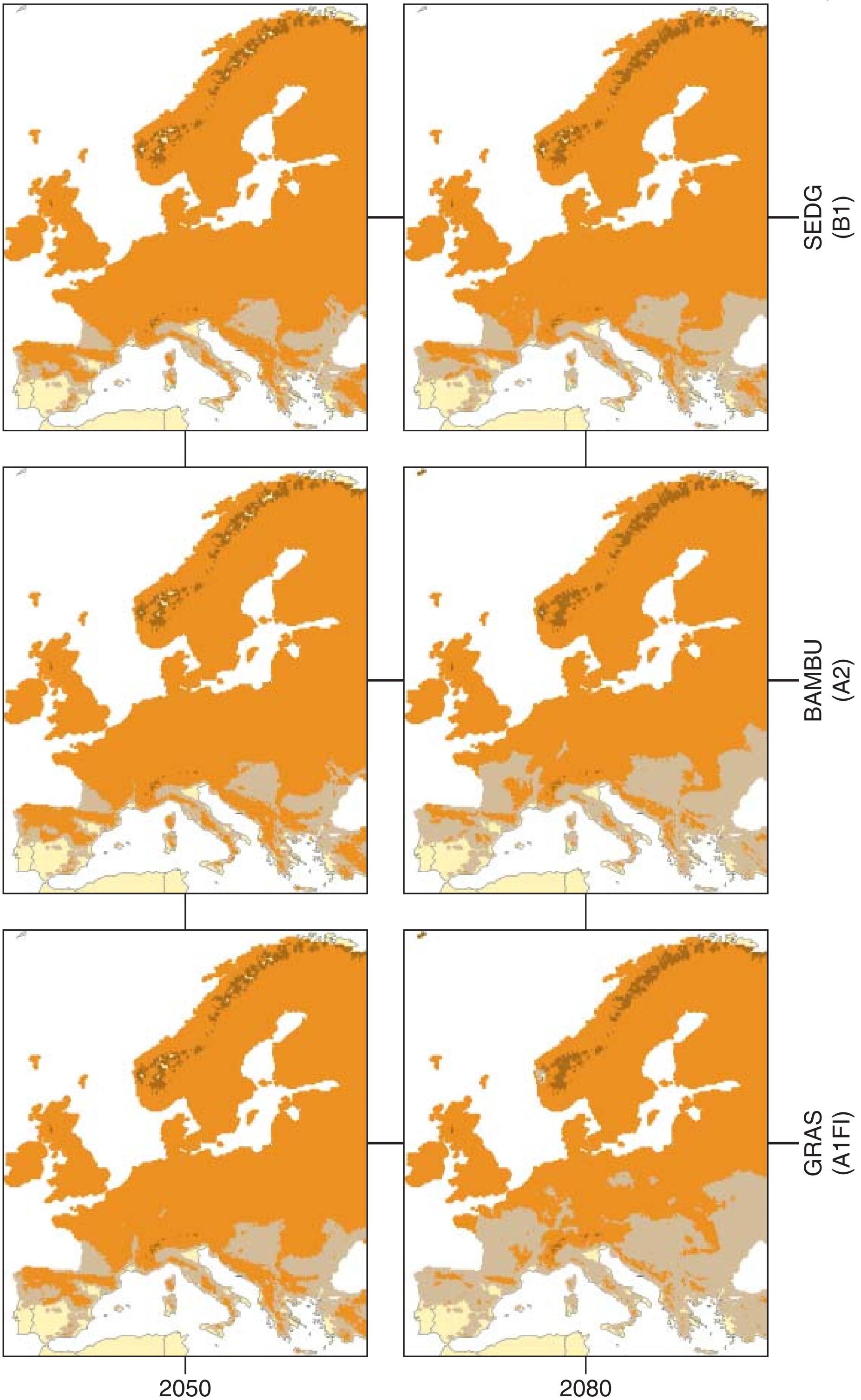
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.73). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pieris bryoniae (Hübner, 1791) – Mountain Green-veined White

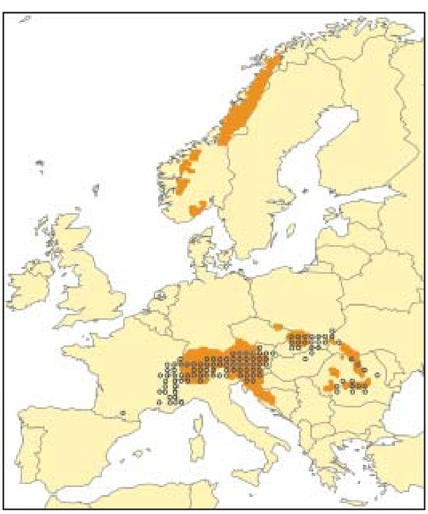
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-421 (-35.59%)	-520 (-43.96%)
	BAMBU	-320 (-27.05%)	-418 (-35.33%)
	GRAS	-521 (-44.04%)	-594 (-50.21%)
2080	SEDG	-312 (-26.37%)	-637 (-53.85%)
	BAMBU	-197 (-16.65%)	-655 (-55.37%)
	GRAS	-303 (-25.61%)	-844 (-71.34%)

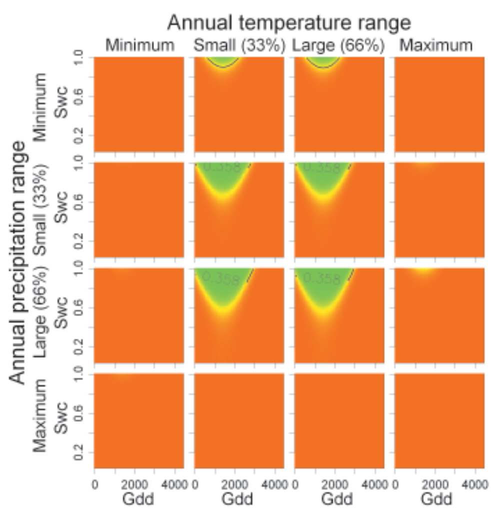
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 1183 cells)

The butterfly of the Mountain Green-veined White strongly resembles that of the Green-veined White (*P. napi*). The eggs, caterpillars and pupae are also almost indistinguishable. In some places, such as in the Alps and the Jura Mountains, these species occur together. The Mountain Green-veined White is found in flower-rich grasslands along river banks, and at woodland edges. Buckler Mustard (*Biscutella laevigata*), pennycresses (*Thlaspi* spp.) and bittercresses (*Cardamine* spp.) are used as foodplants. The female, heavily dusted on her upperside with yellow or grey, lays her eggs singly on the flowers or leaves of the larval foodplant. She shows a preference for smaller plants growing on poor ground. It has one or two generations a year and hibernates in the pupal stage. In areas where this species occurs together with *P. napi* (like in the SE Alps), one may often find hybrids of both species.

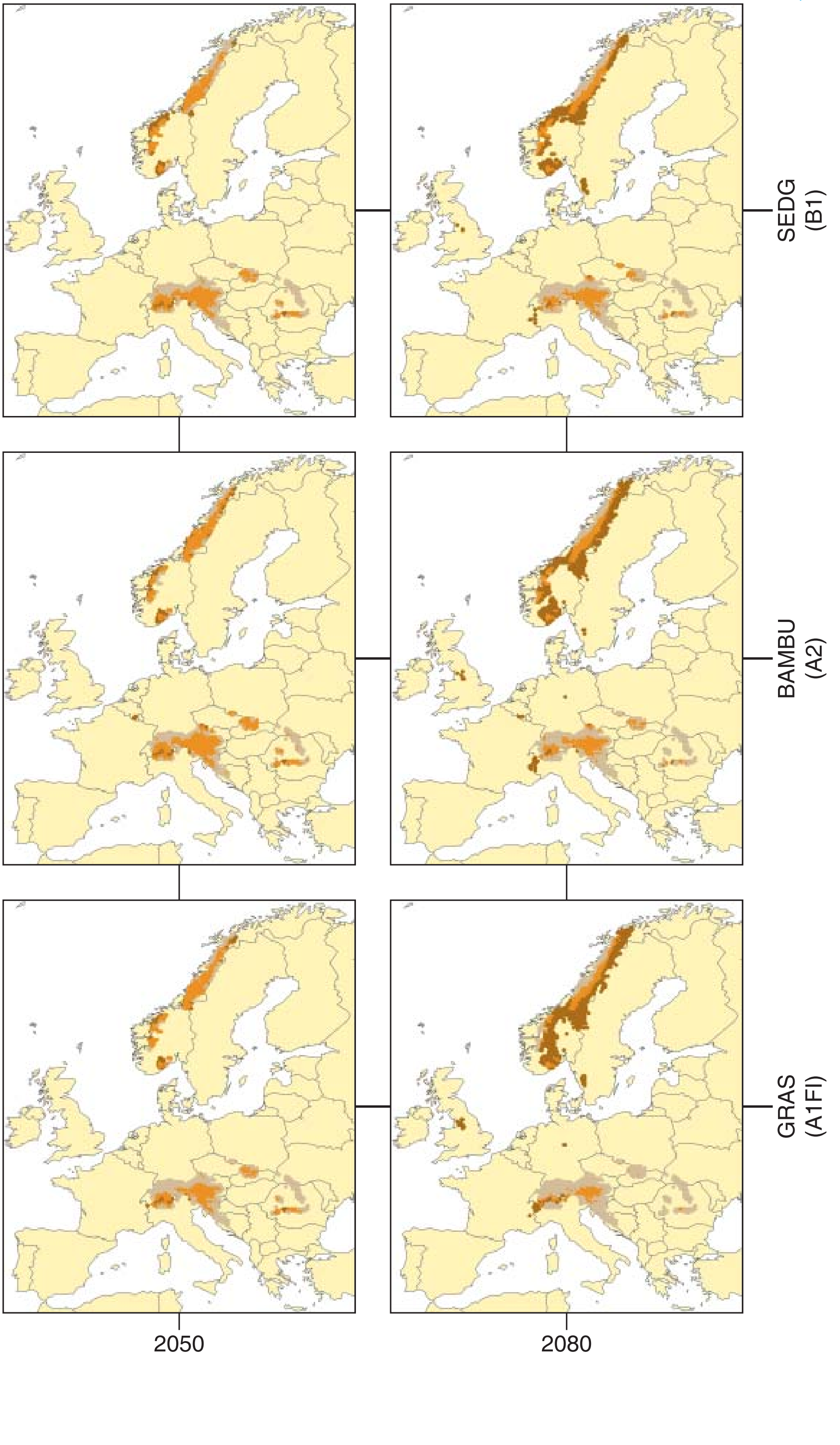
Present distribution can be well explained by climatic variables (AUC = 0.92).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pontia callidice (Hübner, 1800) – Peak White

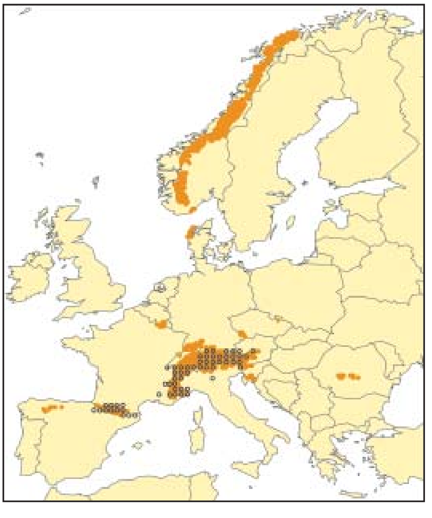
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-182 (-20.43%)	-347 (-38.95%)
	BAMBU	-97 (-10.89%)	-296 (-33.22%)
	GRAS	-211 (-23.68%)	-370 (-41.53%)
2080	SEDG	-452 (-50.73%)	-639 (-71.72%)
	BAMBU	-280 (-31.43%)	-509 (-57.13%)
	GRAS	-481 (-53.98%)	-682 (-76.54%)

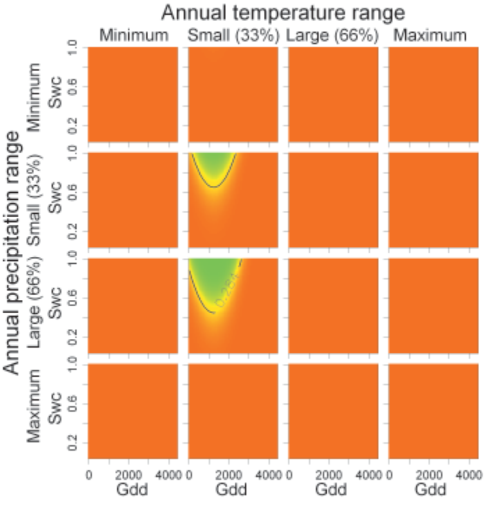
Changes in climatic niche distribution (in 10'×10' grid cells; present niche space: 891 cells)

The Peak White is found high in the mountains in flower-rich grasslands. The eggs are laid singly on Alpine Bittercress (*Cardamine bellidifolia* ssp. *alpina*), *Hutchinsia alpina, Erysimum helveticum*, and *Reseda glauca*, especially on those growing on open stony patches. The caterpillars mostly eat the lower leaves, and hide under stones when the weather is bad. In the Alps, the Peak White usually has only one generation a year and hibernates as a pupa. However, in good summers or at lower altitudes, a partial second generation is sometimes produced that passes the winter as a caterpillar. In the Spanish Pyrenees, two generations a year are usual, and it hibernates either as a pupa or a caterpillar.

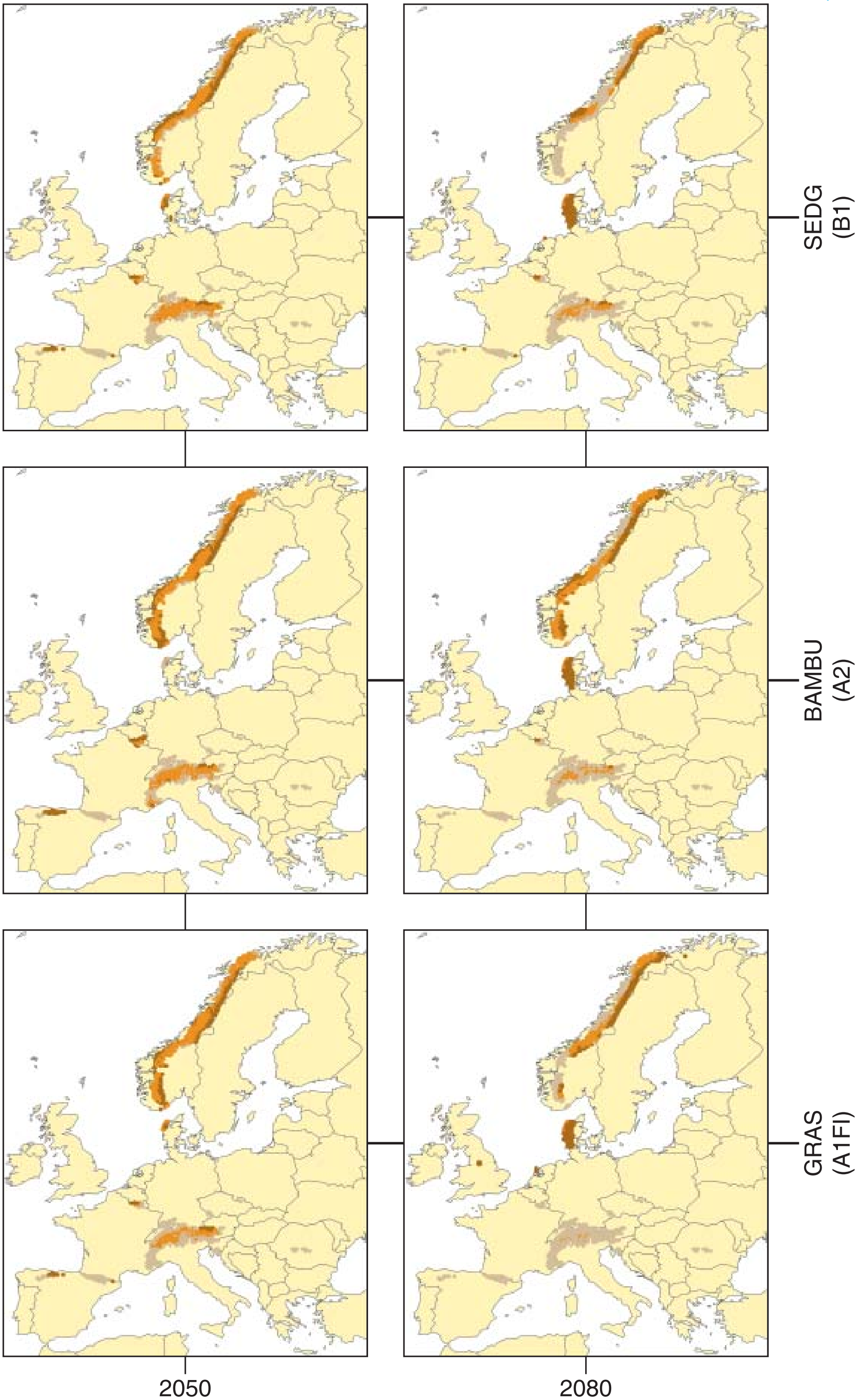
Present distribution can be very well explained by climatic variables (AUC = 0.98).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pontia daplidice (Linnaeus, 1758) / *edusa* (Fabricius, 1777) (complex) – Bath White

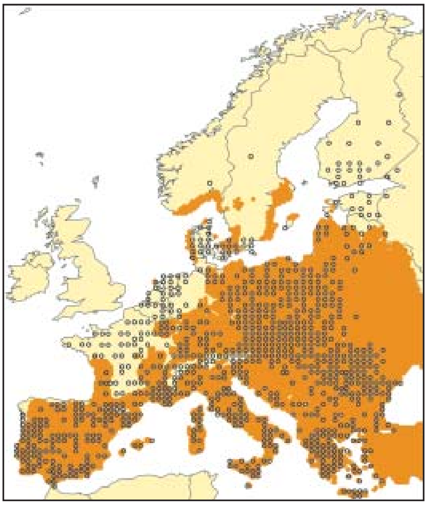
© Peter Ginzinger

		Full dispersal	No dispersal
2050	SEDG	4490 (29.33%)	-364 (-2.38%)
	BAMBU	1973 (12.89%)	-918 (-6%)
	GRAS	3493 (22.82%)	-842 (-5.5%)
2080	SEDG	3091 (20.19%)	-2391 (-15.62%)
	BAMBU	-157 (-1.03%)	-5708 (-37.28%)
	GRAS	-1327 (-8.67%)	-7478 (-48.84%)

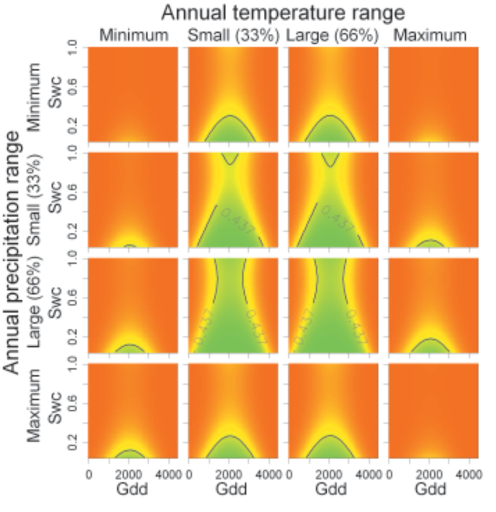
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 15310 cells)

The Bath White complex has been split into two species in the 1980s, *P. daplidice* (Linnaeus, 1758), which mainly occurs in the Western Mediterranean, and *P. edusa* (Fabricius, 1777), which is distributed over the rest of Europe. However, these two species cannot be distinguished in the field. Their life cycles are also very similar. The adult butterflies are very mobile, fast flying and migrate northwards and westwards in warm years. They occur in warm, stony places; often disturbed ground, such as road verges, abandoned agricultural land or quarries. The females lay their eggs on such crucifers as mustards (*Sinapis* spp.), *Alyssum* spp., and also on mignonettes (*Reseda* spp.). The caterpillars feed mainly on the flowers and seeds. Pupation takes place on the stalk of the foodplant. These species have two or more broods a year and hibernate as pupae.

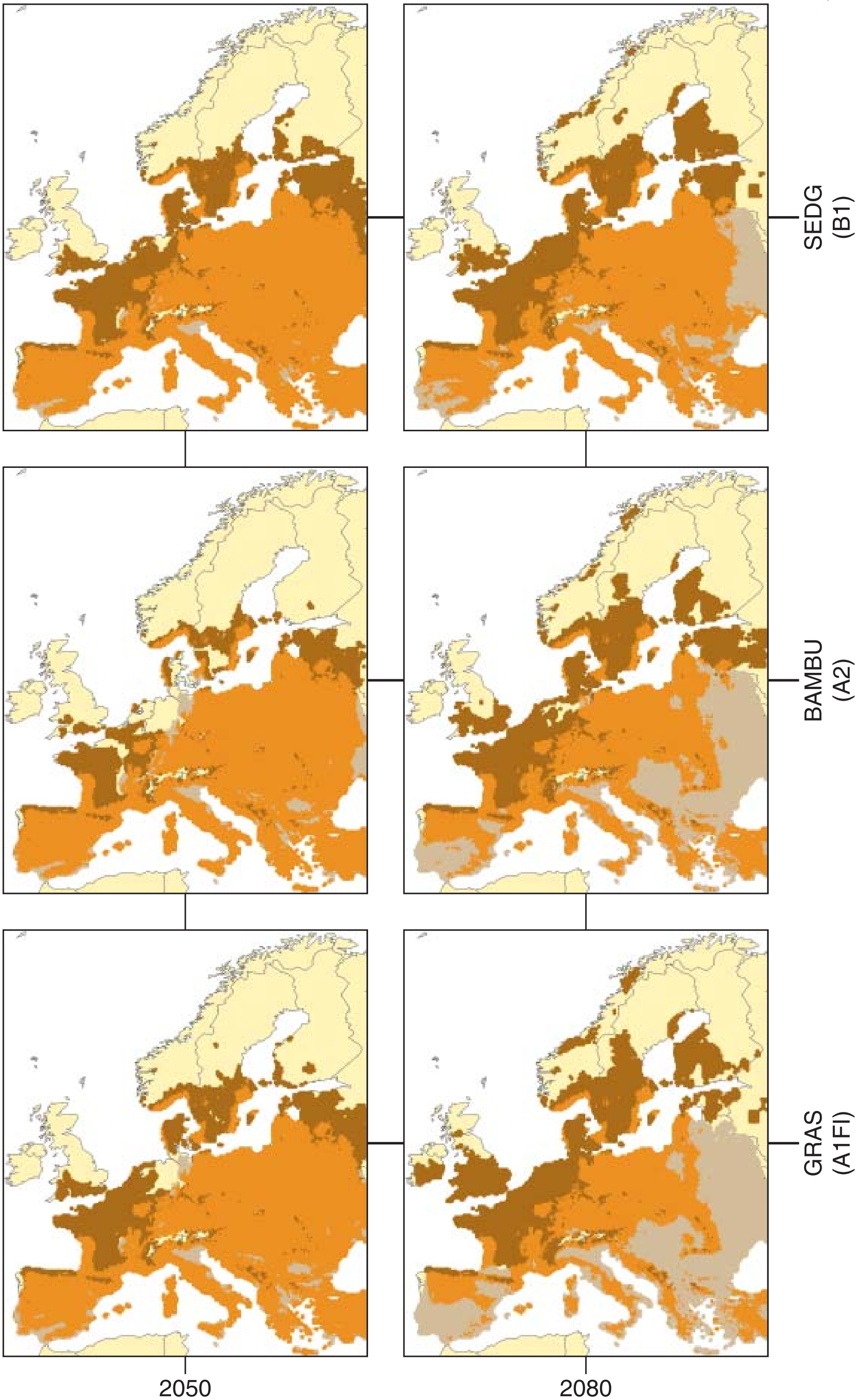
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.72). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG (B1)
BAMBU (A2)
GRAS (A1FI)
2050
2080

Colias phicomone (Esper, 1780) – Mountain Clouded Yellow

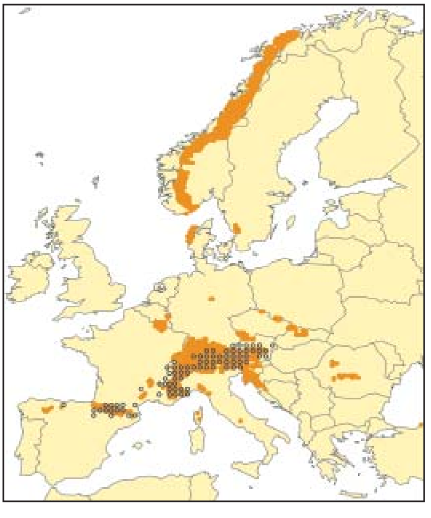
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-306 (-21.5%)	-513 (-36.05%)
	BAMBU	-209 (-14.69%)	-450 (-31.62%)
	GRAS	-432 (-30.36%)	-611 (-42.94%)
2080	SEDG	-562 (-39.49%)	-890 (-62.54%)
	BAMBU	-426 (-29.94%)	-781 (-54.88%)
	GRAS	-665 (-46.73%)	-1017 (-71.47%)

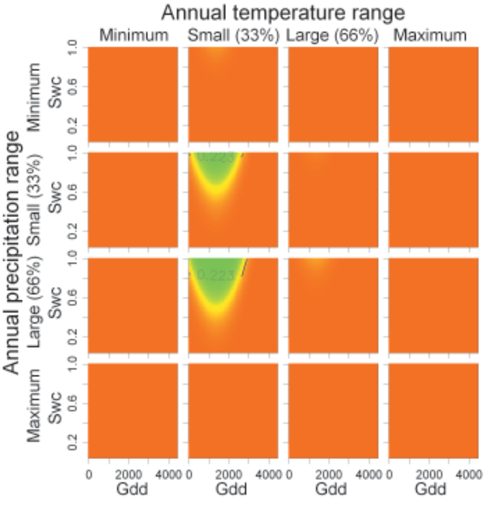
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1423 cells)

The Mountain Clouded Yellow has its breeding ground in flower-rich alpine meadows. Although they are quick, strong flyers, they are not migrants and do not leave their habitat. Various leguminous plants are used as larval foodplant, including Horseshoe Vetch (*Hippocrepis comosa*), White Clover (*Trifolium repens*), Common Birdsfoot-trefoil (*Lotus corniculatus*), and vetches (*Vicia* spp.). This butterfly species usually only has one generation a year, but in some years there is a partial second brood. The caterpillars hibernate after their second moult.

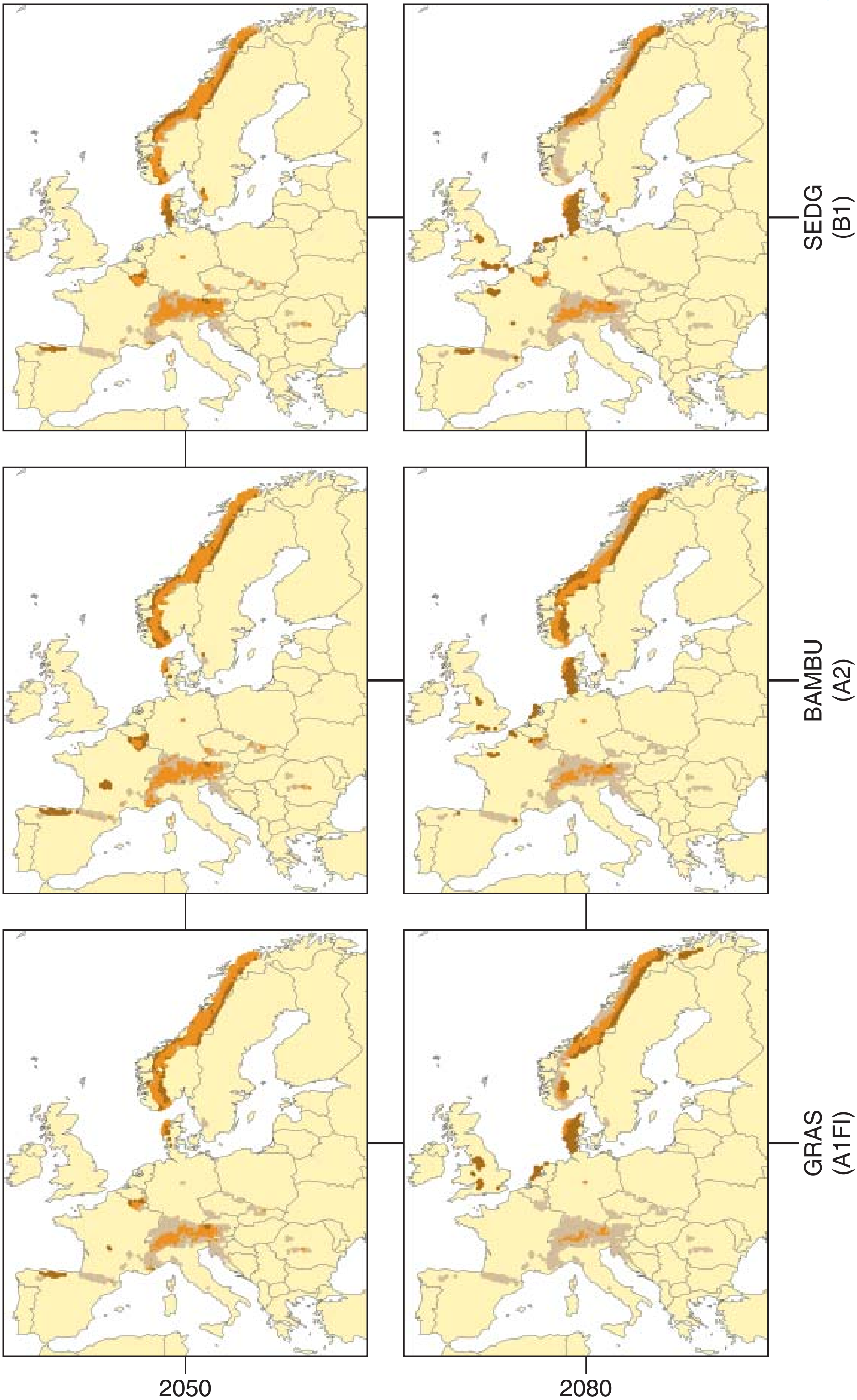
Present distribution can be very well explained by climatic variables (AUC = 0.96).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Colias palaeno (Linnaeus, 1758) – Moorland Clouded Yellow

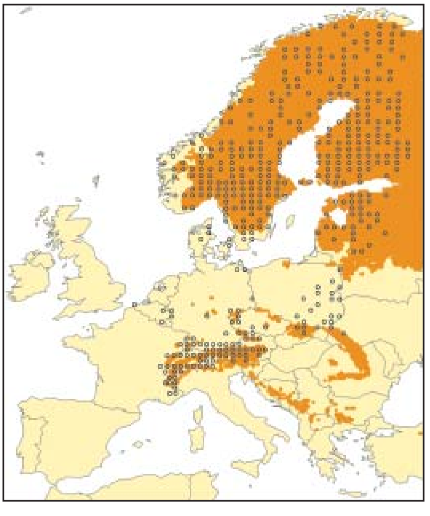
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-2875 (-29.08%)	-3210 (-32.47%)
	BAMBU	-2799 (-28.31%)	-3063 (-30.98%)
	GRAS	-3095 (-31.31%)	-3361 (-34%)
2080	SEDG	-3370 (-34.09%)	-3889 (-39.34%)
	BAMBU	-4202 (-42.5%)	-4562 (-46.15%)
	GRAS	-5087 (-51.46%)	-5433 (-54.96%)

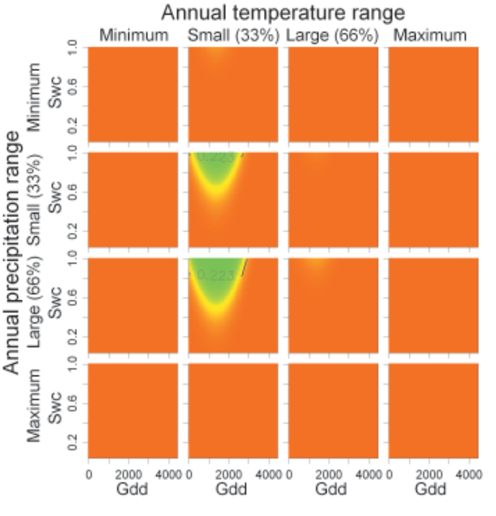
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 9886 cells)

The Moorland Clouded Yellow occurs at the edges of raised bogs, and also on blanket bogs. At high altitudes, it is found in drier habitats. Eggs are laid singly on Bog Whortleberry (*Vaccinium uliginosum*). At first, the caterpillars only eat the upper layers of the leaf , producing “windows”, but later, the whole leaf is eaten. The caterpillars hibernate among the dry leaves of the litter layer, and the next spring feed and grow further, before finally pupating on a branch of the foodplant. It has one generation a year.

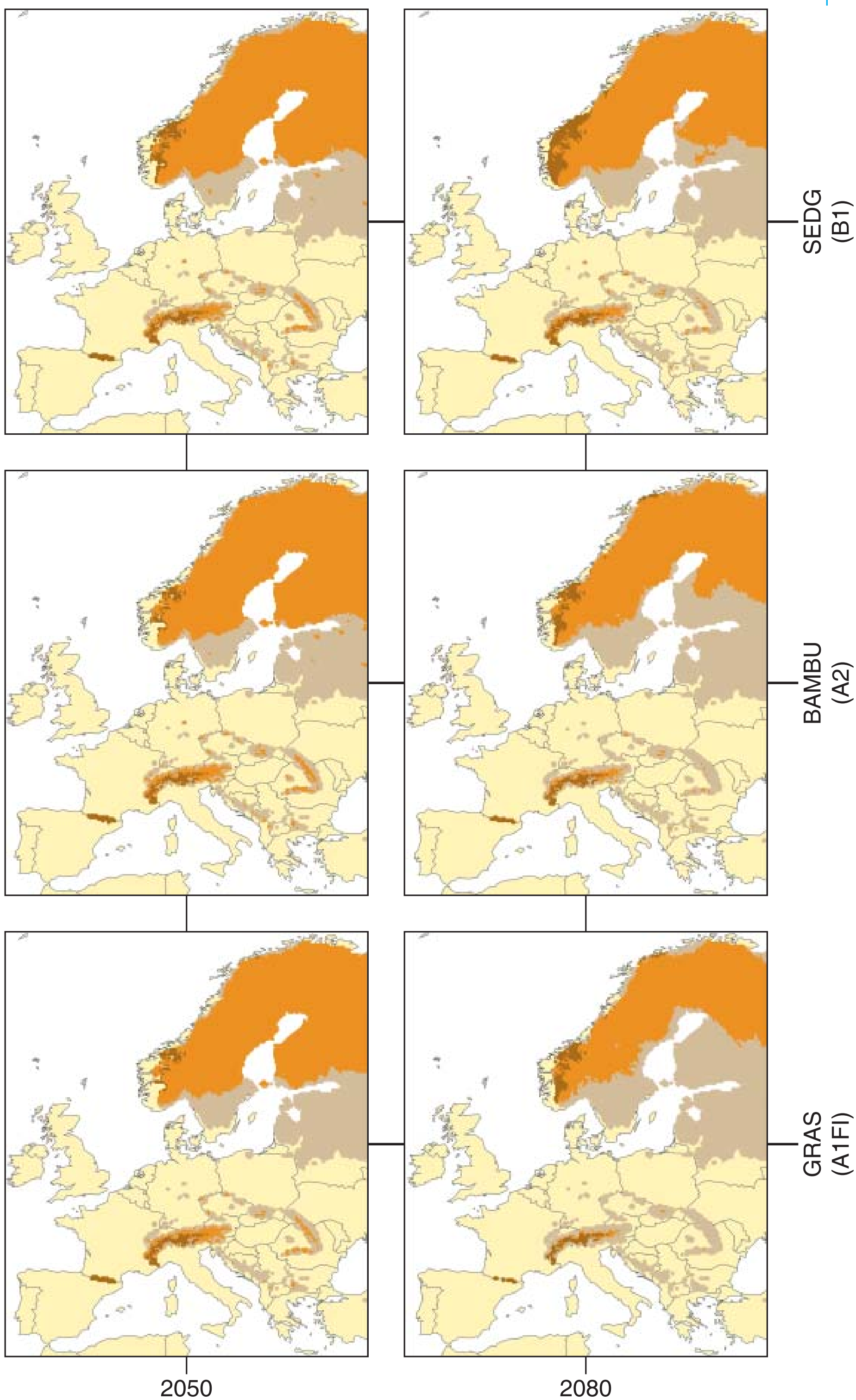
Present distribution can be well explained by climatic variables (AUC = 0.9).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Colias erate (Esper, 1805) – Eastern Pale Clouded Yellow

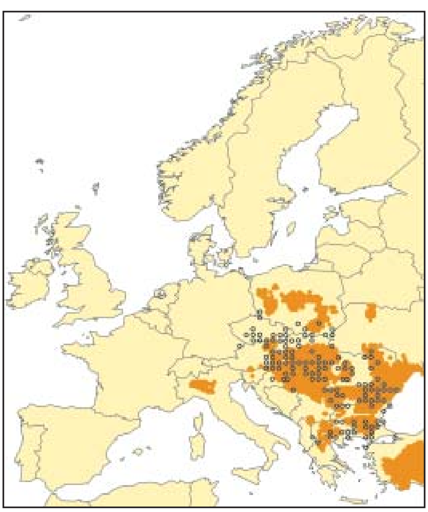
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	2797 (116.83%)	-331 (-13.83%)
	BAMBU	815 (34.04%)	-1199 (-50.08%)
	GRAS	1982 (82.79%)	-989 (-41.31%)
2080	SEDG	1379 (57.6%)	-1160 (-48.45%)
	BAMBU	-317 (-13.24%)	-2059 (-86.01%)
	GRAS	44 (1.84%)	-2260 (-94.4%)

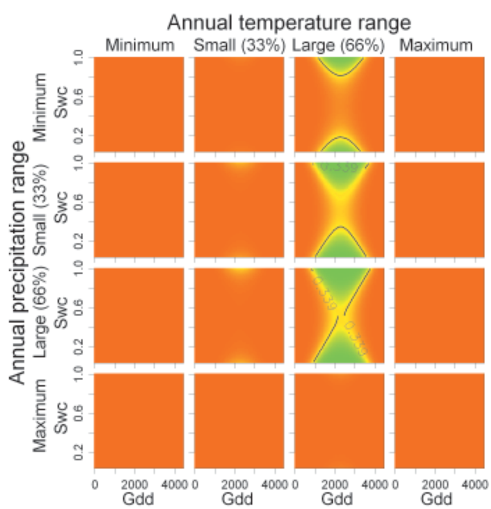
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2394 cells)

The Eastern Pale Clouded Yellow is a very mobile species and can therefore be seen in all sorts of places. This species greatly extended its range during the 1970s and 80s. 50 years ago this mainly Asian species was known in Europe only from the Black Sea coast. Lucerne (*Medicago sativa*) is its most important larval foodplant and they are most numerous in areas where it is grown. The caterpillars can also be found on other leguminous plants. This species has several generations a year; three to five have been reported from Bulgaria and Romania. This species passes the winter as a caterpillar (probably without diapause).

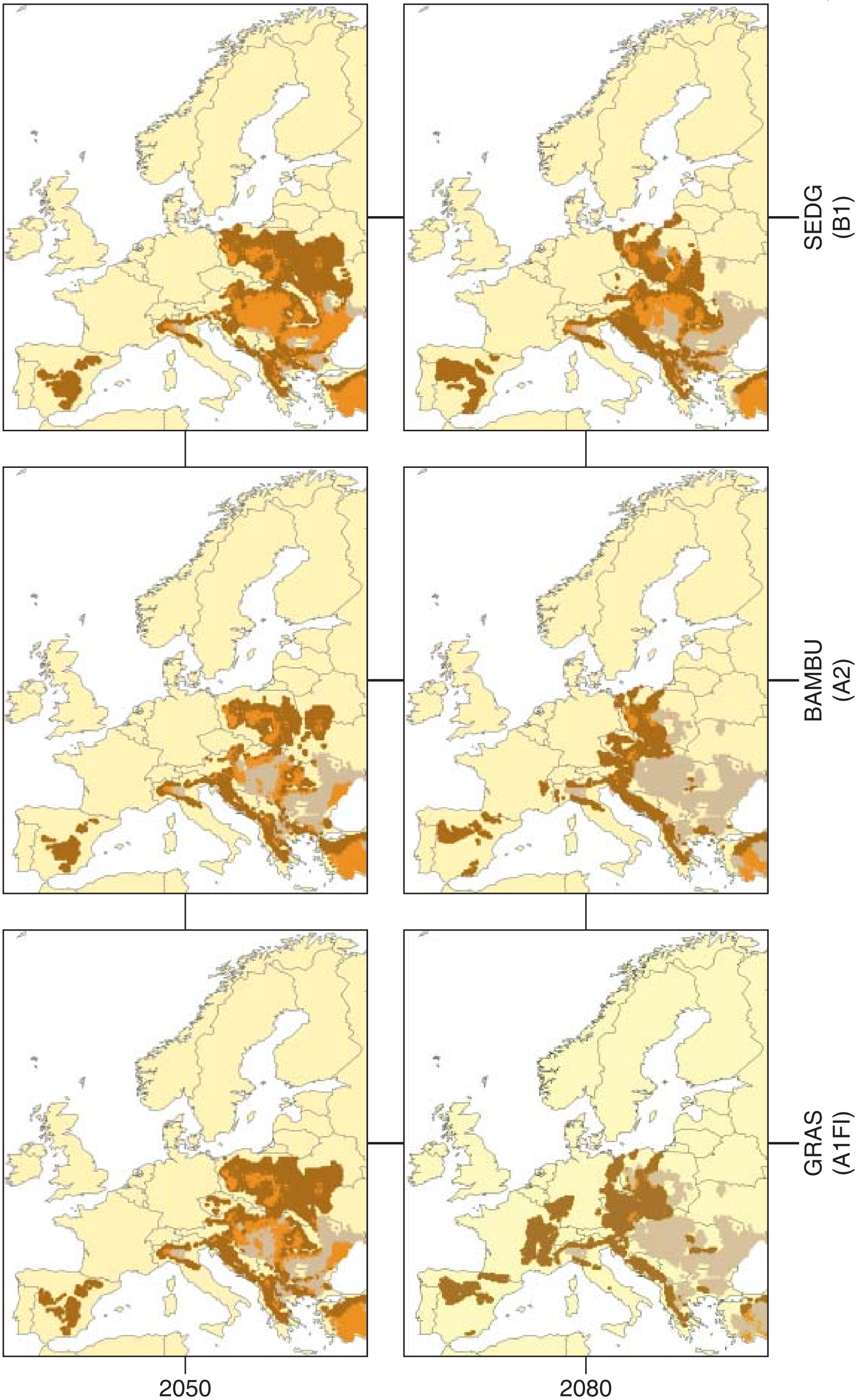
Present distribution can be well explained by climatic variables (AUC = 0.92).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Colias croceus (Geoffroy, 1785) – Clouded Yellow

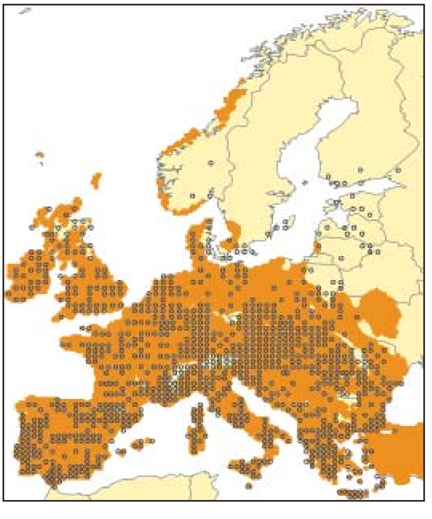
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	1037 (6.41%)	-1750 (-10.81%)
	BAMBU	-123 (-0.76%)	-2525 (-15.6%)
	GRAS	-420 (-2.59%)	-2931 (-18.11%)
2080	SEDG	-962 (-5.94%)	-3518 (-21.74%)
	BAMBU	-3091 (-19.1%)	-5896 (-36.43%)
	GRAS	-4329 (-26.75%)	-7460 (-46.09%)

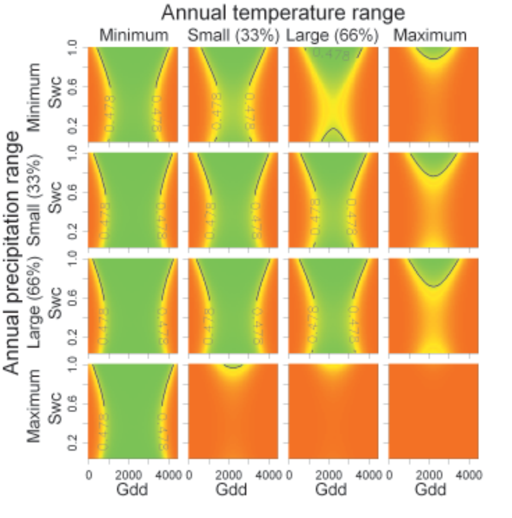
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 16185 cells)

In good summers, the Clouded Yellow is a very fast flyer and can be seen practically over the whole of Europe, often on fields of clover or lucerne, or other flower-rich vegetations. It lays its eggs one by one, on the leaves of such leguminous plants as Lucerne (*Medicago sativa*), clovers (*Trifolium* spp.), and vetches (*Vicia* spp.). It pupates, suspended in a silken girdle on the foodplant. In the south, it usually passes the winter as a caterpillar. In the north, because it cannot tolerate the cold, it only appears as a summer migrant, recolonizing from the south. This species has four to six broods a year.

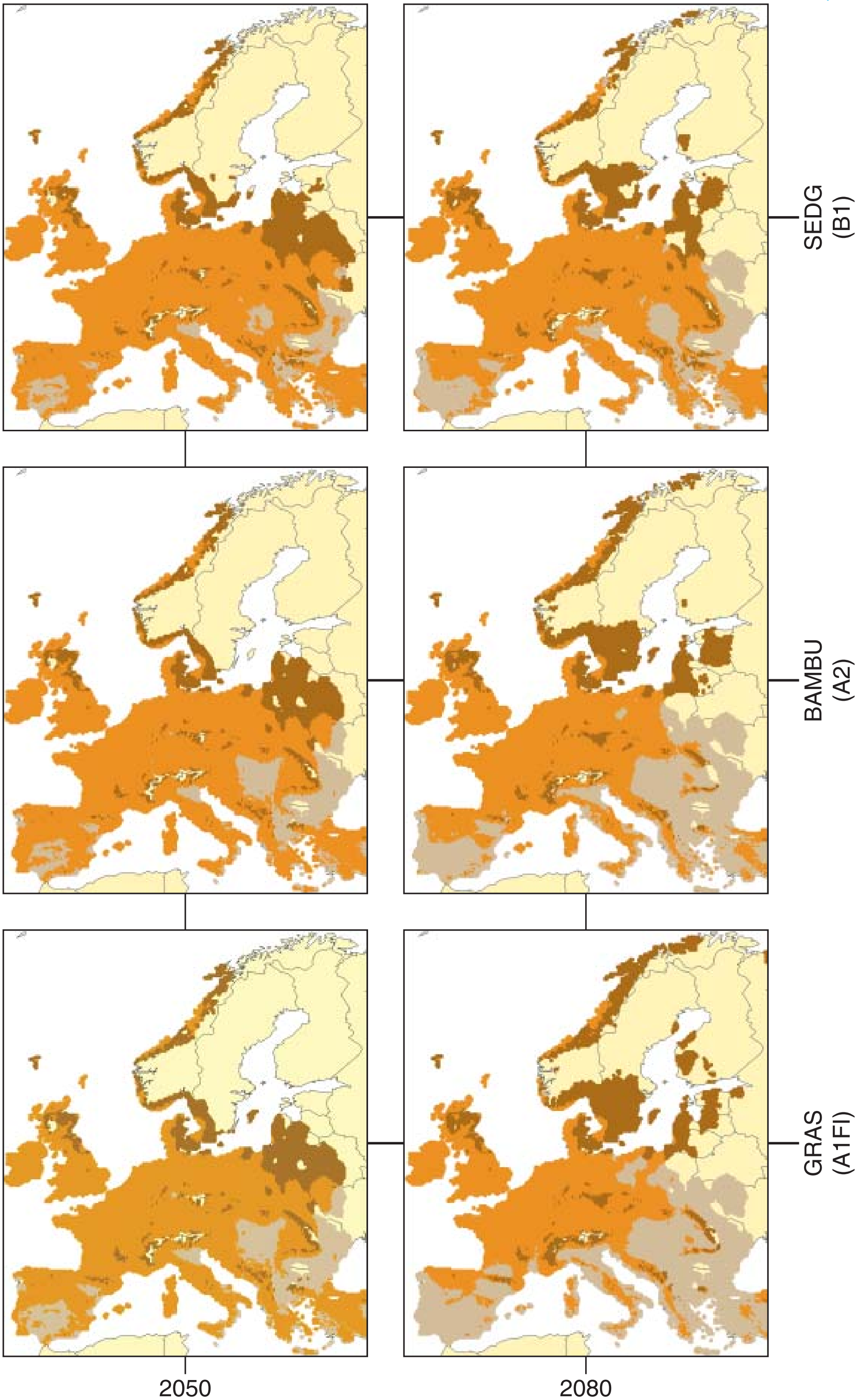
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.76). Climate risk category: LR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Colias hecla Lefebvre, 1836 – Northern Clouded Yellow

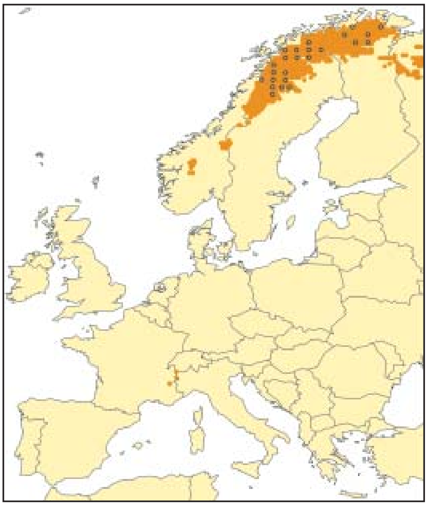
© Jostein Engdal

		Full dispersal	No dispersal
2050	SEDG	-736 (-75.1%)	-785 (-80.1%)
	BAMBU	-767 (-78.27%)	-791 (-80.71%)
	GRAS	-784 (-80%)	-805 (-82.14%)
2080	SEDG	-828 (-84.49%)	-879 (-89.69%)
	BAMBU	-931 (-95%)	-949 (-96.84%)
	GRAS	-963 (-98.27%)	-964 (-98.37%)

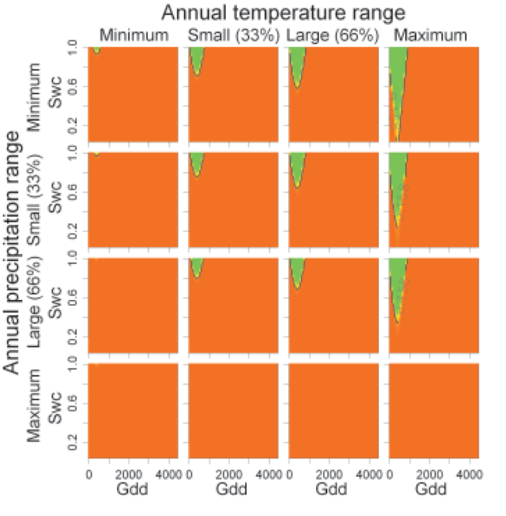
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 980 cells)

The Northern Clouded Yellow occurs in the mountains of Lapland above the birch zone, on open, grassy meadows, and stony slopes. The butterflies fly very quickly and are difficult to approach. Eggs are laid singly or in small groups on the larval foodplants, or on neighbouring plants. Alpine Milk-vetch (*Astragalus alpinus*) is the most important foodplant, but other milk-vetches (*Astragalus* spp.) may also be used. The caterpillars feed on the flowers, leaves and stems, sometimes taking two years to complete their life-cycle. Hibernation can take place as a caterpillar or a pupa.

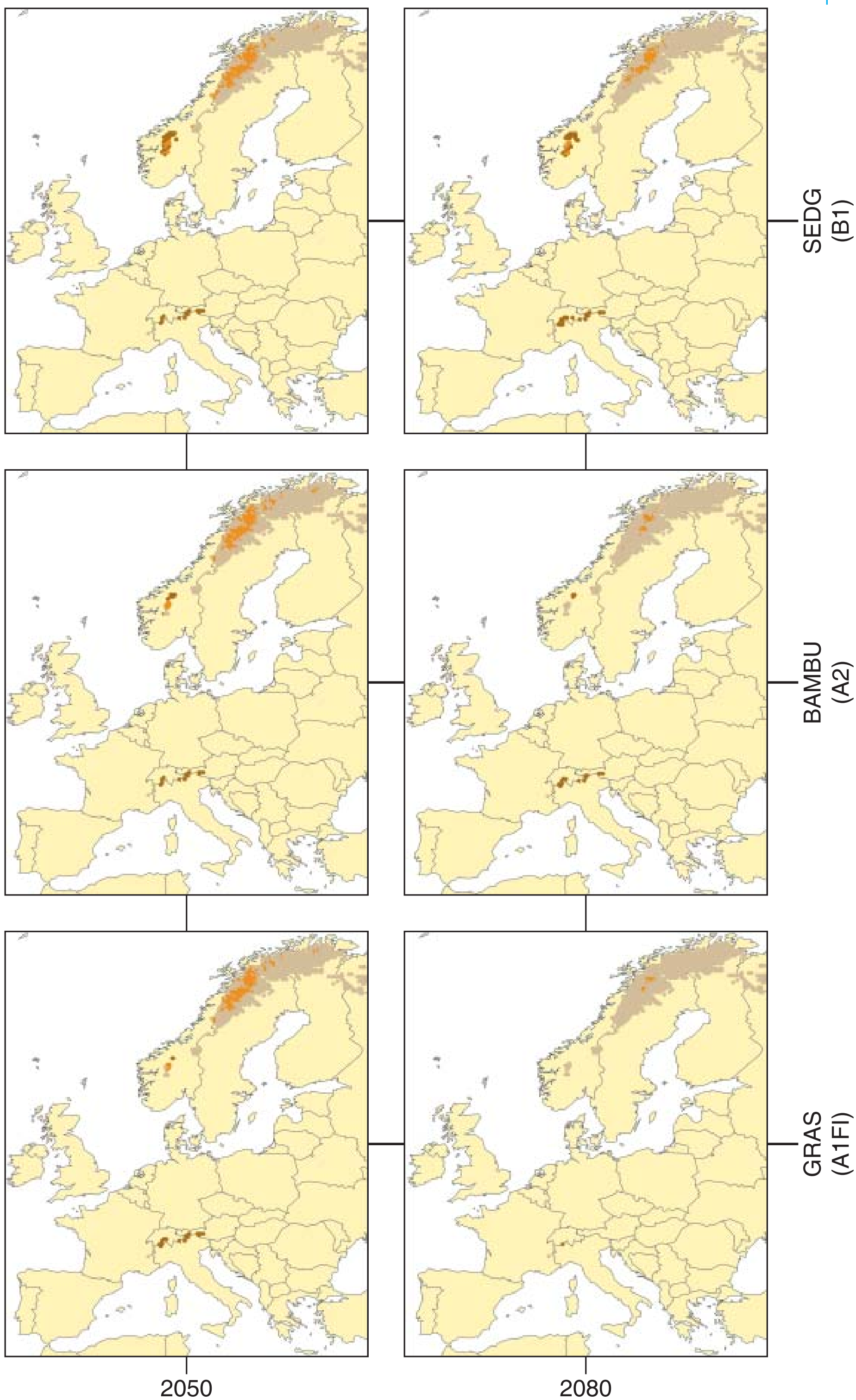
Present distribution can be very well explained by climatic variables (AUC = 0.99).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Colias myrmidone (Esper, 1780) – Danube Clouded Yellow

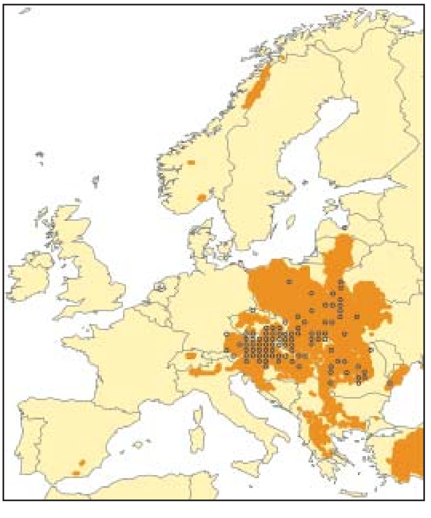
© Martin Wiemers

		Full dispersal	No dispersal
2050	SEDG	-329 (-7.74%)	-1351 (-31.77%)
	BAMBU	-2181 (-51.29%)	-2616 (-61.52%)
	GRAS	-1528 (-35.94%)	-2196 (-51.65%)
2080	SEDG	-1896 (-44.59%)	-3193 (-75.09%)
	BAMBU	-2971 (-69.87%)	-3887 (-91.42%)
	GRAS	-2667 (-62.72%)	-4048 (-95.2%)

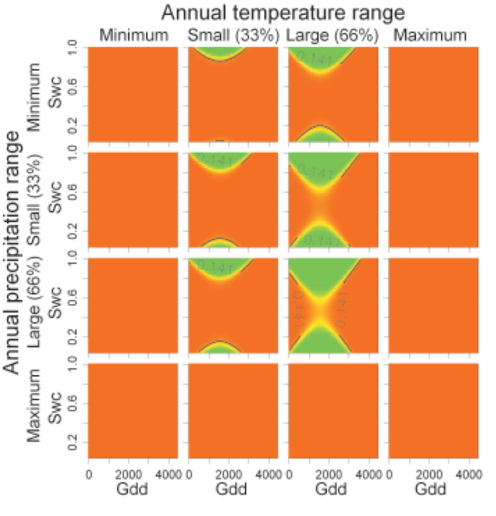
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 4252 cells)

The Danube Clouded Yellow occurs in dry, warm grassland where its foodplant, the broom *Chamaecytisus ratisbonensis*, *C. supnus*, *C. capitatus*, *C. austiracus* are abundant. However, the amount of shelter from bushes can vary considerably. The female lays her eggs on the foodplant, the caterpillars hibernate in the litter layer. It has two to three broods a year. In contrast to the Eastern Pale Clouded Yellow, this species has disappeared from most of its former locations in Central Europe and is now extinct in several countries.
This species is listed in Annexes II and IV of the Habitats' Directive.

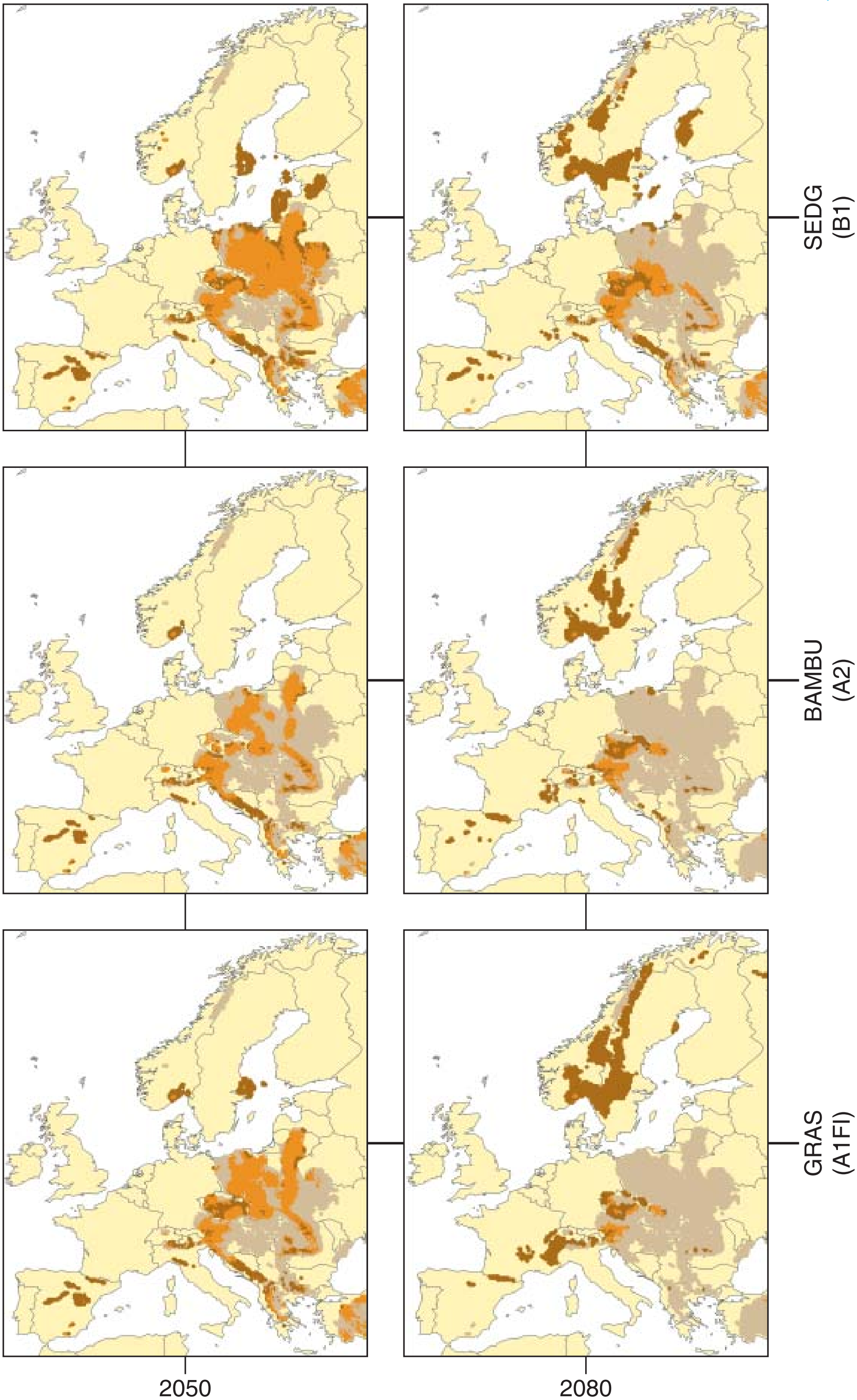
Present distribution can be well explained by climatic variables (AUC = 0.92).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Colias chrysotheme (Esper, 1780) – Lesser Clouded Yellow

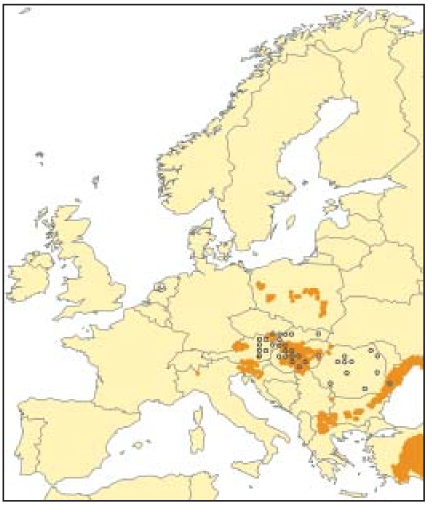
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	416 (55.32%)	-489 (-65.03%)
	BAMBU	-246 (-32.71%)	-565 (-75.13%)
	GRAS	463 (61.57%)	-559 (-74.34%)
2080	SEDG	-519 (-69.02%)	-665 (-88.43%)
	BAMBU	-490 (-65.16%)	-707 (-94.02%)
	GRAS	-550 (-73.14%)	-733 (-97.47%)

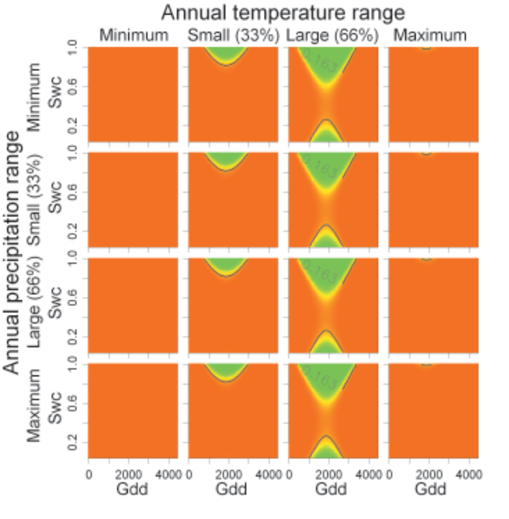
Changes in climatic niche distribution (in 10’×10’ grid cells; present niche space: 752 cells)

The Lesser Clouded Yellow is found on open, dry, steppe-like grassland and rocky slopes. Its main foodplant is the Milk-vetch (*Astragalus austriacus*), but Milk-vetch (*A. glycyphyllos*) and vetches (*Vicia* spp.) are also used. This species has three to four broods a year and hibernates as a caterpillar.

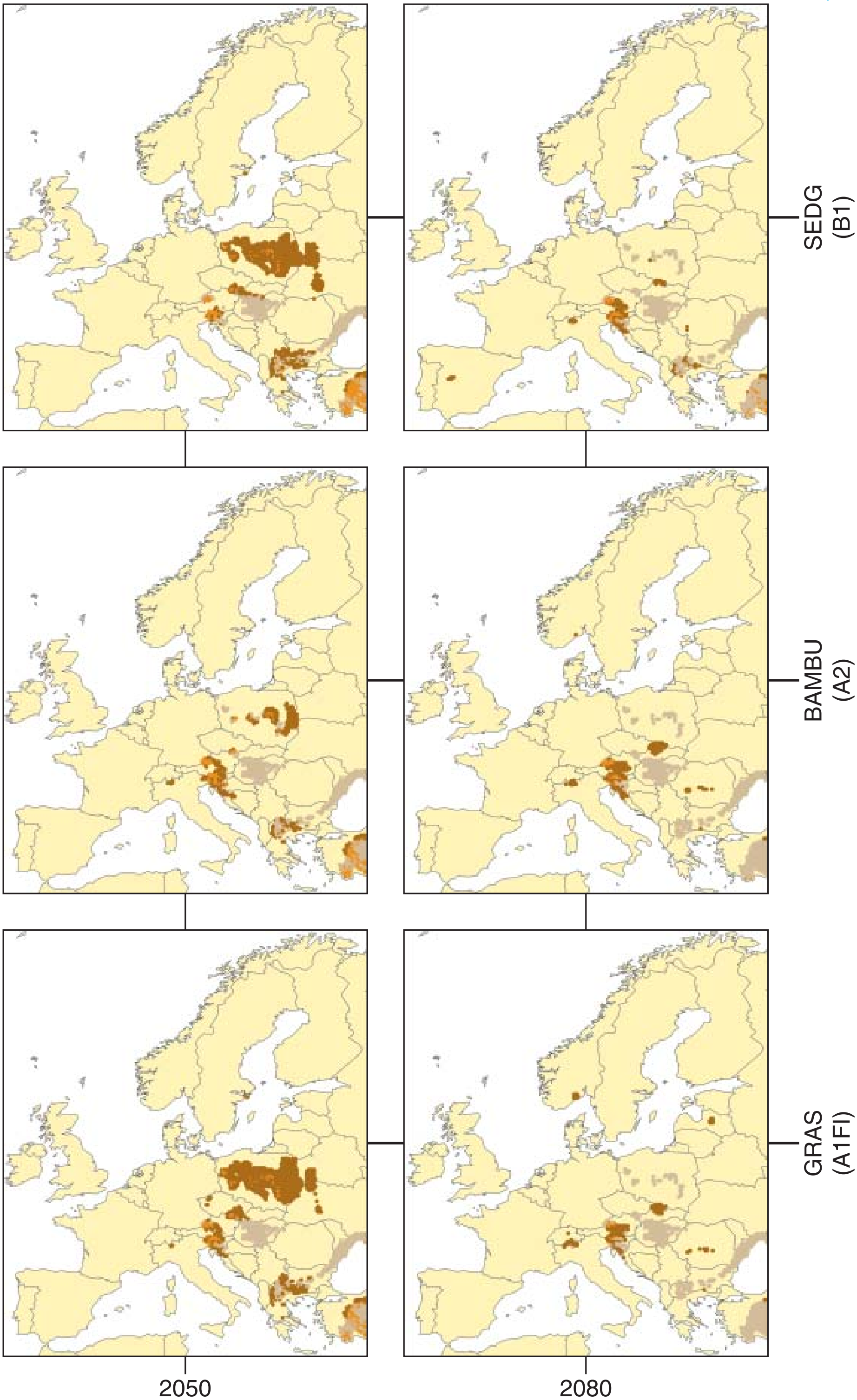
Present distribution can be well explained by climatic variables (AUC = 0.89).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Colias hyale (Linnaeus, 1758) – Pale Clouded Yellow

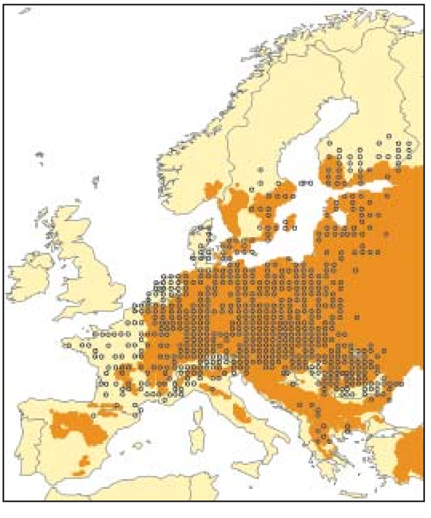
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	-437 (-3.49%)	-2793 (-22.28%)
	BAMBU	-305 (-2.43%)	-2961 (-23.62%)
	GRAS	-786 (-6.27%)	-3393 (-27.07%)
2080	SEDG	-905 (-7.22%)	-5229 (-41.72%)
	BAMBU	-1777 (-14.18%)	-7208 (-57.5%)
	GRAS	-3035 (-24.21%)	-9284 (-74.06%)

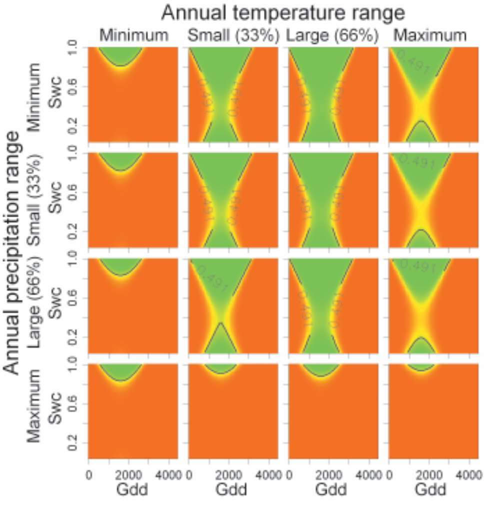
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 12535 cells)

The Pale Clouded Yellow is mostly found on fields of clover or lucerne, but also on meadows that are lightly grazed where many leguminous plants are growing. It prefers open landscapes with few trees or bushes. Eggs are laid singly on many species of Leguminosae. The caterpillar feeds on young leaves and overwinters as half-grown caterpillar. It pupates, suspended in a girdle from a stalk on the foodplant. The Pale Clouded Yellow has two or three generations a year. In the northern part of its range, it is a migrant species, but in most of Central Europe it is a resident. The adult Pale Clouded Yellow is very hard to distinguish from Berger's Clouded Yellow (*Colias alfacariensis*), while the larvae are very different.

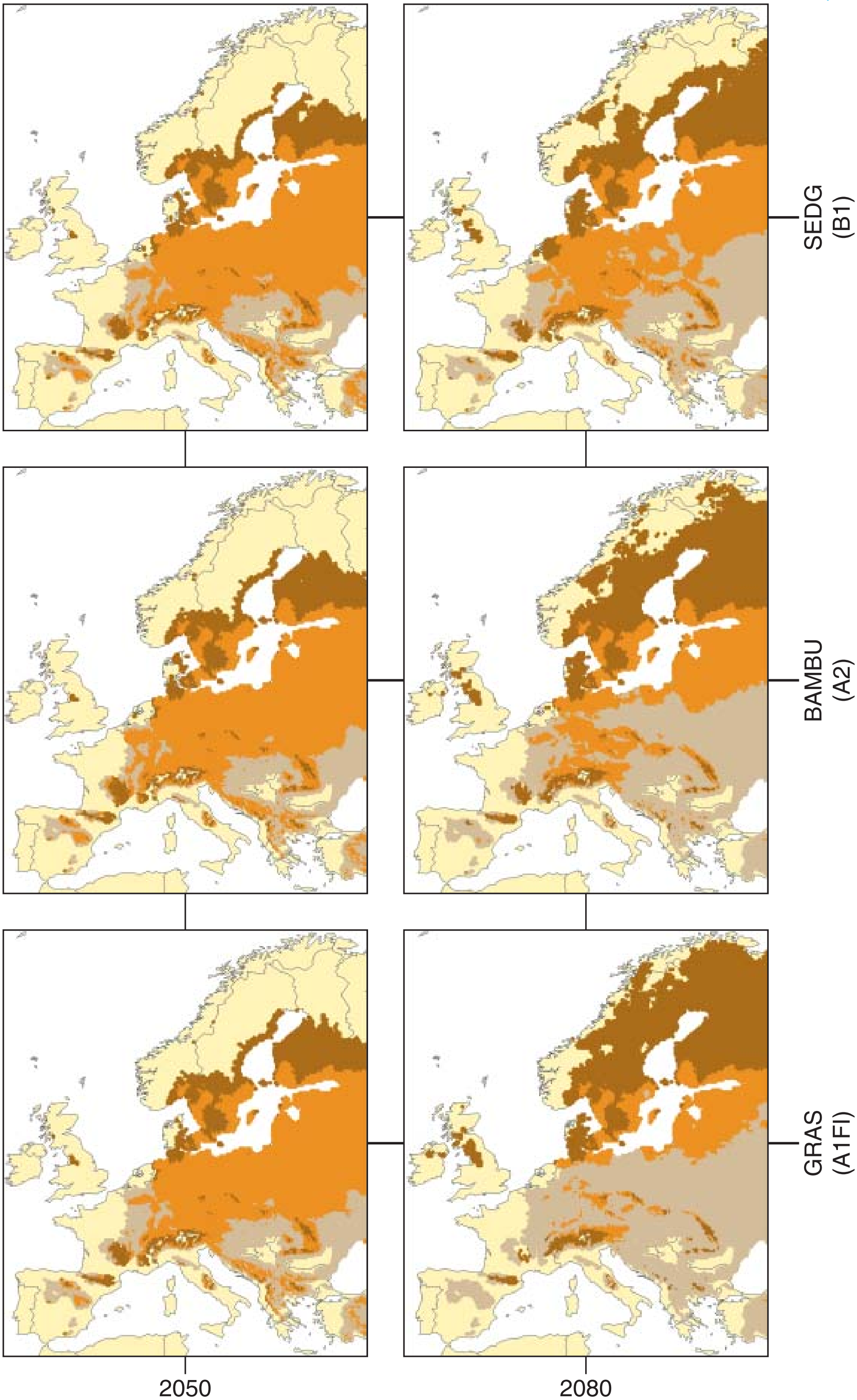
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.84). Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Colias alfacariensis Ribbe, 1905 – Berger's Clouded Yellow

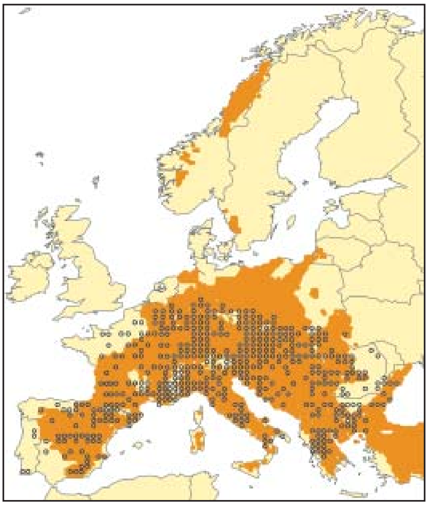
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	983 (10.19%)	-2101 (-21.78%)
	BAMBU	32 (0.33%)	-2997 (-31.06%)
	GRAS	-144 (-1.49%)	-3278 (-33.98%)
2080	SEDG	-812 (-8.42%)	-4054 (-42.02%)
	BAMBU	-1547 (-16.03%)	-5409 (-56.06%)
	GRAS	-2461 (-25.51%)	-6649 (-68.92%)

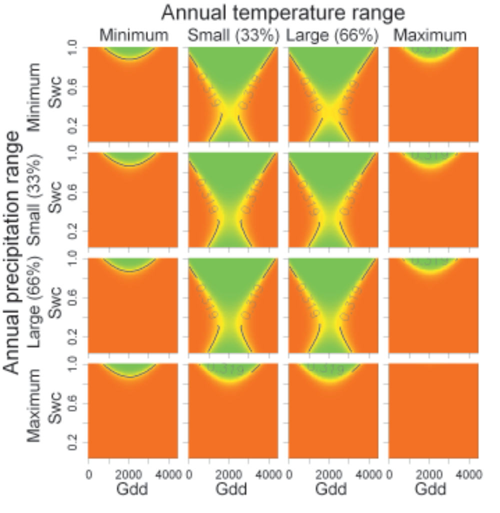
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 9648 cells)

The Berger's Clouded Yellow is a butterfly of dry, open grasslands on calcareous soils. In the northern part of its distribution range, it often occurs on the south-facing slopes of hills or mountains. Eggs are mostly laid on Horseshoe Vetch (*Hippocrepis comosa*), also on Crown Vetch (*Coronilla varia*). Hibernation takes place on the foodplant, or on the ground in the litter layer. For pupation the caterpillar attaches itself to a foodplant, turning into a pupa, suspended by a silken girdle. This species has two or three broods a year. The adult Berger's Clouded Yellow and Pale Clouded Yellow are so similar that it is not possible to identify them with certainty, while this is easy for the caterpillars.

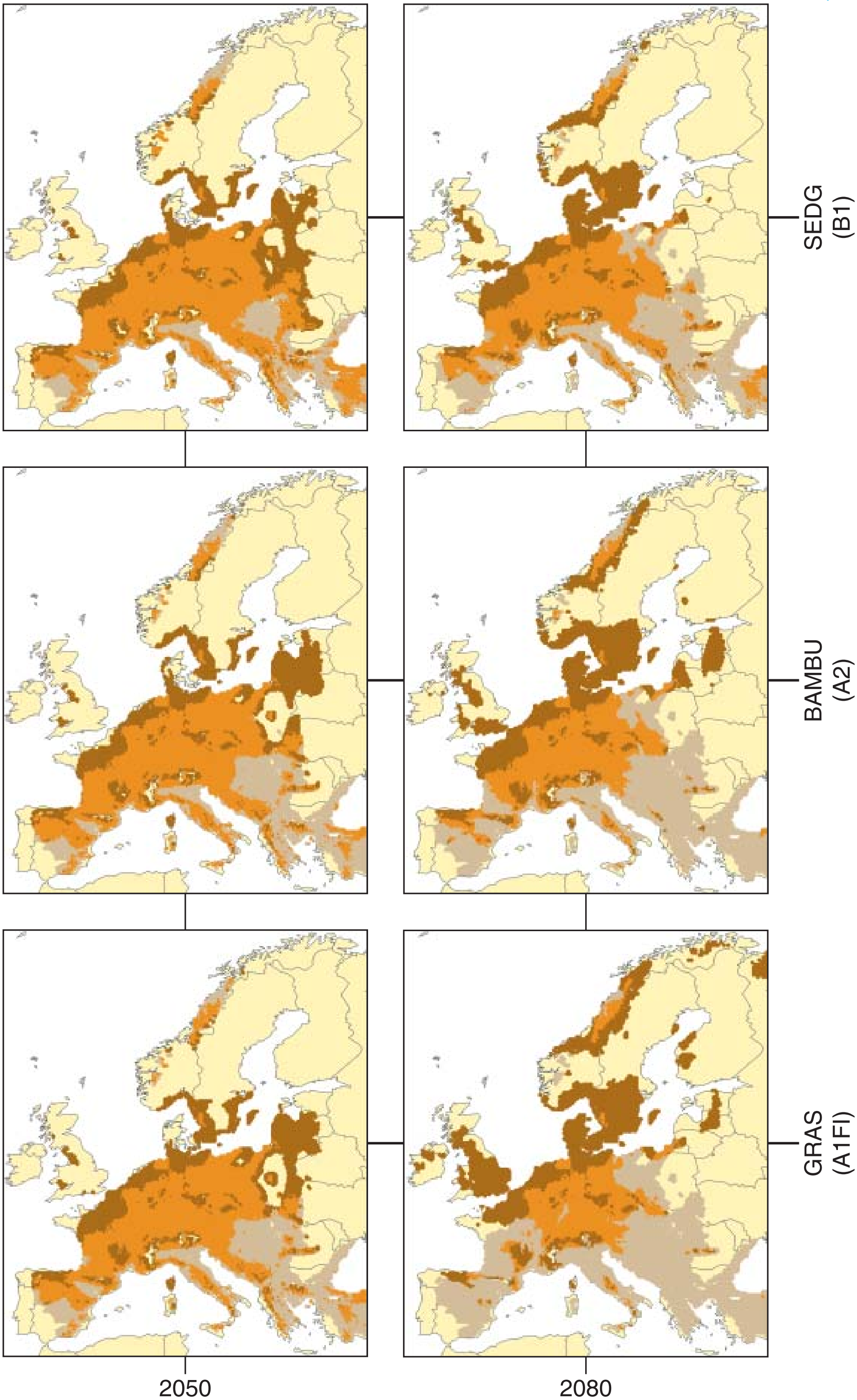
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.84).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Gonepteryx rhamni (Linnaeus, 1758) – Brimstone

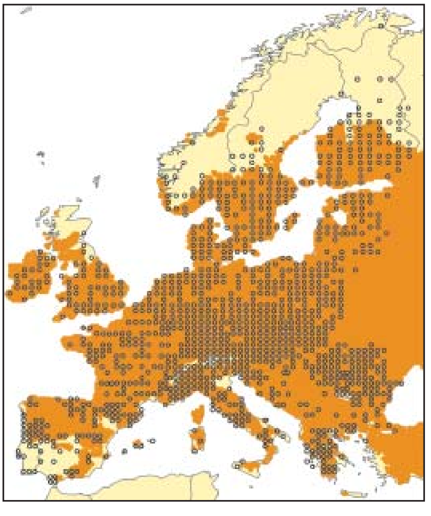
© Peter Ginzinger

		Full dispersal	No dispersal
2050	SEDG	-1084 (-5.26%)	-3228 (-15.67%)
	BAMBU	-1593 (-7.73%)	-3440 (-16.7%)
	GRAS	-1973 (-9.58%)	-4092 (-19.87%)
2080	SEDG	-1165 (-5.66%)	-4835 (-23.47%)
	BAMBU	-2555 (-12.4%)	-7022 (-34.09%)
	GRAS	-4146 (-20.13%)	-9486 (-46.05%)

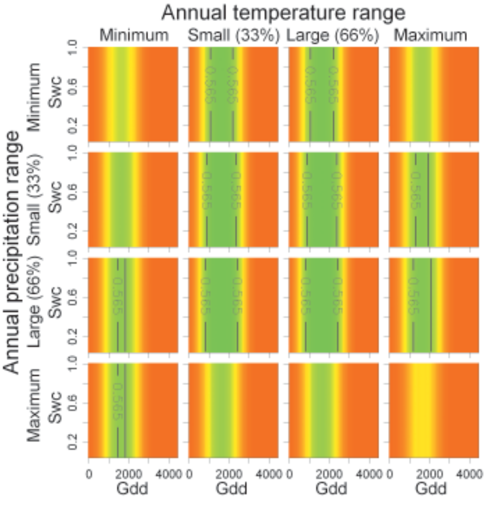
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 20599 cells)

For many, the Brimstone is the first sign of spring. The butterflies hibernate in heaps of twigs or grass tussocks, and on any warm day, even in January, the males appear. The females, that are paler in colour, are seen a little later. The eggs are laid apart on the young branches and leaves of buckthorns (*Rhamnus* spp.). The caterpillars feed on the young leaves. They pupate, suspended from the underside of a twig or nerve of a leaf. In the summer, when the butterflies emerge, they do not mate but instead may become inactive for quite long periods before they hibernate. Courtship and mating do not take place until the spring. The Brimstone always has just one generation a year.

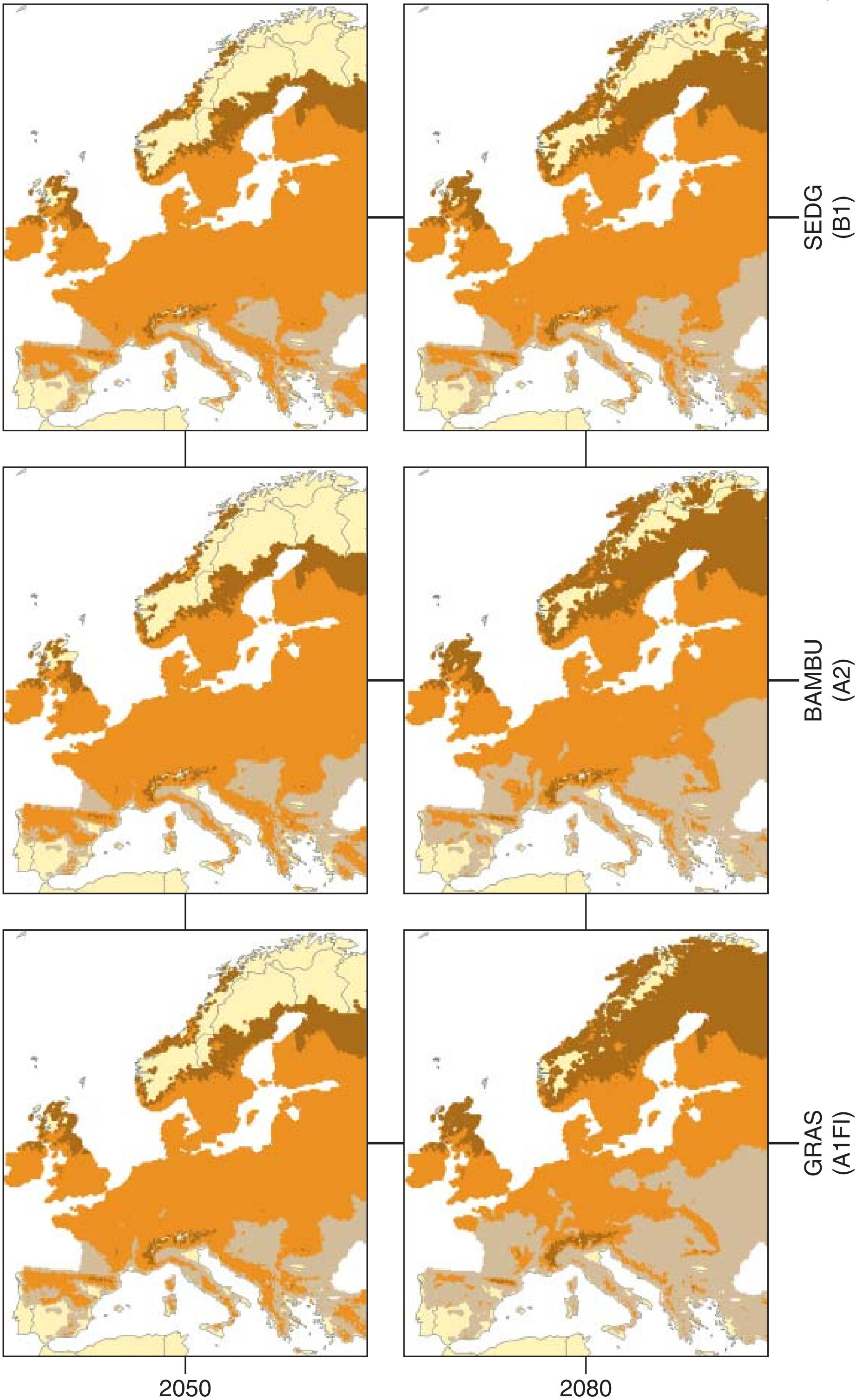
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.73). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

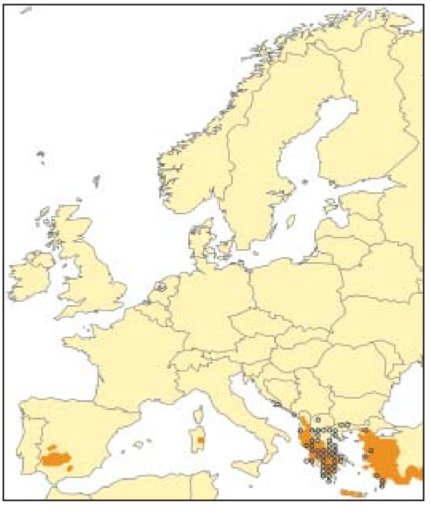
Gonepteryx farinosa Zeller, 1847 – Powdered Brimstone

		Full dispersal	No dispersal
2050	SEDG	89 (13.8%)	-189 (-29.3%)
	BAMBU	75 (11.63%)	-188 (-29.15%)
	GRAS	84 (13.02%)	-231 (-35.81%)
2080	SEDG	334 (51.78%)	-210 (-32.56%)
	BAMBU	-27 (-4.19%)	-369 (-57.21%)
	GRAS	-144 (-22.33%)	-519 (-80.47%)

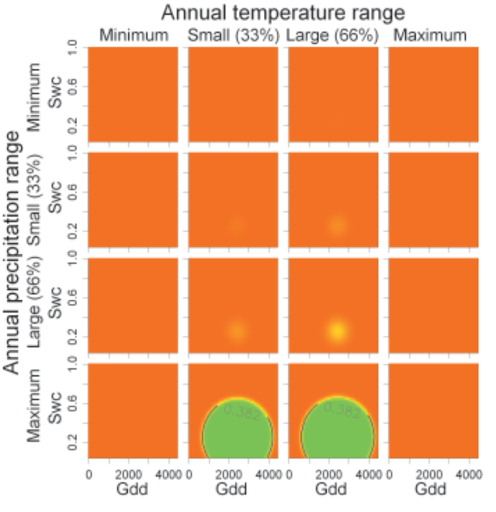
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 645 cells)

The Powdered Brimstone larvae feed on the prickly Christ’s Thorne (*Paliurus spina-christi*) and on various buckthorns, such as *Rhamnus alpinus*, *R. sibthorpianus* and *R. lycioides*. They are therefore often seen on bushy vegetation, namely in warm, dry places and on rocky slopes. However, in their search for nectar, they also fly in other places. It has one generation a year and, like other brimstones, hibernates as a butterfly.

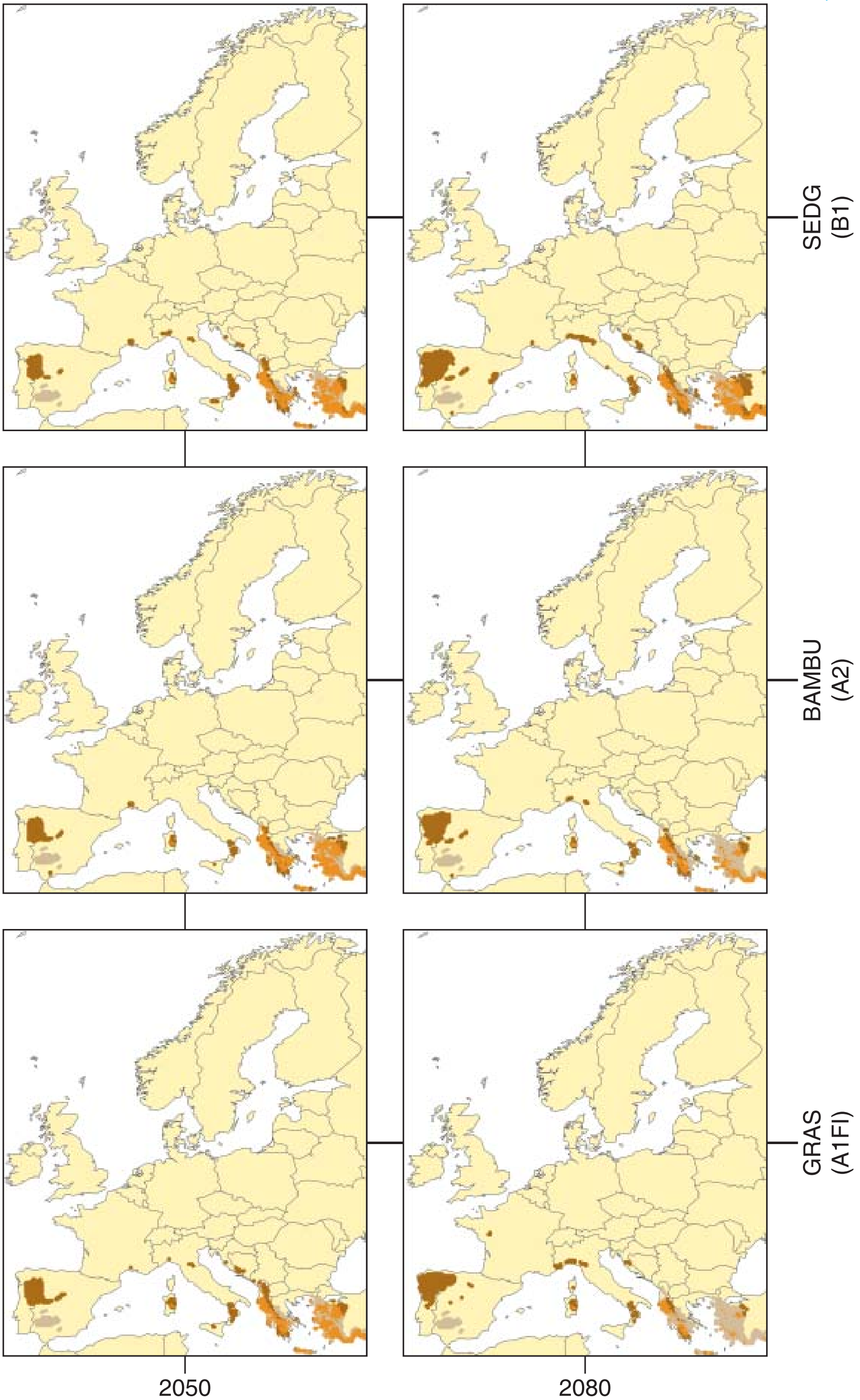
Present distribution can be well explained by climatic variables (AUC = 0.94).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Gonepteryx cleopatra (Linnaeus, 1767) – Cleopatra

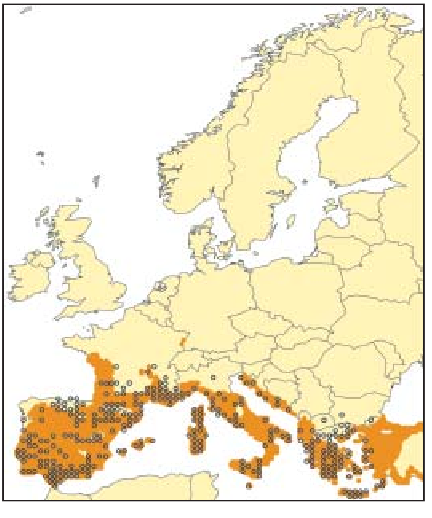
© Peter Ginzinger

		Full dispersal	No dispersal
2050	SEDG	-17 (-0.4%)	-1417 (-33.35%)
	BAMBU	-595 (-14%)	-1527 (-35.94%)
	GRAS	-31 (-0.73%)	-1653 (-38.9%)
2080	SEDG	-143 (-3.37%)	-1918 (-45.14%)
	BAMBU	-1013 (-23.84%)	-2621 (-61.69%)
	GRAS	-1293 (-30.43%)	-3250 (-76.49%)

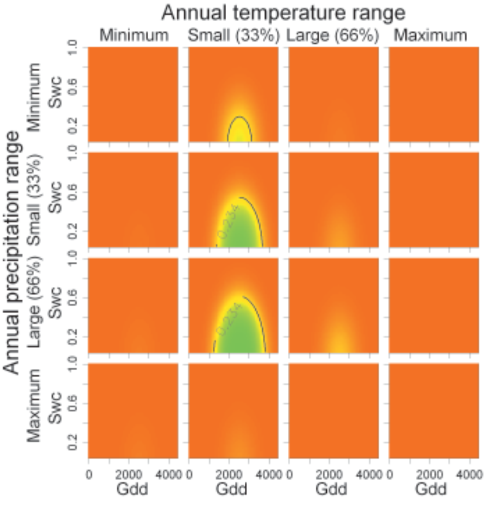
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 4249 cells)

The Cleopatra is found in light woodland, woodland edges and open bushy places. The males are easily recognized in flight by the orange patches on their forewings; the female looks very much like an ordinary brimstone. They are strong flyers that sometimes roam outside their breeding area. The eggs are laid on the young leaves of various buckthorns, such as Buckthorn (*Rhamnus catharticus*), Mediterranean Buckthorn (*R. alaternus*), and Alpine Buckthorn (*R. alpinus*). The caterpillars feed on the leaves, and pupate on the twigs of the foodplant. The Cleopatra hibernates as an adult butterfly, and therefore can be seen flying for most of the year. Probably, it has only one generation a year.

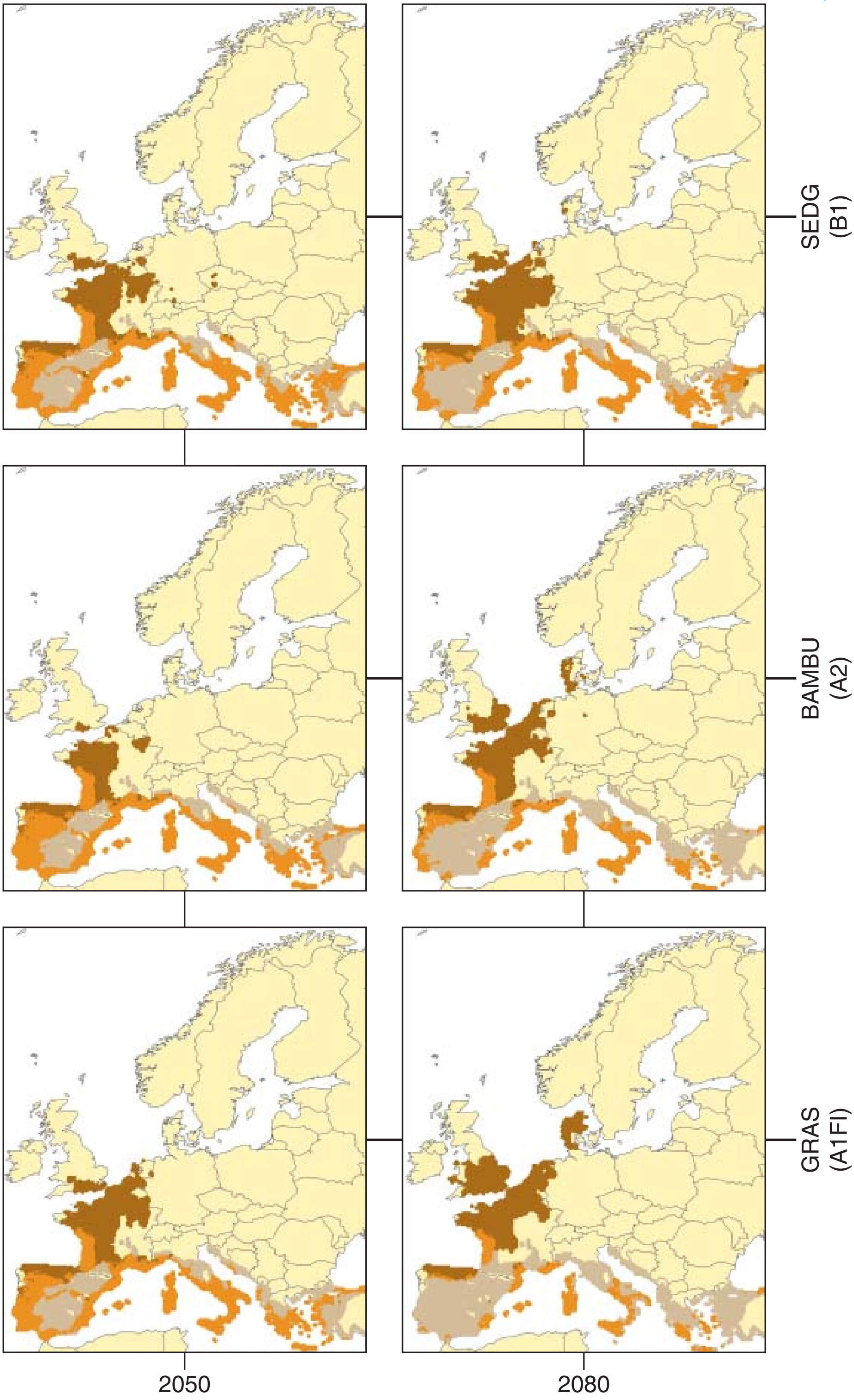
Present distribution can be well explained by climatic variables (AUC = 0.92).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Lycaena phlaeas (Linnaeus, 1761) – Small Copper

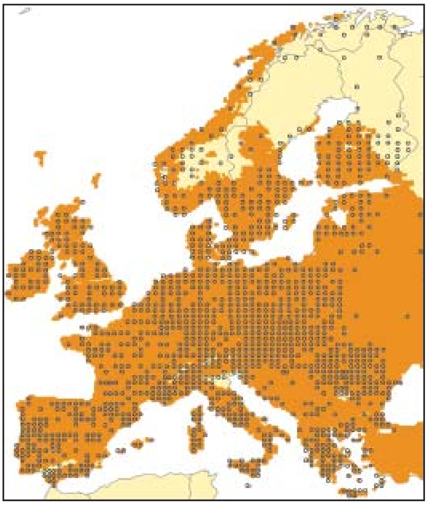
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-2168 (-9.07%)	-3372 (-14.1%)
	BAMBU	-4048 (-16.93%)	-4602 (-19.25%)
	GRAS	-3923 (-16.41%)	-4776 (-19.97%)
2080	SEDG	-5057 (-21.15%)	-6765 (-28.29%)
	BAMBU	-8526 (-35.66%)	-10086 (-42.18%)
	GRAS	-11453 (-47.9%)	-13177 (-55.11%)

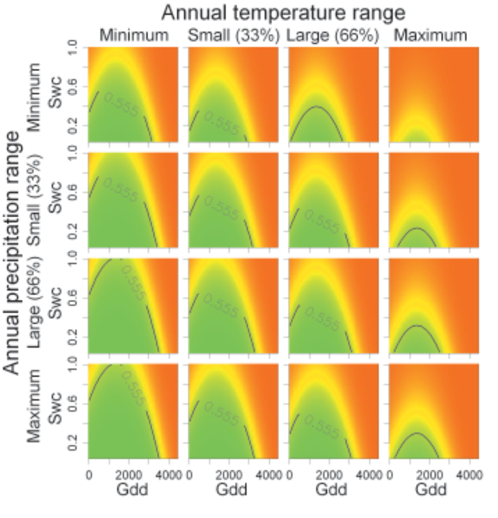
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 23910 cells)

The Small Copper is a very common, widespread butterfly. It is found on all sorts of grasslands and heathlands, roadsides and along the banks of canals. The butterflies often visit flowers, and the males, perched on a tall blade of grass, defend their territory fiercely, flying out at other males of its sort. Eggs are laid on different species of acidic sorrels, mainly Common Sorrel (*Rumex acetosa*). This butterfly species overwinters as a caterpillar. In the north of its range, the Small Copper has two generations a year, whereas in the southern part, it may have three or four.

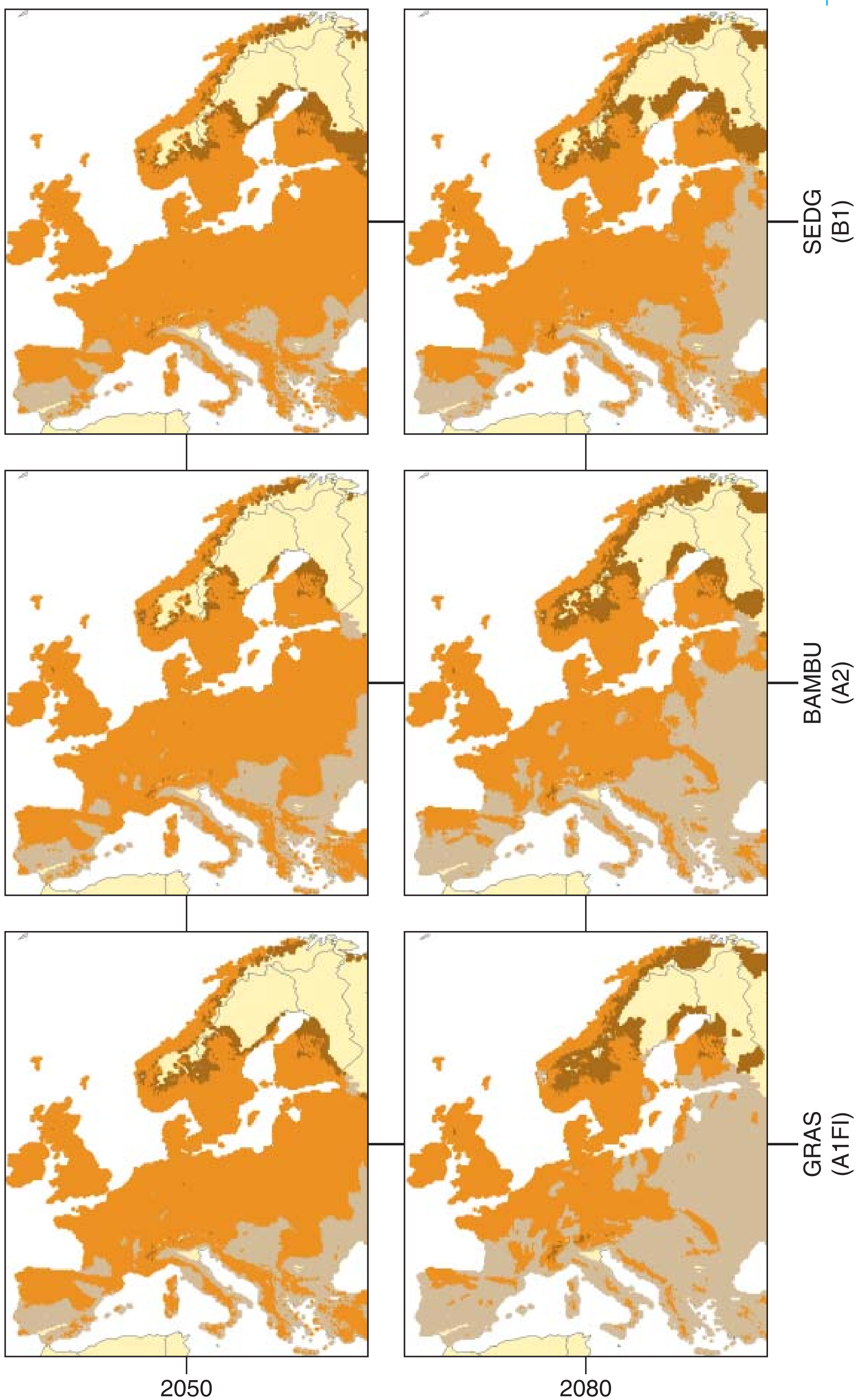
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.65). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Lycaena helle ([Schiffermüller], 1775) – Violet Copper

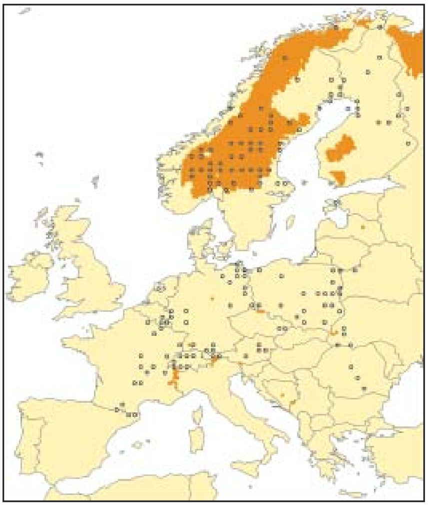
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	159 (6.52%)	-563 (-23.08%)
	BAMBU	229 (9.39%)	-487 (-19.97%)
	GRAS	-41 (-1.68%)	-686 (-28.13%)
2080	SEDG	-197 (-8.08%)	-1073 (-43.99%)
	BAMBU	-36 (-1.48%)	-968 (-39.69%)
	GRAS	-466 (-19.11%)	-1201 (-49.24%)

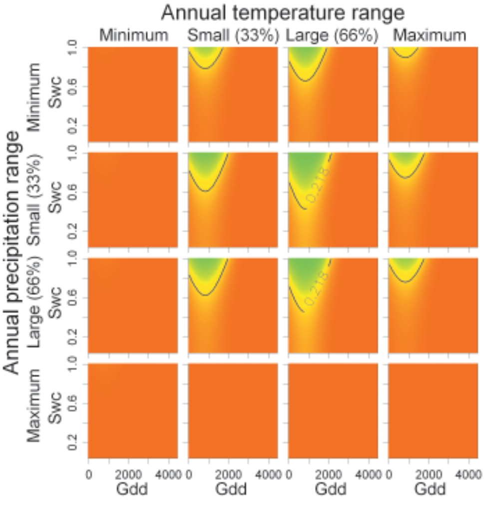
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 2439 cells)

The Violet Copper is a rare butterfly and often confined to very small sites (where it may occur in large numbers). It is found in swampy, wet grassland and rough vegetation bordering streams and lakes. In Central Europe, eggs are laid on the underside of the leaves of Bistort (*Polygonum bistorta*). In the north of its range Viviparous Bistort (*Polygonum vivipara*) is also used as larval foodplant. The young caterpillars eat the lower epidermis, thus making the characteristic “windows”. It passes the winter as a pupa. It has one, sometimes two, generations a year.
This species is listed in Annexes II and IV of the Habitats’ Directive.

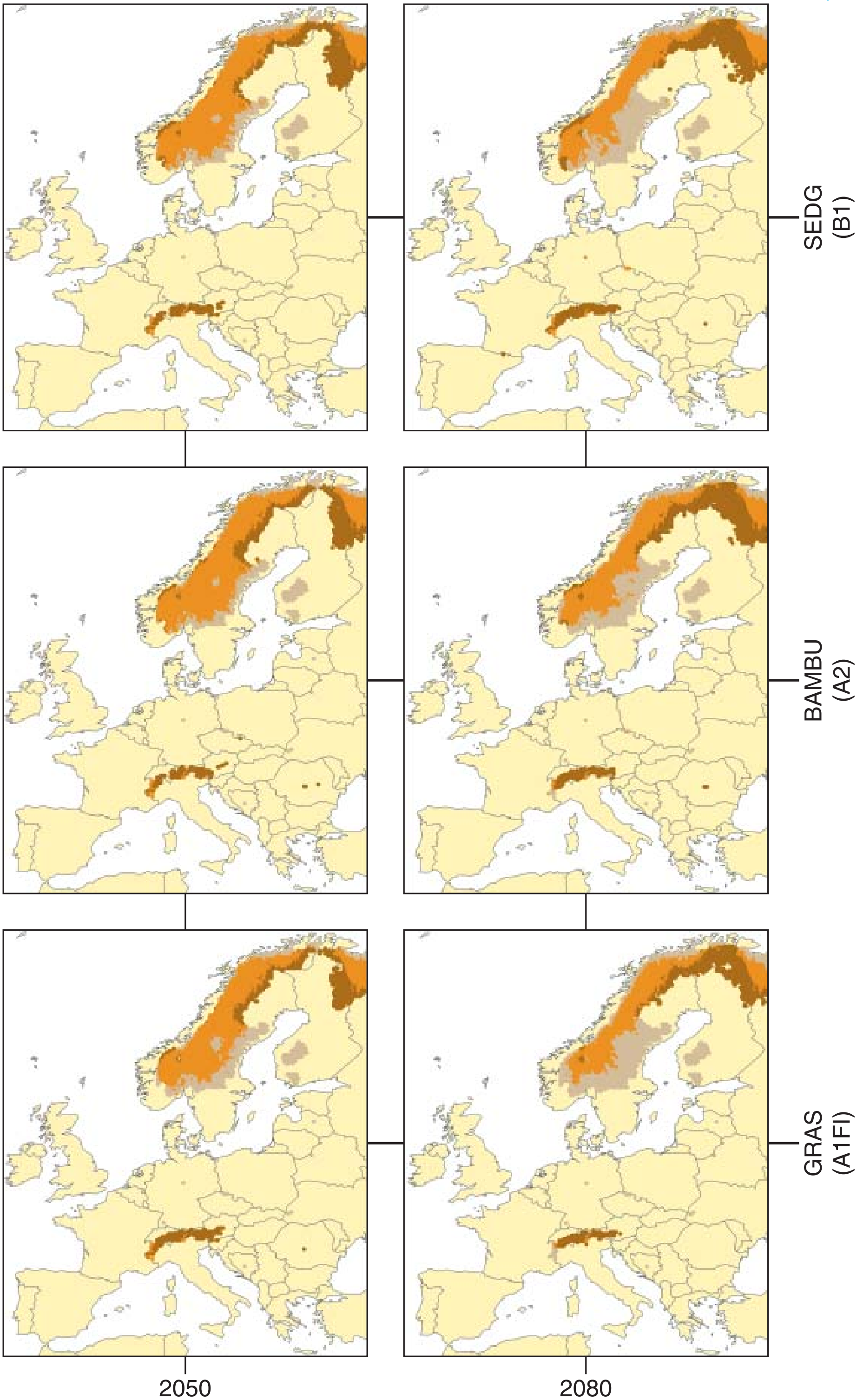
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.78).
Climate risk category: LR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Lycaena dispar (Haworth, 1803) – Large Copper

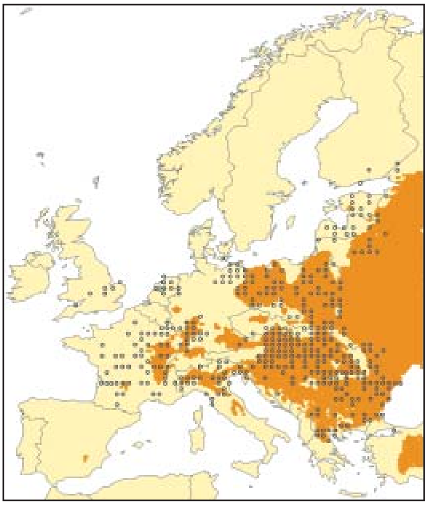
© Josef Settele

		Full dispersal	No dispersal
2050	SEDG	2192 (27.24%)	-1539 (-19.12%)
	BAMBU	3583 (44.52%)	-1262 (-15.68%)
	GRAS	2980 (37.03%)	-1764 (-21.92%)
2080	SEDG	3656 (45.43%)	-2587 (-32.14%)
	BAMBU	4992 (62.03%)	-3071 (-38.16%)
	GRAS	4375 (54.36%)	-4188 (-52.04%)

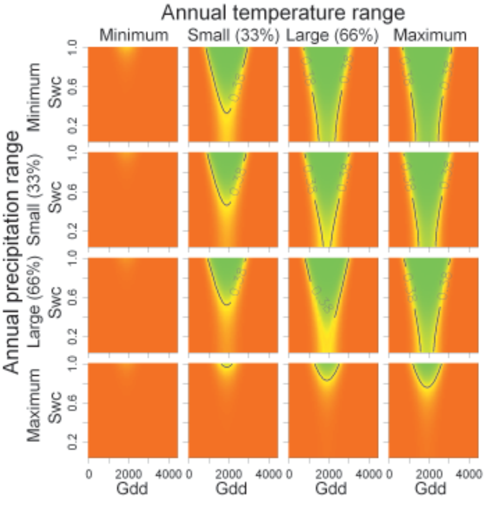
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 8048 cells)

The Large Copper occurs in marshy habitats, and on the peaty banks of lakes, rivers and streams, more to the East also on waste lands. Nectar plants are important for the females, which lay more eggs when there is more food available for them. Eggs are laid on large non-acidic sorrels (like *Rumex crispus*, *R. obtusifolius*, but never *R. acetosa* or *R. acetosella*). The young caterpillars first eat from the underside of the leaves, making the characteristic 'windows'. Later caterpillars feed on the whole leaf. They hibernate when half-grown between withered leaves at the foot of the foodplant and are sometimes associated with ants (*Myrmica rubra* and *Lasius niger*). The Large Copper has several subspecies in Europe. The subspecies *L. d. batava* has one generation a year, and the others two and sometimes even three.
This species is listed in Annexes II and IV of the Habitats' Directive.

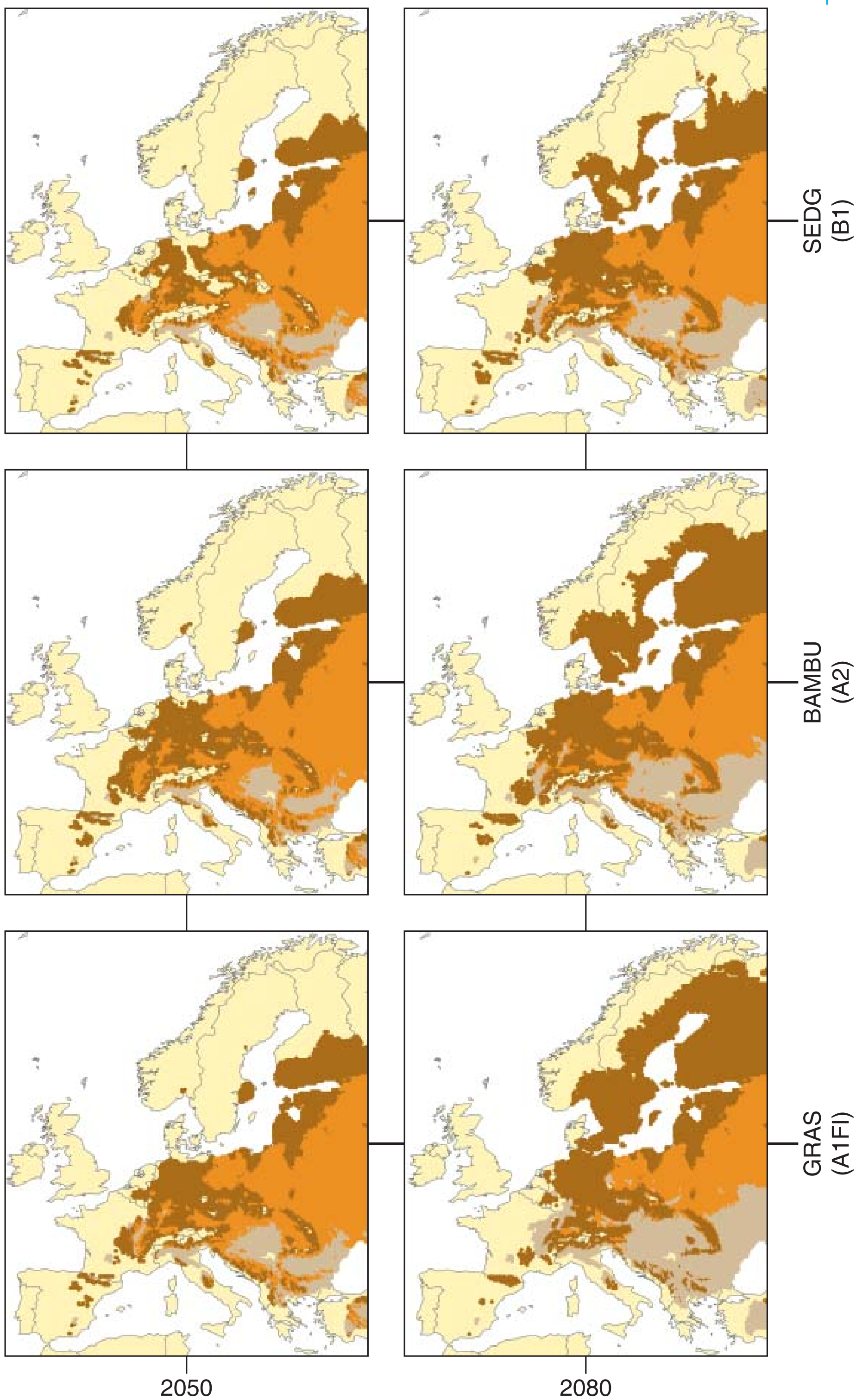
Present distribution can be well explained by climatic variables (AUC = 0.88).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Lycaena virgaureae (Linnaeus, 1758) – Scarce Copper

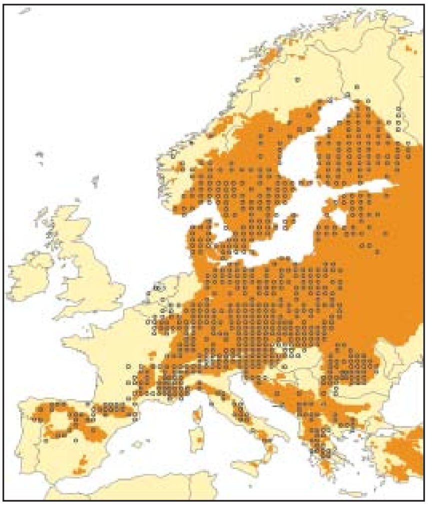
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-780 (-5.26%)	-2762 (-18.63%)
	BAMBU	-2665 (-17.98%)	-3876 (-26.15%)
	GRAS	-3078 (-20.77%)	-4622 (-31.18%)
2080	SEDG	-2694 (-18.18%)	-6097 (-41.13%)
	BAMBU	-5416 (-36.54%)	-8571 (-57.83%)
	GRAS	-7216 (-48.68%)	-10671 (-71.99%)

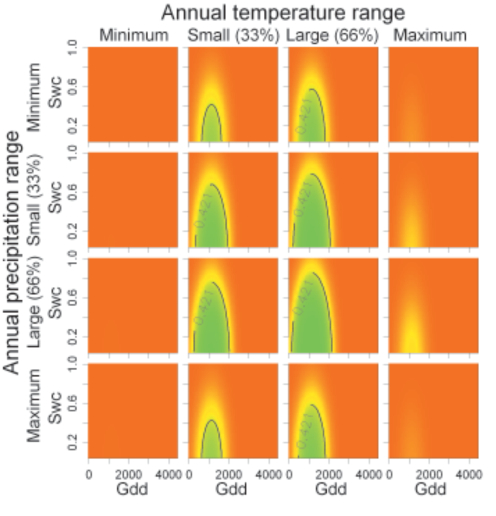
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 14822 cells)

It would be difficult to miss the beautiful and conspicuous Scarce Copper. The white patches on the underside of the hindwing distinguish it from other coppers. It prefers sheltered, flower-rich grassland in or near woods. The female visits a wide range of composites, especially Golden-rod (*Solidago virgaureae*) from where it gets its species name. The female lays her eggs at the base of the flowering stems of acidic sorrels like *Rumex acetosa* and *R. acetosella*. The eggs do not hatch until the following spring when the small caterpillars make a good meal of the new, fresh vegetation. It has one generation a year.

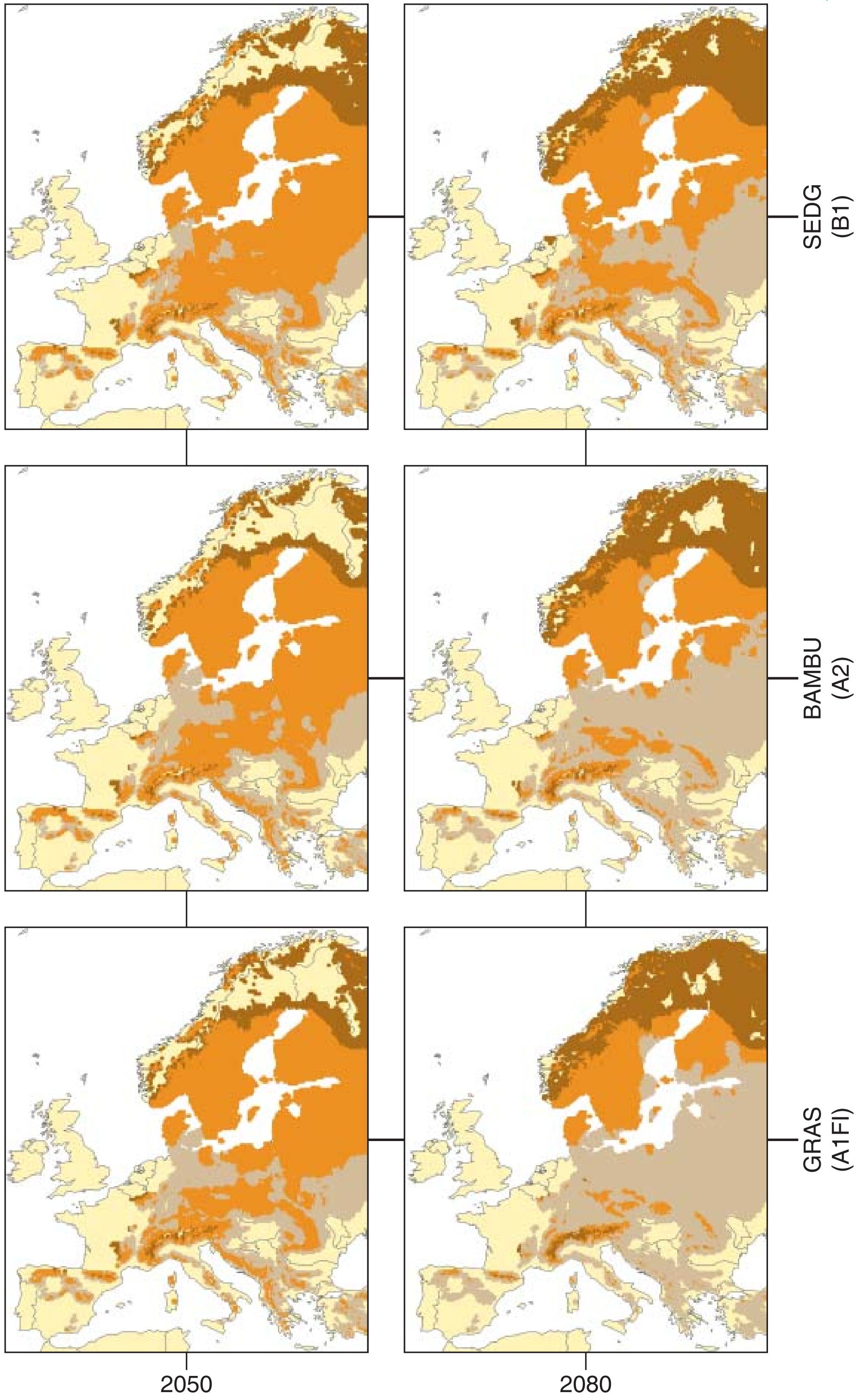
Present distribution can be well explained by climatic variables (AUC = 0.86).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Lycaena ottomana (Lefebvre, 1830) – Grecian Copper

© Chris van Swaay

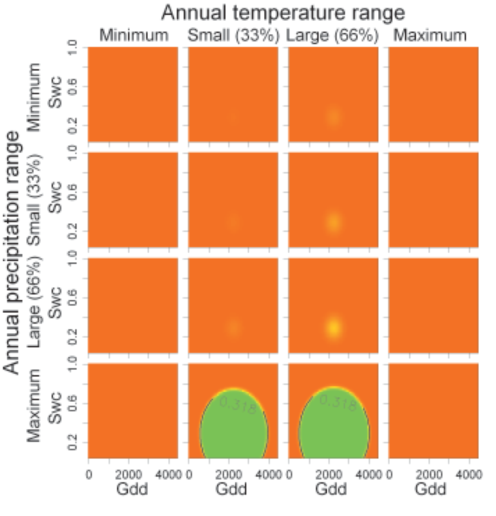
		Full dispersal	No dispersal
2050	SEDG	103 (21.78%)	-182 (-38.48%)
	BAMBU	72 (15.22%)	-204 (-43.13%)
	GRAS	102 (21.56%)	-247 (-52.22%)
2080	SEDG	264 (55.81%)	-220 (-46.51%)
	BAMBU	-54 (-11.42%)	-346 (-73.15%)
	GRAS	-89 (-18.82%)	-405 (-85.62%)

Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 473 cells)

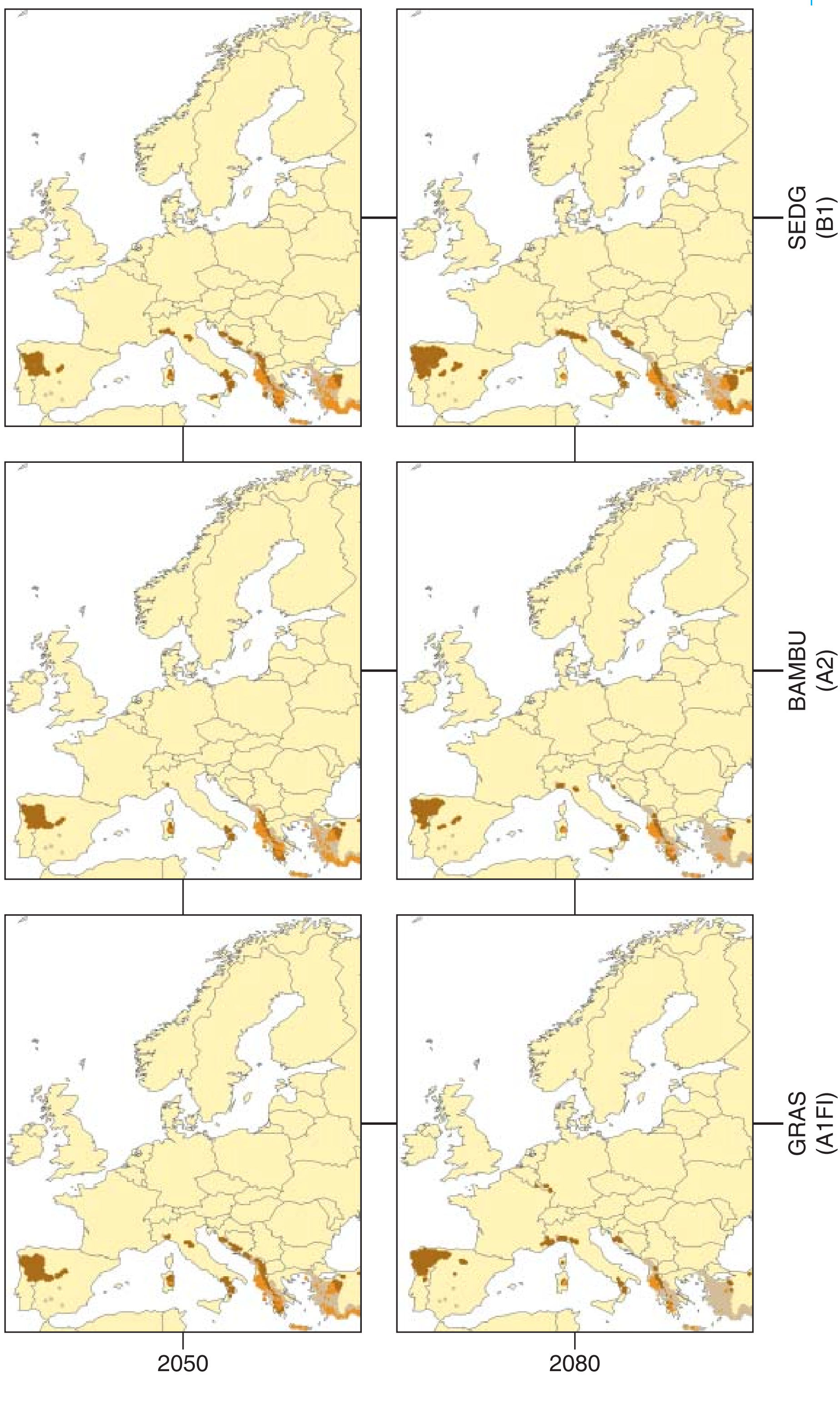
The Grecian Copper can be found in low, scrubby vegetation, maquis and woodland clearings and also occurs in dry and moist grassland at the bottom of valleys. It is the males that are usually seen; the females seem to live a more sheltered existence and are difficult to find. However, the males also take cover in trees if disturbed. They fly close to the ground. Sorrel, especially Sheep's Sorrel (*Rumex acetosella*), is used as larval foodplant. This butterfly species has two generations a year.

Present distribution can be very well explained by climatic variables (AUC = 0.98).
Climate risk category: HHR.

Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Lycaena tityrus (Poda, 1761) – Sooty Copper

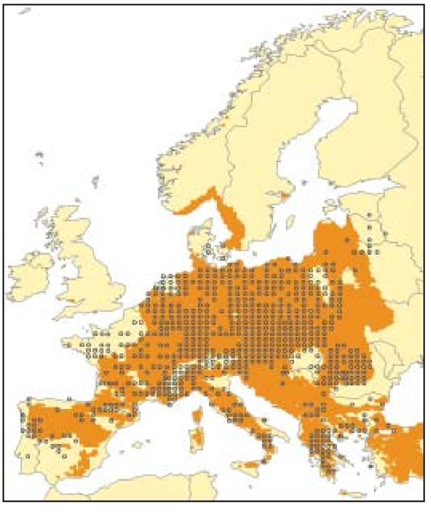
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	119 (1.07%)	-2721 (-24.36%)
	BAMBU	-636 (-5.69%)	-3400 (-30.43%)
	GRAS	-1329 (-11.9%)	-4083 (-36.55%)
2080	SEDG	-2294 (-20.53%)	-5357 (-47.95%)
	BAMBU	-3278 (-29.34%)	-6816 (-61.01%)
	GRAS	-4194 (-37.54%)	-8250 (-73.85%)

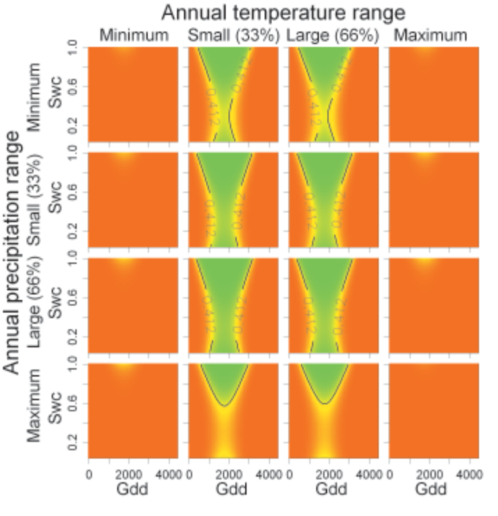
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 11172 cells)

The Sooty Copper is found in a variety of habitats, damp and dry grassland, heathland, bogs, but also scrub and clearings in woodland, mostly in small numbers. Eggs are laid on sorrels (*Rumex* spp.), especially on Common Sorrel (*R. acetosa*). The caterpillar hibernates at the foot of the plant in any of the instars. They pupate in the litter layer. It has up to three generations a year.

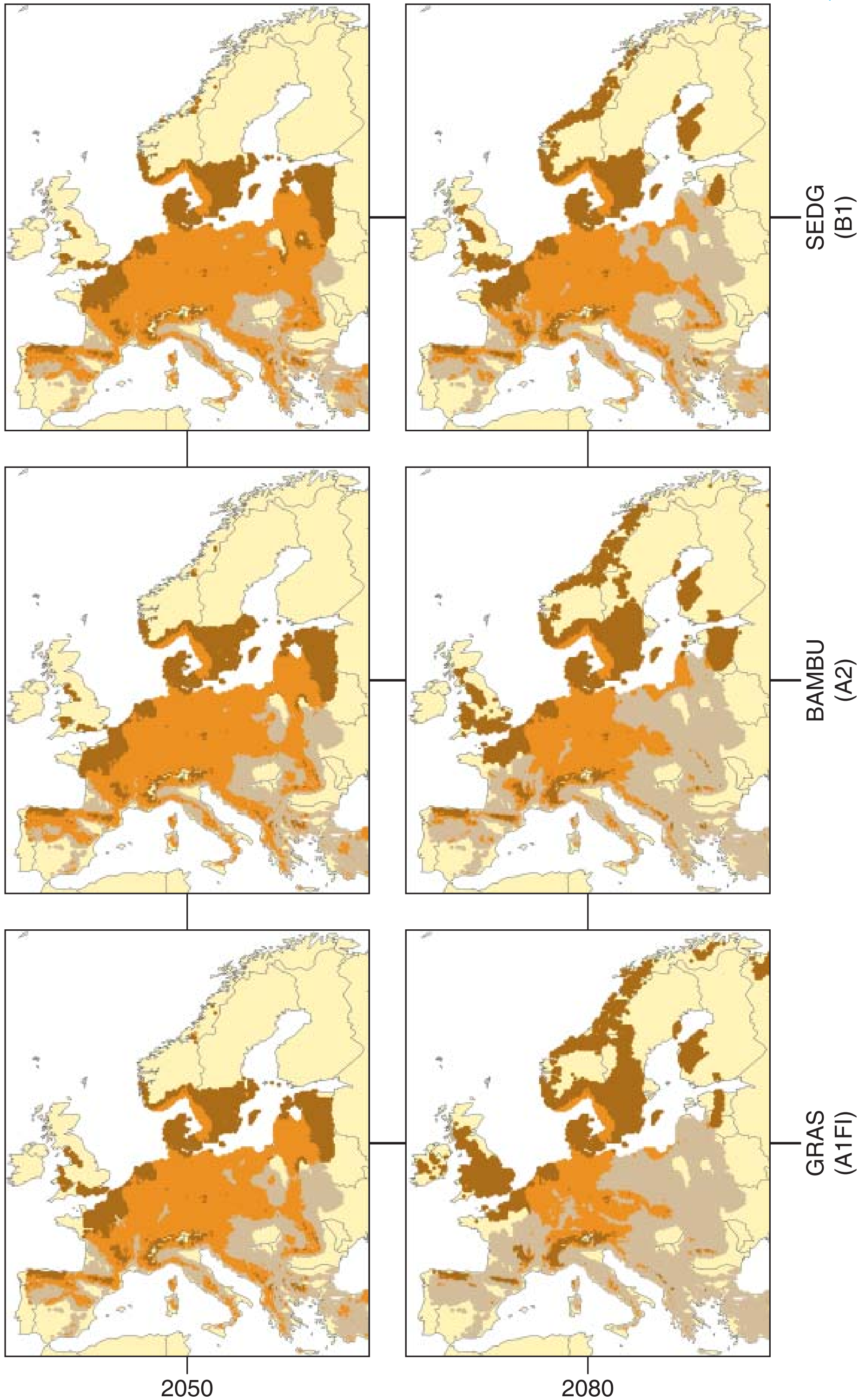
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.82).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Lycaena alciphron (Rottemburg, 1775) – Purple-shot Copper

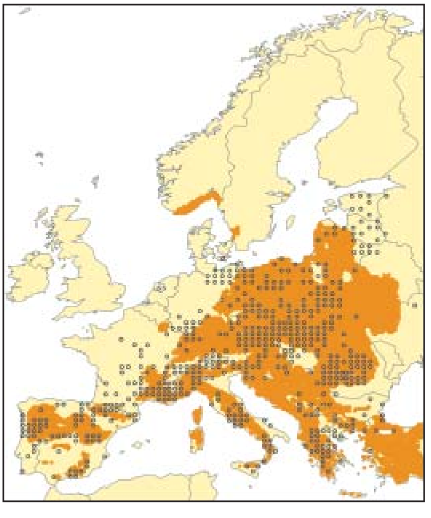
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-503 (-5.52%)	-2545 (-27.93%)
	BAMBU	-2988 (-32.79%)	-3855 (-42.3%)
	GRAS	-2959 (-32.47%)	-4292 (-47.1%)
2080	SEDG	-1861 (-20.42%)	-5247 (-57.58%)
	BAMBU	-4297 (-47.15%)	-6740 (-73.96%)
	GRAS	-4303 (-47.22%)	-7612 (-83.53%)

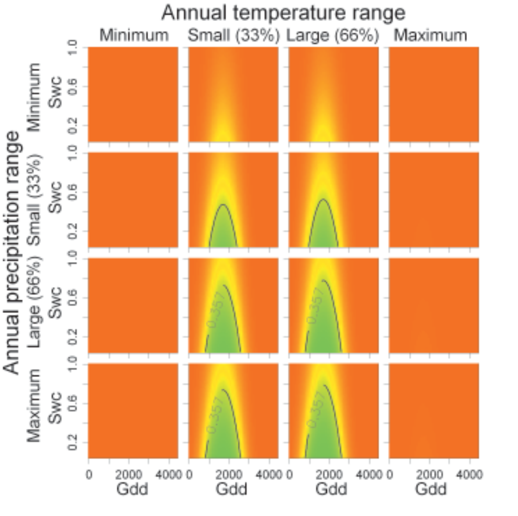
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 9113 cells)

The Purple-shot Copper is found both in damp and dry places on many kinds of flower-rich grassland. Only the male has the beautiful purple sheen on the upperside of its wings. Eggs are laid on sorrels (*Rumex* spp.), mainly Common Sorrel (*R. acetosa*). This butterfly species hibernates as a fully-developed caterpillar in the egg, or in the first instar. The caterpillars are nocturnal. They pupate in the litter layer. It has one generation a year. It hibernates as a caterpillar outside the egg. Across Europe there are different subspecies.

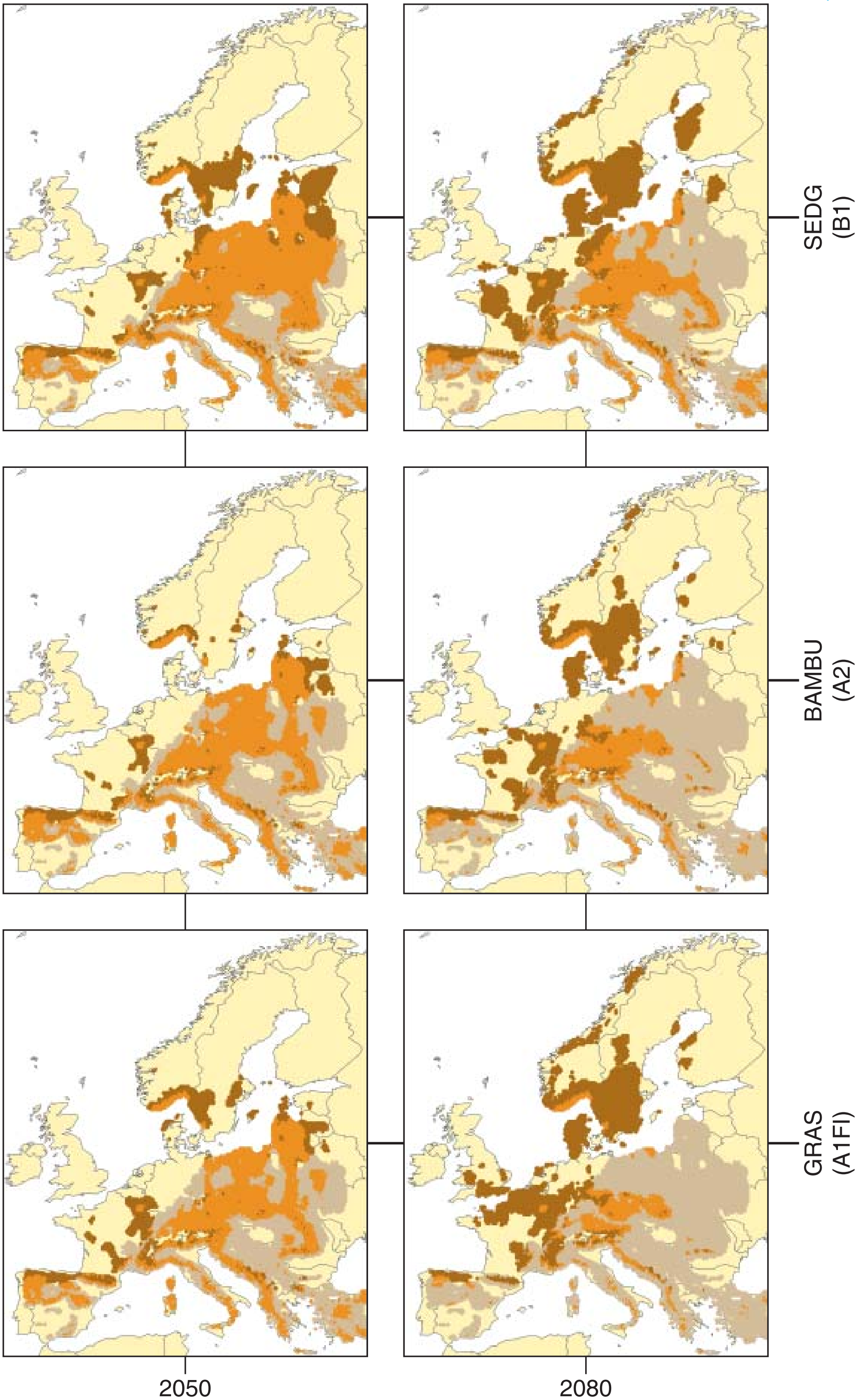
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.8).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Lycaena hippothoe (Linnaeus, 1761) – Purple-edged Copper

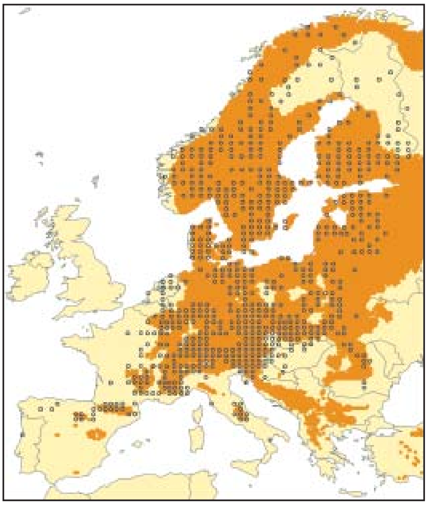
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-4111 (-29.14%)	-5600 (-39.69%)
	BAMBU	-3282 (-23.26%)	-4839 (-34.3%)
	GRAS	-4808 (-34.08%)	-6020 (-42.67%)
2080	SEDG	-5935 (-42.07%)	-7427 (-52.64%)
	BAMBU	-6505 (-46.11%)	-8317 (-58.95%)
	GRAS	-8606 (-61%)	-9862 (-69.9%)

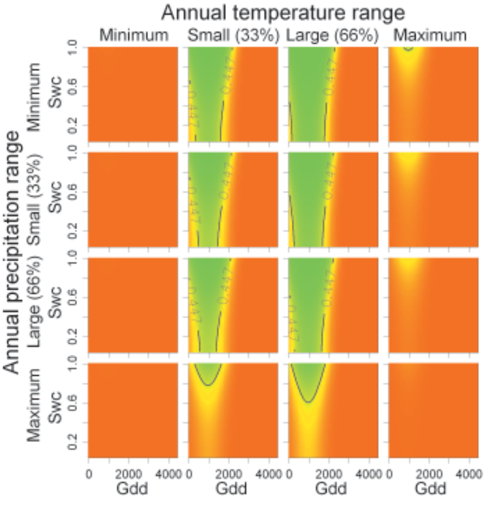
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 14109 cells)

The Purple-edged Copper occurs on wet to damp grasslands, where the male butterflies attract the attention, perched on a tall grass or other plant, watching over their territory. The populations are mostly very local, but in a meadow, the butterflies can often be very numerous. The eggs are laid on various sorrels (*Rumex* spp.). At first the small caterpillar only shaves off a few cell layers on the leaf surface, so making translucent "windows", but later they feed on the whole leaf. The caterpillar hibernates when still small, and completes its growth in the spring, pupating in the litter layer. It has one brood a year. In southern part of its range the species has two generations and can be found on dry grasslands as well. The Purple-edged Copper has a few subspecies.

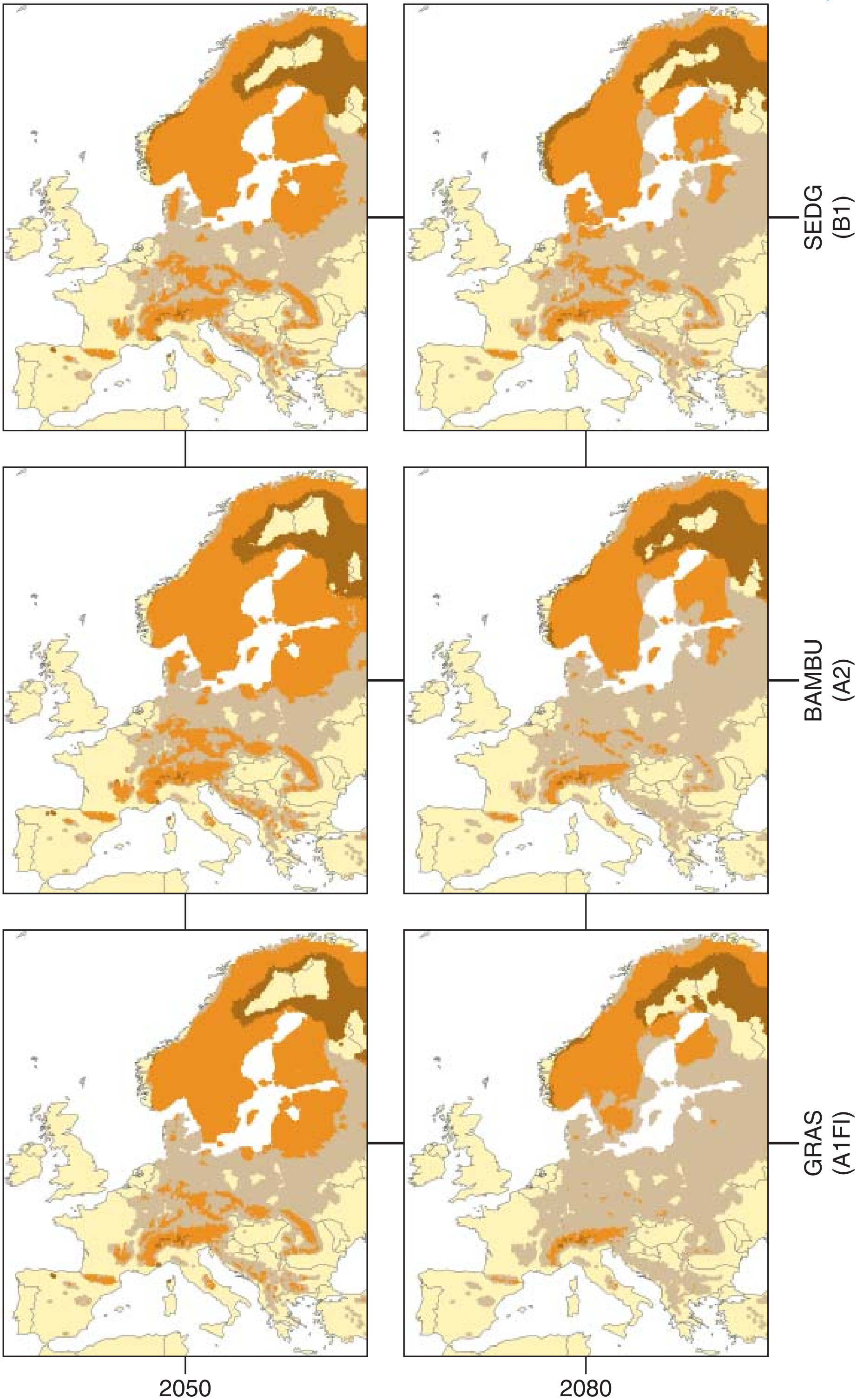
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.85).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Lycaena candens (Herrich-Schäffer, 1844) – Balkan Copper

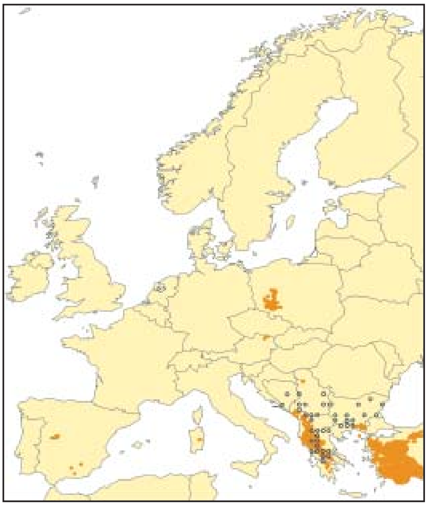
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	192 (29.22%)	-289 (-43.99%)
	BAMBU	-161 (-24.51%)	-376 (-57.23%)
	GRAS	-75 (-11.42%)	-414 (-63.01%)
2080	SEDG	70 (10.65%)	-343 (-52.21%)
	BAMBU	-391 (-59.51%)	-564 (-85.84%)
	GRAS	-394 (-59.97%)	-624 (-94.98%)

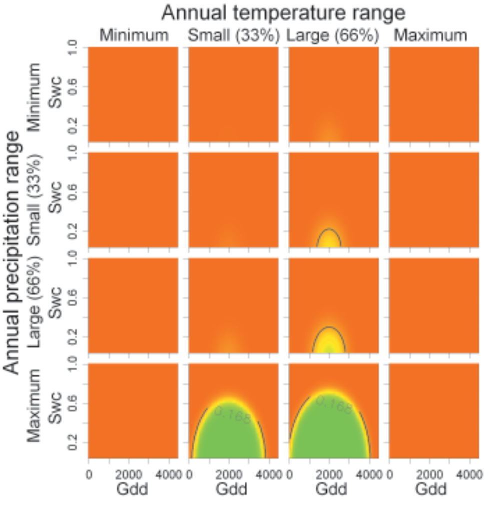
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 657 cells)

The Balkan Copper can be found in damp grassland, sub-alpine and alpine meadows, and in woodland clearings with a well-developed herb layer. Different sorrels (*Rumex* spp.), including Common Sorrel (*R. acetosa*) are used as larval foodplants. It has one generation a year. This butterfly looks very like the Purple-edged Copper (*Lycaena hippothoe*), and used to be classified as a subspecies of it.

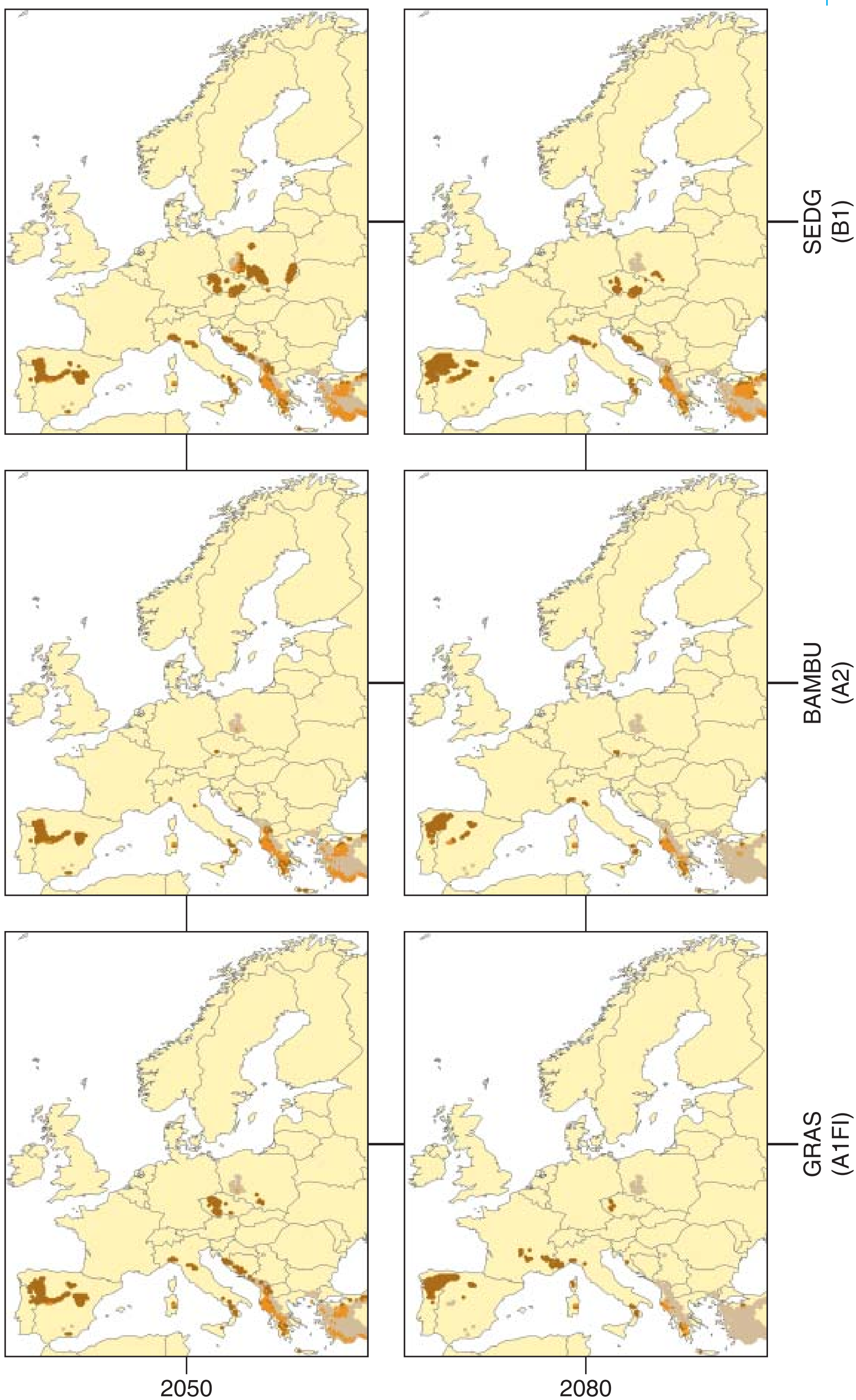
Present distribution can be well explained by climatic variables (AUC = 0.86).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Lycaena thersamon (Esper, 1784) – Lesser Fiery Copper

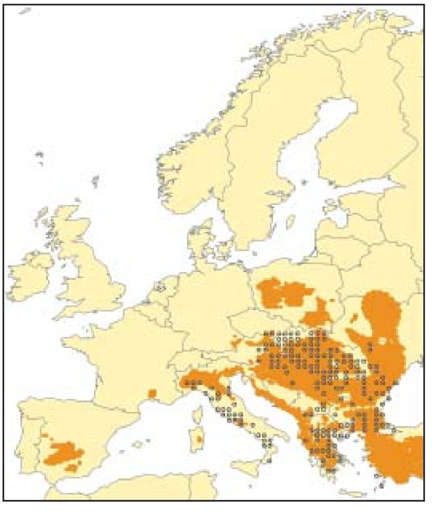
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	1838 (40.44%)	-1584 (-34.85%)
	BAMBU	1632 (35.91%)	-1421 (-31.27%)
	GRAS	2941 (64.71%)	-757 (-16.66%)
2080	SEDG	2058 (45.28%)	-3651 (-80.33%)
	BAMBU	574 (12.63%)	-3143 (-69.15%)
	GRAS	2327 (51.2%)	-1739 (-38.26%)

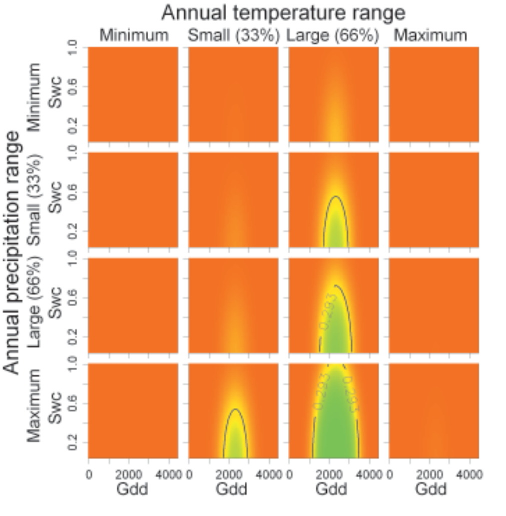
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 4545 cells)

The Lesser Fiery Copper is mostly found on dry, flower-rich grasslands, both on calcareous and acid soils. They are also seen on waste land, very open scrub and rocky slopes. The butterflies are often seen drinking from the flowers of Danewort (*Sambucus ebulus*). Its most important larval foodplant is Knotgrass (*Polygonum aviculare*), although other Polygonaceae species are perhaps also used. The caterpillars feed on both the flowers and the leaves. This butterfly species hibernates as a caterpillar and has several generations a year.

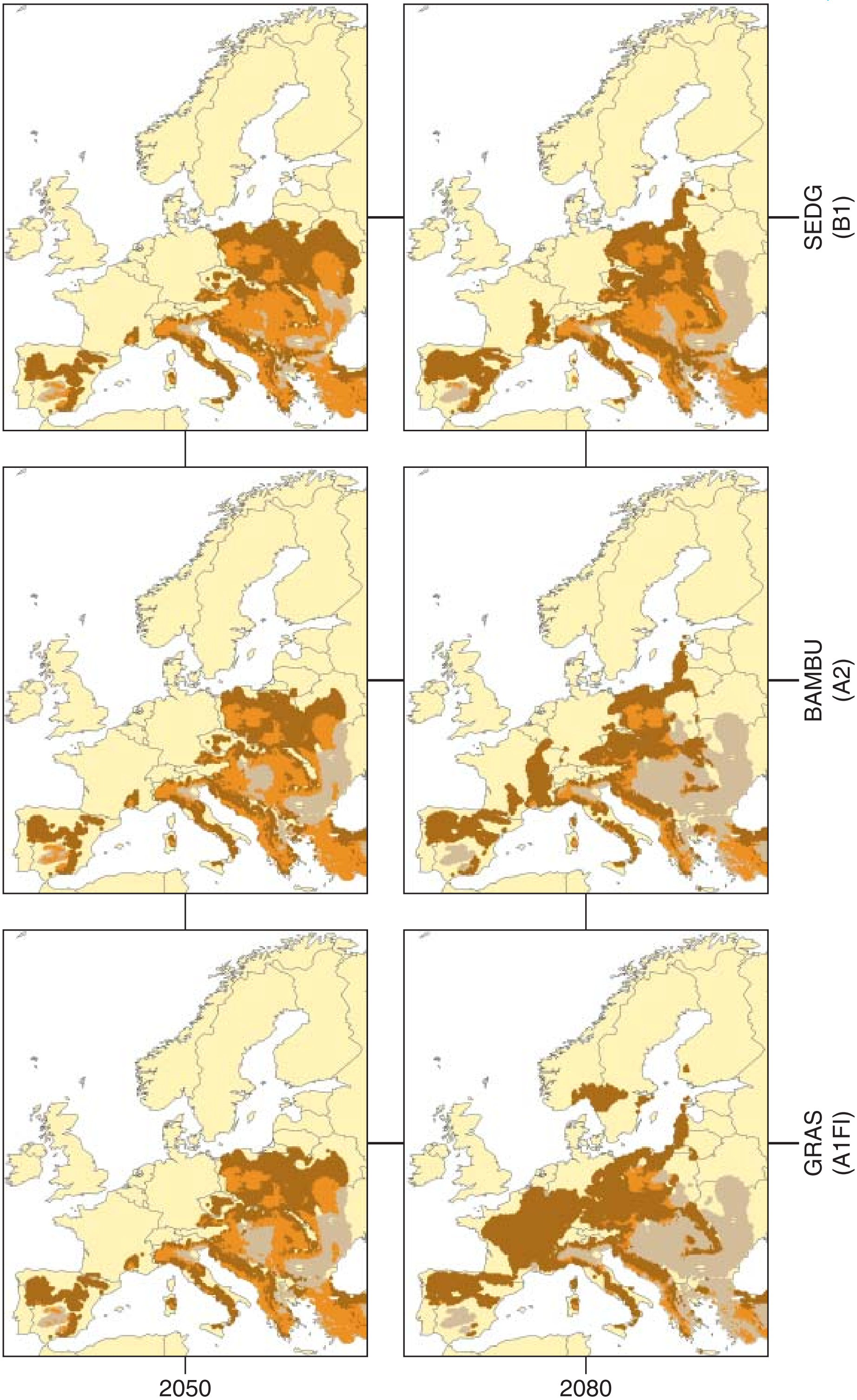
Present distribution can be well explained by climatic variables (AUC = 0.93).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold



SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Thecla betulae (Linnaeus, 1758) – Brown Hairstreak

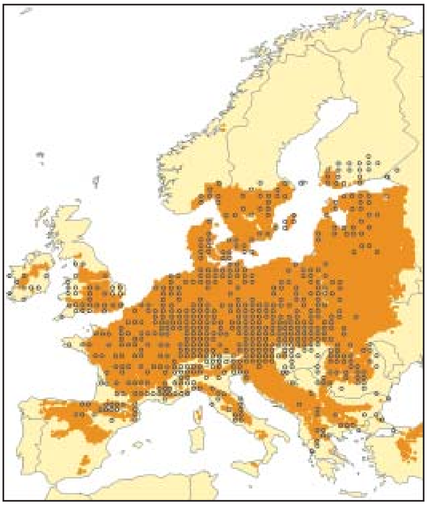
© Kars Veling

		Full dispersal	No dispersal
2050	**SEDG**	-2243 (-17.38%)	-3619 (-28.04%)
	BAMBU	-1298 (-10.06%)	-3214 (-24.9%)
	GRAS	-2925 (-22.66%)	-4462 (-34.57%)
2080	**SEDG**	-3697 (-28.64%)	-5889 (-45.62%)
	BAMBU	-3110 (-24.09%)	-6912 (-53.55%)
	GRAS	-5029 (-38.96%)	-9532 (-73.85%)

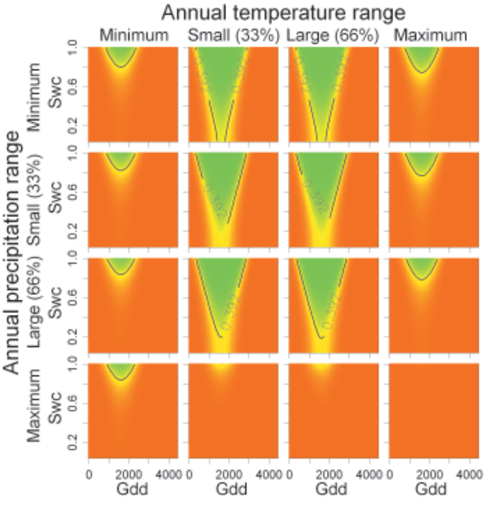
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 12908 cells)

The Brown Hairstreak occurs in scrub, along woodbanks at the edge of deciduous woodland, and in parks, but the butterfly is rarely seen. However, the eggs that are laid at the base of the buds of various *Prunus* species are easy to find. In the winter the pearly-white eggs show up on the bare twigs of the shrubs or trees. The egg, thus, hibernates, hatching in the spring. The small caterpillar bores its way into a bud, hollowing it out, later on also eating the leaves of Blackthorn (*Prunus spinosa*), but also cultivated species of *Prunus*, such as plum and cherry trees. The caterpillars are visited by ants of the genera *Lasius* and *Formica*. They pupate in the shrub layer under the tree serving as foodplant. This butterfly species is single-brooded.

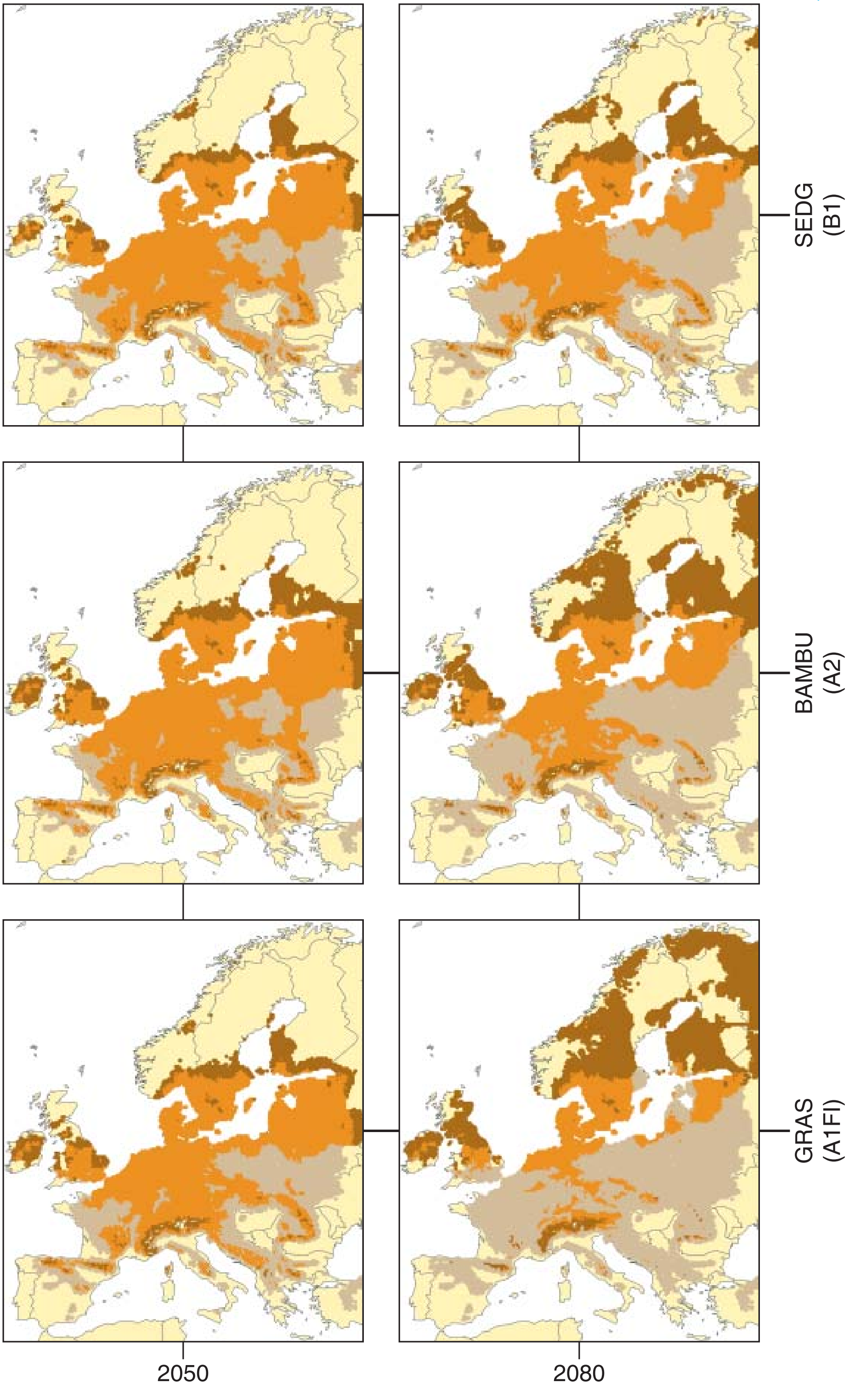
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.79).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Favonius quercus (Linnaeus, 1758) – Purple Hairstreak

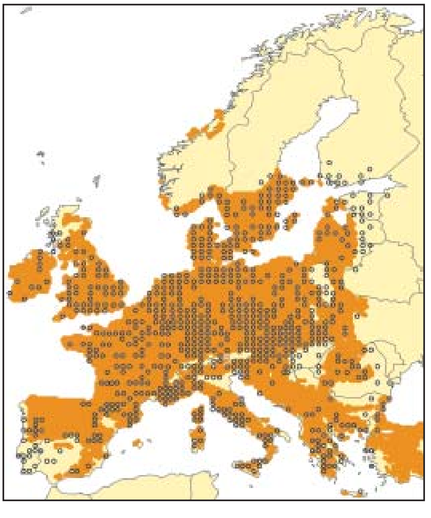
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-2079 (-14.97%)	-3083 (-22.2%)
	BAMBU	-2778 (-20.01%)	-3767 (-27.13%)
	GRAS	-3105 (-22.36%)	-4170 (-30.03%)
2080	SEDG	-4962 (-35.73%)	-5822 (-41.93%)
	BAMBU	-6242 (-44.95%)	-7466 (-53.77%)
	GRAS	-7703 (-55.47%)	-9184 (-66.14%)

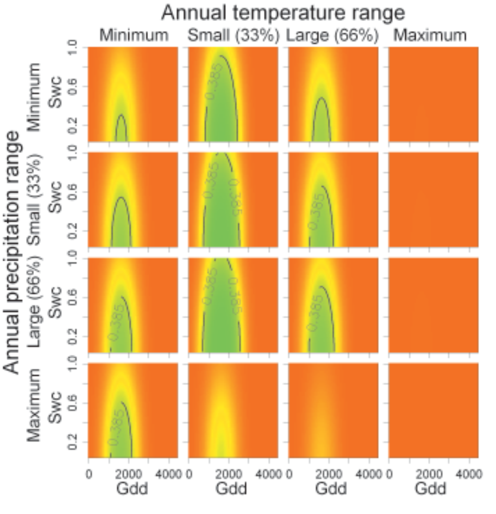
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 13886 cells)

The Purple Hairstreak is only found around oaks, its only foodplant. Although the butterflies need food, they do not visit flowers. Instead, they remain near the tree, looking for leaves with a layer of honeydew left behind by aphids. This sugary secretion is the butterflies' most important source of energy. The eggs are laid at the base of the buds. The small caterpillar has developed by the time winter comes, but it remains in the egg, emerging in the spring to feed on the buds and also on the flowers of the oak. It does not eat the leaves and is sometimes visited by ants of the genus *Lasius*. When mature, the caterpillars leave the foodplant, and pupate in the moss layer. The Purple Hairstreak has one generation a year.

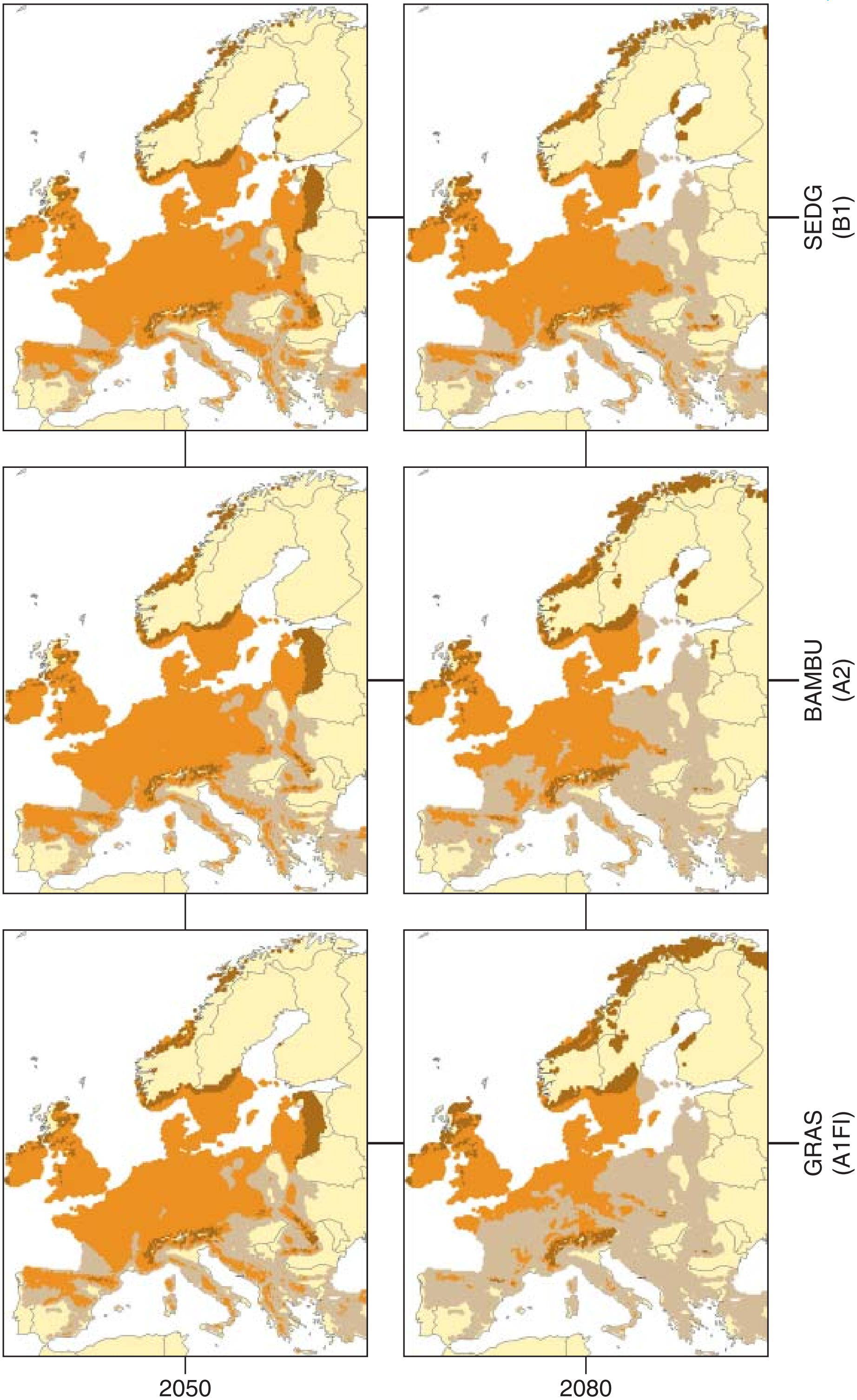
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.72).
Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Laeosopis roboris (Esper, 1793) – Spanish Purple Hairstreak

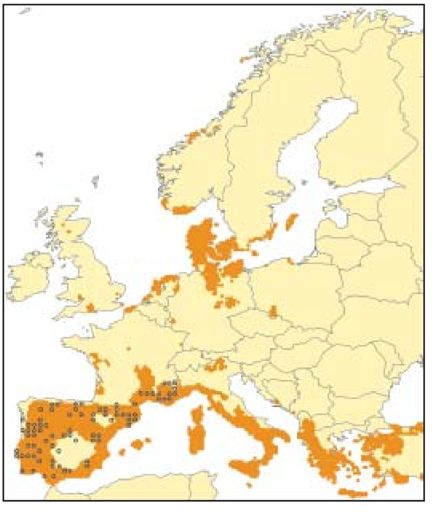
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-912 (-22.66%)	-2173 (-54%)
	BAMBU	-1864 (-46.32%)	-2456 (-61.03%)
	GRAS	-1551 (-38.54%)	-2621 (-65.13%)
2080	SEDG	-1773 (-44.06%)	-2963 (-73.63%)
	BAMBU	-2535 (-63%)	-3335 (-82.88%)
	GRAS	-2757 (-68.51%)	-3709 (-92.17%)

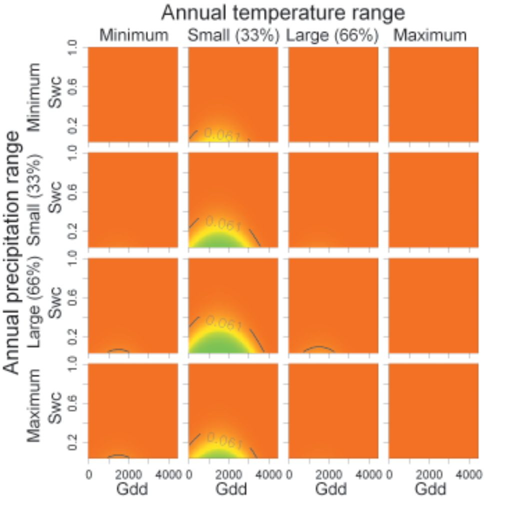
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 4024 cells)

The Spanish Purple Hairstreak occurs in damp, deciduous woods, on rough vegetation beside streams and rivers, and in parkland. The butterflies spend most of their time in the top of ash trees, the larval foodplant, and are difficult to see. The female lays her eggs on Ash (*Fraxinus excelsior*) and other species of *Fraxinus*, and possibly also Common Privet (*Ligustrum vulgare*). The eggs remain on the tree for the rest of the summer, autumn and winter. The small caterpillars that emerge in the spring, feed on the flowers and new leaves of the foodplants. They are visited by ants of the genus *Lasius*. They pupate among the leaf litter. This species has one brood a year.

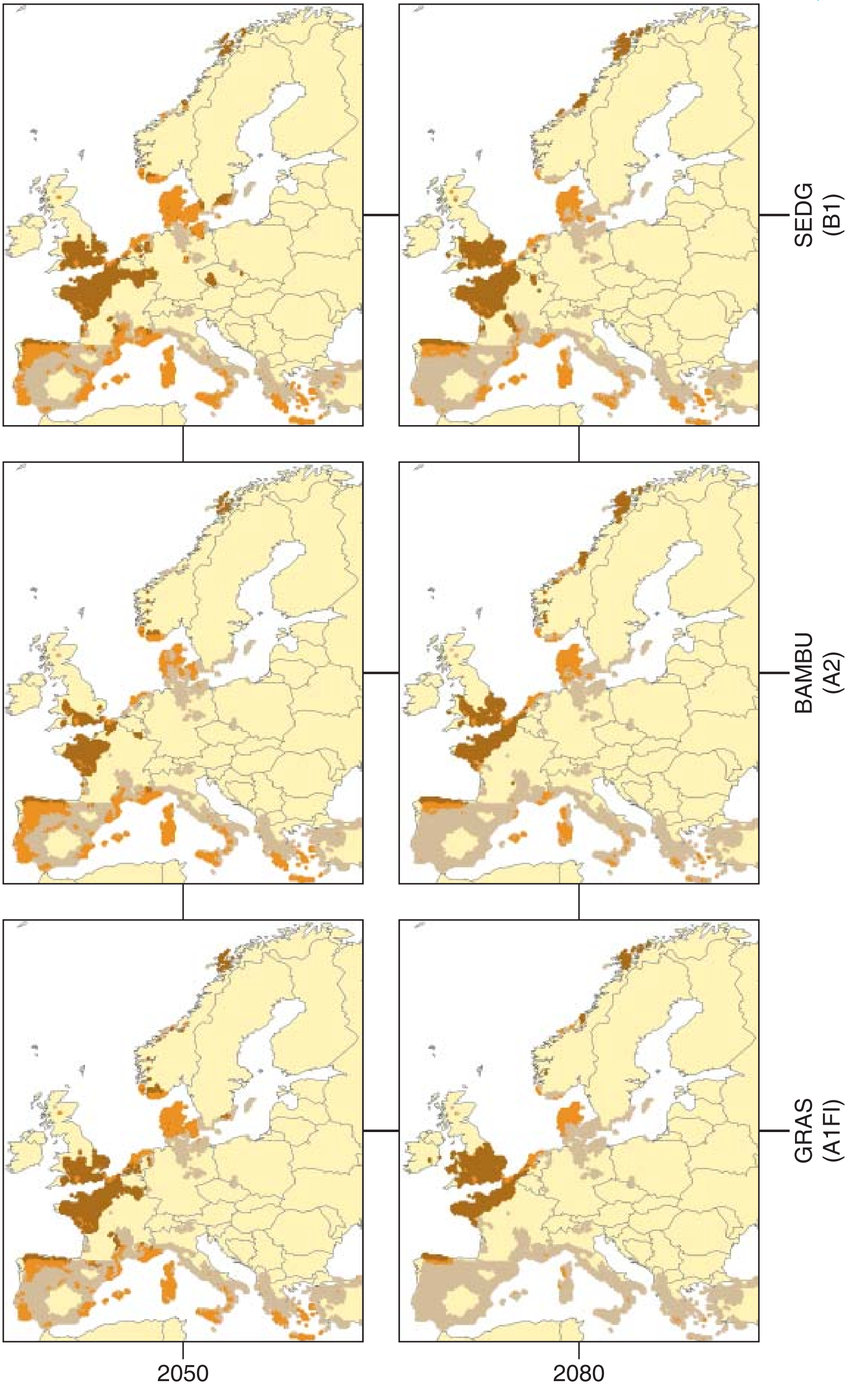
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.81).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Tomares ballus (Fabricius, 1787) – Provence Hairstreak

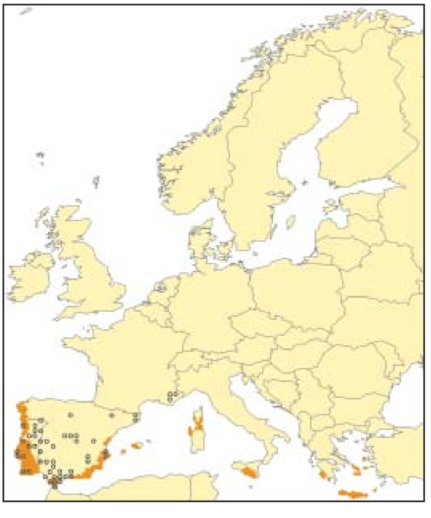
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-285 (-71.79%)	-309 (-77.83%)
	BAMBU	-296 (-74.56%)	-315 (-79.35%)
	GRAS	-316 (-79.6%)	-341 (-85.89%)
2080	SEDG	-309 (-77.83%)	-358 (-90.18%)
	BAMBU	-340 (-85.64%)	-368 (-92.7%)
	GRAS	-386 (-97.23%)	-394 (-99.24%)

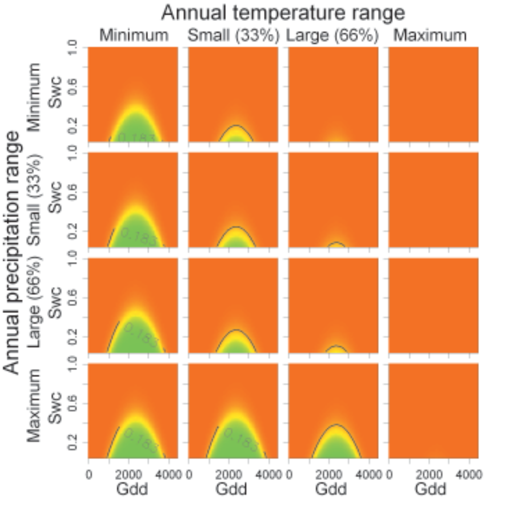
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 397 cells)

The Provence Hairstreak can be found on abandoned agricultural land, especially on calcareous soils, in abandoned vineyards and bushy areas. Various leguminous plants are used as larval foodplant, including Bladder Vetch (*Anthyllis tetraphylla*), *Dorycnium hirsutum*, Iberian Milk-vetch (*Astragalus lusitanicus*), Hairy Medick (*Medicago polymorpha*), Black Medick (*M. lupulina*) and birdsfoot-trefoils (*Lotus* spp.). The female deposits her eggs singly on the unopened leaves. The caterpillars are sometimes attended by ants (e.g. *Plagiolepis pygmaea*). This species has one generation a year, and passes the winter as a pupa in the soil.

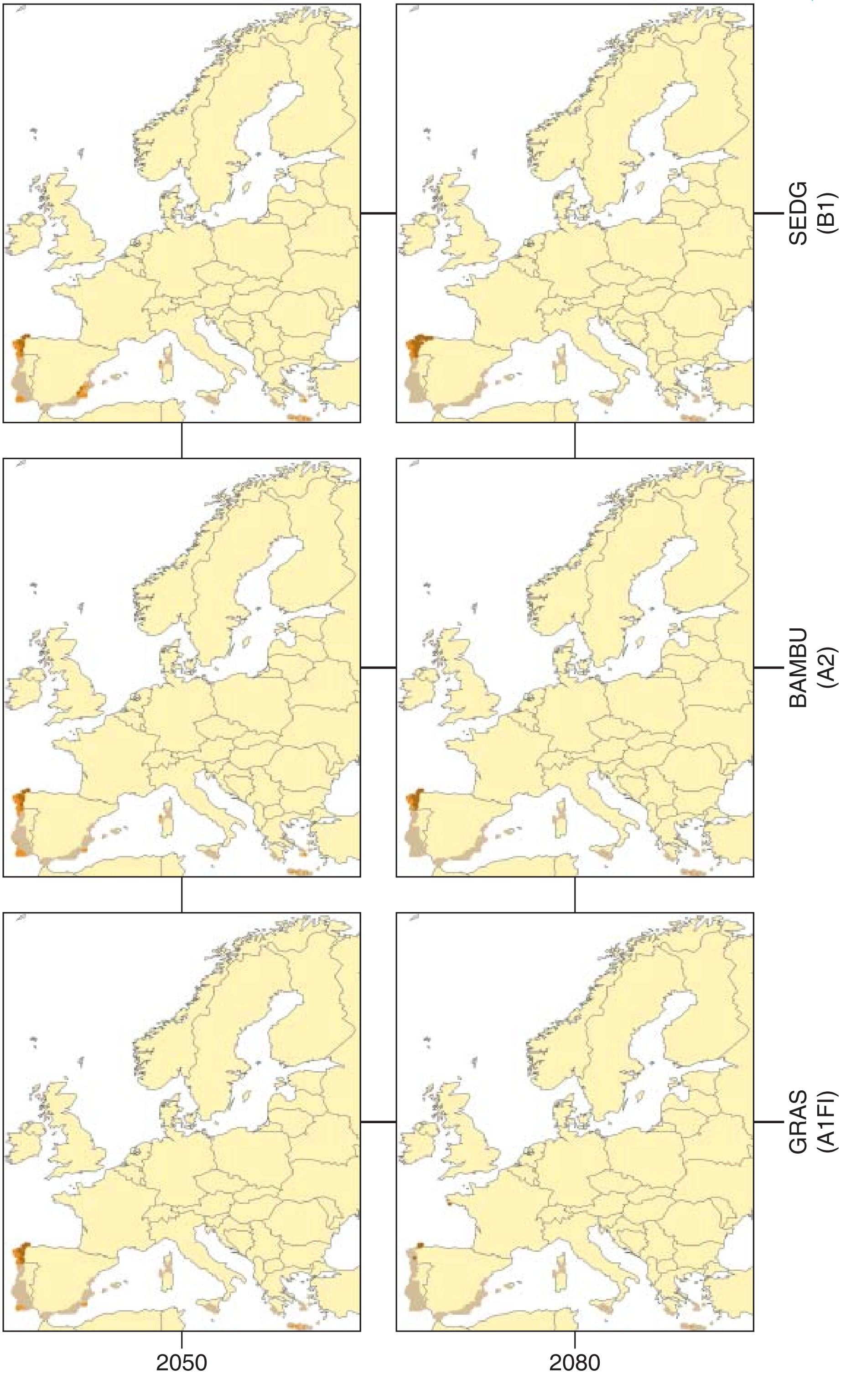
Present distribution can be well explained by climatic variables (AUC = 0.91).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Callophrys rubi (Linnaeus, 1758) – Green Hairstreak

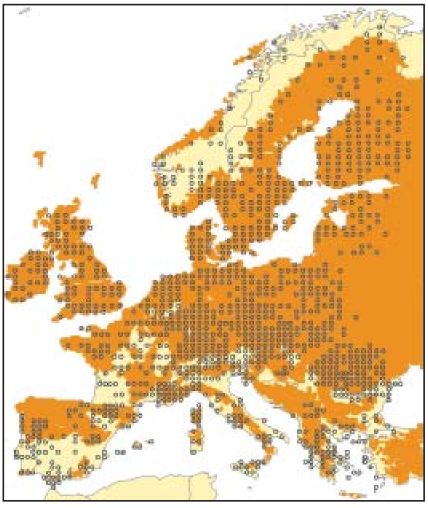
© Peter Ginzinger

		Full dispersal	No dispersal
2050	SEDG	-2600 (-12.16%)	-3401 (-15.91%)
	BAMBU	-3921 (-18.34%)	-4487 (-20.99%)
	GRAS	-4049 (-18.94%)	-4842 (-22.65%)
2080	SEDG	-4212 (-19.7%)	-5250 (-24.56%)
	BAMBU	-7570 (-35.41%)	-8595 (-40.2%)
	GRAS	-10212 (-47.76%)	-11497 (-53.77%)

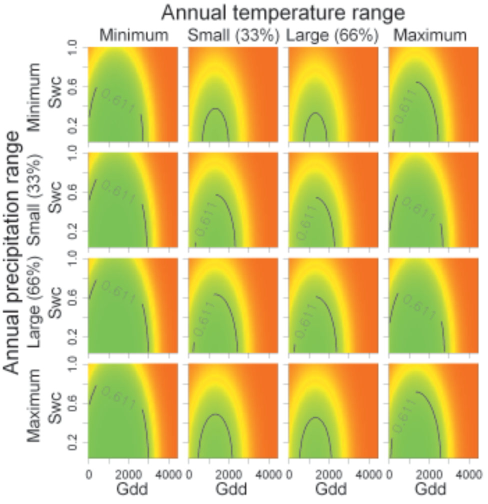
Changes in climatic niche distribution (in 10'×10' grid cells; present niche space: 21380 cells)

The Green Hairstreak can be found on poor grassland, heathland and at the edges of bogs and marshes. The butterflies like resting in trees and shrubs, such as Alder Buckthorn (*Frangula alnus*), where they are well hidden by their green colour. However, a sharp tap on a branch brings tens of them out into the air. The Green Hairstreak is extremely polyphagous. The eggs are laid on a variety of plants, including Heather (*Erica* spp.), rockroses (*Helianthemum* spp.), and Alder Buckthorn (*Frangula alnus*), leguminous plants and species of Rosaceae. The caterpillars feed on the buds, flowers and young leaves. They pupate in the litter layer and the pupa hibernates. The Green Hairstreak is single-brooded.

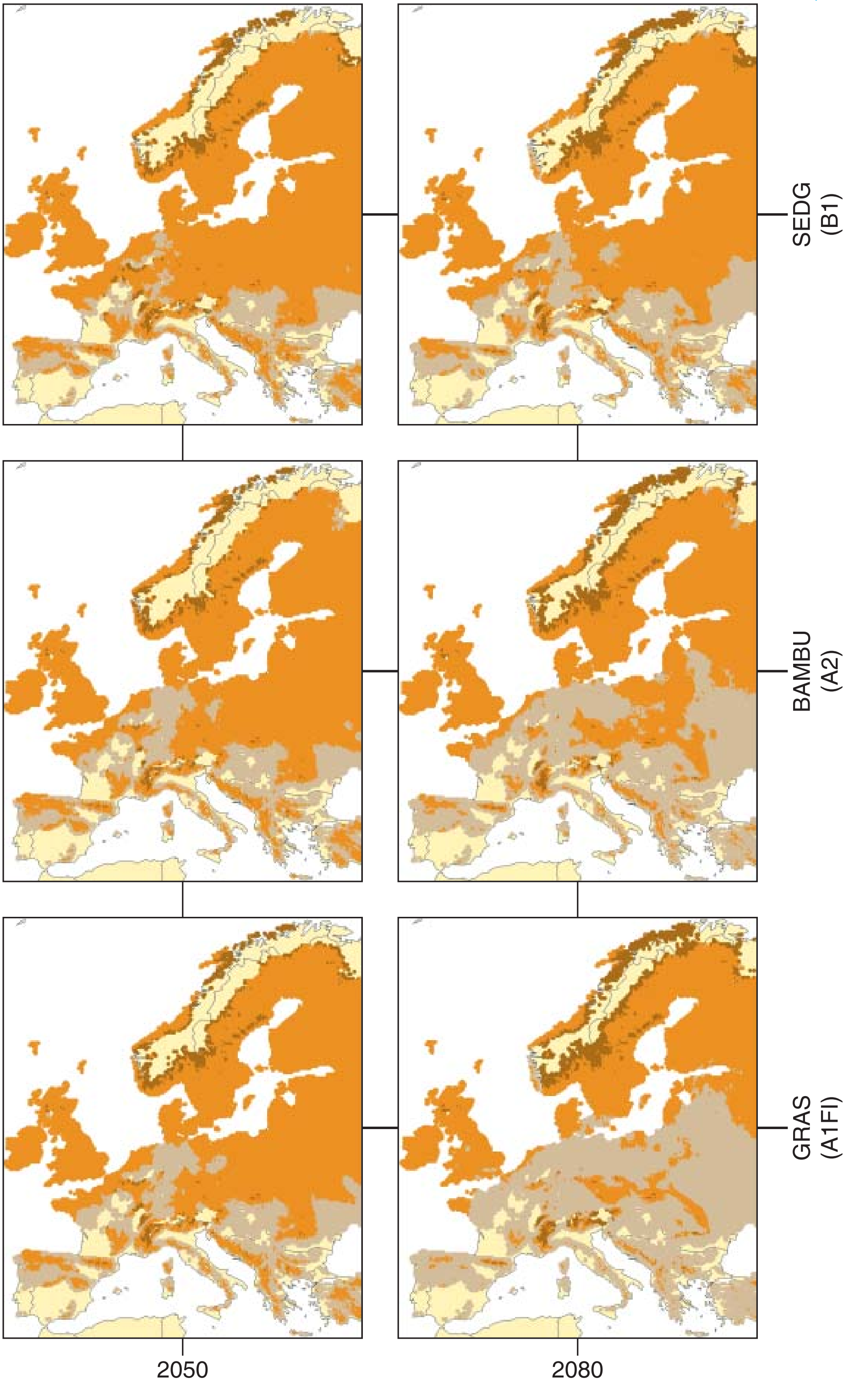
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.63).
Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Callophrys avis Chapman, 1909 – Chapman's Green Hairstreak

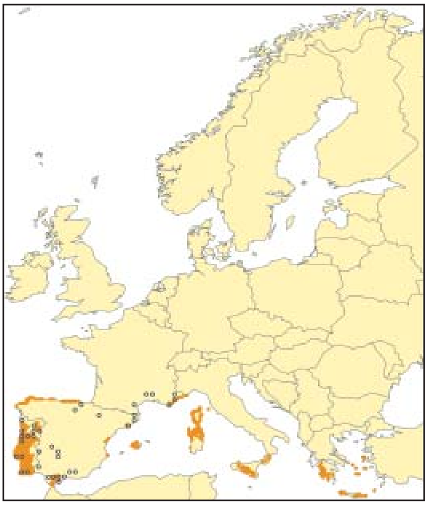
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-283 (-65.36%)	-386 (-89.15%)
	BAMBU	-320 (-73.9%)	-378 (-87.3%)
	GRAS	-275 (-63.51%)	-390 (-90.07%)
2080	SEDG	-294 (-67.9%)	-408 (-94.23%)
	BAMBU	-303 (-69.98%)	-415 (-95.84%)
	GRAS	-243 (-56.12%)	-425 (-98.15%)

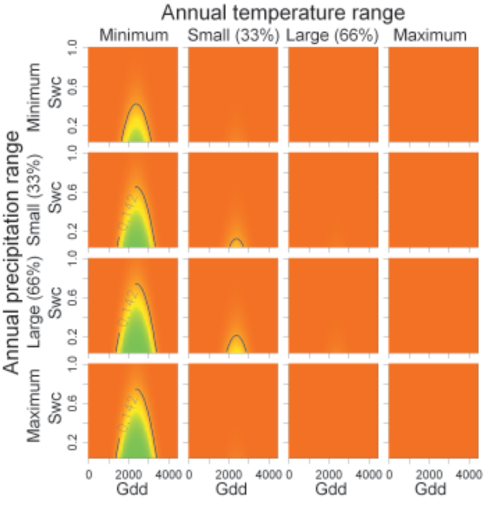
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 433 cells)

Chapman's Green Hairstreak is mostly found in woods and scrubs where the Strawberry Tree (*Arbutus unedo*) grows. The female chooses the young leaves of the older, larger bushes on which to lay her eggs. *Coriaria myrtifolia* and the broom *Cytisus malacitanus* ssp. *catalaunicus* have also been named as foodplants. It pupates on the ground at the foot of the foodplant. It is single-brooded.

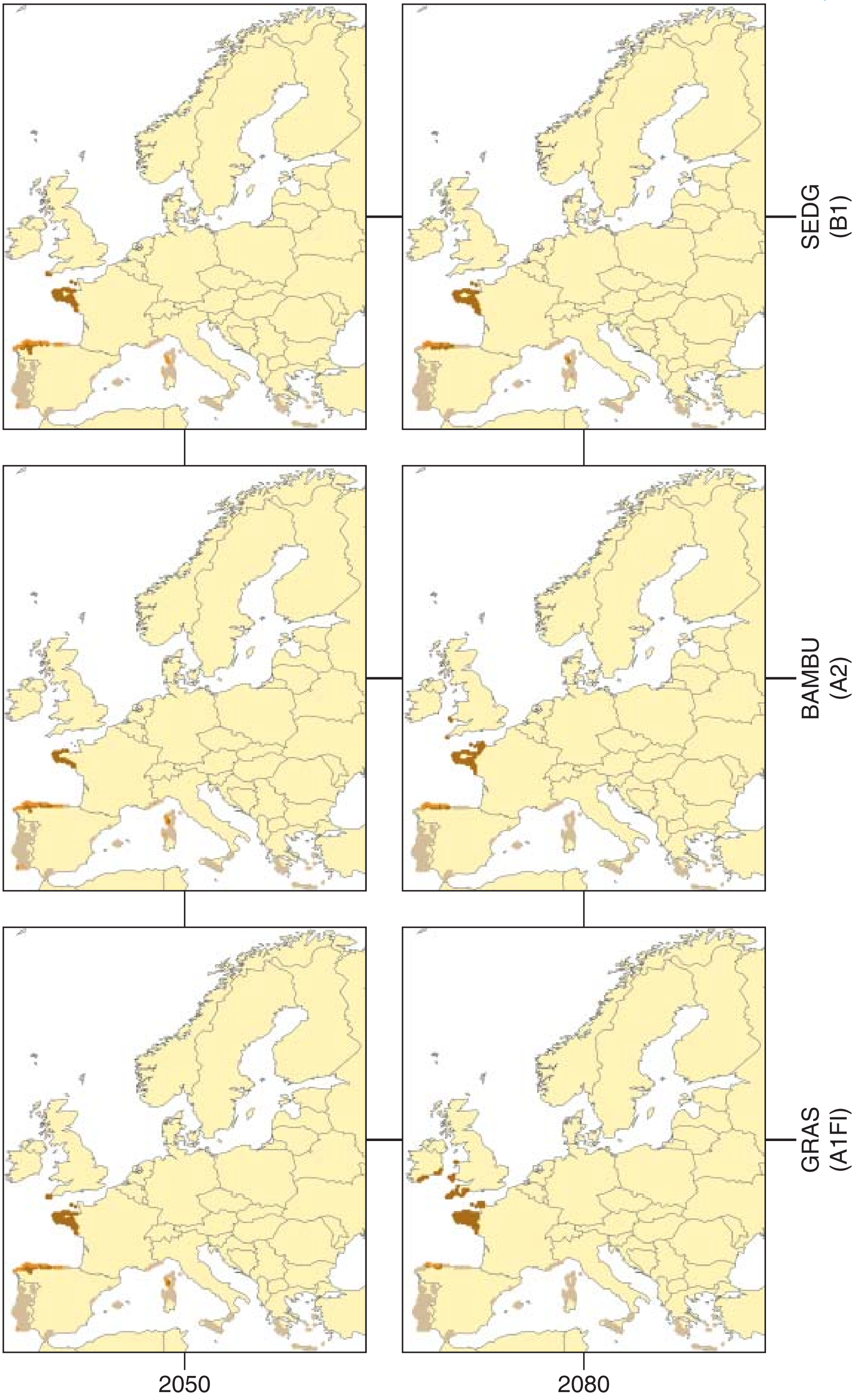
Present distribution can be well explained by climatic variables (AUC = 0.9).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Satyrium w-album (Knoch, 1782) – White-letter Hairstreak

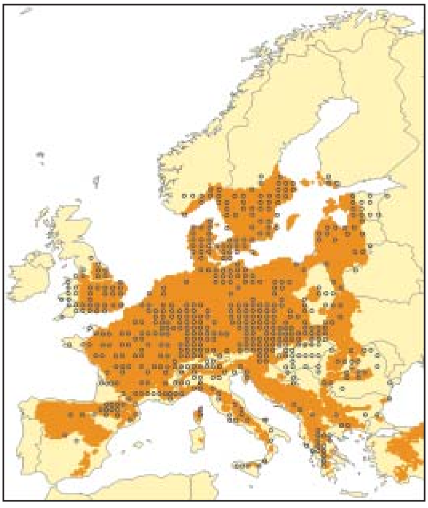
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-1917 (-17.27%)	-2641 (-23.79%)
	BAMBU	-2141 (-19.28%)	-2955 (-26.61%)
	GRAS	-2827 (-25.46%)	-3629 (-32.68%)
2080	SEDG	-4836 (-43.56%)	-5477 (-49.33%)
	BAMBU	-5644 (-50.83%)	-6698 (-60.33%)
	GRAS	-7380 (-66.47%)	-8657 (-77.97%)

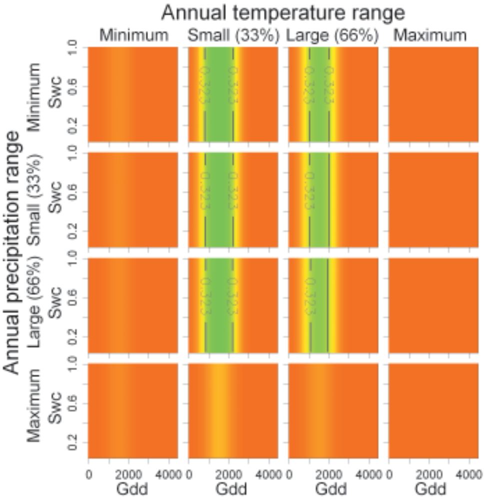
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 11103 cells)

The White-letter Hairstreak usually occurs where there is a group of elm (*Ulmus* spp.) trees, either growing in a wood, or apart, sometimes even in the centre of a large town. However, there are populations known that occupy a solitary tree. The eggs are laid on the wood at the base of the flower buds, the female favouring terminal buds situated at the top of the tree. The small caterpillar stays inside the egg during the winter months, emerging in the spring, boring its way into a flowerbud. It feeds on flowerbuds and flowers, but not on leaves. A non-flowering tree is therefore not a suitable foodplant. The caterpillars are sometimes visited by ants of the genus *Lasius* and *Formica* and pupate in the litter layer under the tree. The White-Letter Hairstreak has one generation a year.

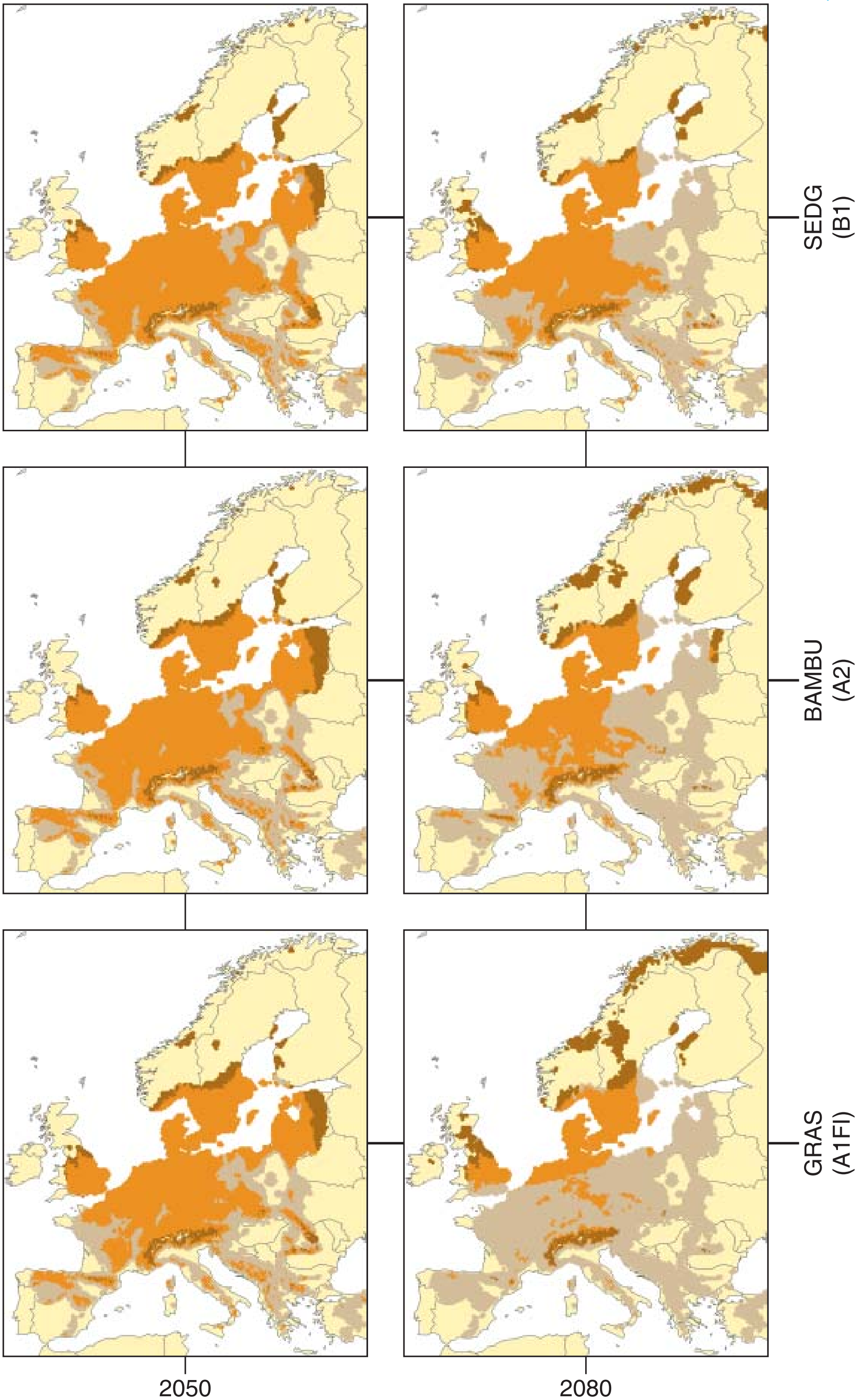
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.78).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Satyrium pruni (Linnaeus, 1758) – Black Hairstreak

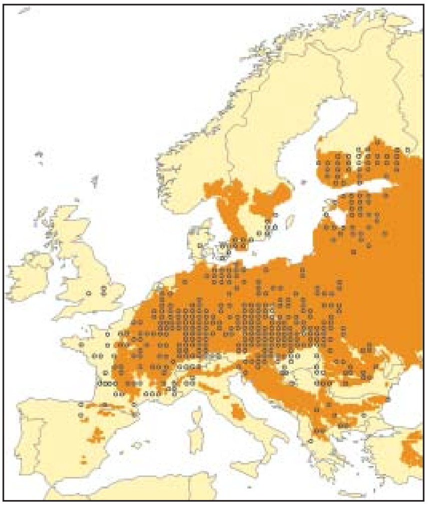
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-289 (-2.36%)	-3101 (-25.27%)
	BAMBU	1089 (8.88%)	-2245 (-18.3%)
	GRAS	-404 (-3.29%)	-3596 (-29.31%)
2080	SEDG	-255 (-2.08%)	-4671 (-38.07%)
	BAMBU	-702 (-5.72%)	-6066 (-49.44%)
	GRAS	-2244 (-18.29%)	-7988 (-65.1%)

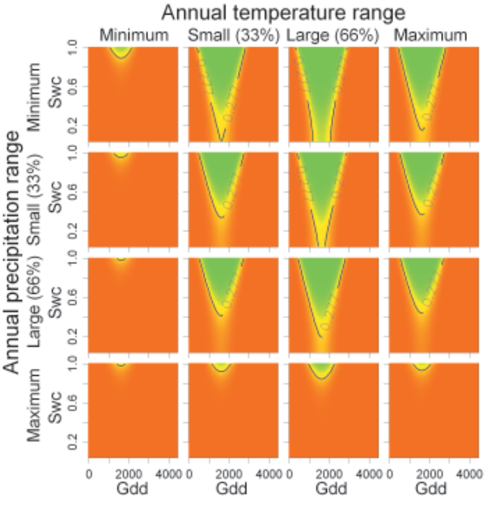
Changes in climatic niche distribution (in 10’×10’ grid cells; present niche space: 12270 cells)

The Black Hairstreak can be found where there are Blackthorn (*Prunus spinosa*) bushes growing. This may be in moderately dry woodland, or in a hedgerow, or on a woodbank, but it also occurs on solitary groups of Blackthorn bushes. Places with brambles are favorable, providing the nectar the butterflies need. The eggs are laid on Blackthorn (*Prunus spinosa*), but sometimes other *Prunus* species are used. The female chooses twigs that will flower the next spring. The small caterpillars that develop, pass the winter in the eggshell. When they emerge, they feed on the buds and flowers. When the caterpillars are fully-grown, they pupate. The black and white pupa, suspended in a silken girdle from a twig, looks very like a bird dropping, an attempt to avoid predation. The Black Hairstreak is single-brooded.

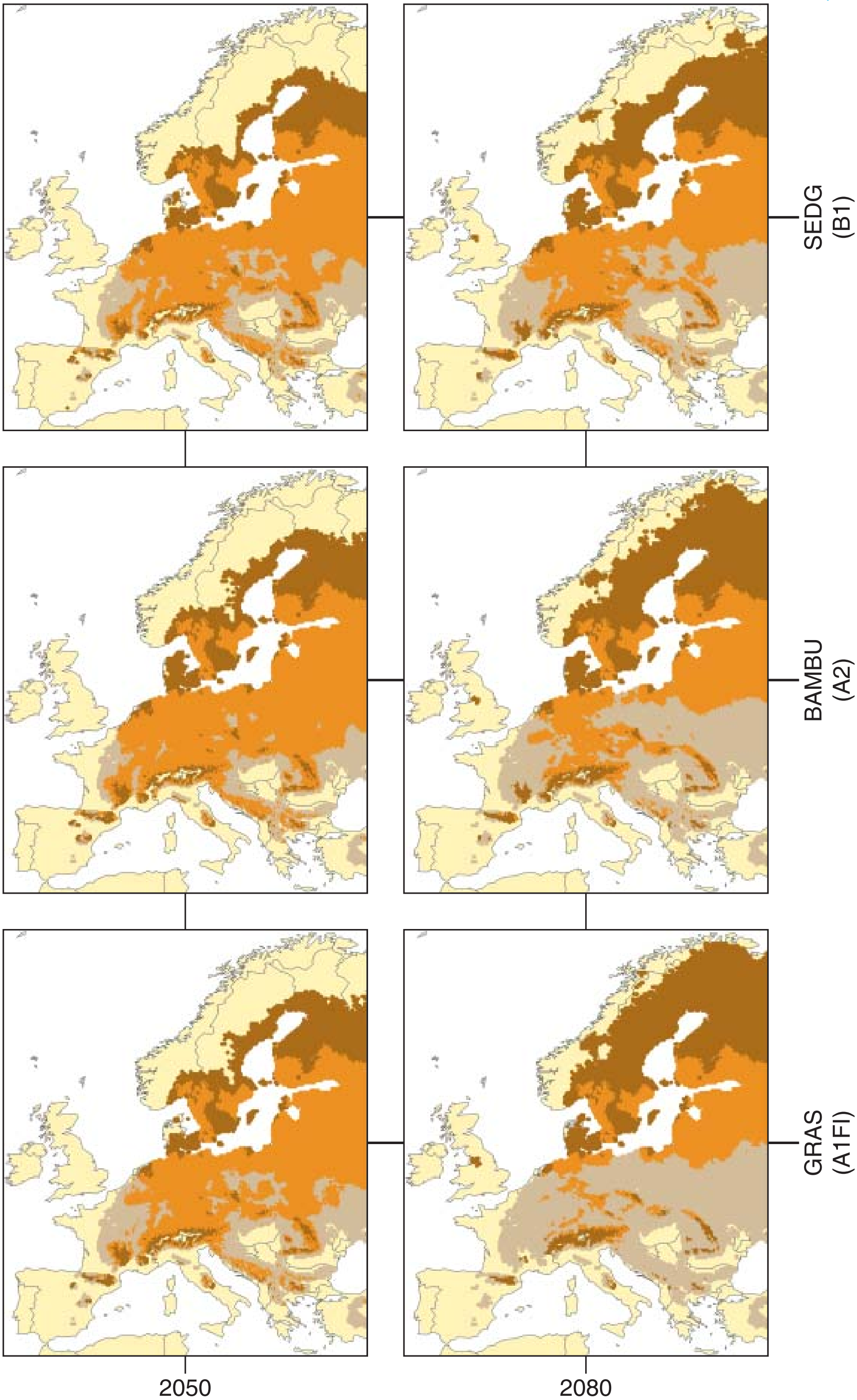
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.83). Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Satyrium spini (Fabricius, 1787) – Blue-spot Hairstreak

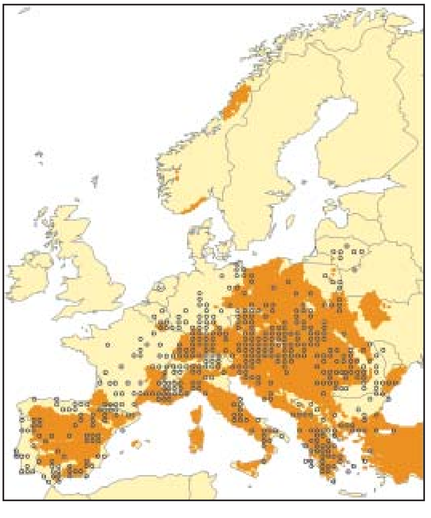
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-1547 (-18.11%)	-3552 (-41.59%)
	BAMBU	-2078 (-24.33%)	-3494 (-40.91%)
	GRAS	5 (0.06%)	-2382 (-27.89%)
2080	SEDG	-1885 (-22.07%)	-6706 (-78.52%)
	BAMBU	-2494 (-29.2%)	-5899 (-69.07%)
	GRAS	-695 (-8.14%)	-4290 (-50.23%)

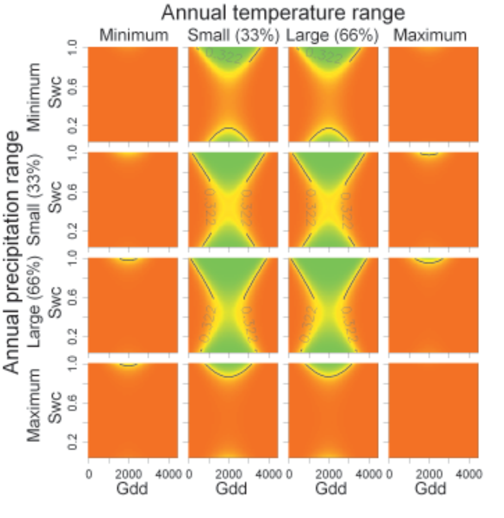
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 8540 cells)

The Blue-spot Hairstreak can be found in sunny, warm places, on groups of bushes, or on scrub at the edge of a wood, with some flowering vegetation as nectar source nearby. The female lays her eggs on various buckthorns (*Rhamnus* spp.), choosing branches situated in the sun. The small caterpillar only emerges in the spring, having passed the winter in the eggshell. It wastes no time in beginning to eat buds and young leaves. Ants of the genera *Lasius* and *Formica* may visit the caterpillar. When fully-grown, it pupates on the foodplant, the pupa suspended by a silken girdle. The Blue-spot Hairstreak has one generation a year.

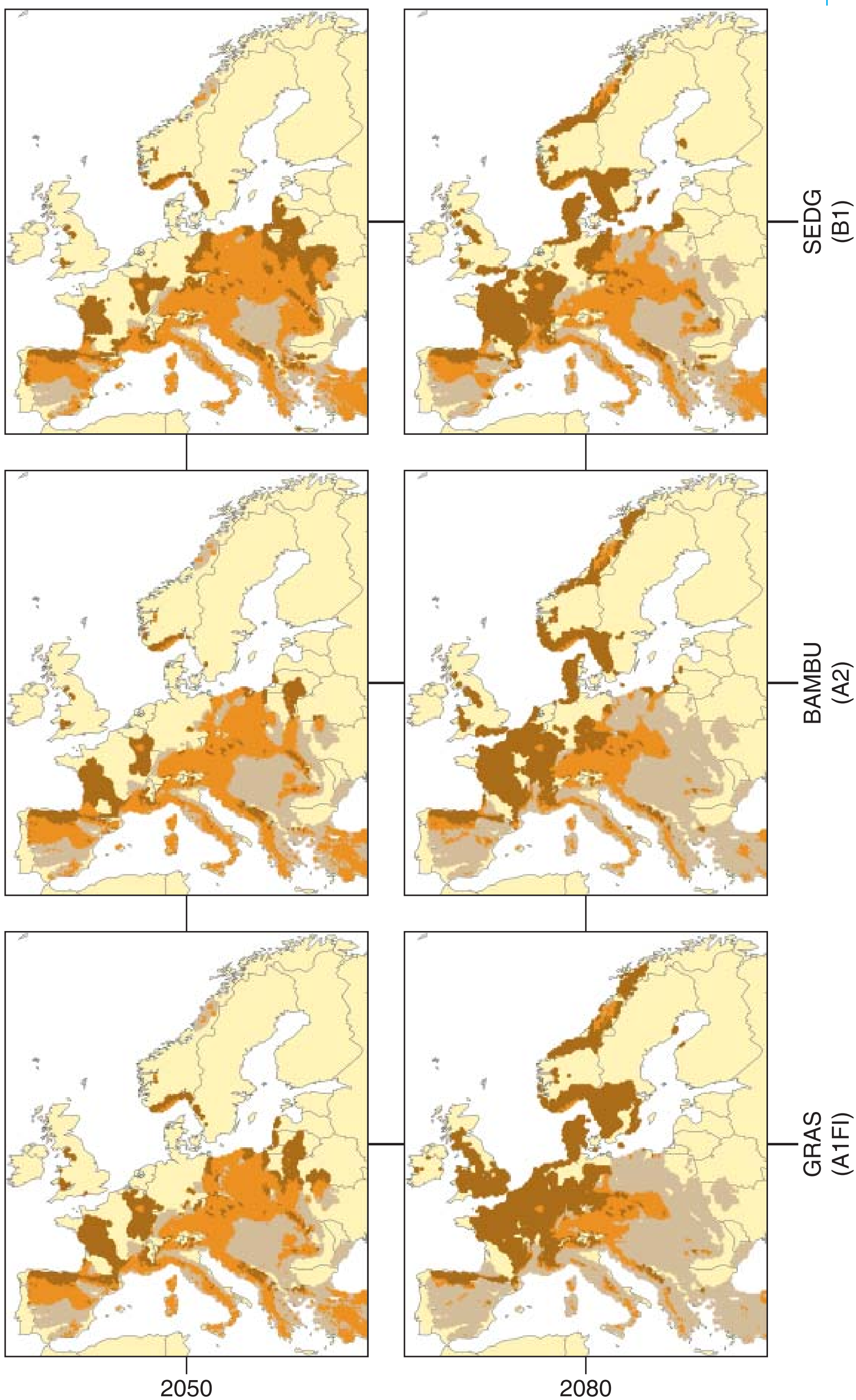
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.71).
Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Satyrium ilicis (Esper, 1779) – Ilex Hairstreak

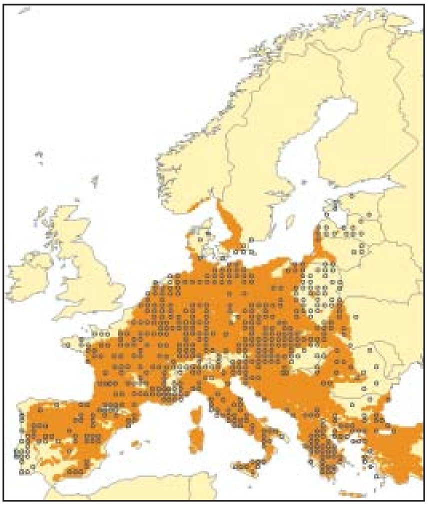
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-164 (-1.51%)	-2441 (-22.49%)
	BAMBU	-613 (-5.65%)	-2924 (-26.93%)
	GRAS	-966 (-8.9%)	-3370 (-31.04%)
2080	SEDG	-2100 (-19.34%)	-4264 (-39.28%)
	BAMBU	-3154 (-29.05%)	-5618 (-51.75%)
	GRAS	-4333 (-39.91%)	-7136 (-65.73%)

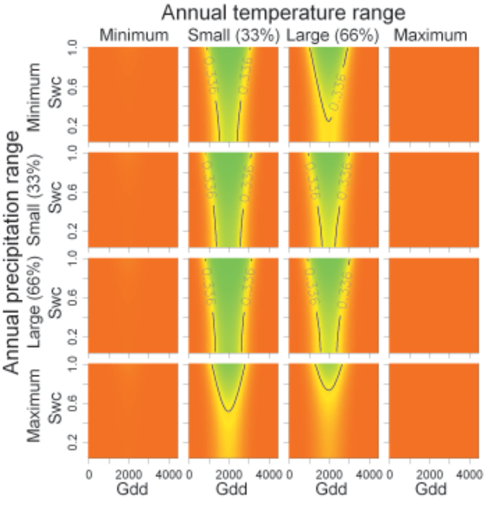
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 10856 cells)

The Ilex Hairstreak occurs locally at woodland edges, and in coppices with warm, dry oak scrub. The female lays her eggs on the rather stunted oak trees, and certainly not on large oaks. The tiny caterpillar hibernates in the egg, or in the first larval instar. It feeds on the young oak leaves, eventually pupating in the litter layer under the foodplant. The caterpillars have been found in association with ants of the genera *Camponotus* and *Crematogaster*. The adult butterflies need nectar, feeding on flowering Common Privet (*Ligustrum vulgare*) and on bramble blossom (*Rubus* spp.). It is single-brooded.

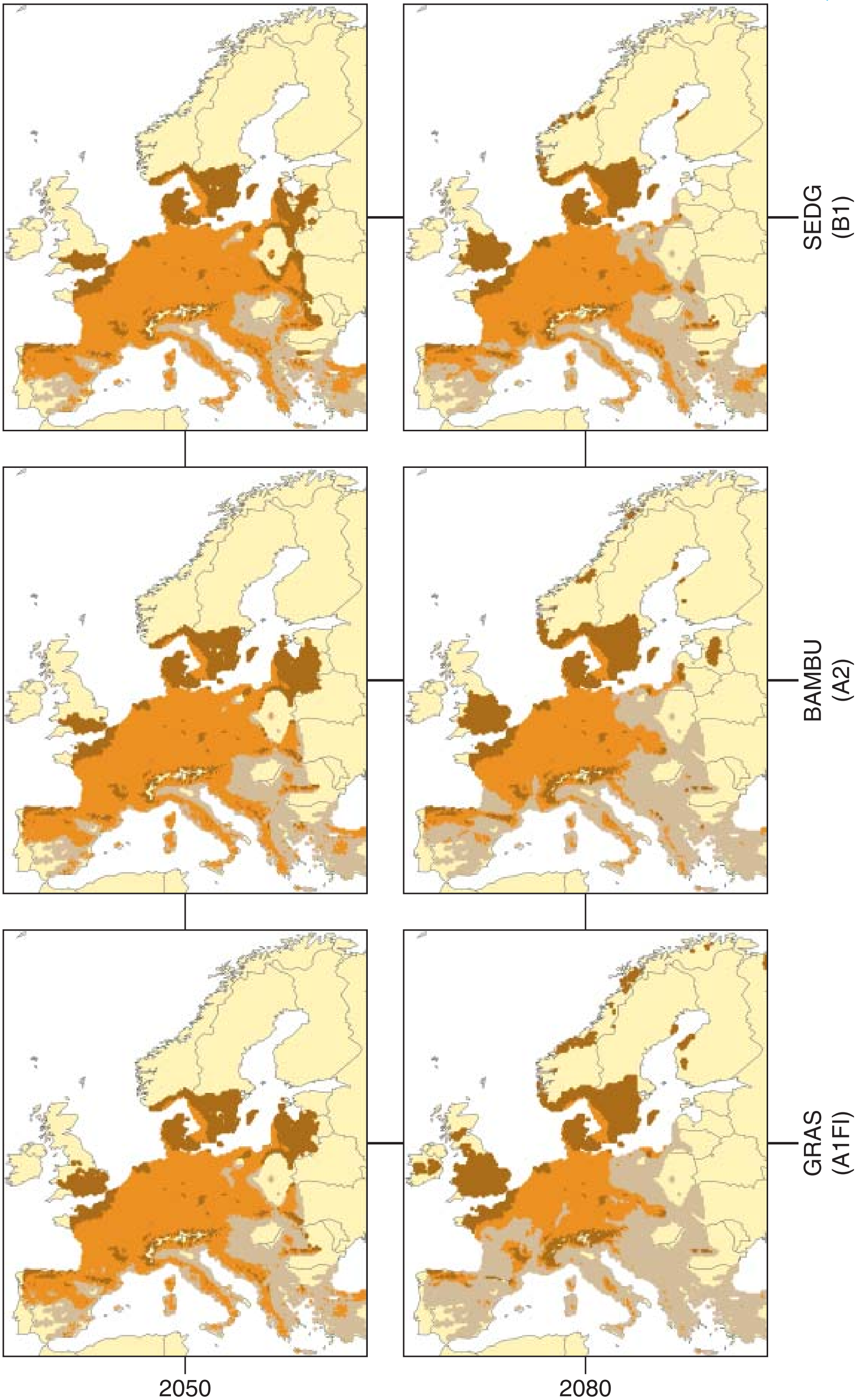
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.71). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


2050
2080
SEDG (B1)
BAMBU (A2)
GRAS (A1FI)

Satyrium esculi (Hübner, 1804) – False Ilex Hairstreak

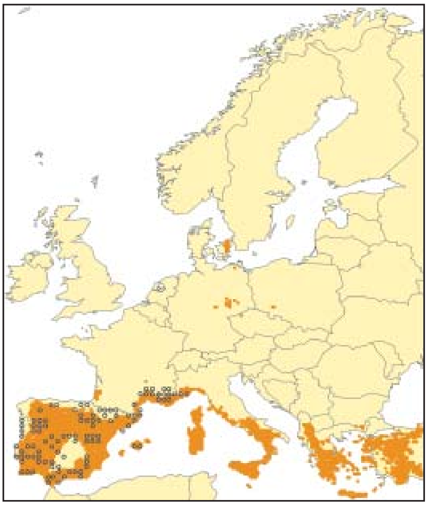
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-1000 (-33.22%)	-1760 (-58.47%)
	BAMBU	-1649 (-54.78%)	-1938 (-64.39%)
	GRAS	-1549 (-51.46%)	-2151 (-71.46%)
2080	SEDG	-1726 (-57.34%)	-2448 (-81.33%)
	BAMBU	-2208 (-73.36%)	-2811 (-93.39%)
	GRAS	-2014 (-66.91%)	-2998 (-99.6%)

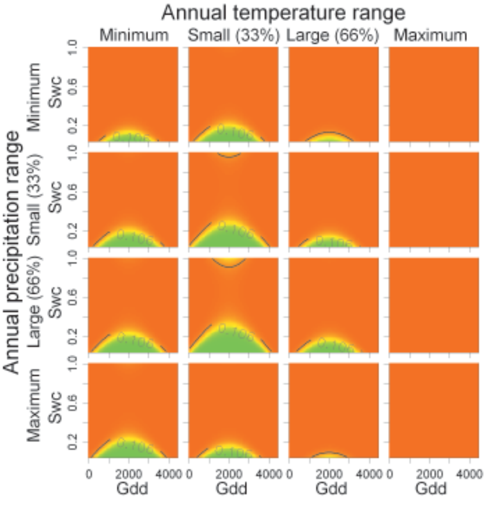
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 3010 cells)

The False Ilex Hairstreak can be found in dry scrub, open, deciduous woodland, or in mixed woodland. The butterflies can often be seen drinking nectar on thyme. The females lay their eggs on various oak species, including the Holm Oak (*Quercus ilex*), Common or Pedunculate Oak (*Q. robur*), Kermes or Holly Oak (*Q. coccifera*), and Pyrenean Oak (*Q. pyrenaica*). The small caterpillars only emerge from the egg the following spring, when they start eating the young oak leaves. The ant *Camponotus cruentatus* has been found in association with them. This species has one brood a year.

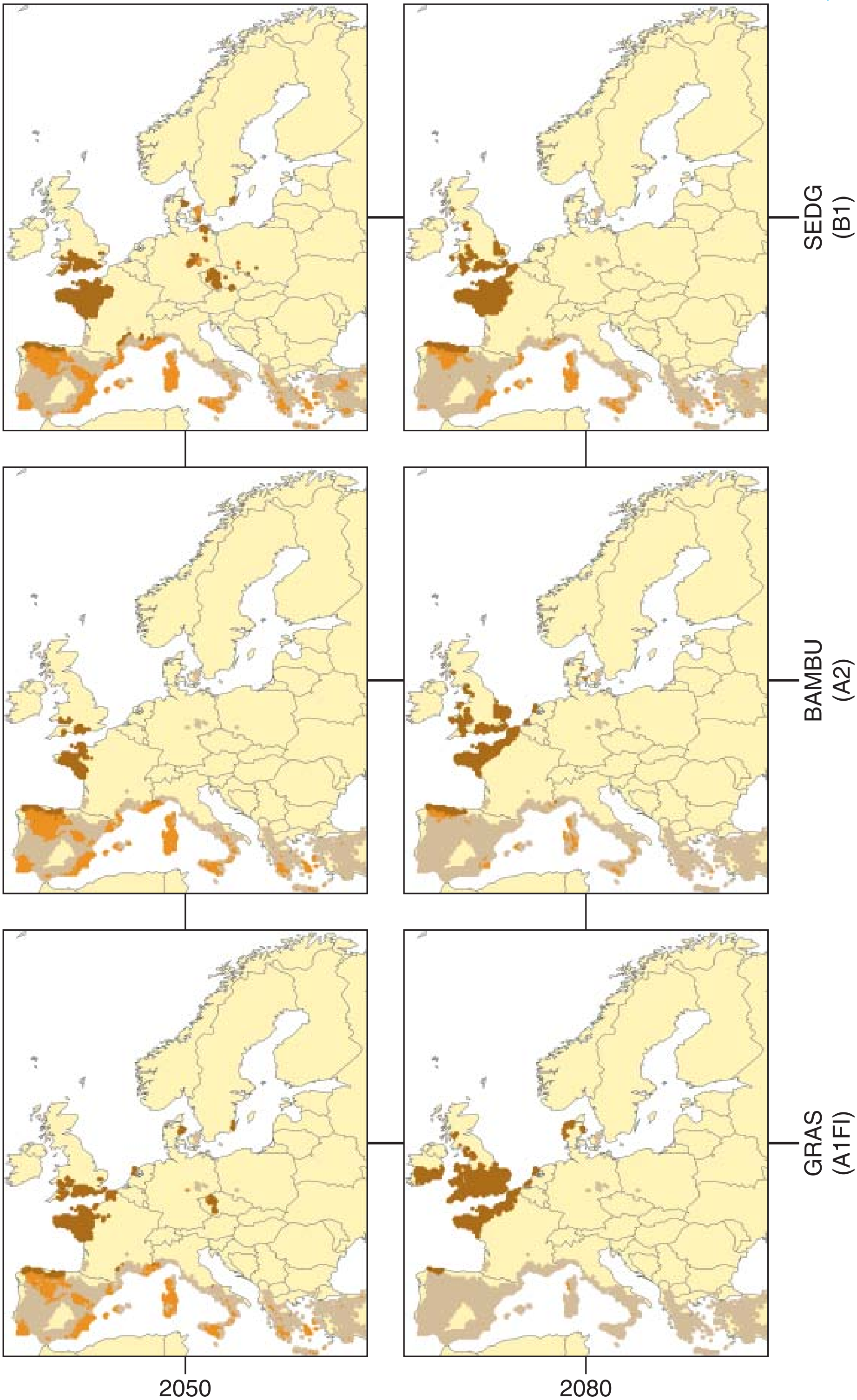
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.82).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Satyrium acaciae (Fabricius, 1787) – Sloe Hairstreak

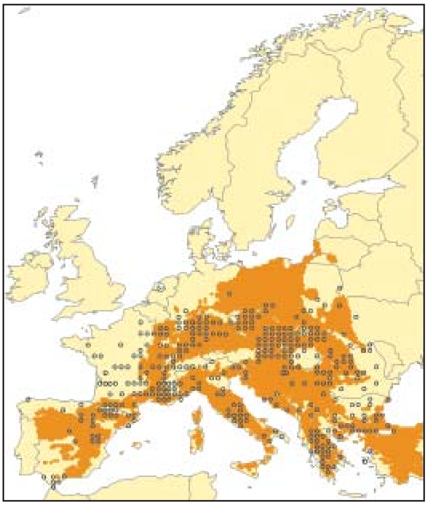
© Martin Wiemers

		Full dispersal	No dispersal
2050	SEDG	1205 (15.48%)	-2303 (-29.59%)
	BAMBU	-492 (-6.32%)	-2953 (-37.94%)
	GRAS	-399 (-5.13%)	-3340 (-42.91%)
2080	SEDG	57 (0.73%)	-3942 (-50.64%)
	BAMBU	-1287 (-16.53%)	-5311 (-68.23%)
	GRAS	-2206 (-28.34%)	-6127 (-78.71%)

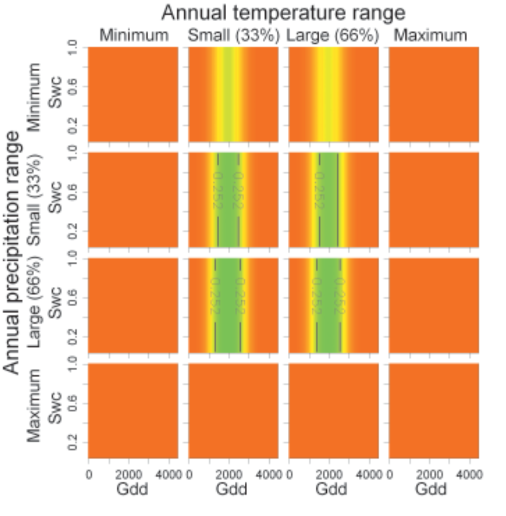
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 7784 cells)

The Sloe Hairstreak is found in dry scrub in woods, at wood margins, or in the open landscape. They are also seen in abandoned vineyards on calcareous soils. When looking for nectar, the butterflies seem to prefer white flowers. Blackthorn or Sloe (*Prunus spinosa*) is practically the only foodplant of the Sloe Hairstreak, and eggs are laid on branches that are in the sun. The small caterpillars stay in the egg until after the winter, emerging in the spring and feeding on the young Blackthorn leaves. When fully-grown, they leave the foodplant to pupate on the ground in leaf litter.

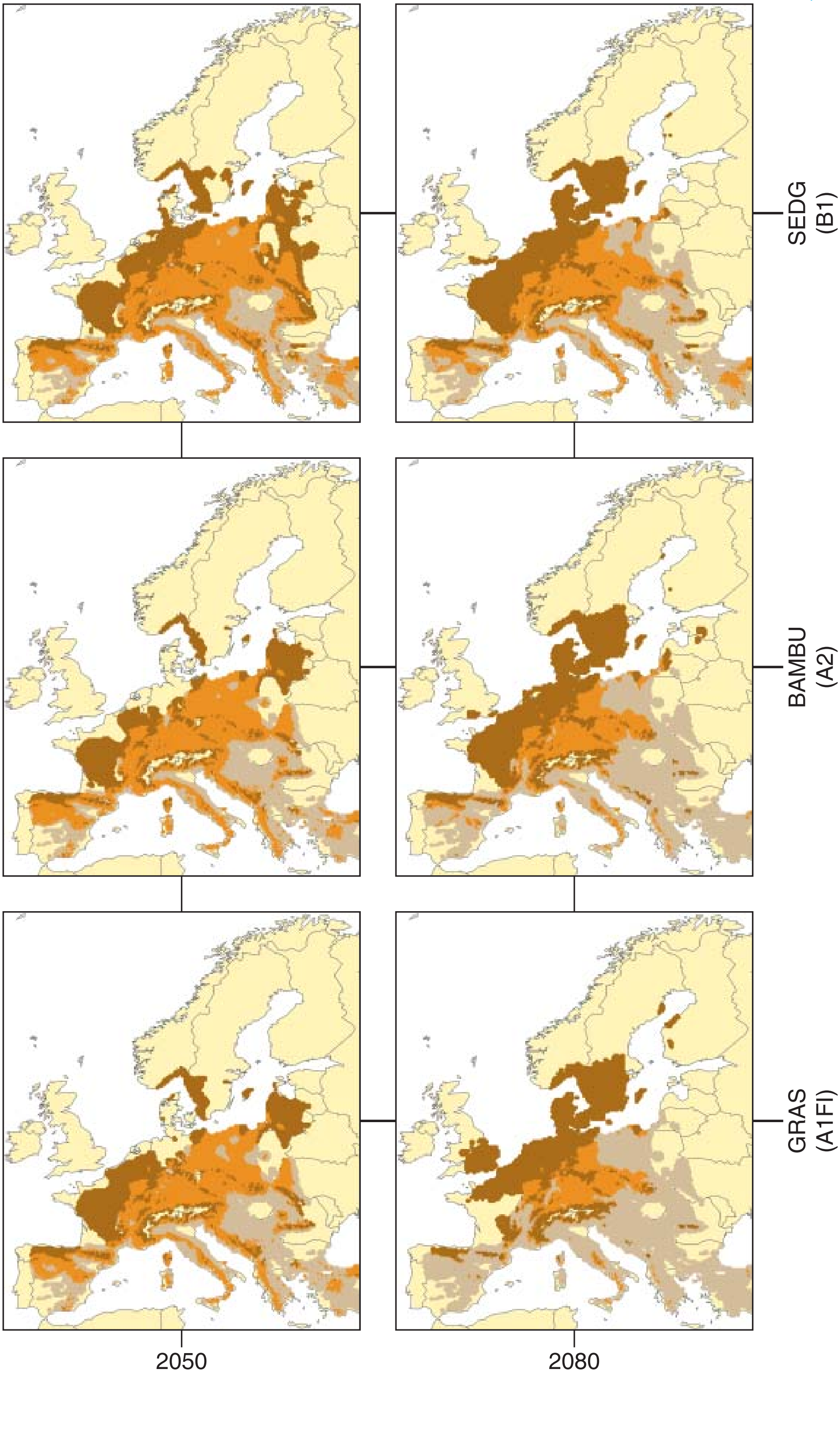
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.76). Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Lampides boeticus (Linnaeus, 1767) – Long-tailed Blue

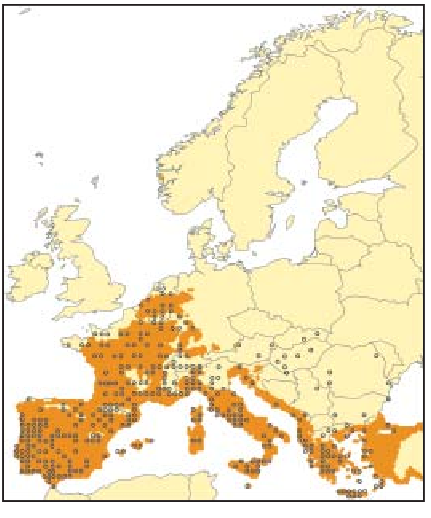
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	950 (14.89%)	-1240 (-19.43%)
	BAMBU	815 (12.77%)	-1156 (-18.12%)
	GRAS	1279 (20.04%)	-1030 (-16.14%)
2080	SEDG	-722 (-11.31%)	-3666 (-57.45%)
	BAMBU	10 (0.16%)	-2770 (-43.41%)
	GRAS	885 (13.87%)	-1663 (-26.06%)

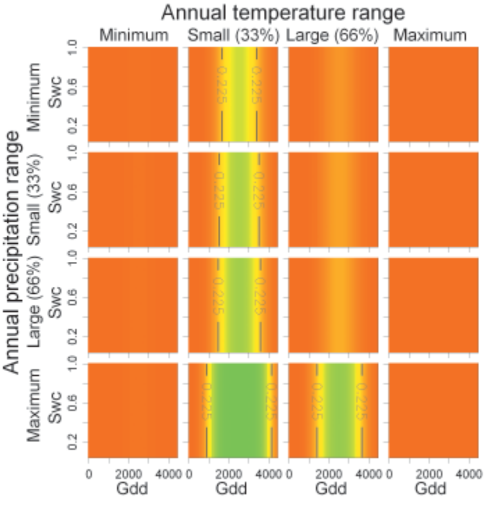
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 6381cells)

The underside of the wings of the Long-tailed Blue have an attractive pattern of fine, wavy lines and two striking eye-spots near the rather long little tails on the hindwings. The habitats are typified by the presence of many kinds of leguminous plants that serve as foodplants, and plenty of nectar-rich flowers for the butterflies. The habitats are warm, dry places, sometimes in agricultural areas. The main foodplant is Bladder Senna (*Colutea arborescens*). The caterpillars feed on the ripening seeds and on farms where peas and beans are grown, they can cause outbreaks. In natural situations, the caterpillars are attended by various ant species. The life cycle of the Long-tailed Blue takes four to six weeks. It does not go into hibernation, and can therefore only occur as a resident where it is warm enough for all stages to survive.

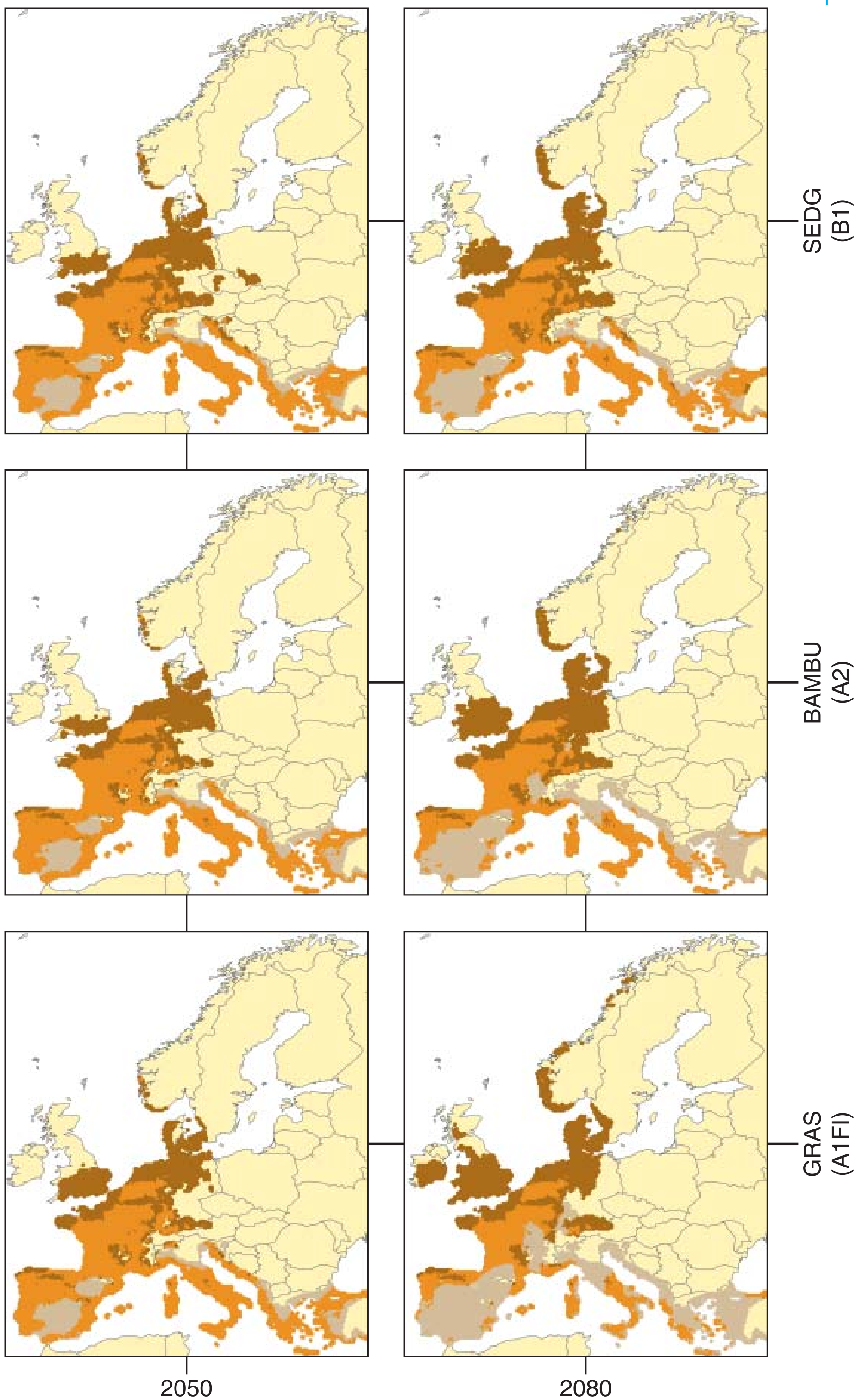
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.83).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Cacyreus marshalli (Butler, 1898) – Geranium Bronze

© Chris van Swaay

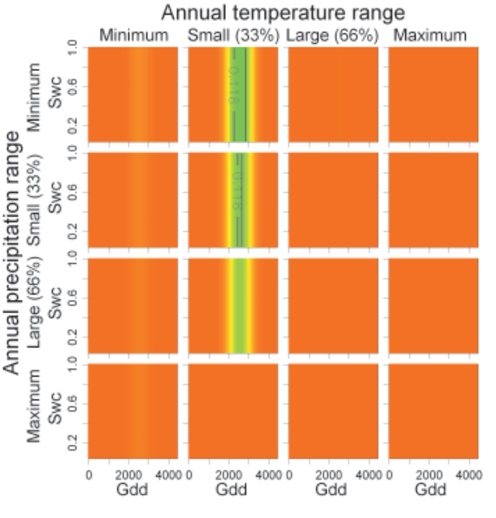
		Full dispersal	No dispersal
2050	SEDG	-207 (-25.87%)	-437 (-54.62%)
	BAMBU	-277 (-34.62%)	-464 (-58%)
	GRAS	-310 (-38.75%)	-557 (-69.62%)
2080	SEDG	-661 (-82.62%)	-746 (-93.25%)
	BAMBU	-592 (-74%)	-780 (-97.5%)
	GRAS	-629 (-78.62%)	-800 (-100%)

Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 800)

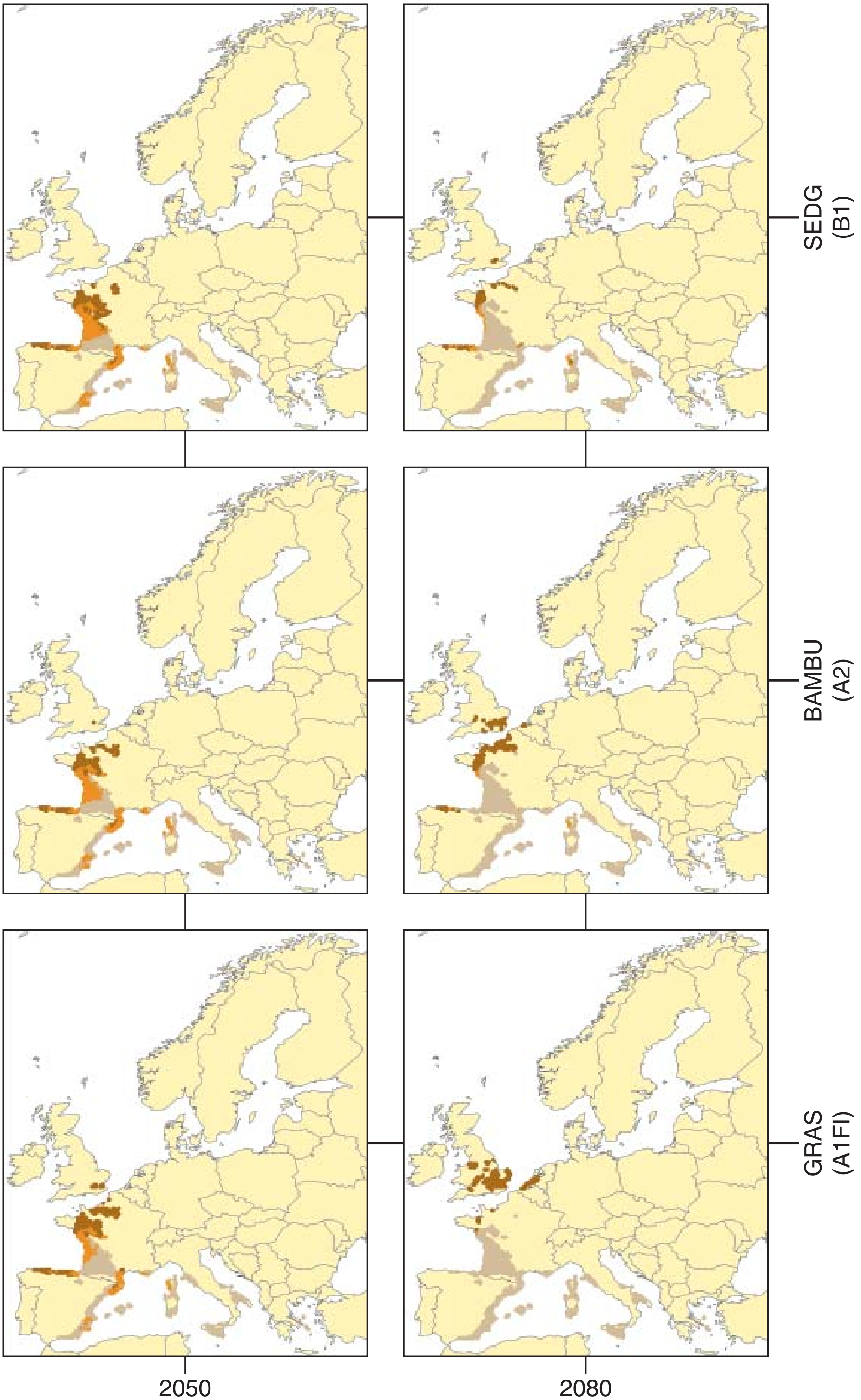
Originally a species from southern Africa, the Geranium Bronze had probably been imported on *Pelargonium* cultivars, the ordinary or garden geraniums. From there out, because of the large popularity of these plants, it occurs e.g. in Spain and France, but is about to colonize larger parts of Europe, using the *Pelargonium* cultivars as foodplant. The caterpillars mostly eat the flowers and buds of *Pelargonium*, but also the rest of the plants. In South Africa, the Geranium Bronze uses wild *Geranium* species as foodplant, making it very probable that this butterfly will establish itself in the wild in warm parts of Europe. However, in cooler areas, it would be impossible for it to settle permanently, because it has no diapause, and could not survive the winter. It has numerous generations a year, depending on the temperature.

Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.85).
Climate risk category: HHHR.

Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Leptotes pirithous (Linnaeus, 1767) – Lang's Short-tailed Blue

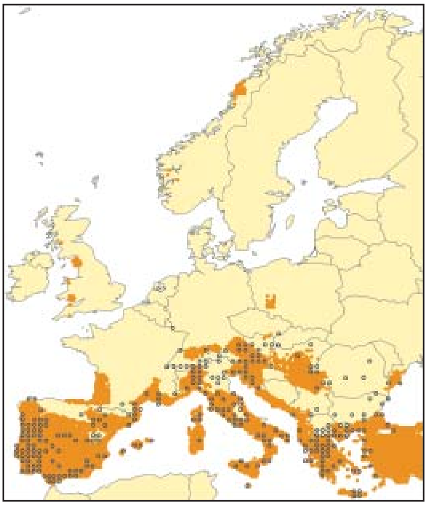
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	998 (18.23%)	-759 (-13.86%)
	BAMBU	259 (4.73%)	-868 (-15.85%)
	GRAS	654 (11.95%)	-1120 (-20.46%)
2080	SEDG	800 (14.61%)	-1775 (-32.42%)
	BAMBU	-30 (-0.55%)	-2922 (-53.37%)
	GRAS	838 (15.31%)	-3855 (-70.41%)

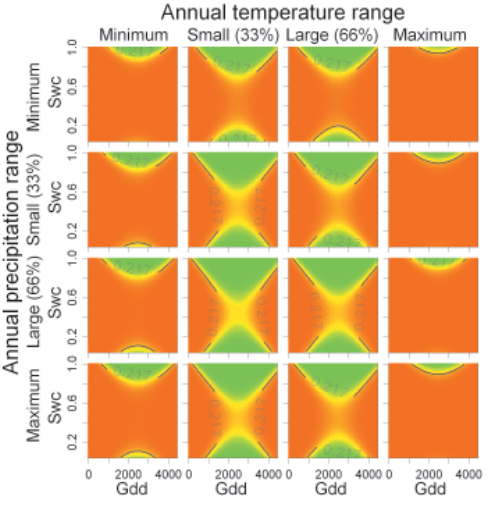
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 5475)

The Lang's Short-tailed Blue is a small, inconspicuous butterfly that occurs in flower-rich places and on rough vegetation. It is often seen near scrub and on fields of Lucerne (*Medicago sativa*). The eggs are laid on various leguminous plants, such as melilots (*Melilotus* spp.), Purple Loosestrife (*Lythrum salicaria*), and also species of Rosaceae and Plumbaginaeceae. The caterpillar feeds on the flowers and seeds of the foodplant and has been found in association with ants of the genus *Lasius*. The life cycle of the Lang's Short-tailed Blue takes four to eight weeks, depending on the temperature. It is not known whether this species enters diapause, but if it does, it should be either in the egg or caterpillar stage.

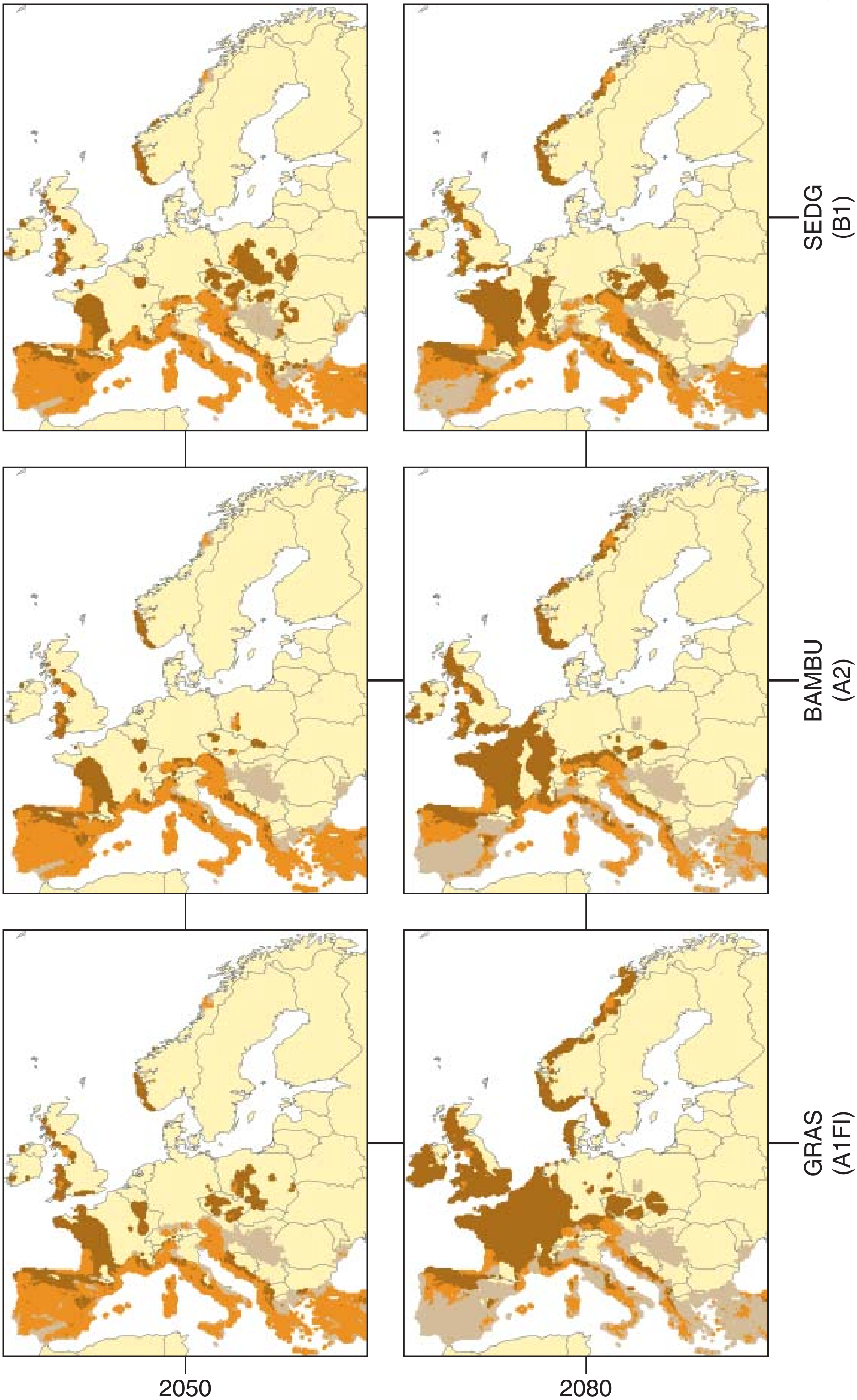
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.83).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Zizeeria knysna (Trimen, 1862) – African Grass Blue

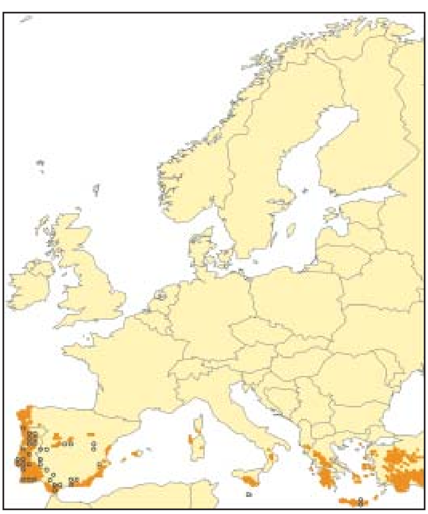
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-528 (-64.23%)	-582 (-70.8%)
	BAMBU	-619 (-75.3%)	-643 (-78.22%)
	GRAS	-619 (-75.3%)	-666 (-81.02%)
2080	SEDG	-575 (-69.95%)	-708 (-86.13%)
	BAMBU	-759 (-92.34%)	-797 (-96.96%)
	GRAS	-711 (-86.5%)	-815 (-99.15%)

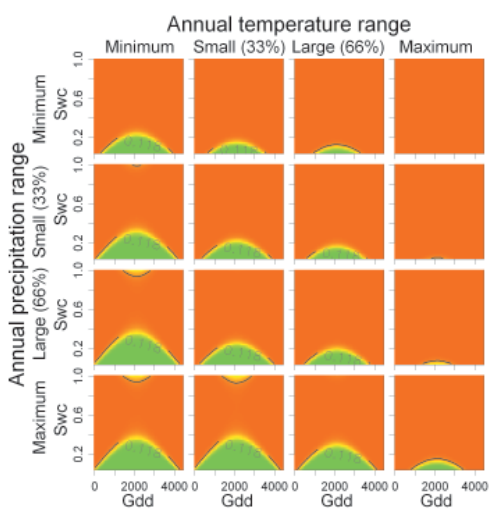
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 822)

The African Grass Blue is a modest little blue, which flies close to the ground. It is a species of dry grassland, road verges, waste ground, and gardens, but sometimes butterflies are found in damp, shady places. Various medicks, are used as foodplant, such as Lucerne (*Medicago sativa*), Tree Medick (*M. arborea*), Small Medick (*M. minima*), Black Medick (*M. lupulina*), and possibly various *Oxalis* species. The caterpillars are attended by ants of the genus *Pheidole*. The African Grass Blue has two or more generations a year and passes the winter as a caterpillar. There are only a few butterflies in the first generation.

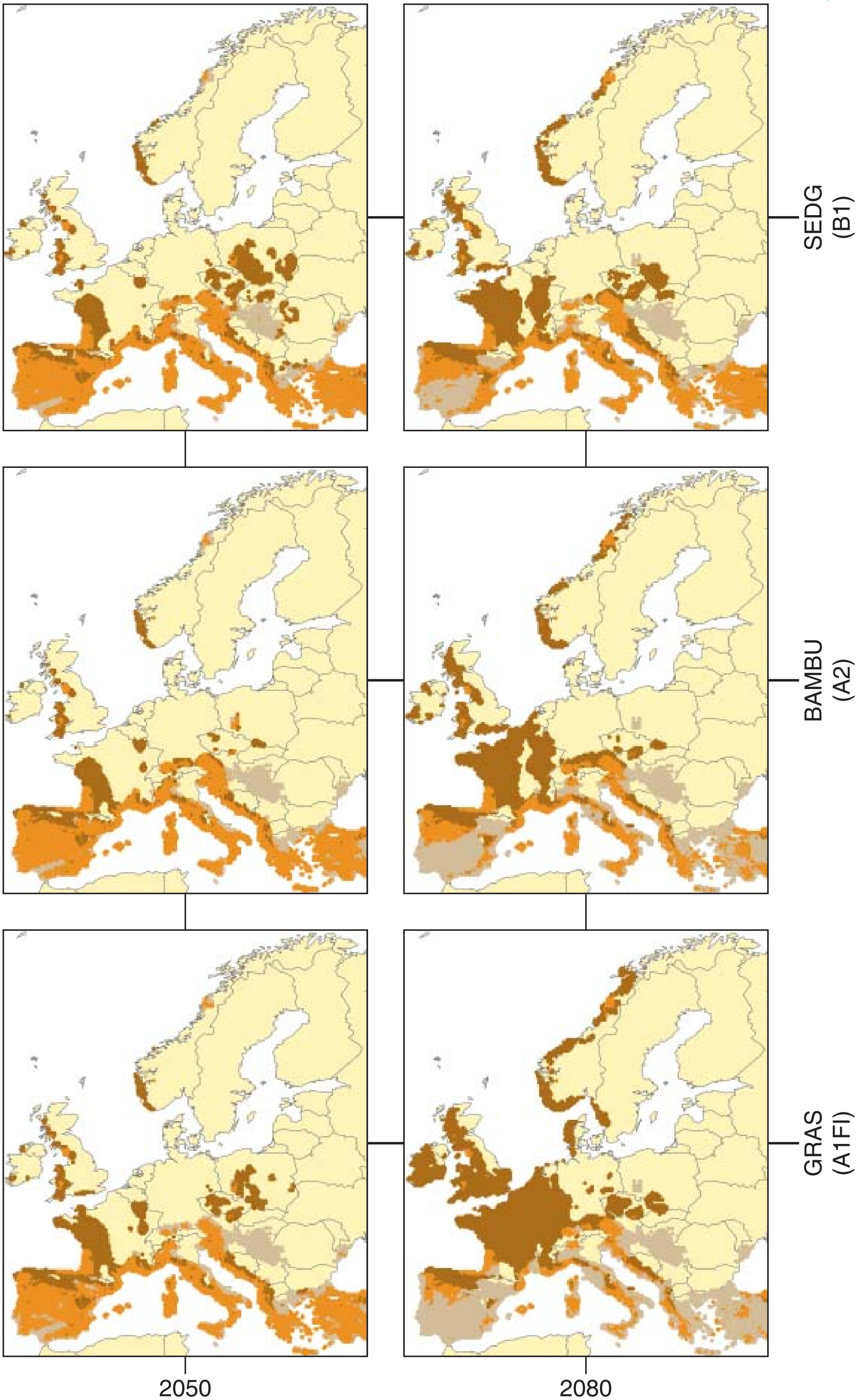
Present distribution can be well explained by climatic variables (AUC = 0.94).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Cupido minimus (Fuessly, 1775) – Small Blue

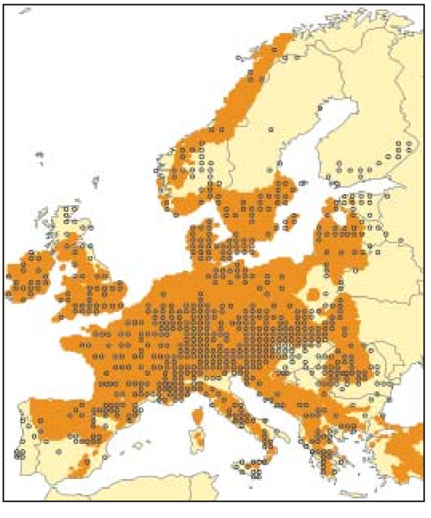
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-2124 (-15.81%)	-3032 (-22.56%)
	BAMBU	-2256 (-16.79%)	-3275 (-24.37%)
	GRAS	-3245 (-24.15%)	-4134 (-30.77%)
2080	SEDG	-4157 (-30.94%)	-5451 (-40.57%)
	BAMBU	-4491 (-33.42%)	-6672 (-49.65%)
	GRAS	-6299 (-46.88%)	-8702 (-64.76%)

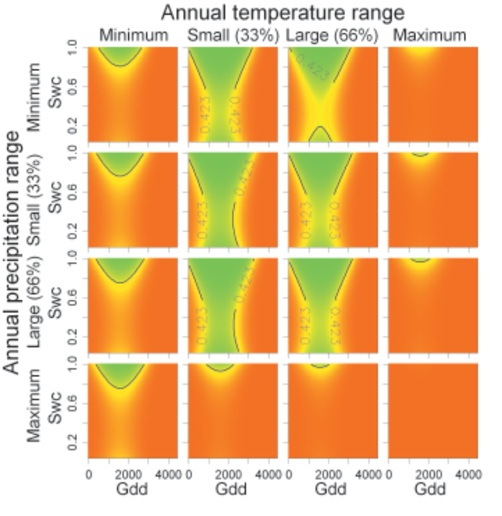
Changes in climatic niche distribution (in 10’×10’ grid cells; present niche space: 13437)

This butterfly is well named. It is very small and its modest colours make it even seem smaller than it really is. The Small Blue can only be found on calcareous soils. Open, mostly rather short vegetation and a warm microclimate typify its habitat. The butterflies may occur in large numbers. They lay their small, white eggs singly between the flowers and the sepals of Kidney-vetch (*Anthyllis vulneraria*), where a practised eye can detect them. The creamy-white caterpillars feed on the flowers and seeds, and are seldom seen. However, workers of various ant species attend them regularly. When fully-grown, the caterpillars hibernate either between the withered petals of dead flowers, or in the litter layer and pupate on the ground. The Small Blue has one or two broods a year.

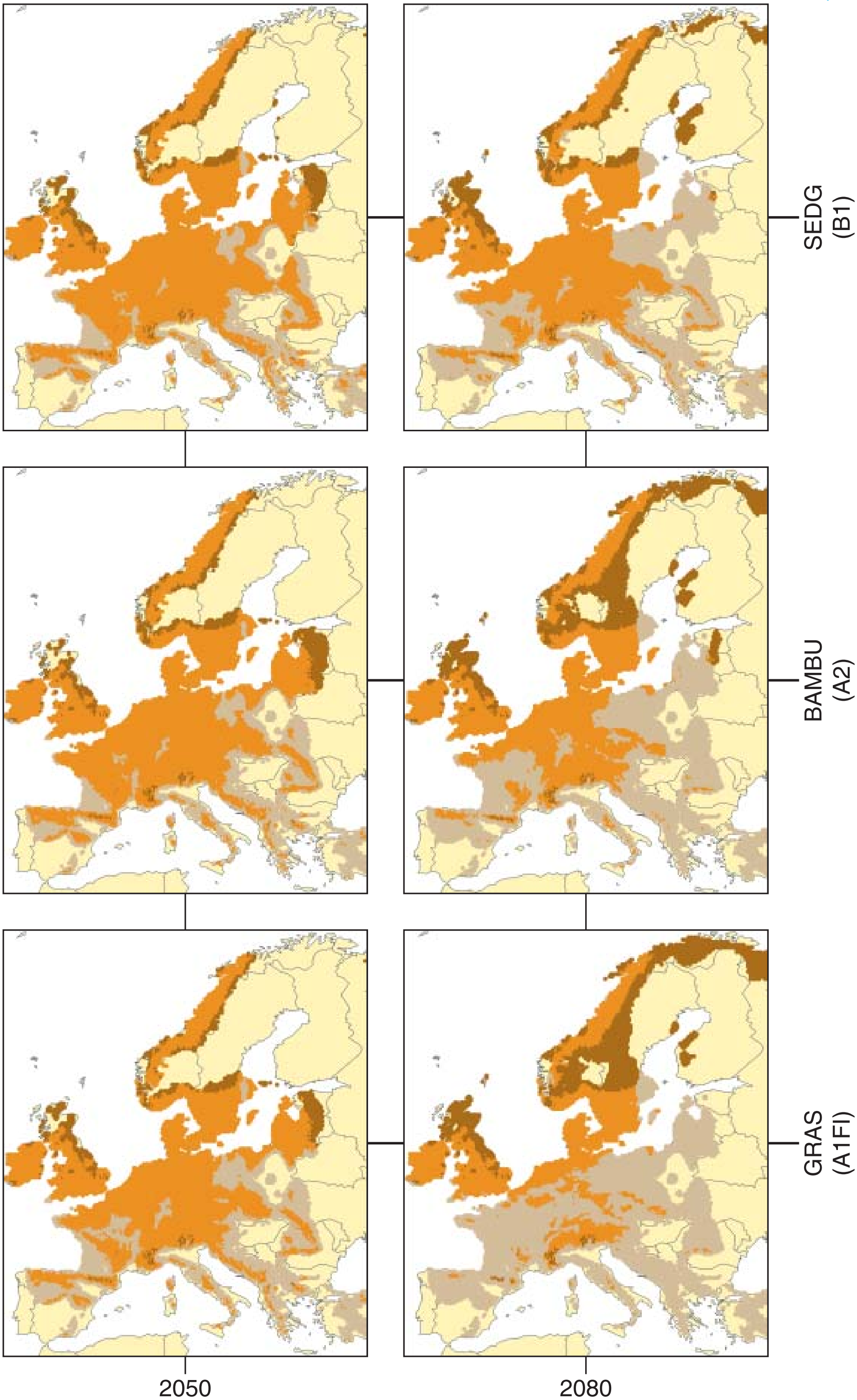
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.71). Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Cupido osiris (Meigen, 1829) – Osiris Blue

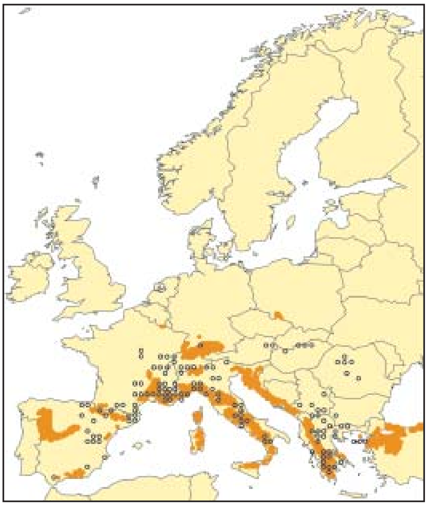
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-470 (-42.11%)	-810 (-72.58%)
	BAMBU	-506 (-45.34%)	-847 (-75.9%)
	GRAS	-566 (-50.72%)	-961 (-86.11%)
2080	SEDG	-154 (-13.8%)	-1003 (-89.87%)
	BAMBU	-427 (-38.26%)	-1039 (-93.1%)
	GRAS	-373 (-33.42%)	-1101 (-98.66%)

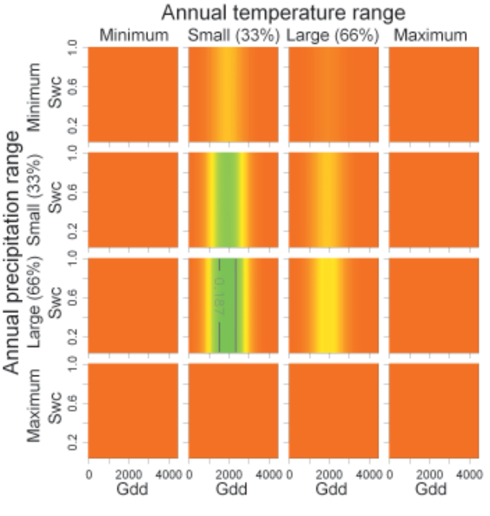
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1116)

The Osiris Blue lives on sunny, flower-rich grassland and road verges rich in sainfoin (*Onobrychis* spp.), which it uses for its nectar and as foodplant. The caterpillar feeds on various sainfoins (*Onobrychis* spp.), such as Sainfoin (*O. viciifolia*), Mountain Sainfoin (*O. montana*), and *O. arenaria*. In the literature, other leguminous plants are mentioned, e.g. Bladder Senna (*Colutea arborescens*), Kidney-vetch (*Anthyllis vulneraria*), and Bitter Vetch (*Lathyrus montanus*). The eggs are laid on the flowerheads. The caterpillars feed on both the flowers and developing seeds and are attended by ants (e.g. *Lasius alienus*). The Osiris Blue has one or two broods a year, but the second may only be partial. The caterpillars hibernate and pupate between leaves.

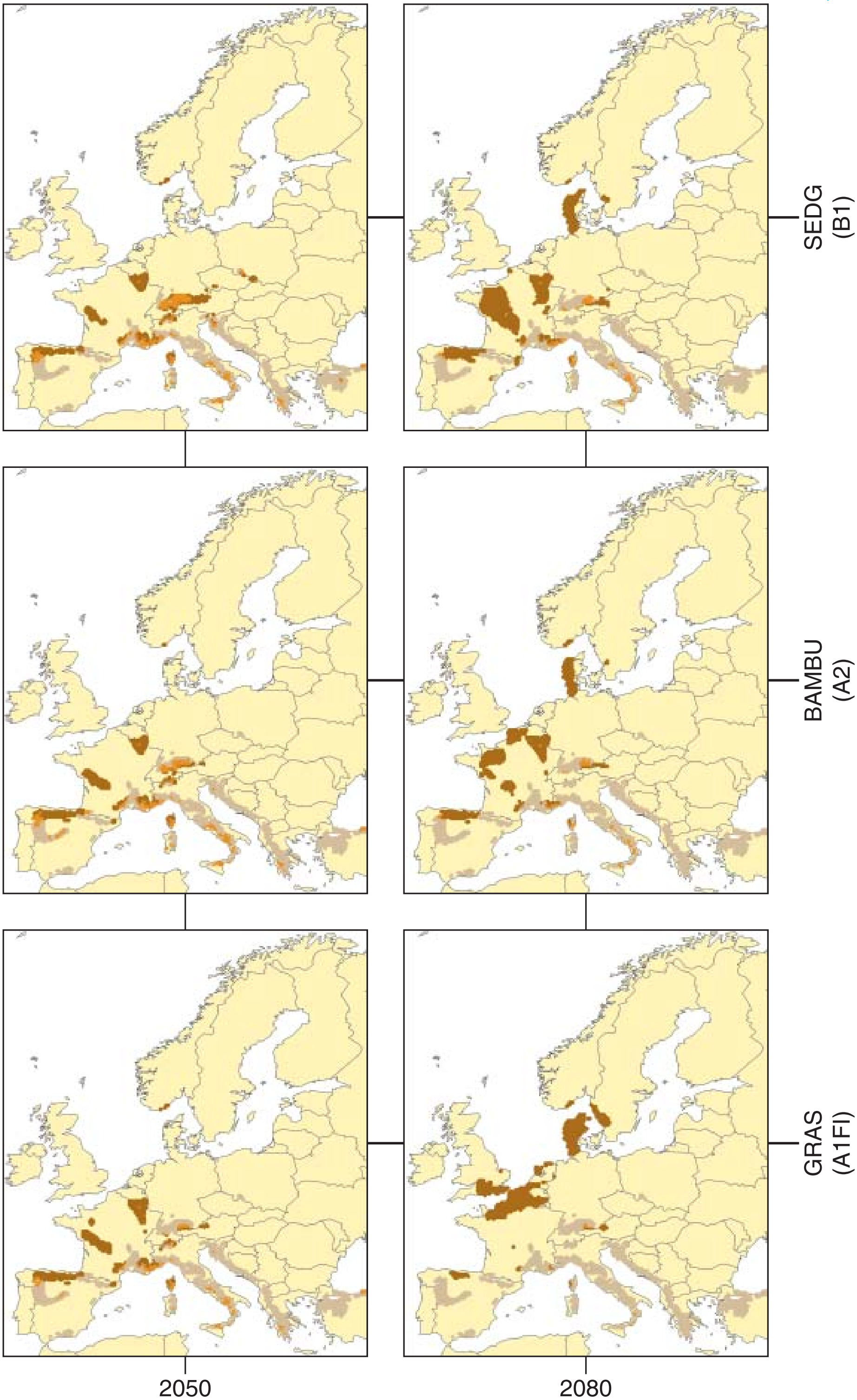
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.76).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Cupido argiades (Pallas, 1771) – Short-tailed Blue

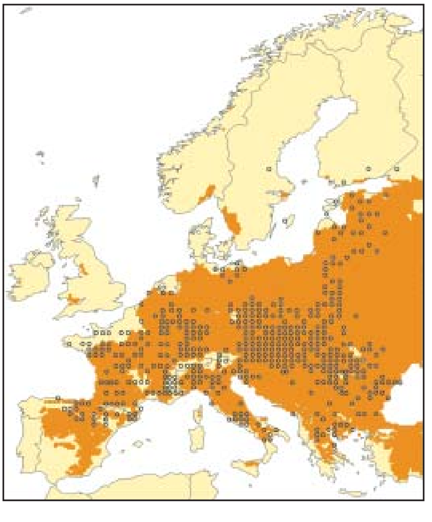
© Josef Settele

		Full dispersal	No dispersal
2050	SEDG	1445 (9.62%)	-1822 (-12.13%)
	BAMBU	1387 (9.23%)	-2139 (-14.24%)
	GRAS	746 (4.96%)	-2692 (-17.92%)
2080	SEDG	1257 (8.37%)	-3979 (-26.48%)
	BAMBU	1482 (9.86%)	-5685 (-37.83%)
	GRAS	626 (4.17%)	-7883 (-52.46%)

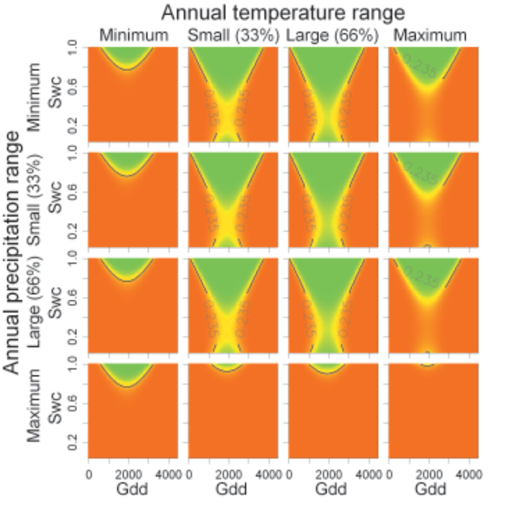
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 15026)

Although the Short-tailed Blue looks rather like the Holly Blue (*Celastrina argiolus*), it has very fine, small tails and prominent eye-spots on the hindwings. The Short-tailed Blue occurs in local populations on damp grassland, heathland and flower-rich verges. It lays its eggs on Lucerne (*Medicago sativa*) and various clovers (*Trifolium* spp.), vetches (*Vicia* spp.), birdsfoot-trefoils (*Lotus* spp.) and melilots (*Melilotus* spp.). When the caterpillars are fully-grown, they leave the foodplant, overwinter, and then pupate in the litter layer. This butterfly species has two to three generations a year.

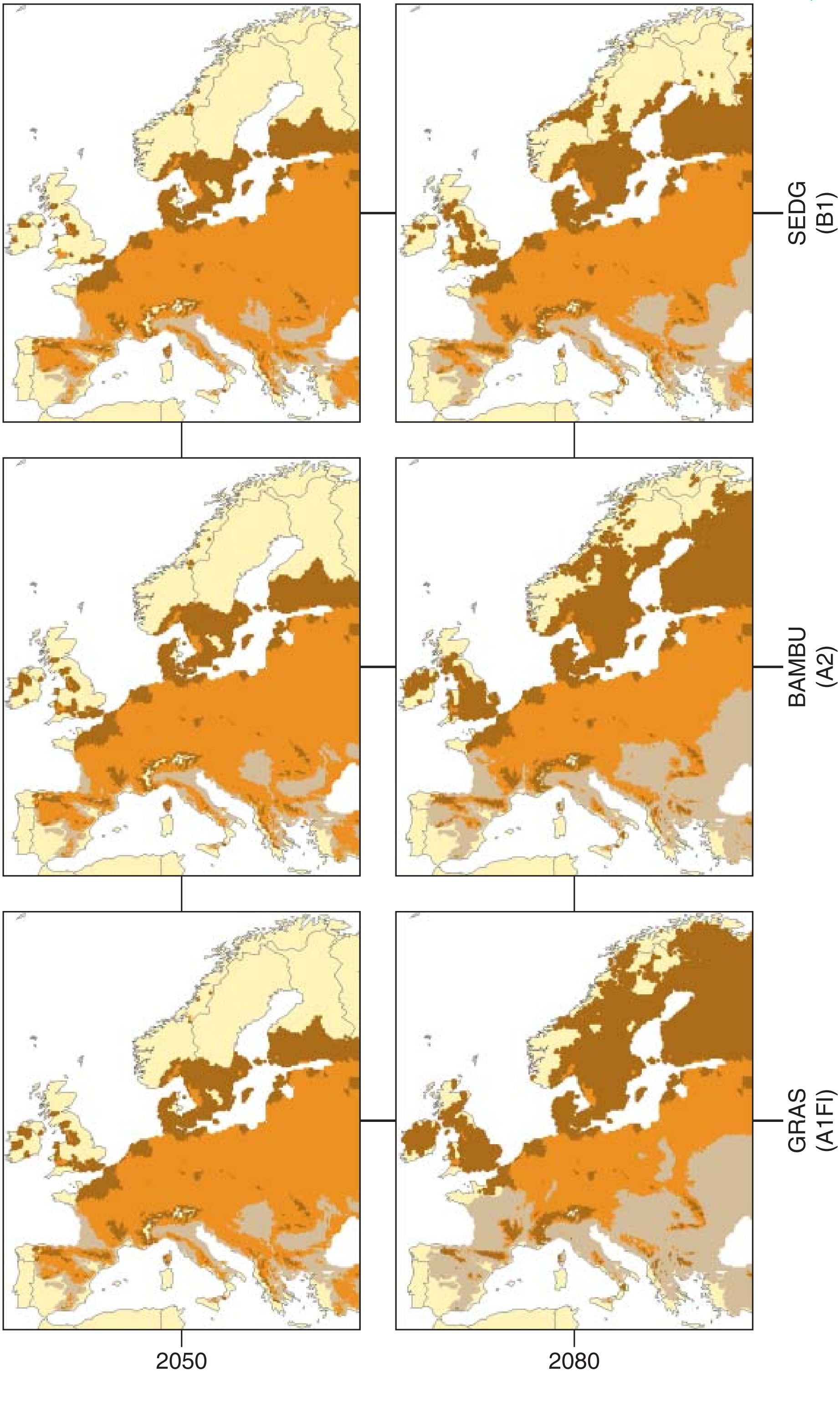
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.81).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Cupido decoloratus (Staudinger, 1886) – Eastern Short-tailed Blue

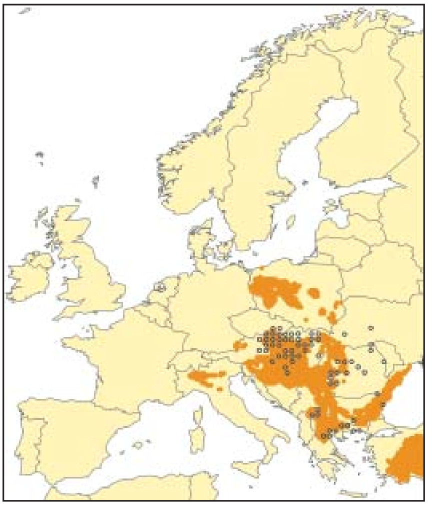
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	775 (37.99%)	-940 (-46.08%)
	BAMBU	-308 (-15.1%)	-1568 (-76.86%)
	GRAS	147 (7.21%)	-1582 (-77.55%)
2080	SEDG	-651 (-31.91%)	-1757 (-86.13%)
	BAMBU	-933 (-45.74%)	-2007 (-98.38%)
	GRAS	-879 (-43.09%)	-2031 (-99.56%)

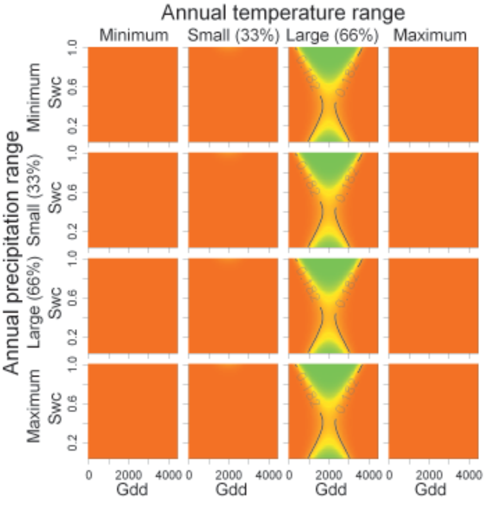
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2040)

The Eastern Short-tailed Blue occurs in clearings in deciduous woodland, and on flower-rich, grassy vegetation with scattered bushes. The caterpillars feed on the flowerheads of Black Medick (*Medicago lupulina*), and Lucerne (*M. sativa*). The Eastern Short-tailed Blue has three generations a year and hibernates as a caterpillar.

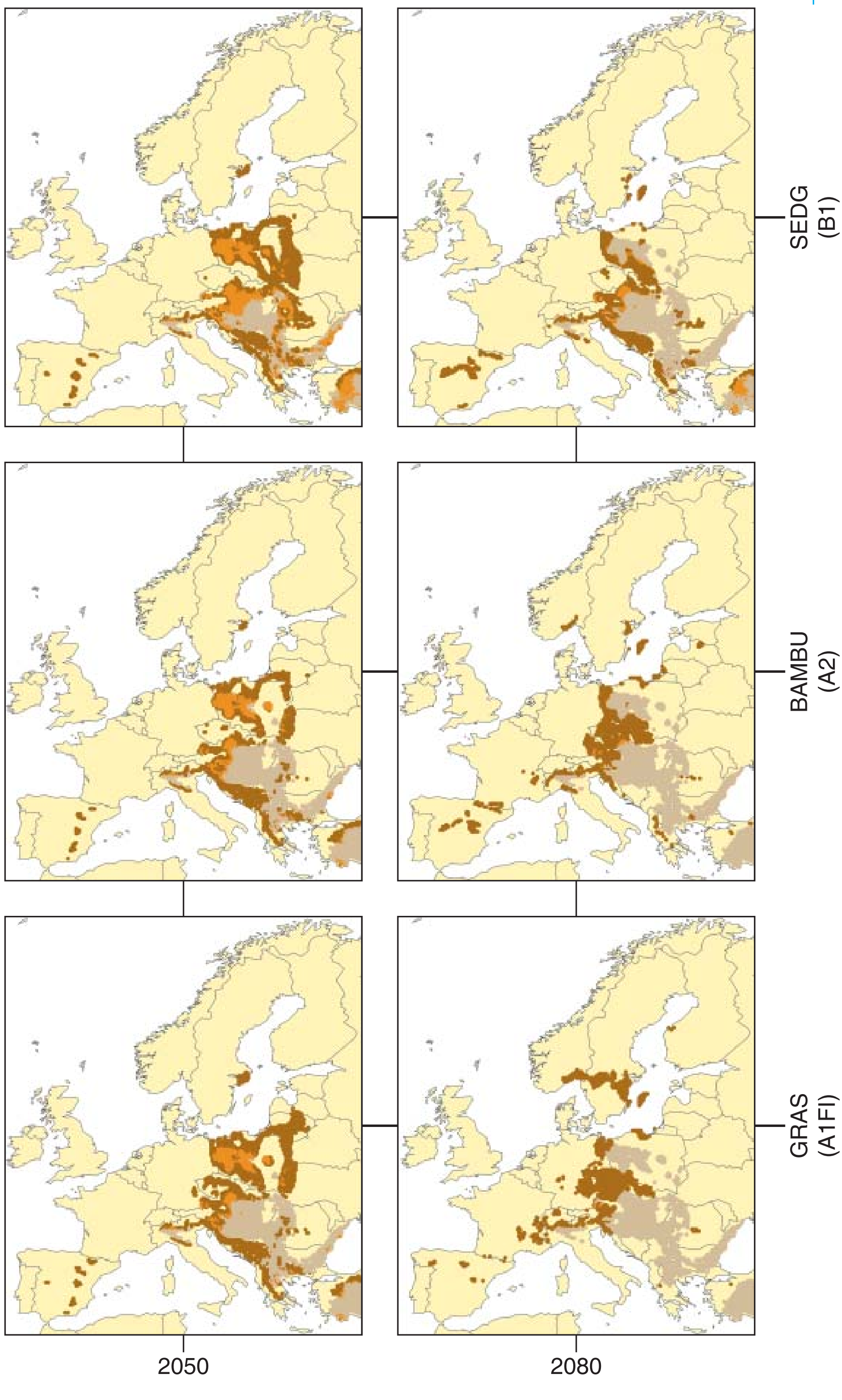
Present distribution can be well explained by climatic variables (AUC = 0.93).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Cupido alcetas (Hoffmannsegg, 1804) – Provençal Short-tailed Blue

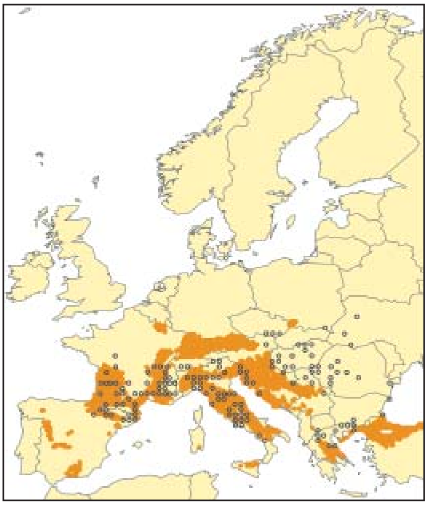
© Kars Veling

		Full dispersal	No dispersal
2050	**SEDG**	321 (14.54%)	-714 (-32.34%)
	BAMBU	796 (36.05%)	-717 (-32.47%)
	GRAS	473 (21.42%)	-933 (-42.26%)
2080	**SEDG**	1589 (71.97%)	-1036 (-46.92%)
	BAMBU	1782 (80.71%)	-1328 (-60.14%)
	GRAS	1325 (60.01%)	-1785 (-80.84%)

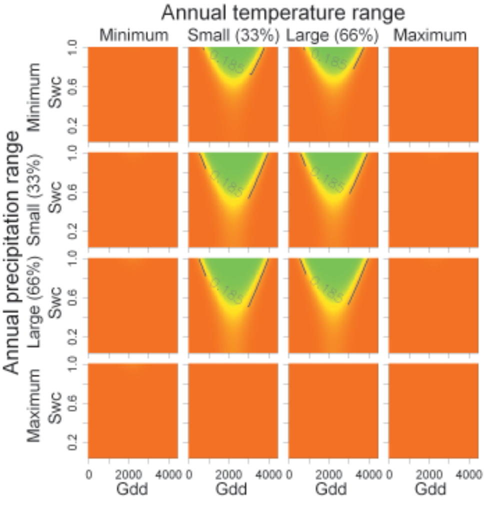
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 2208)

The Provençal Short-tailed Blue occurs in woodland clearings, at the edges of woods, on grassy vegetation near bushes, and along the banks of streams and edges of ditches. Goat’s-rue (*Galega officinalis*) and Crown Vetch (*Coronilla varia*) are its most important foodplants, but other leguminous plants, such as Common Birdsfoot-trefoil (*Lotus corniculatus*), Common Vetch (*Vicia sativa*), and Lucerne (*Medicago sativa*) are also used. The caterpillars feed mostly on the flowers, but also on the leaves, and are attended by ants (e.g. of the genus *Formica*). This butterfly species has two to three generations a year and hibernates as a caterpillar.

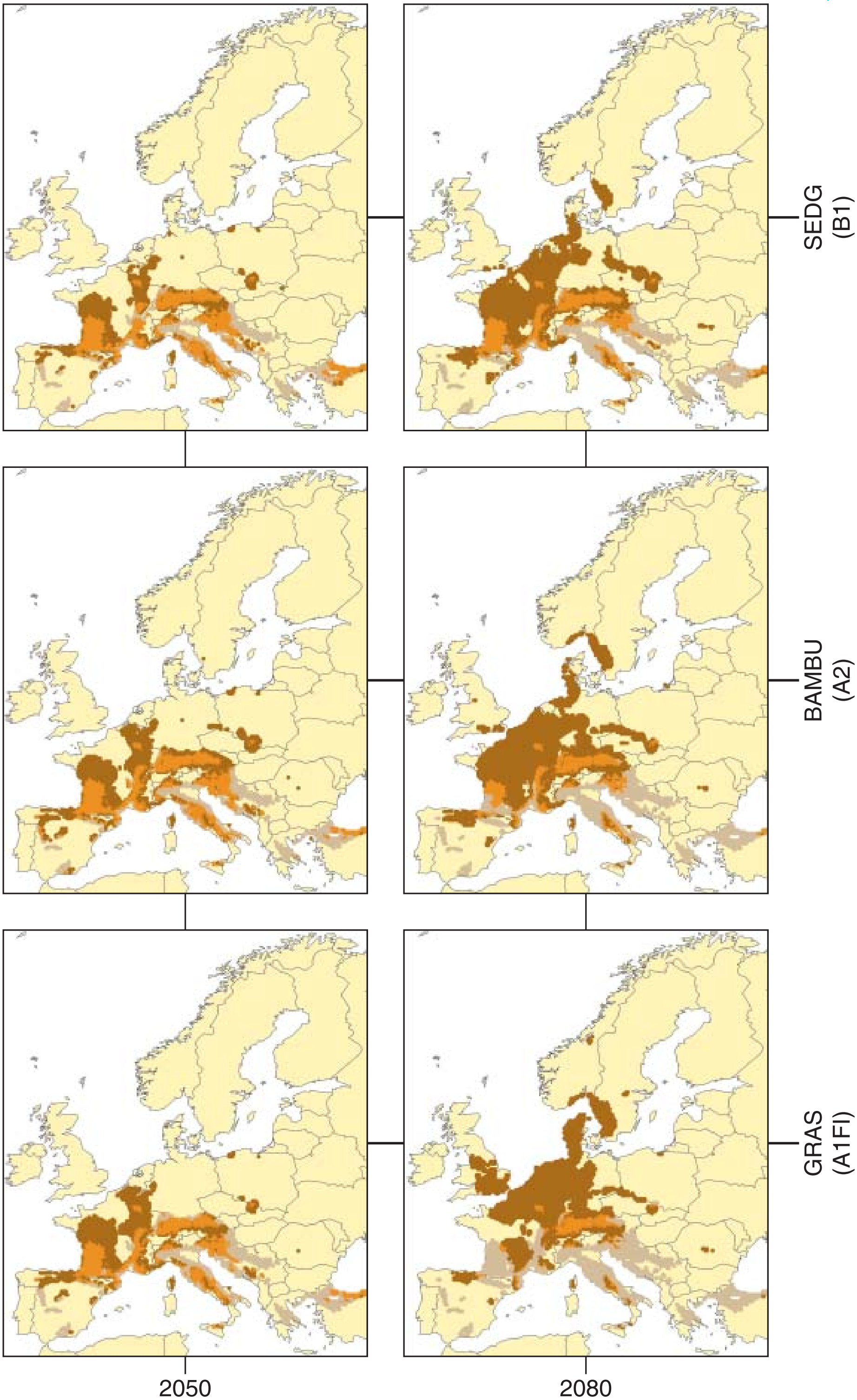
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.77).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG (B1)
BAMBU (A2)
GRAS (A1FI)
2050
2080

Celastrina argiolus (Linnaeus, 1758) – Holly Blue

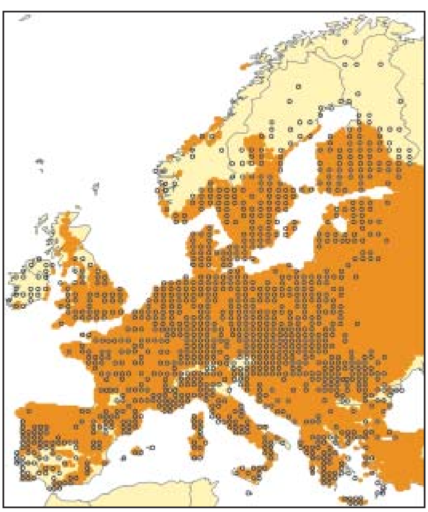
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	**SEDG**	-1703 (-8.34%)	-3387 (-16.59%)
	BAMBU	-2646 (-12.96%)	-3670 (-17.97%)
	GRAS	-2795 (-13.69%)	-4341 (-21.26%)
2080	**SEDG**	-2427 (-11.88%)	-4943 (-24.2%)
	BAMBU	-5101 (-24.98%)	-7524 (-36.84%)
	GRAS	-6682 (-32.72%)	-10036 (-49.14%)

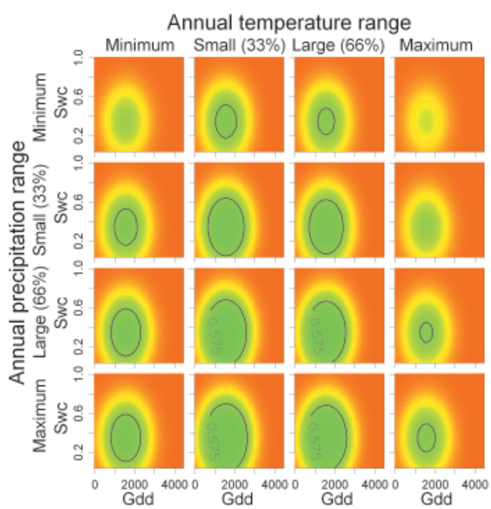
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 20422)

The Holly Blue is widespread, although the populations are always small. This small butterfly is very often seen in parks and gardens, as well as at woodland edges, and in bushy places. The eggs are laid on the calyx or stem of the flowerbuds or on the ripe fruits of various sorts of plants, including Holly (*Ilex aquifolium*), Ivy (*Hedera helix*), Spindle-tree (*Euonymus europaeus*), Alder Buckthorn (*Frangula alnus*), brambles (*Rubus* spp.) and heathers (*Calluna vulgaris* and *Erica* spp.). At first, the caterpillars feed on the buds and fruits of the foodplant, only later eating leaves. They are attended by ants of different genera. The Holly Blue has two broods a year, and hibernates in the pupal stage.

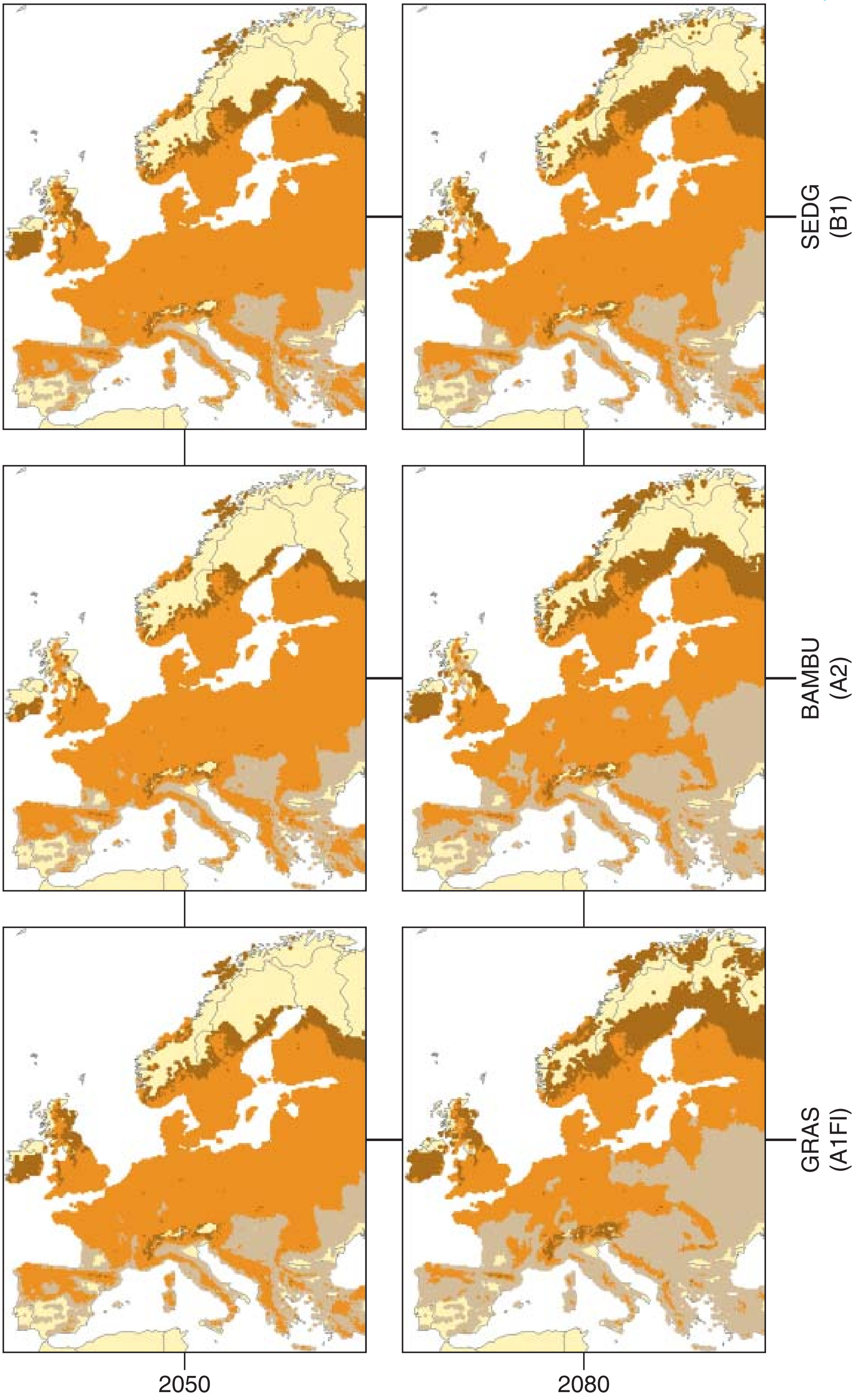
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.66). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Scolitantides baton (Bergsträsser, 1779) – Baton Blue

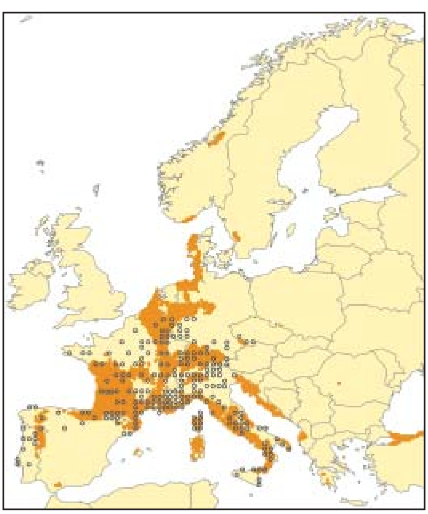
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-226 (-8.55%)	-1037 (-39.24%)
	BAMBU	15 (0.57%)	-964 (-36.47%)
	GRAS	-401 (-15.17%)	-1295 (-49%)
2080	SEDG	-81 (-3.06%)	-1179 (-44.61%)
	BAMBU	-88 (-3.33%)	-1433 (-54.22%)
	GRAS	-847 (-32.05%)	-2209 (-83.58%)

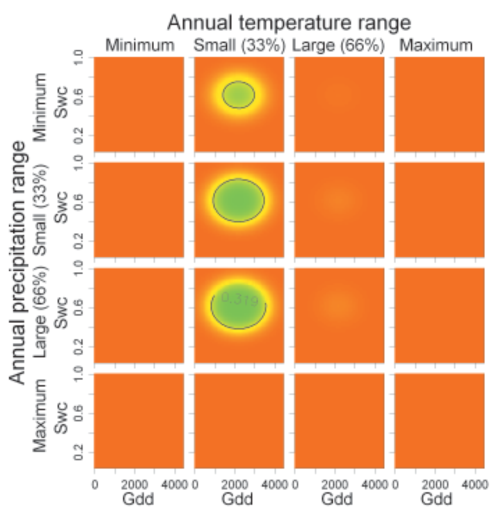
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2643)

The Baton Blue can be found on dry, grassy, and flower-rich vegetation, especially on warm patches. The butterflies are often seen on flowers, drinking nectar. The females lay their eggs on the flowers and leaf stalks of various species of thyme (*Thymus* spp.), savory (*Satureja* spp.), lavender (*Lavandula* spp.), and mint (*Mentha* spp.). The caterpillars feed on the flowers and developing seeds of the foodplant. They are attended by ants (e.g. *Myrmica scabrinodis* and *Lasius alienus*). The Baton Blue passes the winter as a caterpillar or a pupa, and has two generations a year.

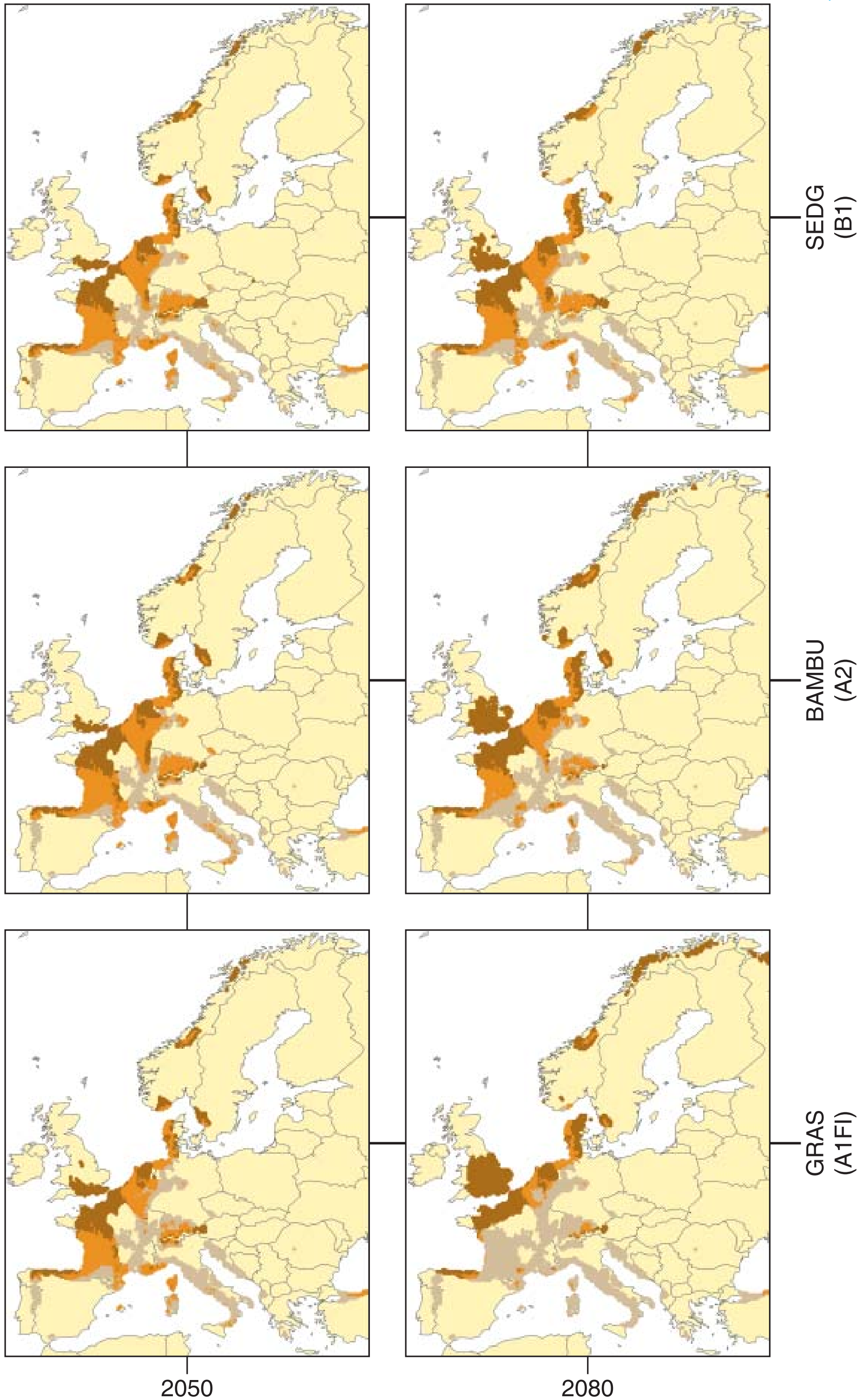
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.83). Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Scolitantides vicrama (Moore, 1865)

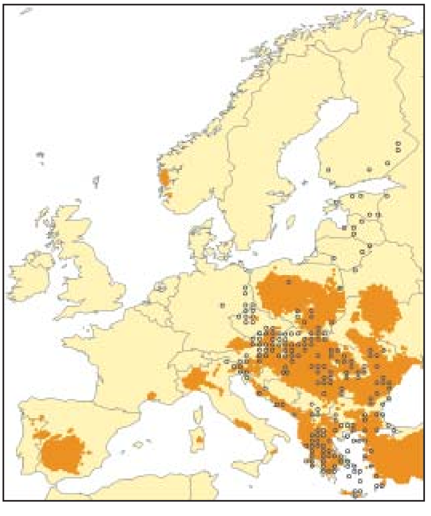
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	2985 (55.35%)	-353 (-6.55%)
	BAMBU	383 (7.1%)	-1599 (-29.65%)
	GRAS	1968 (36.49%)	-962 (-17.84%)
2080	SEDG	2198 (40.76%)	-1457 (-27.02%)
	BAMBU	309 (5.73%)	-2974 (-55.15%)
	GRAS	2622 (48.62%)	-3135 (-58.13%)

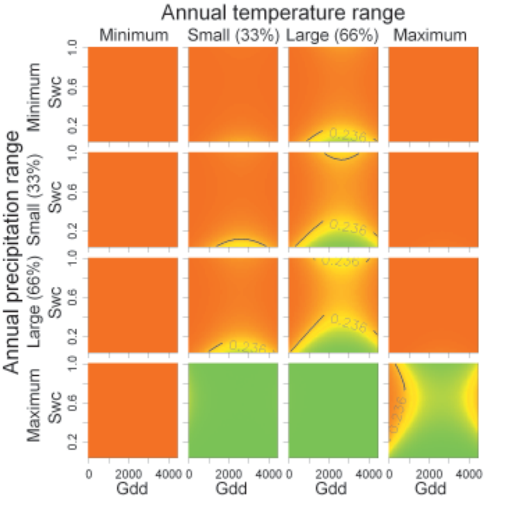
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 5393)

This blue is found on dry grassland on sandy or stony soils, south-facing slopes with grassy vegetation, on steep slopes, in rocky gullies, on railway embankments, on road verges and in scrub. Various sorts of thyme (*Thymus* spp.) and savory (*Satureja* spp.) are used as foodplant, the eggs being mostly laid on the flowerheads. The caterpillars feed on the flowers and ripening seeds, and are often found with ants (e.g. *Myrmica sabuleti*). This butterfly species is double-brooded.

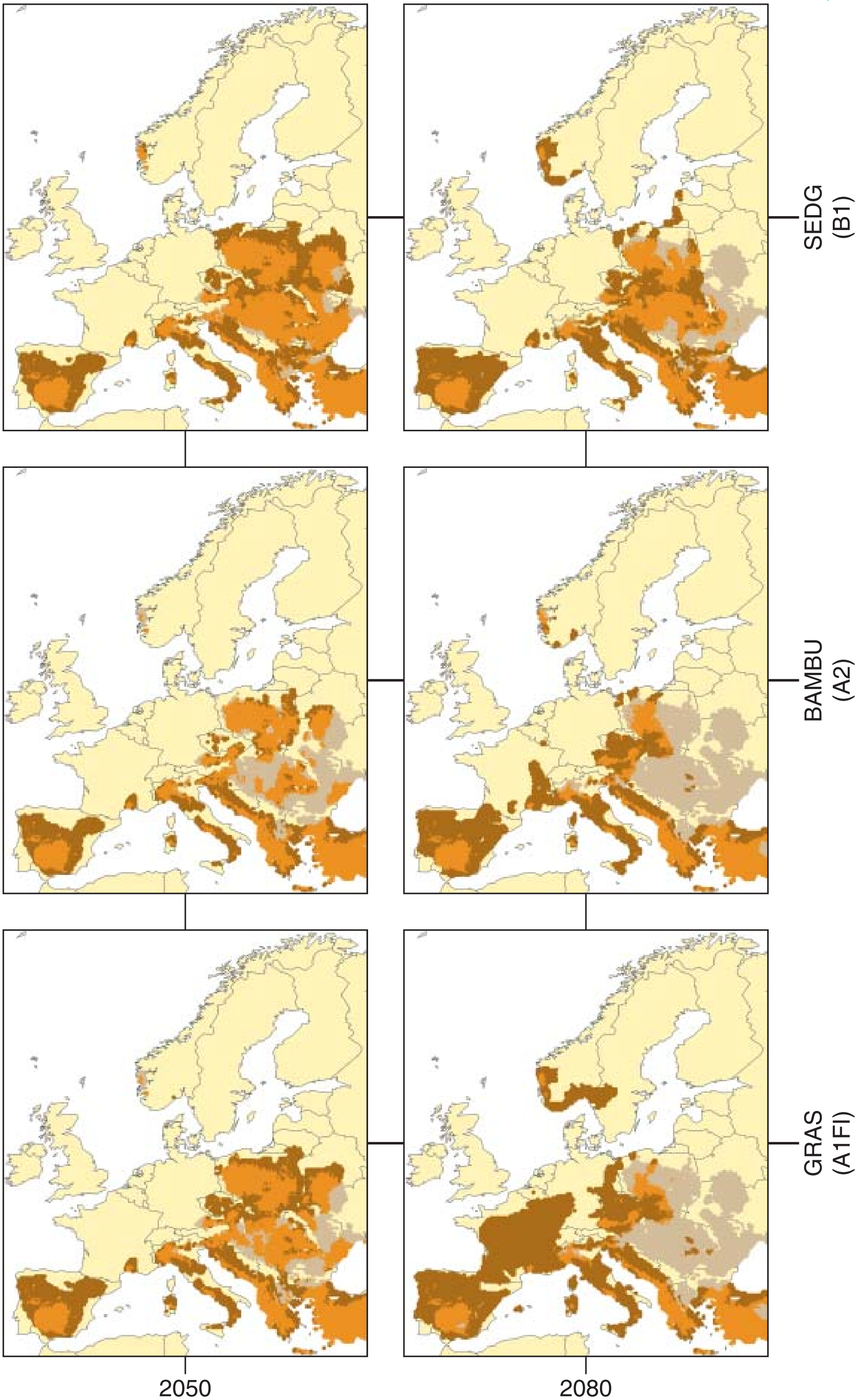
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.85).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Scolitantides abencerragus (Pierret, 1837) – False Baton Blue

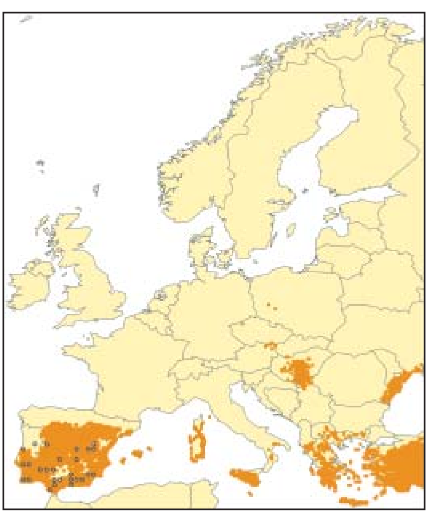
© Bernard Fransen

		Full dispersal	No dispersal
2050	SEDG	-567 (-21.16%)	-1068 (-39.87%)
	BAMBU	-1287 (-48.04%)	-1366 (-50.99%)
	GRAS	-1074 (-40.09%)	-1454 (-54.27%)
2080	SEDG	-1568 (-58.53%)	-1822 (-68.01%)
	BAMBU	-2301 (-85.89%)	-2392 (-89.29%)
	GRAS	-2531 (-94.48%)	-2614 (-97.57%)

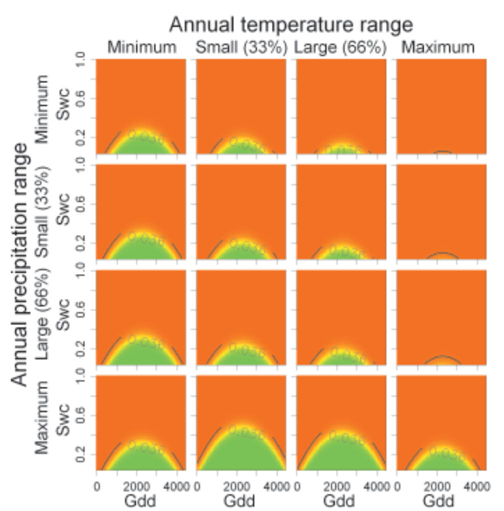
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2679)

The False Baton Blue is restricted to the Iberian Peninsula and is found in stony areas with flower-rich vegetation and scrub. Different plants are given in the literature, such as Thyme (*Thymus vulgaris*), Green Heather (*Erica scoparia*), and the labiate annual *Cleonia lusitanica*. It is on the leaves of *Cleonia lusitanica* that the female lays her eggs, although the caterpillars feed on the flowers. The False Baton Blue hibernates as a caterpillar, and is single-brooded in Europe.

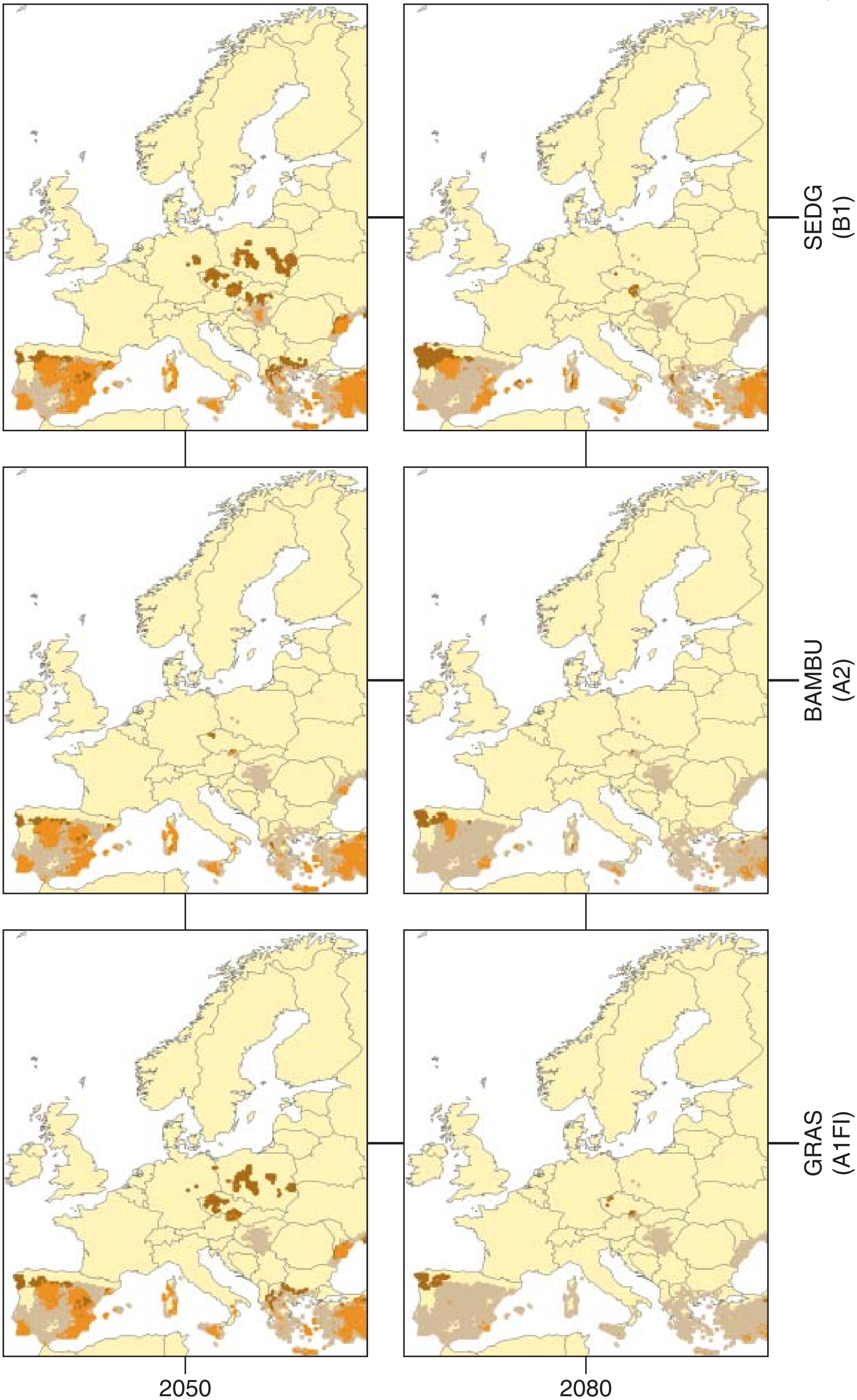
Present distribution can be well explained by climatic variables (AUC = 0.94).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Scolitantides bavius (Eversmann, 1832) – Bavius Blue

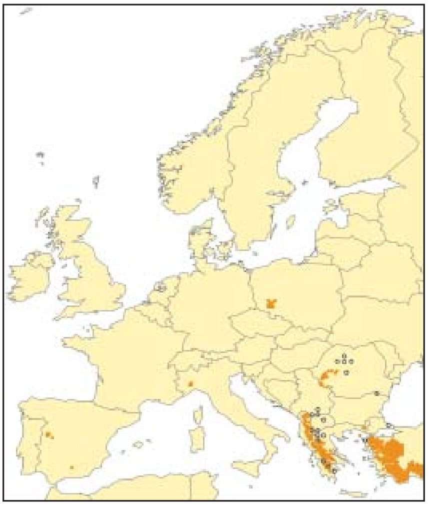
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	**SEDG**	142 (33.18%)	-170 (-39.72%)
	BAMBU	36 (8.41%)	-182 (-42.52%)
	GRAS	74 (17.29%)	-210 (-49.07%)
2080	**SEDG**	307 (71.73%)	-230 (-53.74%)
	BAMBU	-124 (-28.97%)	-331 (-77.34%)
	GRAS	-70 (-16.36%)	-406 (-94.86%)

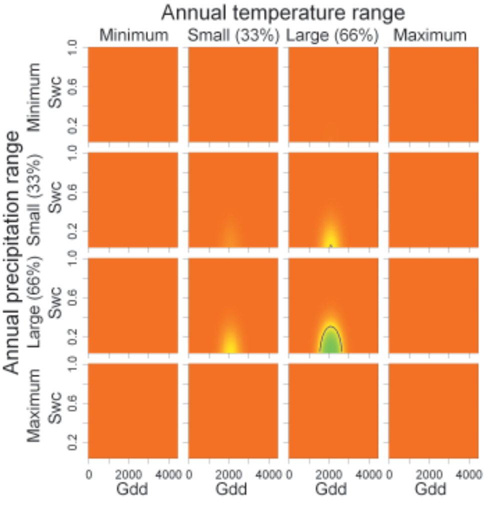
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 428)

The Bavius Blue occurs often on flower-rich, dry grassland, on dry, stony slopes, and on open patches in shrub and in vineyards on calcareous soil. Various species of *Salvia* are used as foodplant, including Sage (*S. officinalis*), *S. nutans*, *S. verbenaca*, and Whorled Clary (*S. verticillata*). The caterpillars feed mostly on the flowers, but sometimes also on the leaves. They are frequently found with ants. The Bavius Blue is single-brooded. The pupa overwinters.
This species is listed in Annexes II and IV of the Habitats’ Directive.

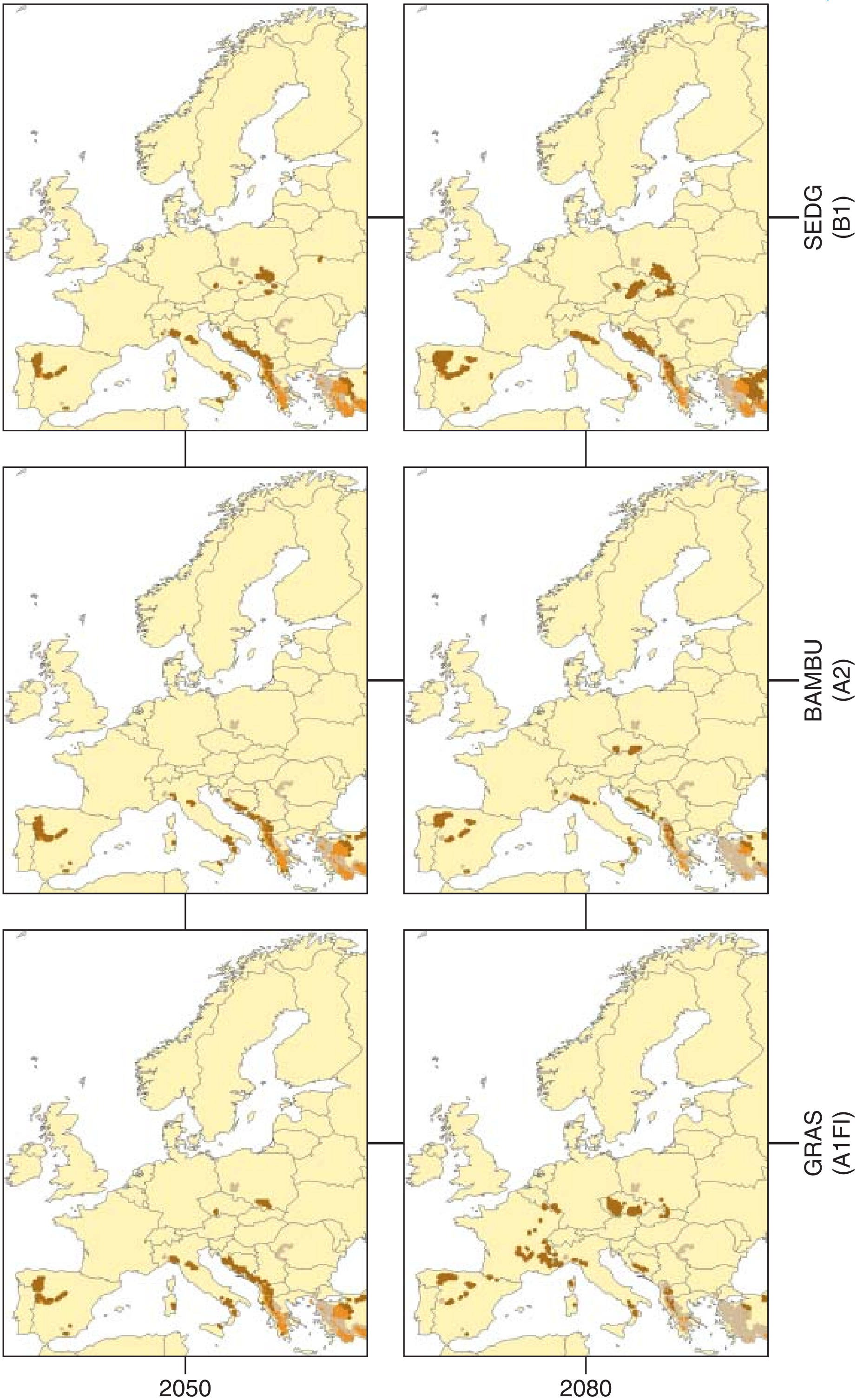
Present distribution can be well explained by climatic variables (AUC = 0.86).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Scolitantides orion (Pallas, 1771) – Chequered Blue

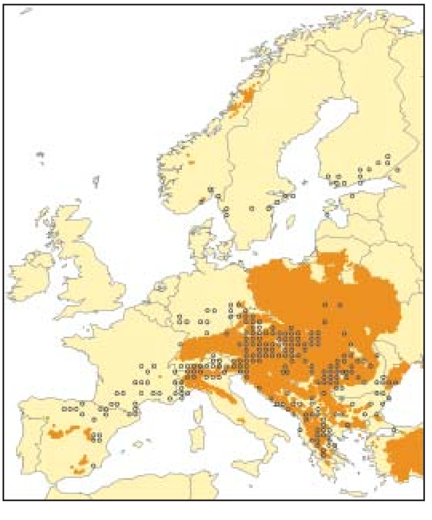
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-24 (-0.38%)	-1835 (-29.27%)
	BAMBU	-1291 (-20.59%)	-2663 (-42.47%)
	GRAS	-1532 (-24.43%)	-2699 (-43.05%)
2080	SEDG	-1446 (-23.06%)	-3844 (-61.31%)
	BAMBU	-2659 (-42.41%)	-4917 (-78.42%)
	GRAS	-2649 (-42.25%)	-5527 (-88.15%)

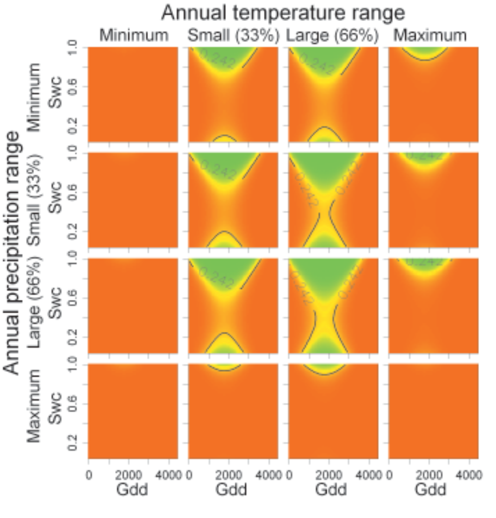
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 6270)

The Chequered Blue, a small but conspicuous butterfly, can be seen on warm, and rocky slopes and narrow ledges, where there is little vegetation, apart from its foodplants White Stonecrop (*Sedum album*) and Orpine (*Sedum telephium*). The females lay their eggs on the leaves of the foodplant near the stem. The caterpillars are often found with different ants. The pupa overwinters, and is often hidden under stones or in small hollows in the ground near the foodplant. The Chequered Blue produces one or two generations a year, depending on its geographical position.

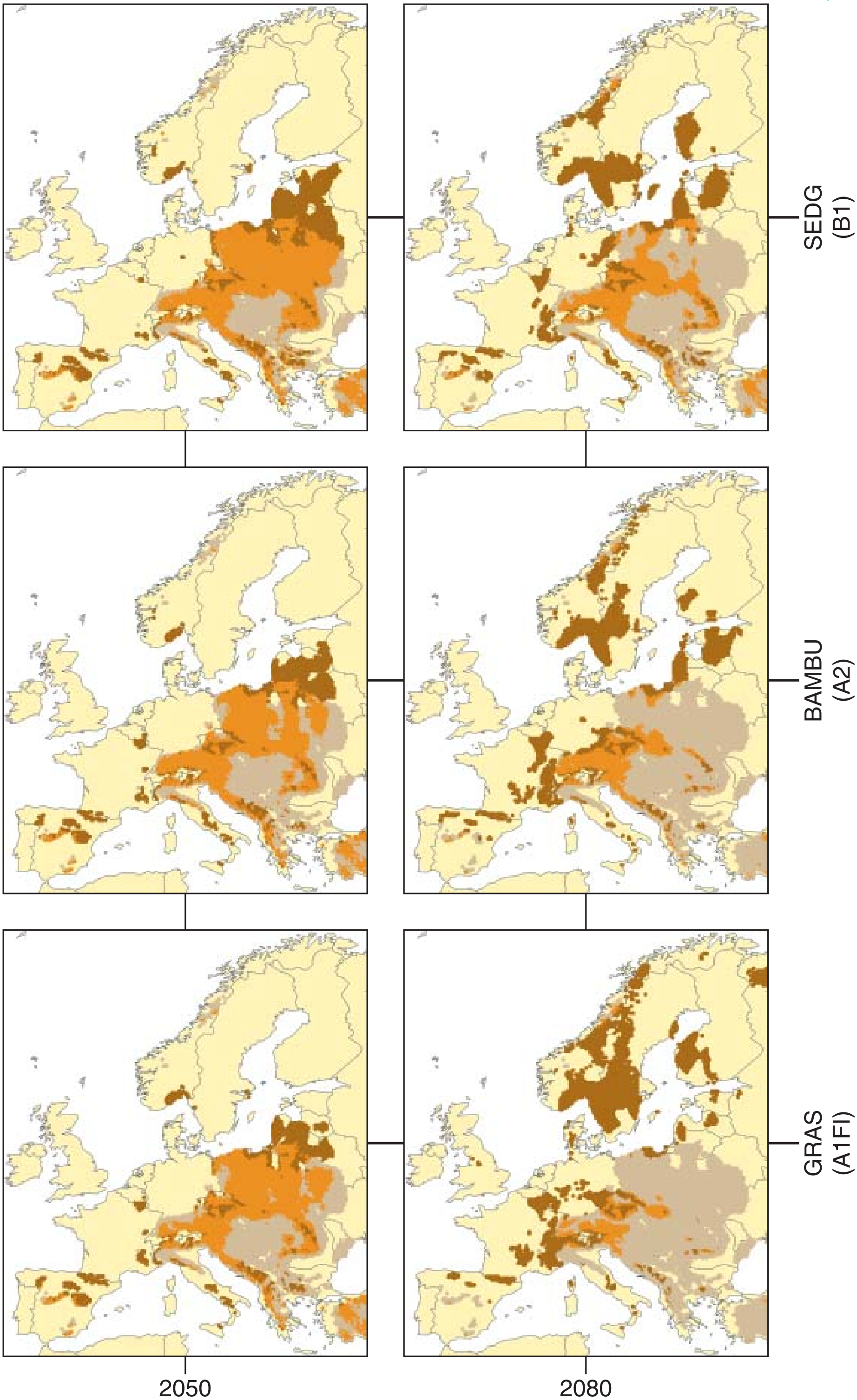
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.78).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Scolitantides panoptes (Hübner, 1813) – Panoptes Blue

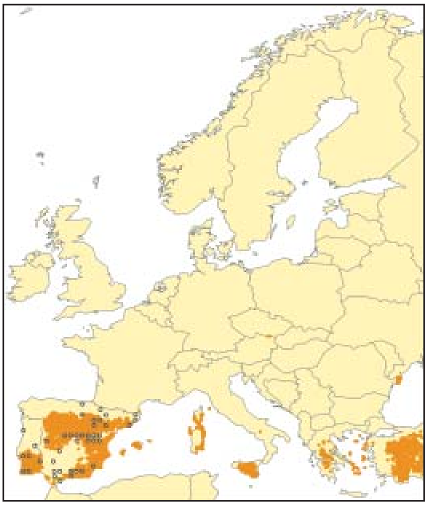
© Bernard Fransen

		Full dispersal	No dispersal
2050	SEDG	-867 (-58.07%)	-971 (-65.04%)
	BAMBU	-1124 (-75.28%)	-1130 (-75.69%)
	GRAS	-1146 (-76.76%)	-1207 (-80.84%)
2080	SEDG	-1324 (-88.68%)	-1344 (-90.02%)
	BAMBU	-1493 (-100%)	-1493 (-100%)
	GRAS	-1493 (-100%)	-1493 (-100%)

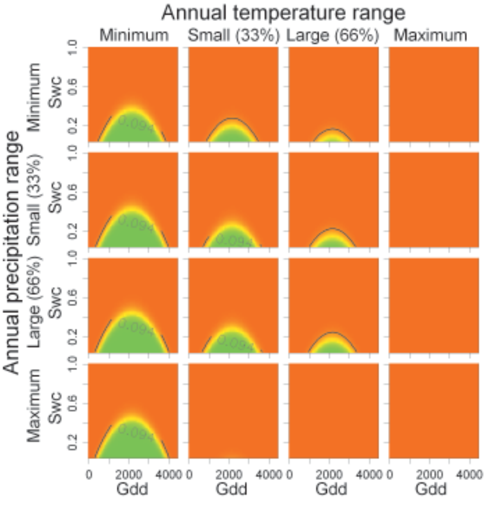
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1493)

At present the species is widespread in the Iberian Peninsula. It lives on dry grasslands between 200 and 1900m elevation. The caterpillars are visited by ants of the genus *Camponotus*. The species has two generations and one can find adults on the wing from March until August. Larval foodplants are *Thymus* and *Saturja* species. The taxonomic status (whether subspecies of *S. baton* or a separate species) is under discussion.

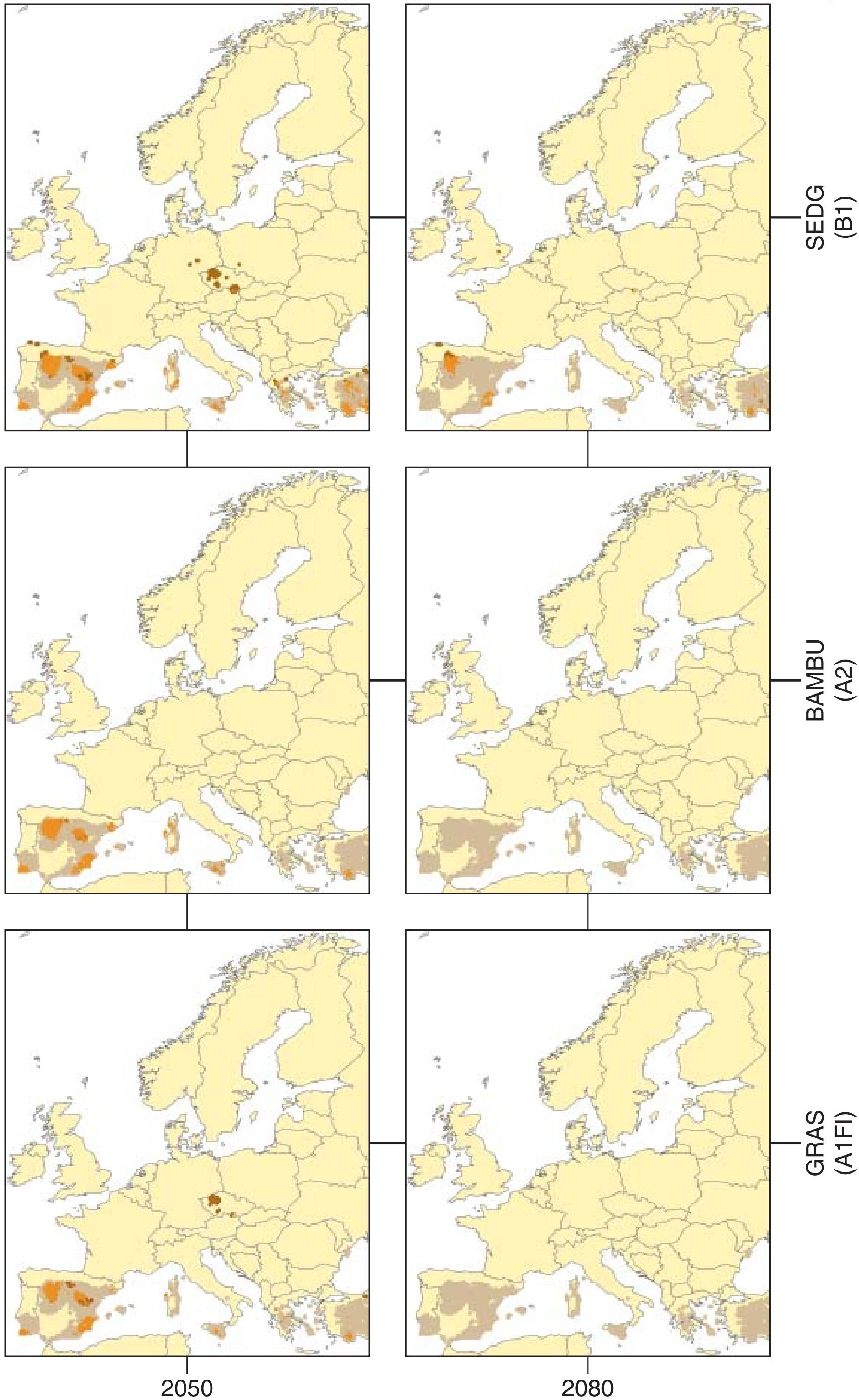
Present distribution can be well explained by climatic variables (AUC = 0.87).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Glaucopsyche alexis (Poda, 1761) – Green-underside Blue

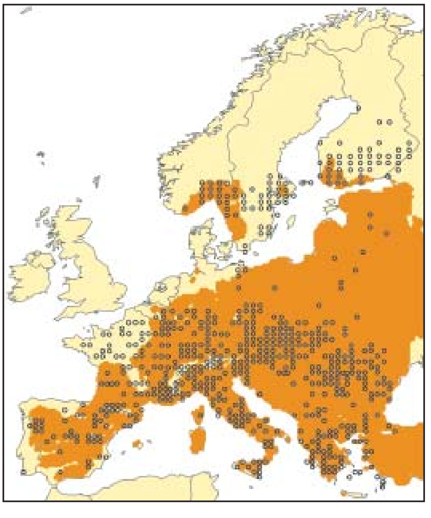
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	2477 (15.8%)	-1128 (-7.2%)
	BAMBU	2034 (12.98%)	-1448 (-9.24%)
	GRAS	1267 (8.08%)	-2065 (-13.17%)
2080	SEDG	3155 (20.13%)	-2810 (-17.93%)
	BAMBU	1588 (10.13%)	-5095 (-32.5%)
	GRAS	1591 (10.15%)	-6785 (-43.28%)

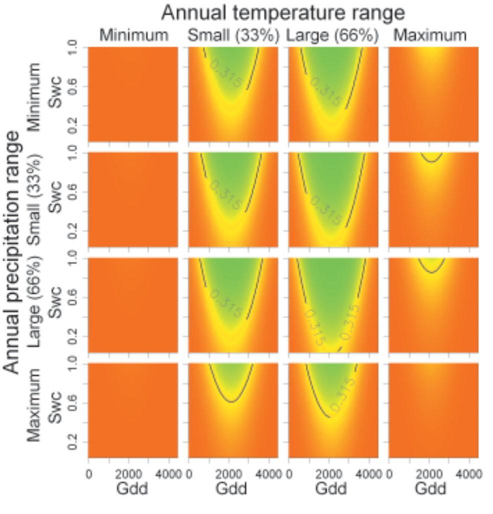
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 15676)

The Green-underside Blue is a pretty sight on both dry and damp flower-rich grassy vegetation, such as meadows and woodland clearings. The females lay their eggs between the flowers of different leguminous plants, including Sainfoin (*Onobrychis viciifolia*), brooms (*Cytisus* spp.), vetches (*Vicia* spp.), Crown Vetch (*Coronilla varia*), *Genista* spp., and melilots (*Melilotus* spp.). The caterpillars feed on the leaves and are frequently attended by the workers of various ants. Hibernation takes place as a pupa. The Green-underside Blue is single-brooded.

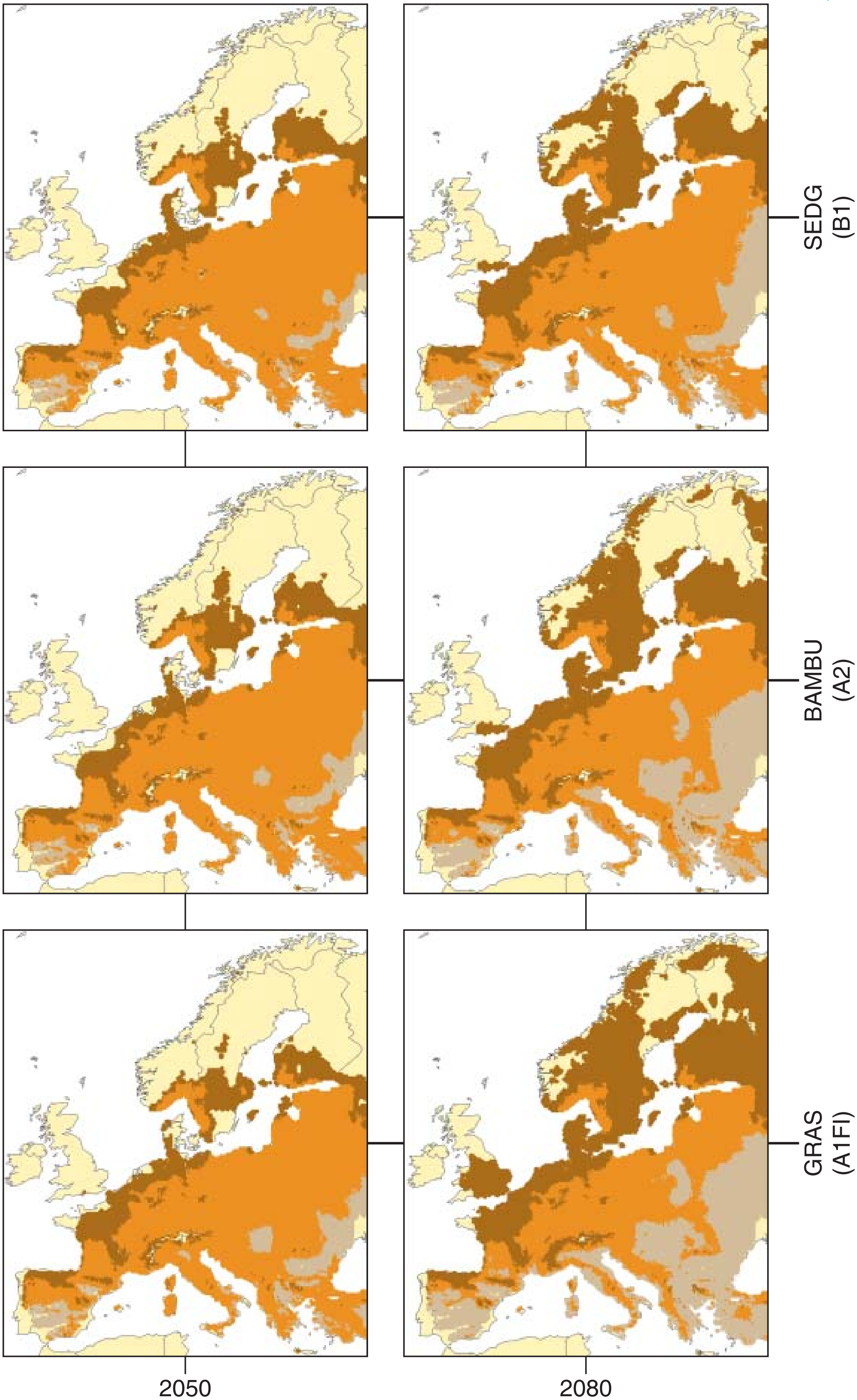
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.7). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Glaucopsyche melanops (Boisduval, 1828) – Black-eyed Blue

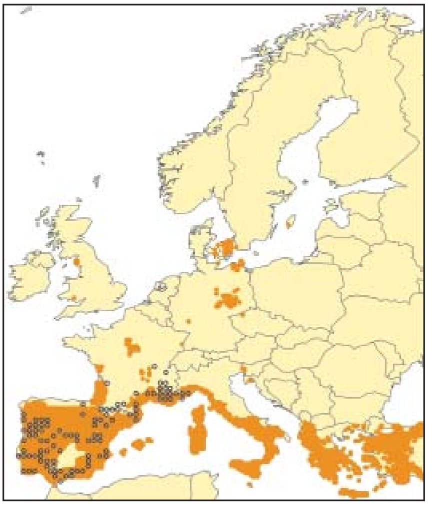
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-720 (-20.13%)	-2069 (-57.84%)
	BAMBU	-1708 (-47.75%)	-2238 (-62.57%)
	GRAS	-1333 (-37.27%)	-2464 (-68.88%)
2080	SEDG	-1767 (-49.4%)	-2884 (-80.63%)
	BAMBU	-2319 (-64.83%)	-3287 (-91.89%)
	GRAS	-2032 (-56.81%)	-3524 (-98.52%)

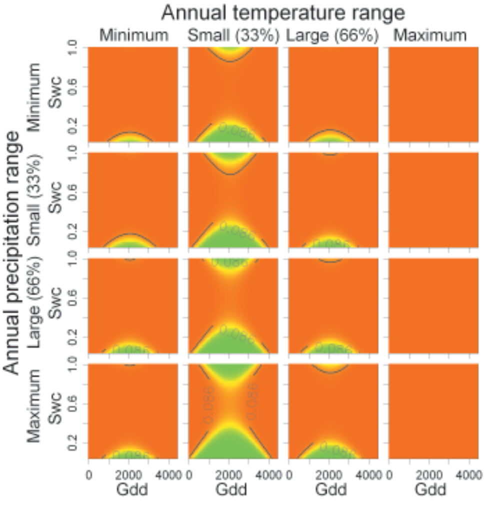
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 3577)

The Black-eyed Blue occurs in open shrub, or open woodland, especially where *Genista* or large bushes of broom (*Cytisus* spp.) are growing. Eggs are laid on the flowers of various leguminous plants, such as *Dorycnium* spp., Birdsfoot-trefoils (*Lotus* spp.), *Anthyllis* spp., brooms (*Cytisus* spp.) and *Genista* spp.. The caterpillars feed on the flowers and are attended by ants of the genus *Camponotus*. The Black-eyed Blue hibernates in the pupal stage. It usually has one generation a year.

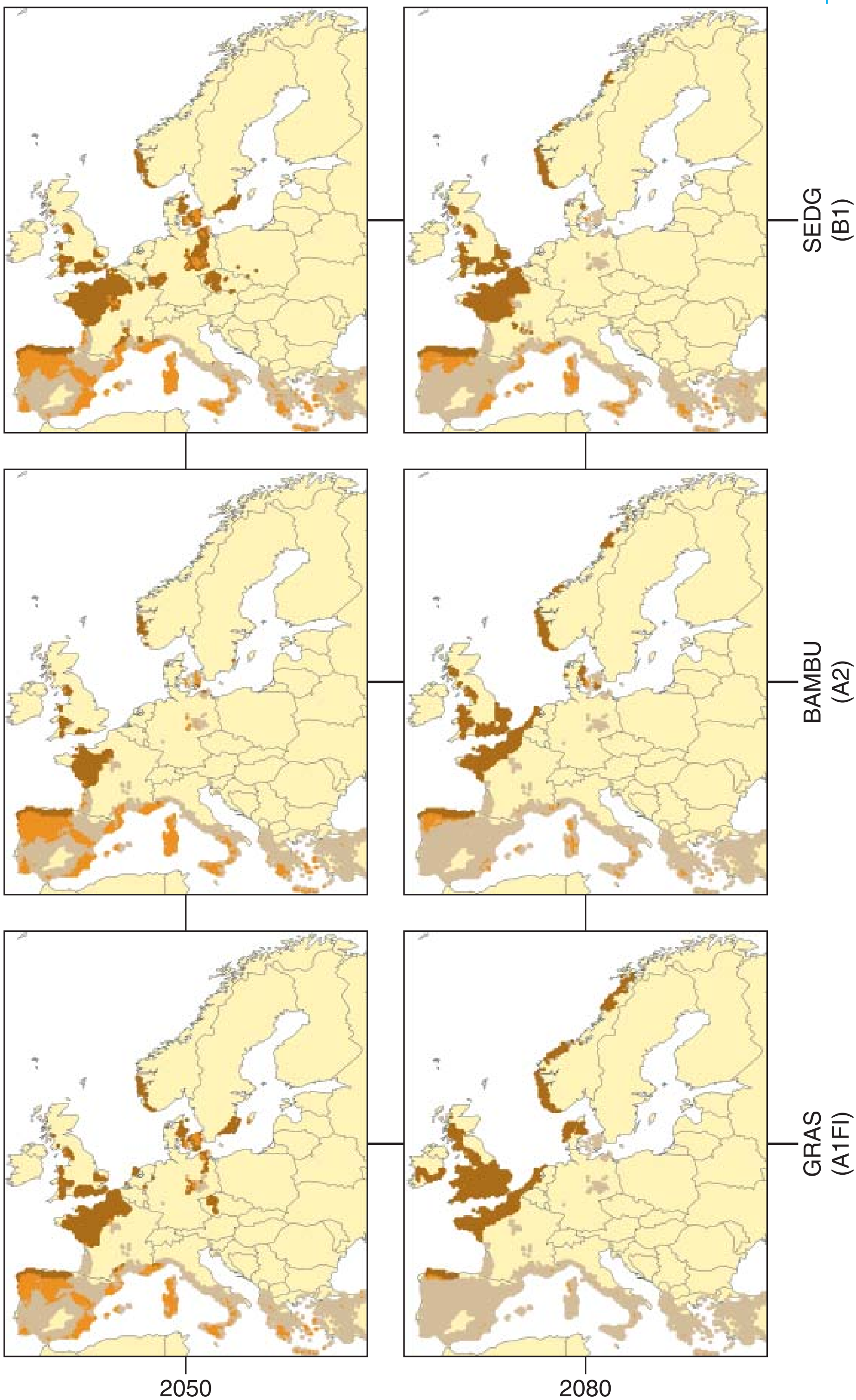
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.8).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Iolana iolas (Ochsenheimer, 1816) – Iolas Blue

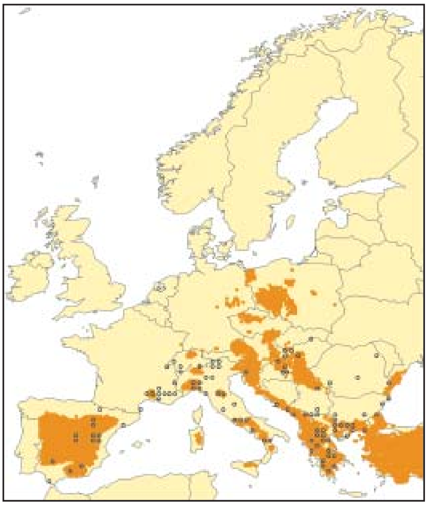
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	-102 (-3.08%)	-1371 (-41.46%)
	BAMBU	-1610 (-48.68%)	-1909 (-57.73%)
	GRAS	-974 (-29.45%)	-1849 (-55.91%)
2080	SEDG	-1564 (-47.29%)	-2149 (-64.98%)
	BAMBU	-2625 (-79.38%)	-2938 (-88.84%)
	GRAS	-2596 (-78.5%)	-3186 (-96.34%)

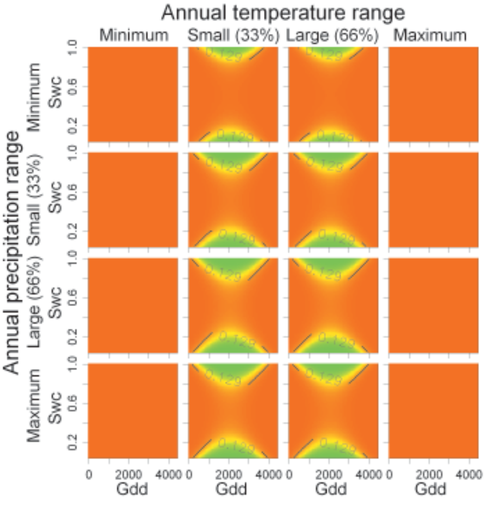
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 3307)

The Iolas Blue is Europe's largest blue. It occurs locally on calcareous soil, where shrubs of its foodplant Bladder Senna (*Colutea arborescens*) are growing. In Greece, *C. cilicica* is also used. This plant is practically the most important source of nectar for the butterflies. At times, the males can be seen some distance away from their habitat, but the females stay near the foodplants. They lay their eggs, usually several at a time, on the inside of the calyx and inside the bladder-like fruits. The caterpillars feed on the seeds and are visited frequently by ants (e.g. *Tapinoma erraticum* and *Camponotus cruentatus*). Usually, they can easily be seen by holding a pod up to the light. When fully-grown, the caterpillars pupate at the foot of the foodplant, passing the winter as a pupa. The Iolas Blue mostly has only one generation a year.

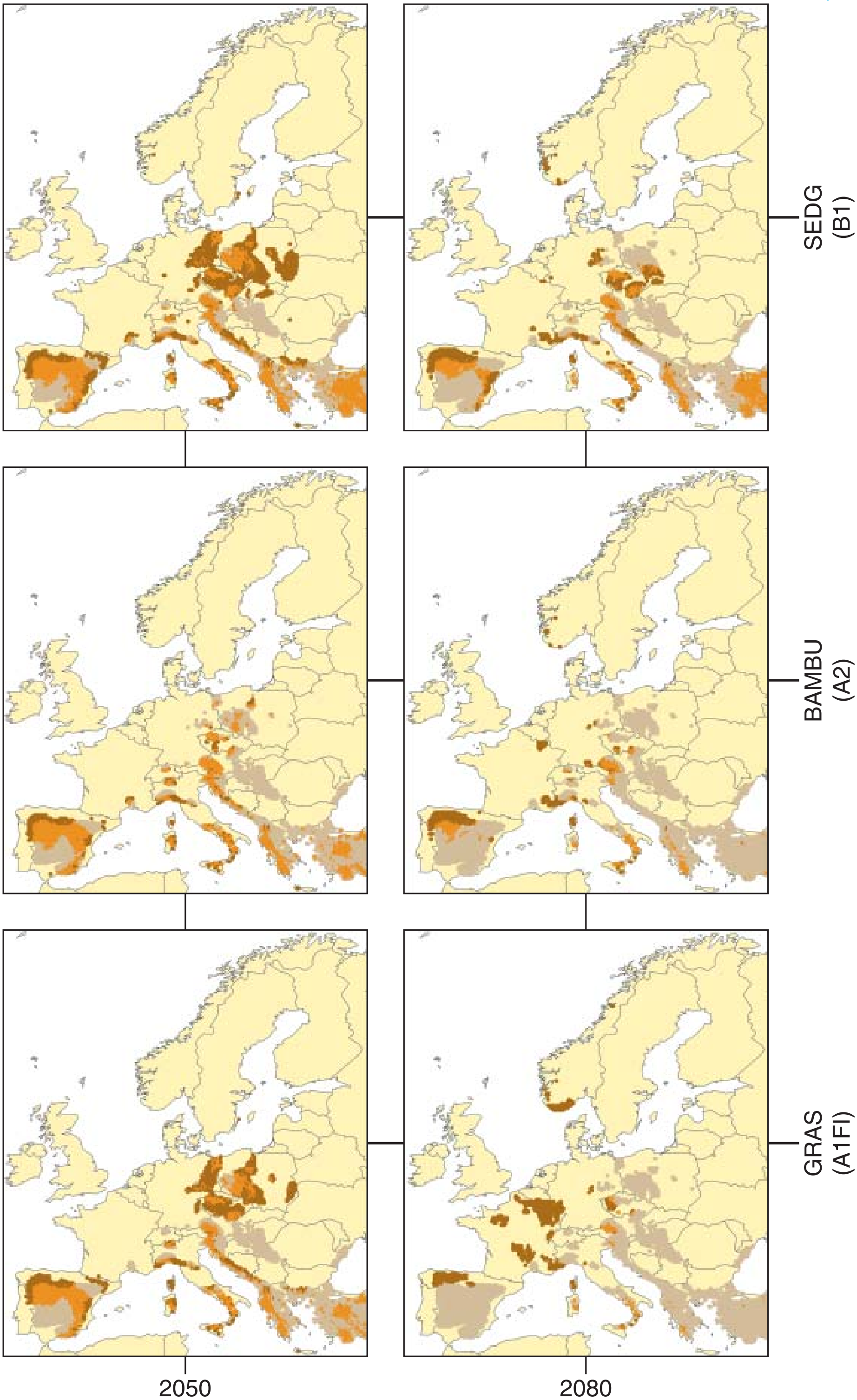
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.82). Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Phengaris arion (LINNAEUS, 1758) – Large Blue

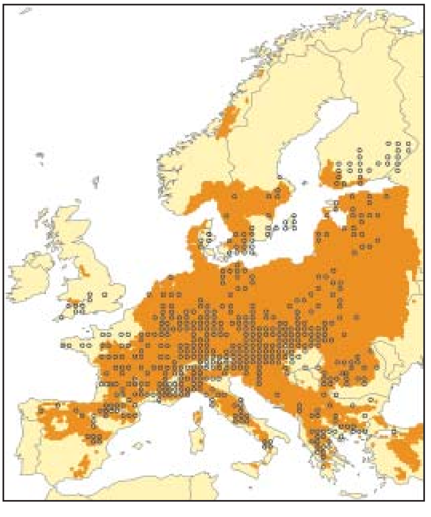
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-992 (-7.49%)	-3076 (-23.23%)
	BAMBU	-330 (-2.49%)	-2858 (-21.58%)
	GRAS	-2206 (-16.66%)	-4172 (-31.51%)
2080	SEDG	-1865 (-14.08%)	-5421 (-40.94%)
	BAMBU	-1732 (-13.08%)	-6599 (-49.83%)
	GRAS	-3006 (-22.7%)	-8692 (-65.64%)

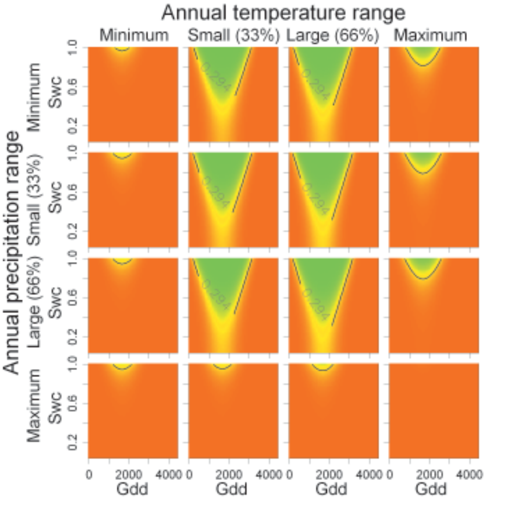
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 13242)

The Large Blue occurs locally on dry, open grasslands on limestone. It is one of the larger, more conspicuous blues. The females lay their eggs on Marjoram (*Origanum vulgare*) and different species of thyme (*Thymus* spp.). The caterpillars feed on the buds and flowers of the foodplant until they reach the last larval instar. They then leave their foodplant, and allow themselves to be taken by workers of *Myrmica sabuleti,* and sometimes of *M. scabrinodis,* to the ants’ nest. The caterpillars feed on the ant grubs, hibernating and pupating in ants’ nests as well.
This species is listed in Annex IV of the Habitats’ Directive.

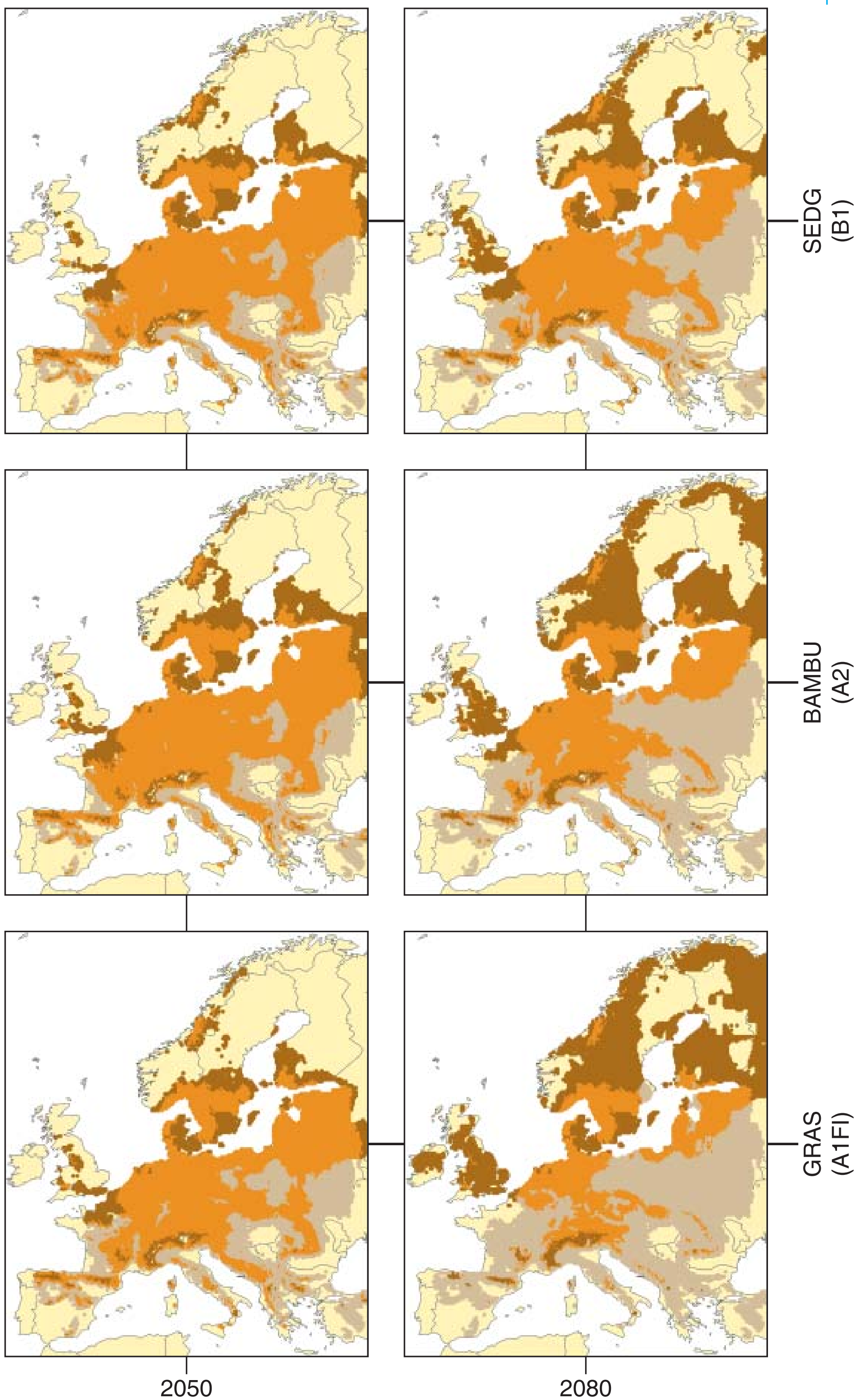
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.77).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Phengaris teleius (Bergsträsser, 1779) – Scarce Large Blue

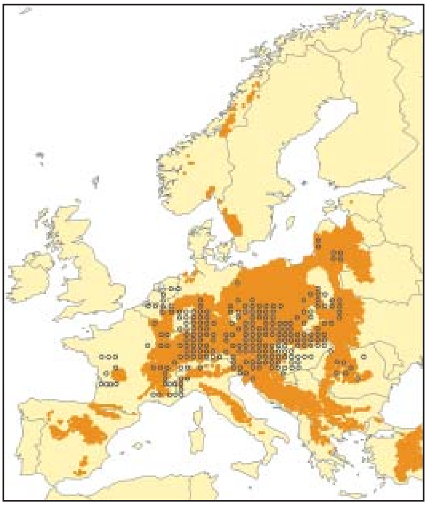
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-35 (-0.54%)	-2184 (-33.69%)
	BAMBU	-551 (-8.5%)	-2612 (-40.29%)
	GRAS	-1537 (-23.71%)	-3224 (-49.73%)
2080	SEDG	-1008 (-15.55%)	-3984 (-61.45%)
	BAMBU	-1587 (-24.48%)	-4723 (-72.85%)
	GRAS	-2476 (-38.19%)	-5731 (-88.4%)

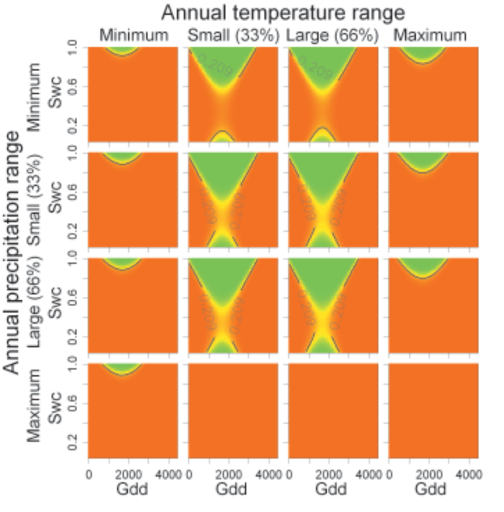
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 6483)

The Scarce Large Blue can be found in moderately nutrient-rich meadows where its foodplant Great Burnet (*Sanguisorba officinalis*) is growing. In northern Europe, it occurs in open, short vegetation, but in the warm, southern parts, it is also found in rough vegetation. The butterflies tend to keep near the foodplants. The small caterpillars only feed on the flowerheads for two or three weeks. They then go down to the ground where they wait to be picked up by worker ants of the genus *Myrmica* and carried off to the ants' nest. There they feed on ant grubs. The caterpillars also hibernate and pupate in the ants' nest. The species of host ant varies in different parts of its range. The Scarce Large Blue is single-brooded.
This species is listed in Annexes II and IV of the Habitats' Directive.

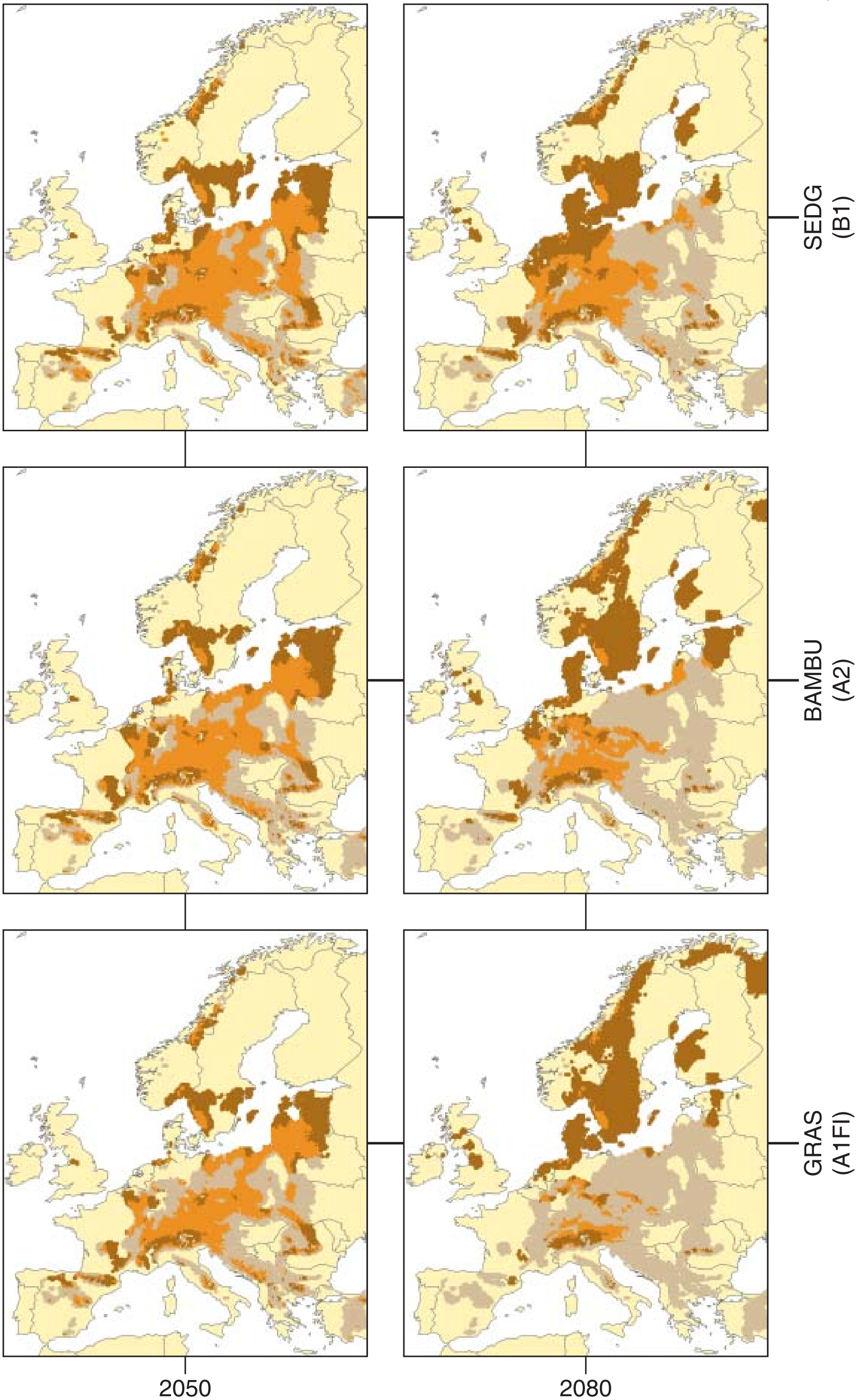
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.84).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Phengaris nausithous (Bergsträsser, 1779) – Dusky Large Blue

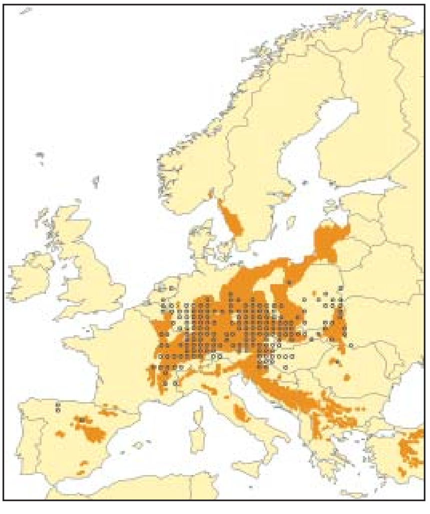
© Josef Settele

		Full dispersal	No dispersal
2050	SEDG	-830 (-22.93%)	-1999 (-55.24%)
	BAMBU	-699 (-19.31%)	-1960 (-54.16%)
	GRAS	-1451 (-40.09%)	-2501 (-69.11%)
2080	SEDG	-789 (-21.8%)	-2643 (-73.03%)
	BAMBU	-1716 (-47.42%)	-3061 (-84.58%)
	GRAS	-2334 (-64.49%)	-3460 (-95.61%)

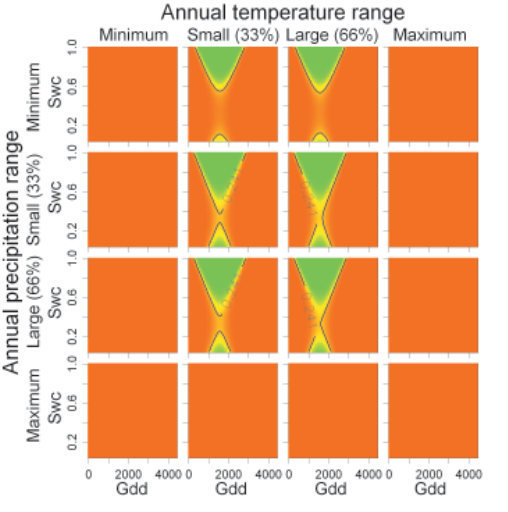
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 3619)

The Dusky Large Blue occurs on damp, moderately nutrient-rich grassland and rough vegetation. The butterflies are usually found on or near the foodplant Great Burnet (*Sanguisorba officinalis*). Having lived on the flowerheads of this plant for a few weeks, the small caterpillars go down to the ground, in order to be carried away by workers of the ant *Myrmica rubra* to an ant nest. There, they remain feeding on ant grubs, hibernating and pupating in the early summer. The newly-emerged butterflies leave the nest. The Dusky Large Blue is one of the most specialized of the “ant blues” being most adapted to one species of host ant. It is single-brooded.
This species is listed in Annexes II and IV of the Habitats’ Directive.

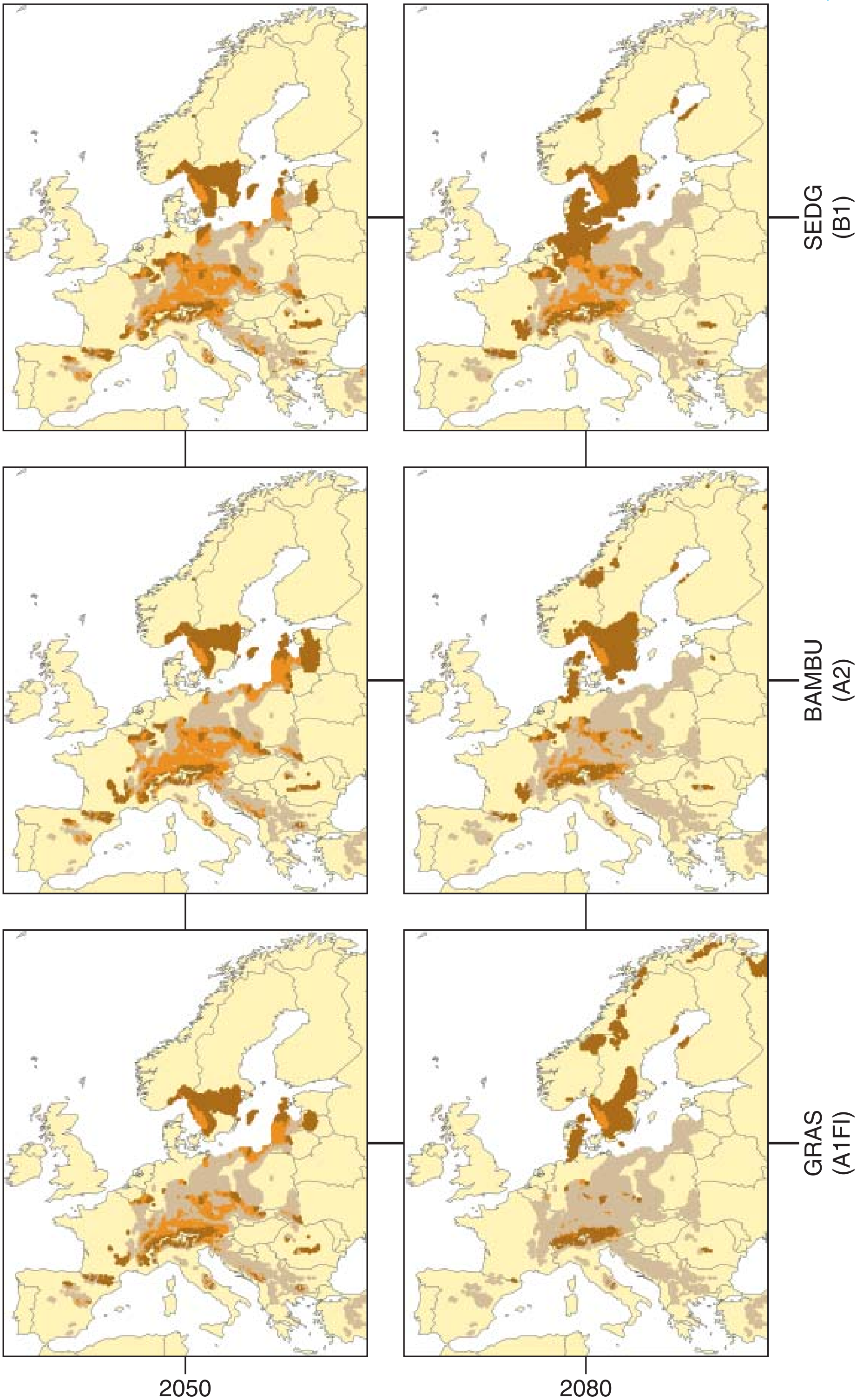
Present distribution can be well explained by climatic variables (AUC = 0.91).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Phengaris alcon ([Schiffermüller], 1775) – Alcon Blue

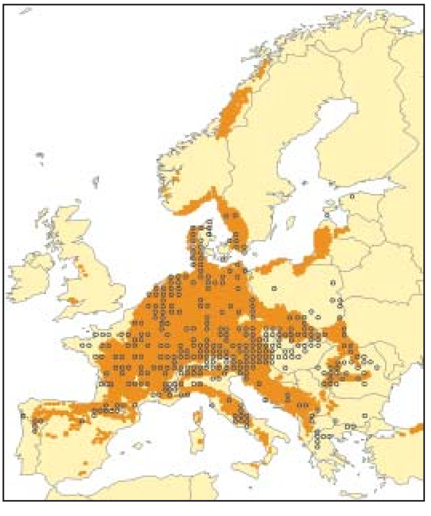
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-800 (-12.04%)	-2001 (-30.12%)
	BAMBU	375 (5.65%)	-1448 (-21.8%)
	GRAS	-1388 (-20.89%)	-2689 (-40.48%)
2080	SEDG	-741 (-11.15%)	-2794 (-42.06%)
	BAMBU	-1062 (-15.99%)	-3525 (-53.06%)
	GRAS	-2097 (-31.57%)	-4883 (-73.51%)

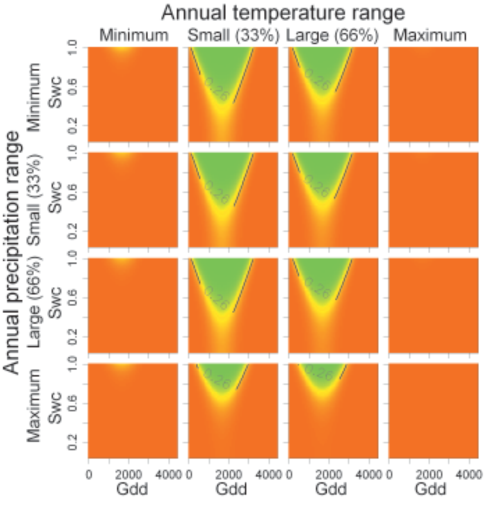
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 6643)

The Alcon Blue occurs in local, scattered populations. Oftentimes it is referred to as two distinct species: *P. alcon* on low-lying wet heathland, on moist fen meadows and bogs, and *P. rebeli* on dry as well as sub-alpine calcareous grasslands. Usually, only a few butterflies are seen. The bright, white eggs are easy to find. Depending on the habitat, they are laid on the flowers and sepals of Marsh Gentian (*Gentiana pneumonanthe*), Willow Gentian (*G. asclepiadea*), and Cross Gentian (*G. cruciata*). At first, the small caterpillars feed on the ovaries of the foodplant, but they pass the last instar in the nests of various *Myrmica* ants, which they parasitize by living like young cuckoos, being fed by the worker ants. They hibernate and pupate in the ant nests. The Alcon Blue has one generation a year.

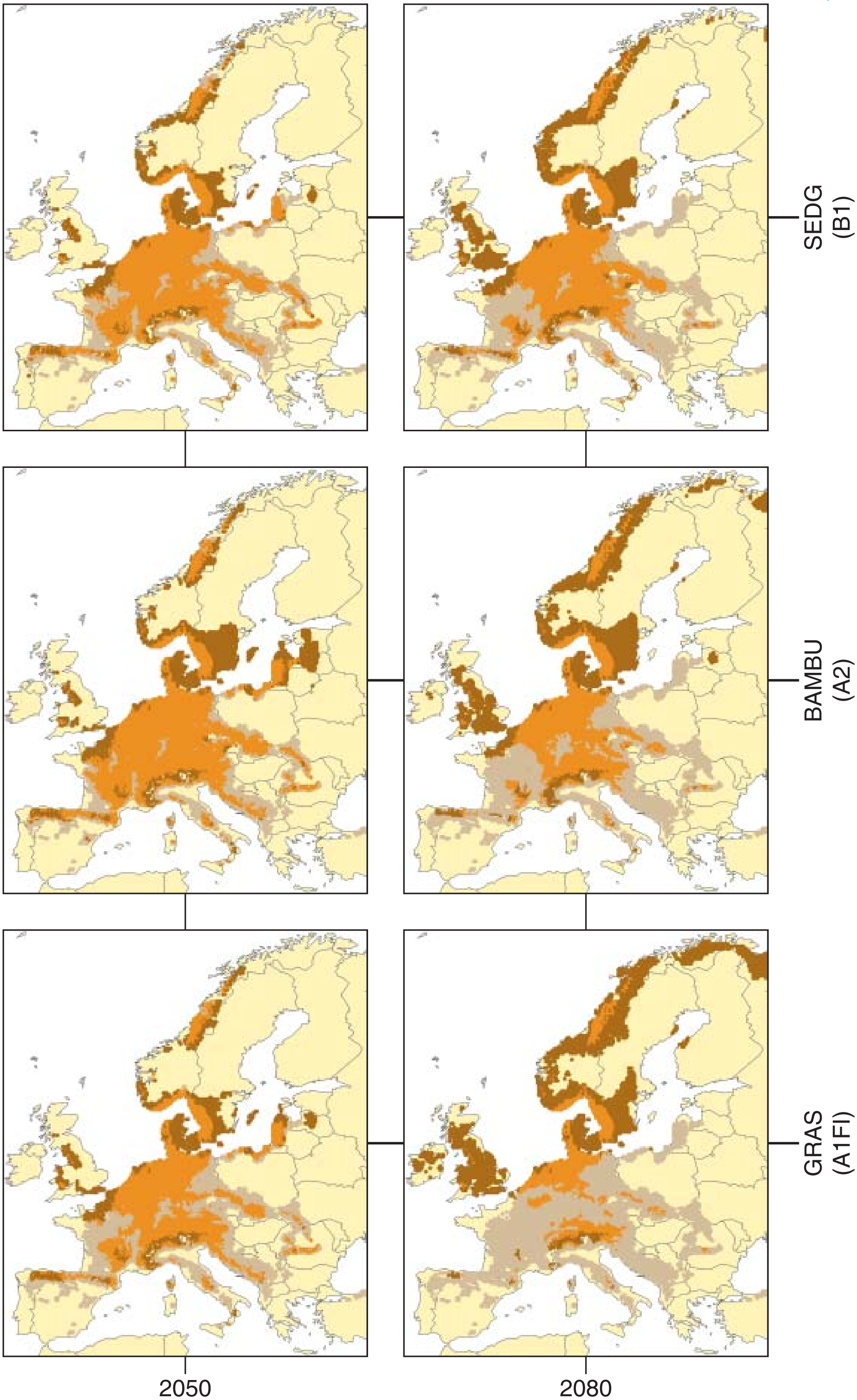
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.83).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Plebejus argus (LINNAEUS, 1758) – Silver-studded Blue

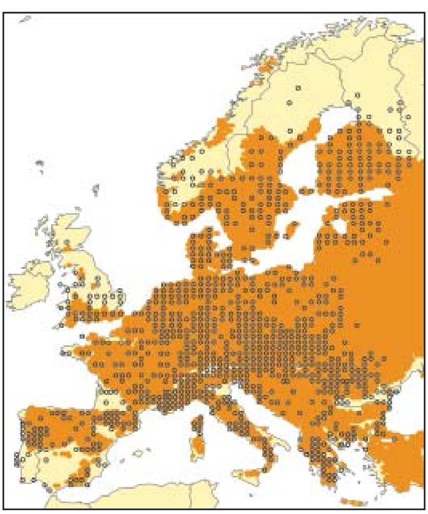
© Martin Wiemers

		Full dispersal	No dispersal
2050	SEDG	-889 (-4.65%)	-3151 (-16.49%)
	BAMBU	-1803 (-9.44%)	-3361 (-17.59%)
	GRAS	-2138 (-11.19%)	-4148 (-21.71%)
2080	SEDG	-865 (-4.53%)	-5024 (-26.29%)
	BAMBU	-3038 (-15.9%)	-7385 (-38.65%)
	GRAS	-4123 (-21.58%)	-9598 (-50.23%)

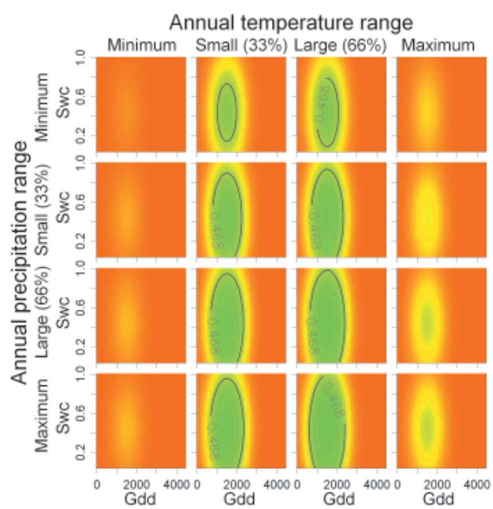
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 19107)

The Silver-studded Blue can be found in warm places on short vegetation, ranging from dry to quite damp, such as heath and poor grassland. Especially impressive are the roosting places with enormous groups, sometimes of hundreds of butterflies, asleep in a very small area. The eggs are laid on Cross-leaved Heath (*Erica tetralix*), and on a wide range of leguminous plants. Usually, the eggs are deposited low down on the foodplant or on its woody parts. The egg hibernates. The caterpillars live on the leaves of the foodplants. They are often tended by ants of the genus *Lasius*. Pupation often takes place in the outer passages of the ant nests. The ants also give the pupa a lot of attention. Depending on the geographical position and altitude of occurrence, the Silver-studded Blue has one or two generations a year.

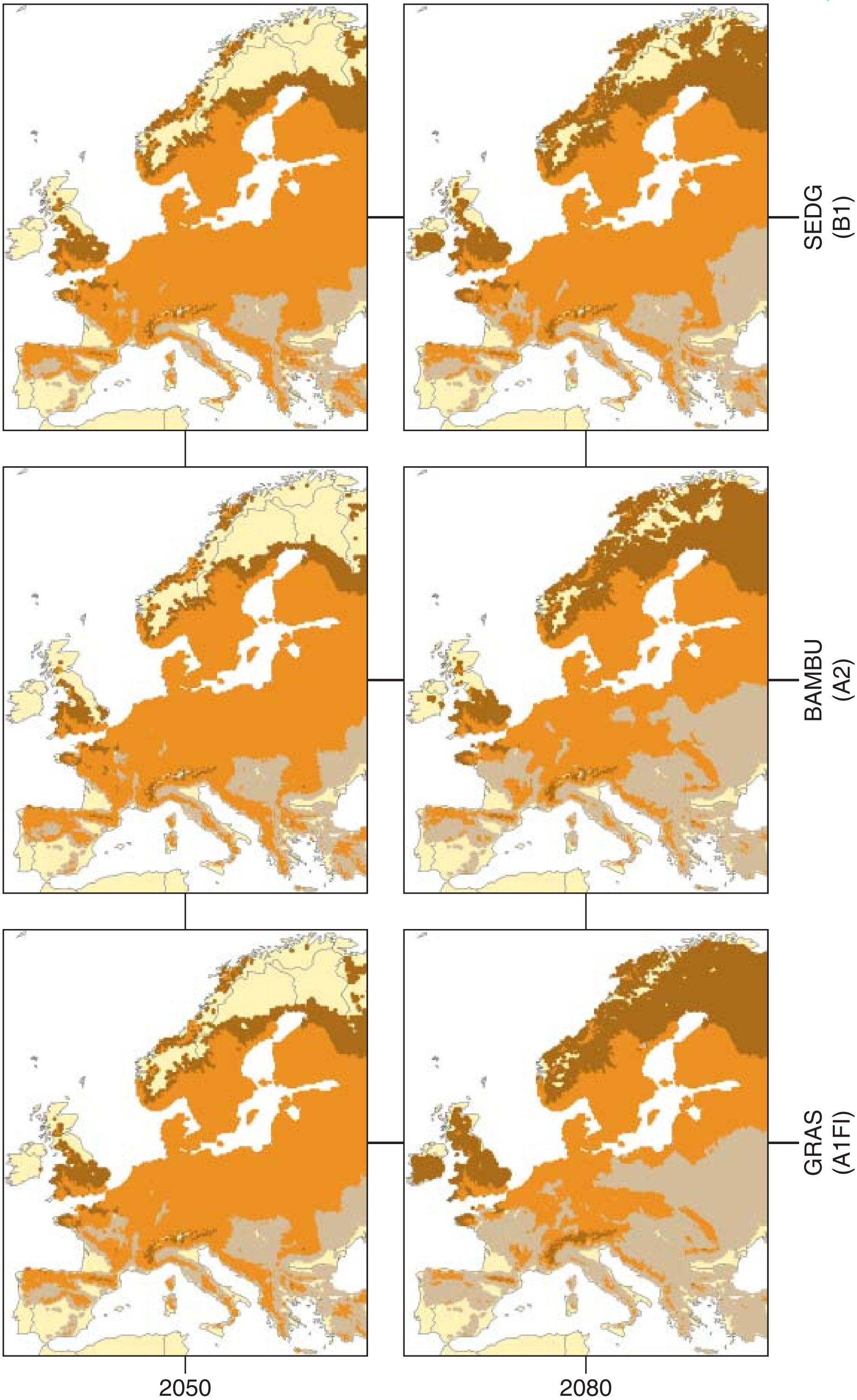
Present distribution can be explained by climatic variables to only a moderate extent (AUC = 0.69). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Plebejus idas (Linnaeus, 1761) – Idas Blue

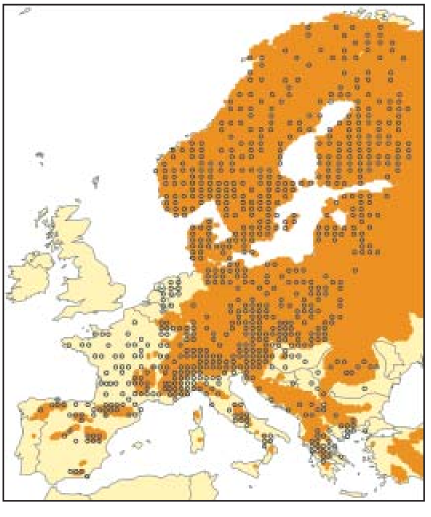
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-3965 (-21.5%)	-3996 (-21.67%)
	BAMBU	-4401 (-23.87%)	-4419 (-23.97%)
	GRAS	-5296 (-28.72%)	-5309 (-28.79%)
2080	SEDG	-6083 (-32.99%)	-6192 (-33.58%)
	BAMBU	-7986 (-43.31%)	-8006 (-43.42%)
	GRAS	-9992 (-54.19%)	-10023 (-54.36%)

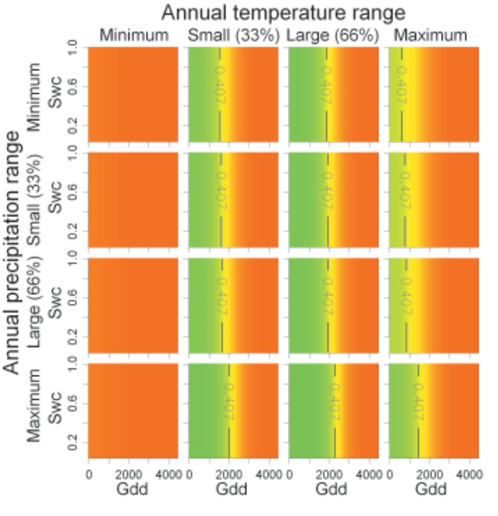
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 18438)

The Idas Blue can be found on poor grassland and heath rich in herbaceous plants, both in open places and woodland. Eggs are laid on many different species of leguminous plants, such as Broom (*Cytisus scoparius*), Hairy Greenweed (*Genista pilosa*), Common Birdsfoot-trefoil (*Coronilla varia*), White Melilot (*Melilotus alba*), and the Ericaceae, Ling or Heather (*Calluna vulgaris*) and Bog Whortleberry (*Vaccinium uliginosum*), and the Yellow Rockrose (*Helianthemum oelandicum*). The female deposits the egg onto a woody part of the foodplant where the egg then hibernates. The caterpillars are attended a lot by ants, especially those of the genera *Formica* and *Lasius*. When fully grown, the caterpillar crawls into the passages of the ant nest to pupate. Depending on the geographical location the Idas Blue produces one or two generations a year.

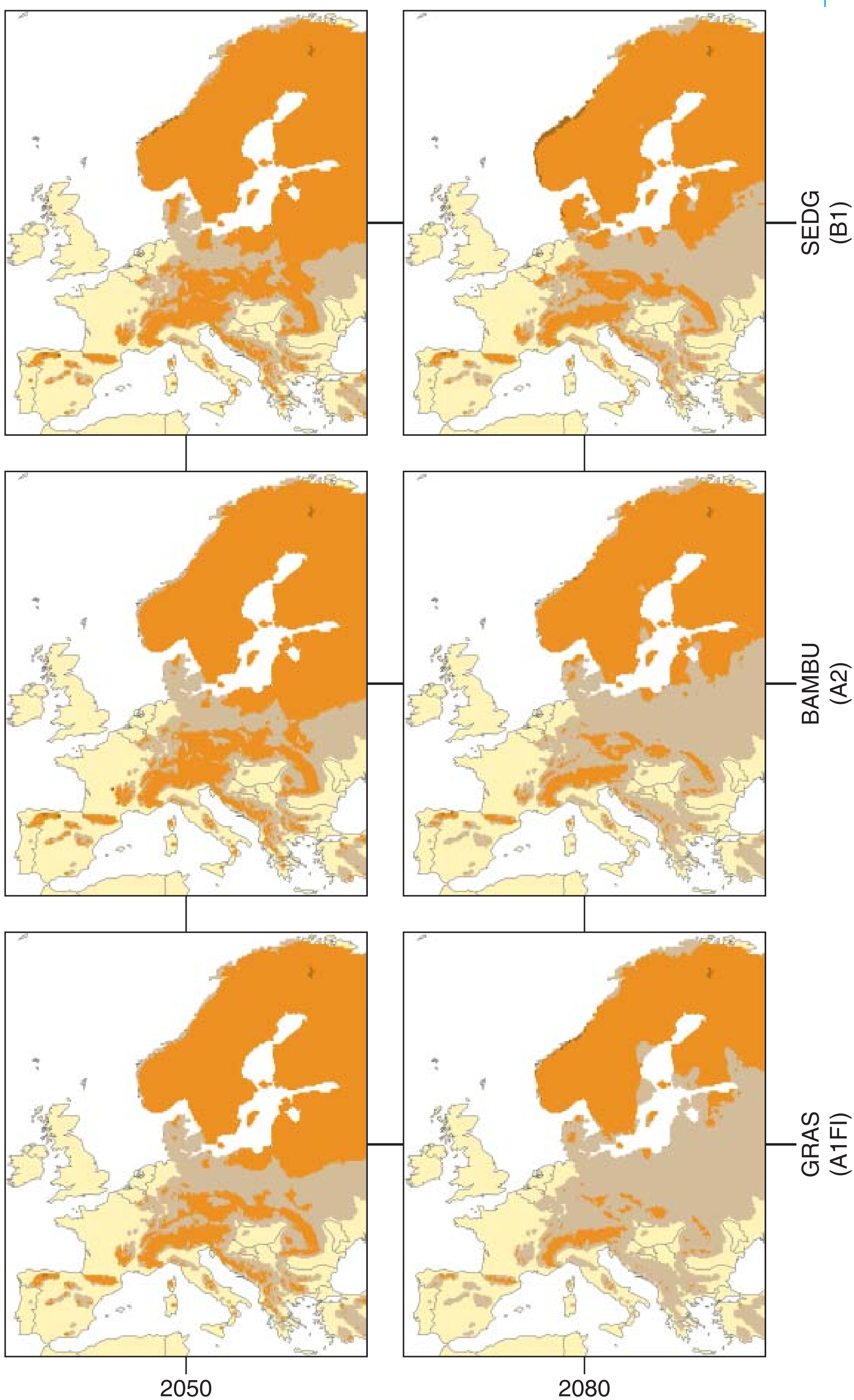
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.74). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Plebejus argyrognomon (Bergsträsser, 1779) – Reverdin's Blue

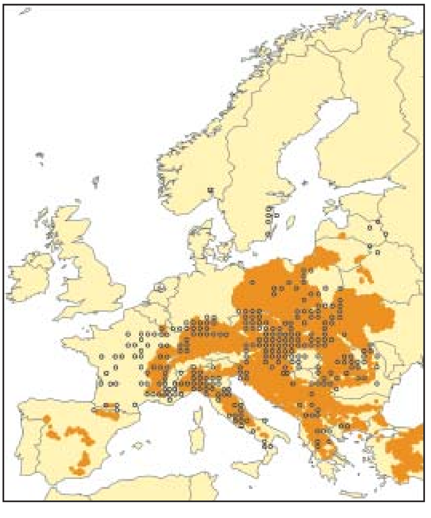
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	995 (17.81%)	-1883 (-33.7%)
	BAMBU	1176 (21.05%)	-2065 (-36.95%)
	GRAS	267 (4.78%)	-2681 (-47.98%)
2080	SEDG	760 (13.6%)	-3178 (-56.87%)
	BAMBU	297 (5.31%)	-4064 (-72.73%)
	GRAS	-655 (-11.72%)	-4776 (-85.47%)

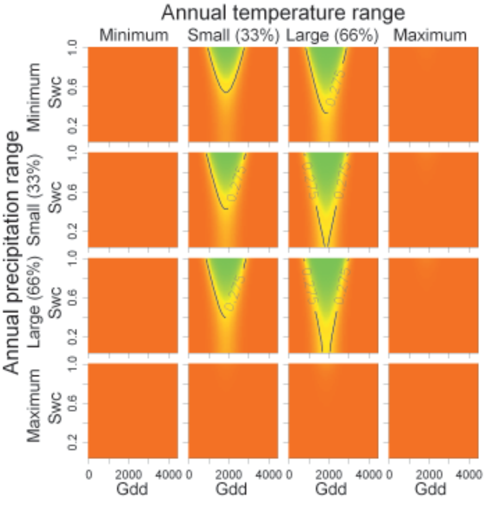
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 5588)

Reverdin's Blue can be found on poor grassland in places ranging from dry to moist at the edges of woodland or scrub. Eggs are laid on Crown Vetch (*Coronilla varia*) and Milk-vetch (*Astragalus glycyphyllos*). The female mostly chooses a woody part of the plant, where the egg may hibernate. The small caterpillars feed on the young leaves. They are attended by *Lasius* and *Myrmica* as well as *Formica* and *Camponotus* ants, and pupate deep down in the vegetation. Except in Scandinavia where it is single-brooded, the Reverdin's Blue has two generations a year.

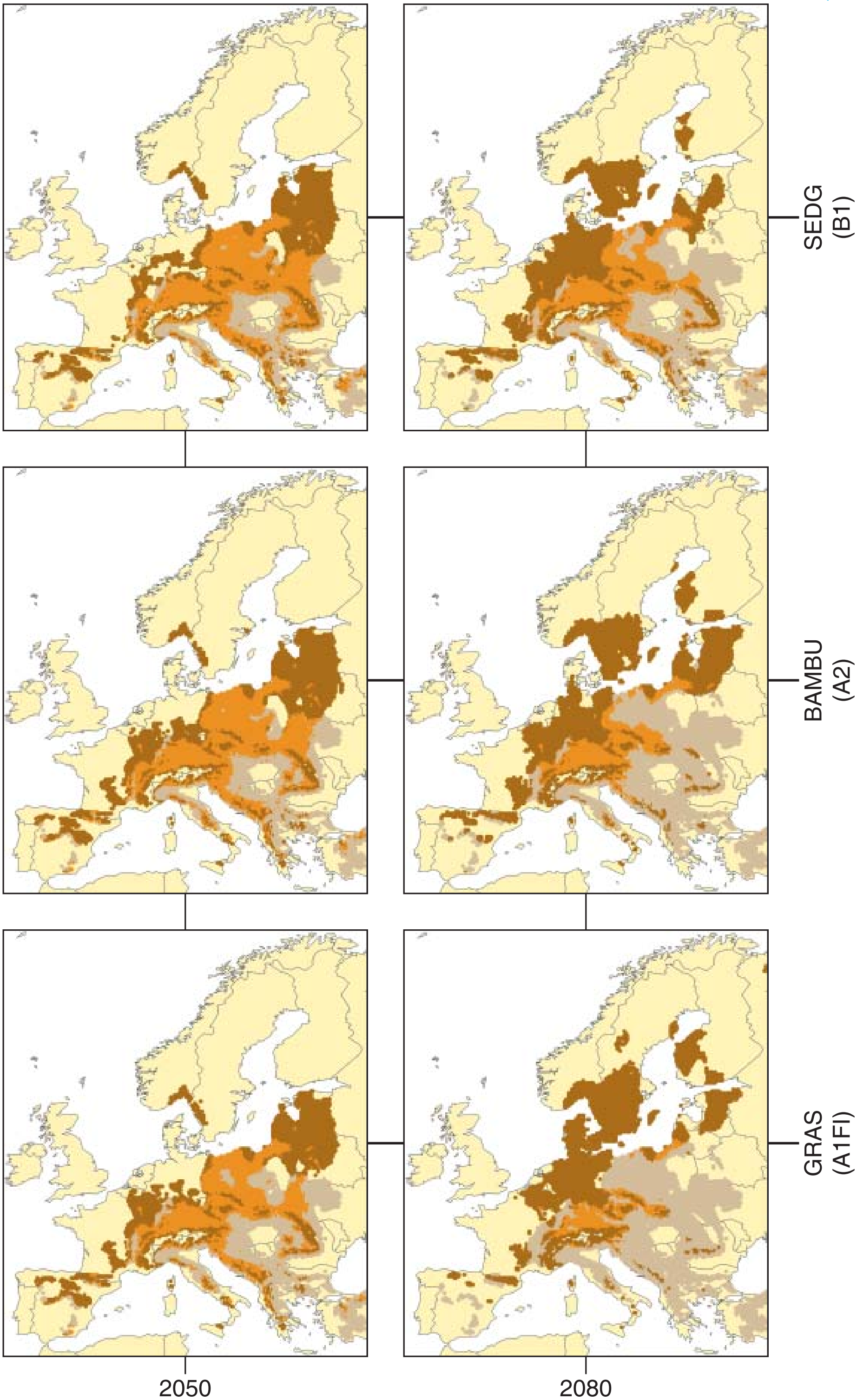
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.8). Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Plebejus optilete (Knoch, 1781) – Cranberry Blue

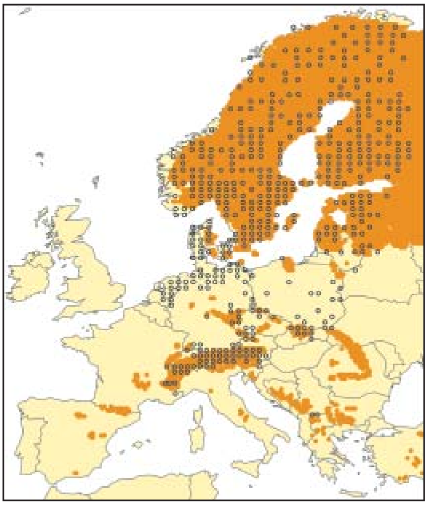
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-2975 (-29.48%)	-3104 (-30.76%)
	BAMBU	-2803 (-27.77%)	-2907 (-28.8%)
	GRAS	-3065 (-30.37%)	-3153 (-31.24%)
2080	SEDG	-4367 (-43.27%)	-4580 (-45.38%)
	BAMBU	-4949 (-49.04%)	-5057 (-50.11%)
	GRAS	-6135 (-60.79%)	-6209 (-61.52%)

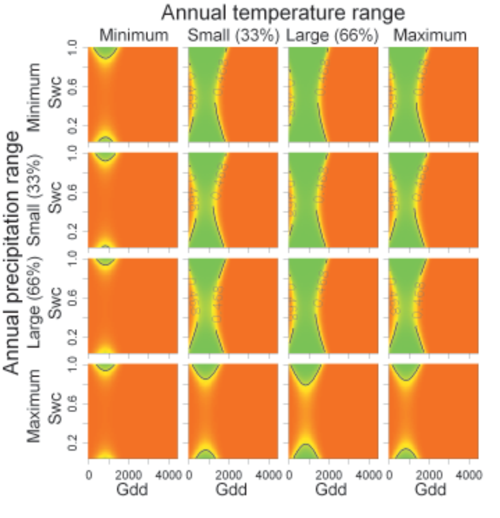
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 10092)

The Cranberry Blue occurs on raised bogs, heath and also in woodland clearings, where dwarf shrubs are growing. Although populations are at times extremely small, they can also have considerable numbers of butterflies. Eggs are laid on Marsh Andromeda (*Andromeda palustris*), *Erica tetralix*, *Empetrum nigrum*, and a small number of *Vaccinium* species, including Cranberry (*V. oxycoccus*). The caterpillars eat both the flowers and leaves of the foodplants, moving from one plant to another. When they are half-grown, they move into the litter layer and hibernate. However, they pupate on the plant, spinning a silken girdle in which the pupa hangs. The Cranberry Blue has one generation a year.

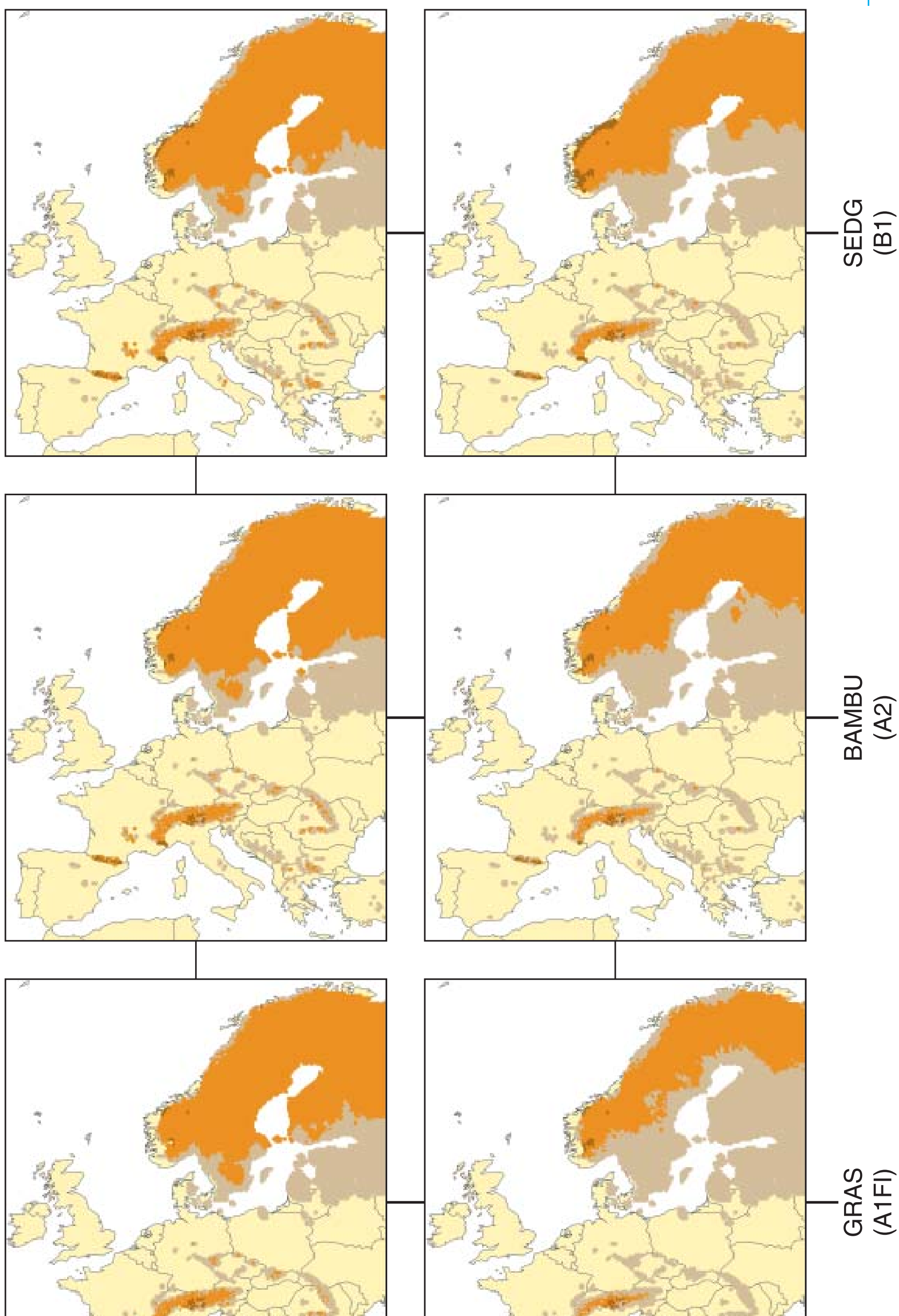
Present distribution can be well explained by climatic variables (AUC = 0.9).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold



SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Plebejus glandon (Prunner, 1798) – Glandon Blue

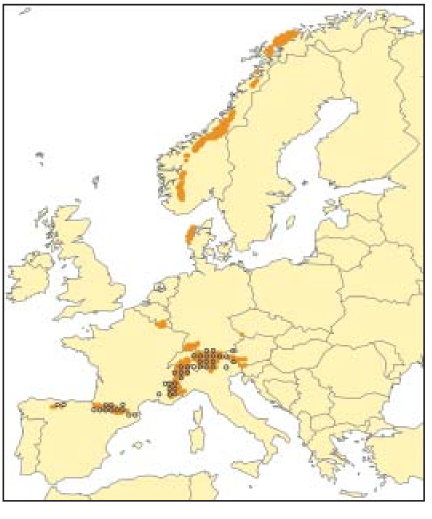
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	14 (3.29%)	-229 (-53.88%)
	BAMBU	94 (22.12%)	-189 (-44.47%)
	GRAS	-2 (-0.47%)	-237 (-55.76%)
2080	SEDG	-221 (-52%)	-348 (-81.88%)
	BAMBU	-93 (-21.88%)	-283 (-66.59%)
	GRAS	-235 (-55.29%)	-363 (-85.41%)

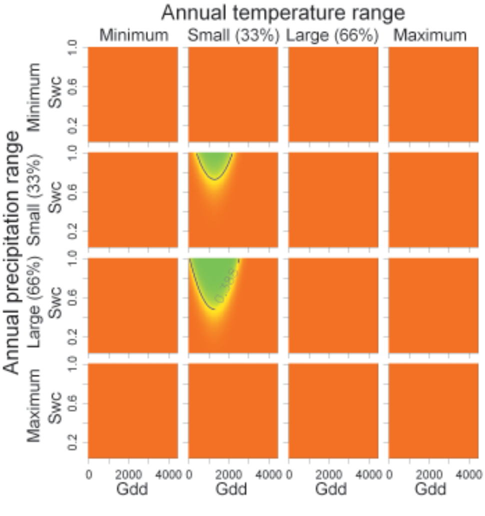
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 425)

In Central Europe, the Glandon Blue is found up to the snow-line on grassy vegetation, where the foodplants grow on open patches. On calcareous soils, *Androsace chamaejasme* is used, and on non-calcareous soils, the caterpillars feed on *A. obtusifolia* and *Vitaliana primuliflora*. The caterpillars feed on the leaves and sometimes the flowers of the foodplants. The Glandon Blue hibernates as a caterpillar, and in all parts of its range has one generation a year. We treat Plebejus glandon as separate from *P. aquilo* (Boisduval, 1832) (see next species) and *P. zuellichi* (Hemming, 1933) (which is endemic to the Sierra Nevada and was not modelled here due to its restricted distribution), while other authors split the species into three subspecies.

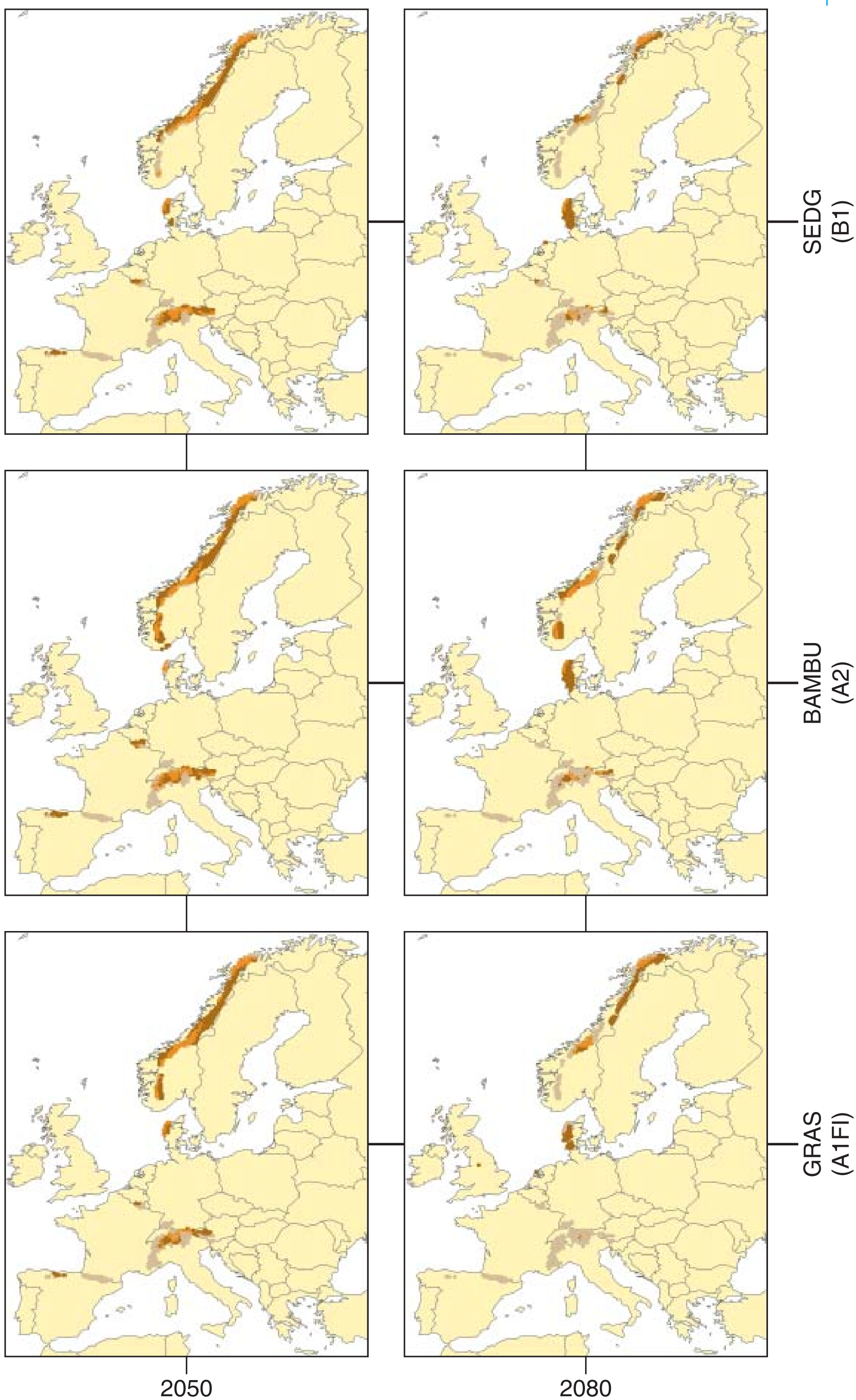
Present distribution can be very well explained by climatic variables (AUC = 0.99).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Plebejus aquilo (Boisduval, 1832) – Arctic Blue

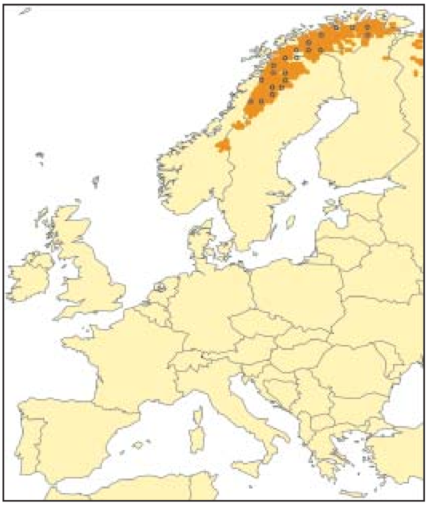
© Bernard Fransen

		Full dispersal	No dispersal
2050	SEDG	-462 (-66.47%)	-529 (-76.12%)
	BAMBU	-479 (-68.92%)	-537 (-77.27%)
	GRAS	-497 (-71.51%)	-553 (-79.57%)
2080	SEDG	-562 (-80.86%)	-637 (-91.65%)
	BAMBU	-646 (-92.95%)	-685 (-98.56%)
	GRAS	-682 (-98.13%)	-695 (-100%)

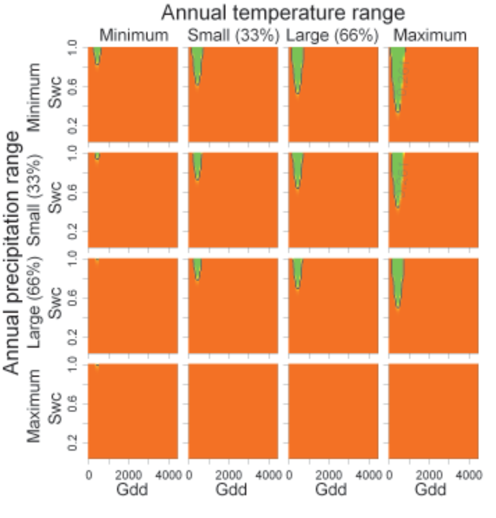
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 695)

This species occurs exclusively in Northern Fennoscandia. It occurs on slate and shale rocks with patches of grassy vegetation and with Crowberry (*Empetrum nigrum*), especially in areas sheltered from the northwestern wind. It lives in elevations between 0 and 900 m asl. Larval foodplants are *Saxifraga aizoides* and *S. oppositifolia*. The small larvae feed on the flower buds and hibernate. Later the larvae feed on the leaves. The species has one generation which is on the wing from late June until early August. It is often considered as a subspecies of *Plebejus glandon*.

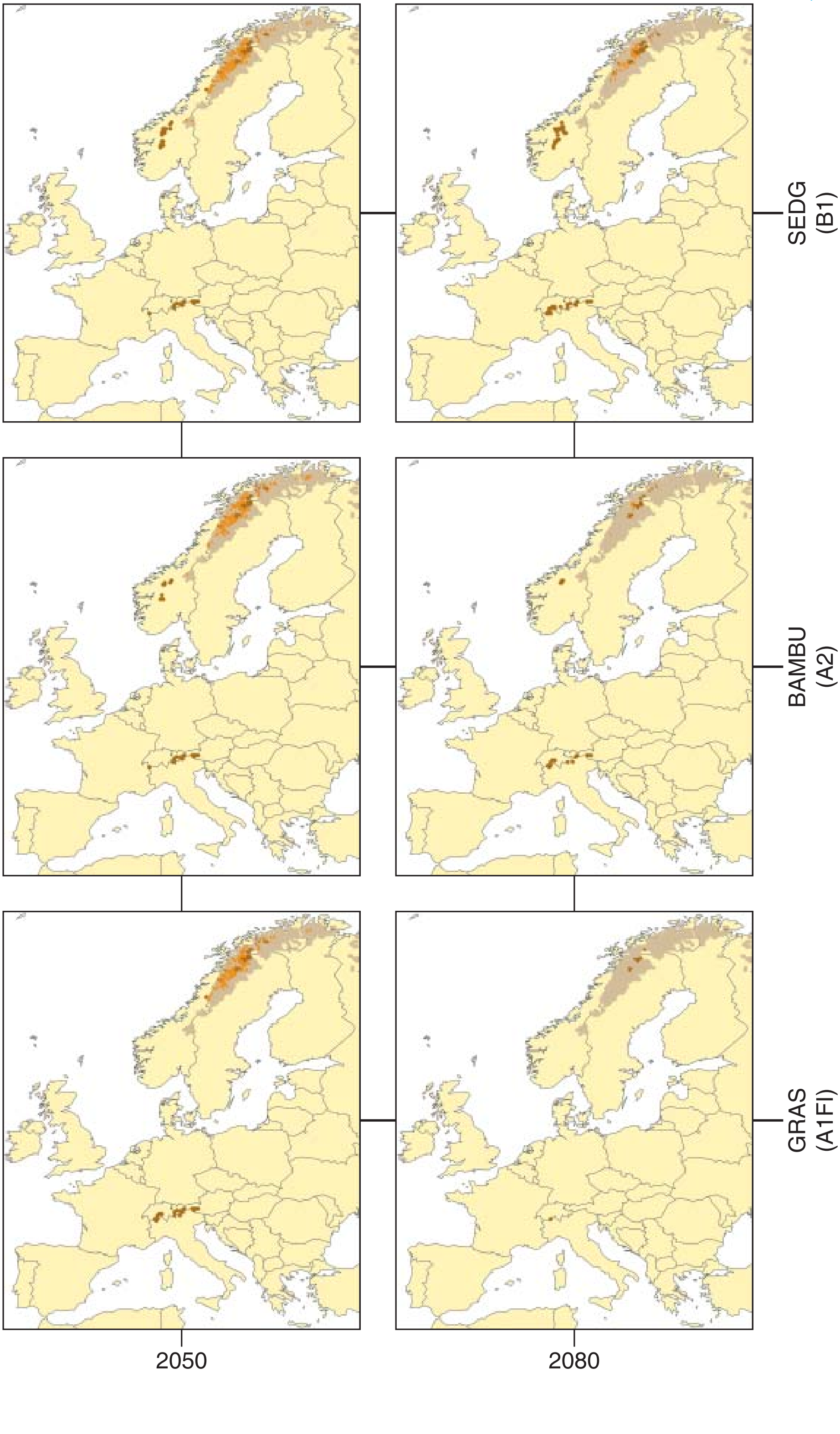
Present distribution can be very well explained by climatic variables (AUC = 1).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Plebejus orbitulus (Prunner, 1798) – Alpine Blue

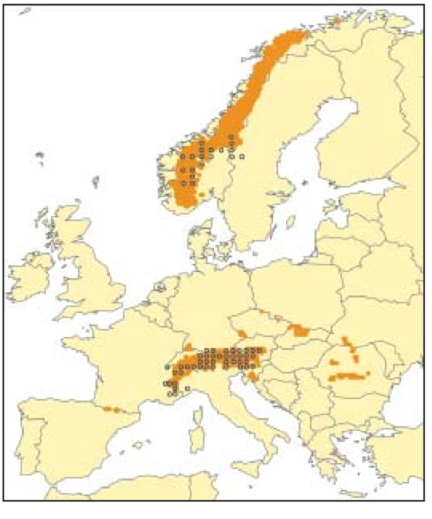
© Martin Wiemers

		Full dispersal	No dispersal
2050	SEDG	-234 (-18.84%)	-356 (-28.66%)
	BAMBU	-226 (-18.2%)	-333 (-26.81%)
	GRAS	-299 (-24.07%)	-397 (-31.96%)
2080	SEDG	-352 (-28.34%)	-505 (-40.66%)
	BAMBU	-365 (-29.39%)	-489 (-39.37%)
	GRAS	-493 (-39.69%)	-615 (-49.52%)

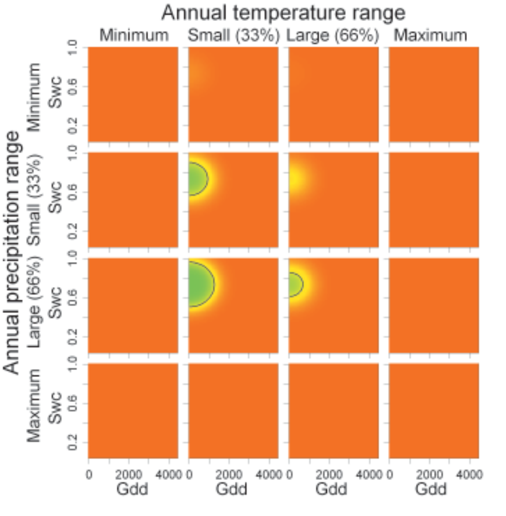
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1242)

In the Alps, the Alpine Blue is mostly found on sunny, rocky slopes, scree slopes with patches of flower-rich vegetation, and often on the rough vegetation growing beside streams. These butterflies usually fly to lower-lying areas in search of nectar. The foodplants are Alpine Milk-vetch (*Astragalus alpinus*), Alpine Sainfoin (*Hedysarum hedysaroides*), and probably Mountain Beaked Milk-vetch (*Oxytropis jacquinii*). In Scandinavia, this blue occurs in the mountains on open, damp slate slopes where its foodplant Alpine Milk-vetch grows. The Alpine Blue hibernates as a small caterpillar and has one generation a year.

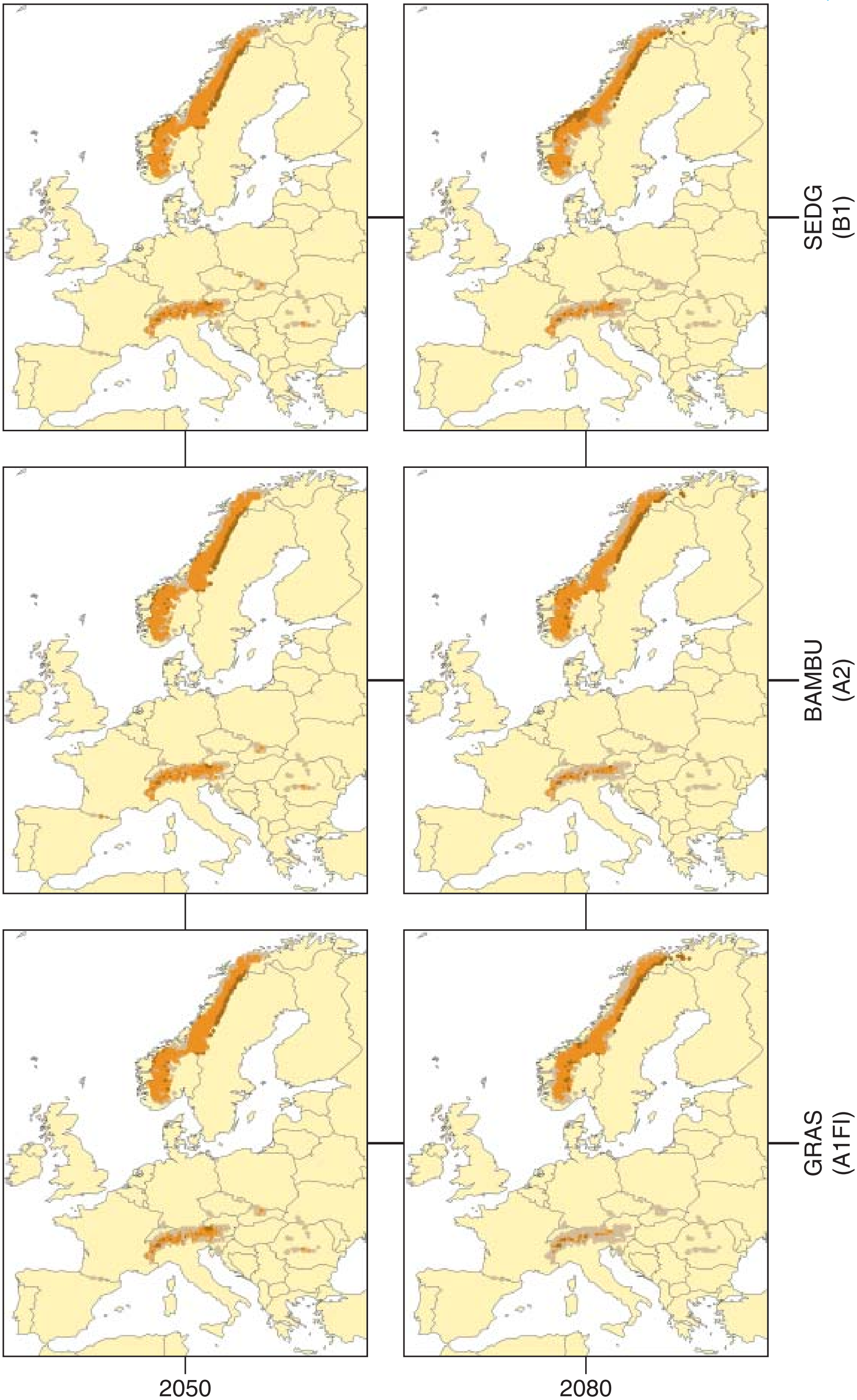
Present distribution can be very well explained by climatic variables (AUC = 0,98).
Climate risk category: LR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Plebejus sephirus (Frivaldszky, 1835)

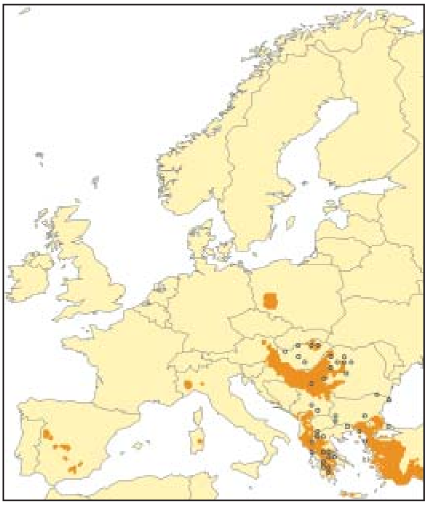
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	3 (0.25%)	-833 (-70.06%)
	BAMBU	-143 (-12.03%)	-760 (-63.92%)
	GRAS	743 (62.49%)	-676 (-56.85%)
2080	SEDG	-100 (-8.41%)	-1115 (-93.78%)
	BAMBU	-441 (-37.09%)	-1020 (-85.79%)
	GRAS	330 (27.75%)	-853 (-71.74%)

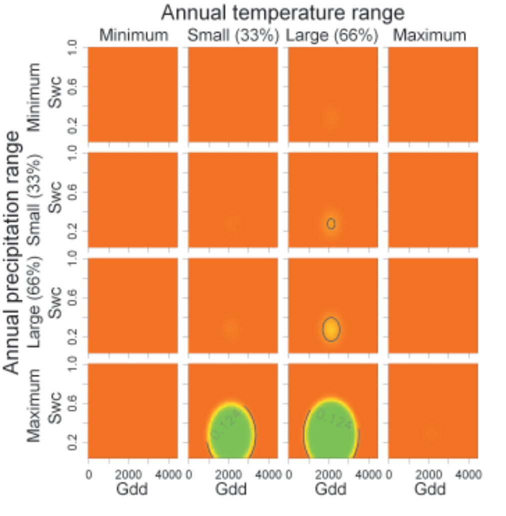
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 1189)

By some authors this species, described from Bulgaria, is treated as a subspecies of *Plebejus pylaon* (Fischer, 1832) and as a distinct species by others. Other taxa besides *P. pylaon*, which are closely related to *P. sephirus*, are *P. hespericus* (Rambur, 1839) from Spain and the Alpine *P. trappi* (Verity, 1927). All of them are not treated here due to their limited distributions. It occurs eastwards of the river Danube to the Dnepr region and southwards through Transylvania to the Balkans. Its habitats are loess steppes and calcareous terrains in the forest steppe belt from sea level to 1600 m. Larval host-plants are *Astragalus* species. The caterpillars are facultatively myrmecophilous and are garded by many different ant species. It has one short generation in May, June or July, depending on altitude and latitude. It hibernates as a small larva.

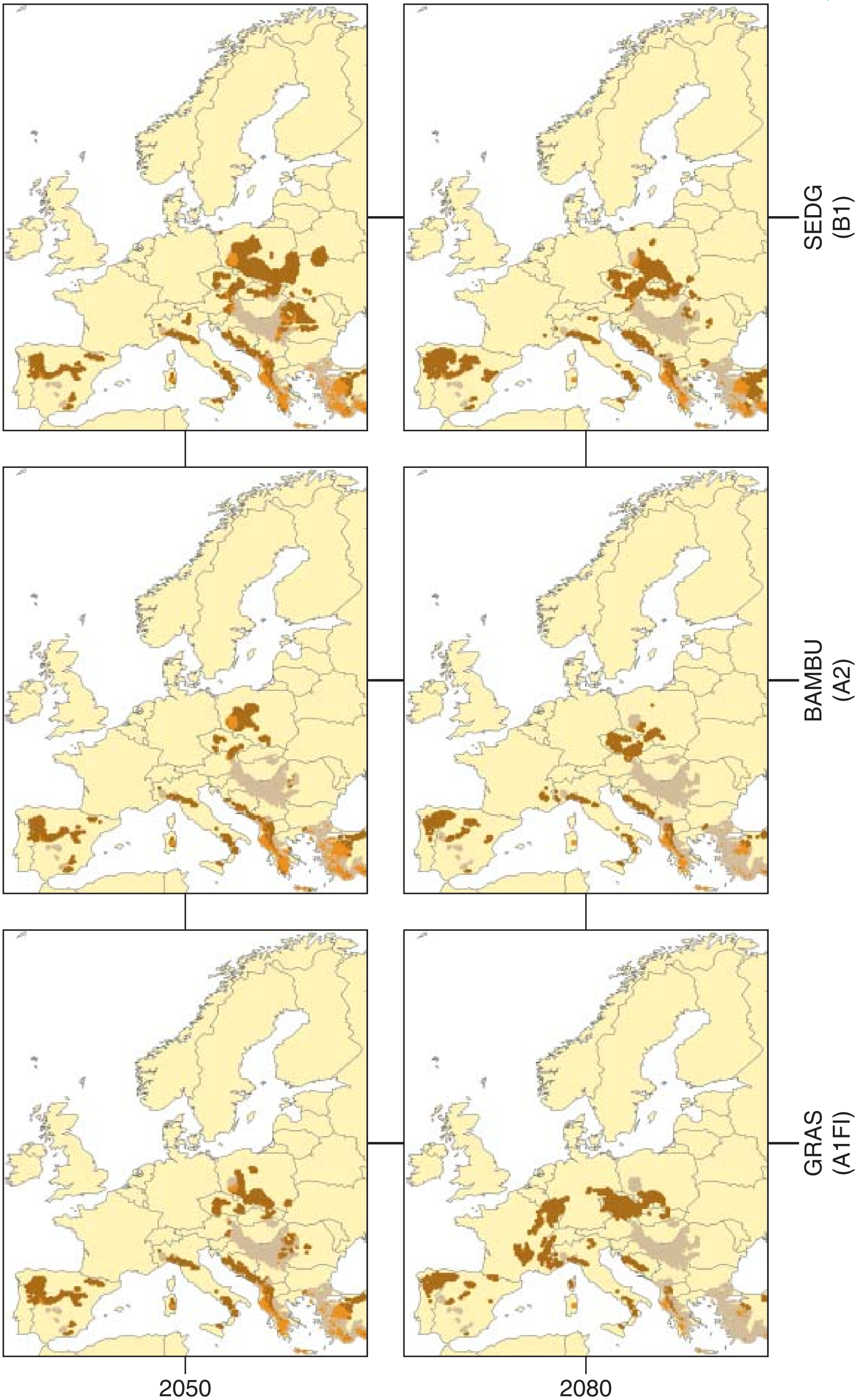
Present distribution can be well explained by climatic variables (AUC = 0.93).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Aricia eumedon (Esper, 1780) – Geranium Argus

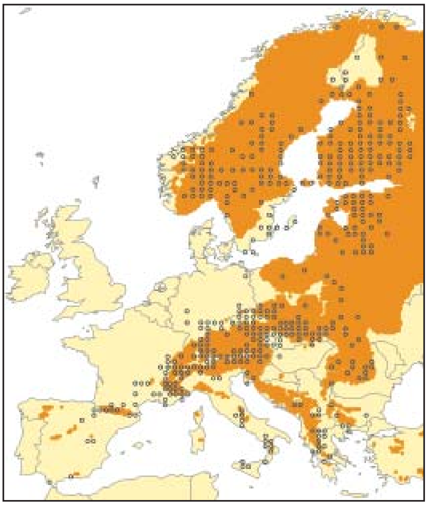
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-3820 (-28.53%)	-4459 (-33.3%)
	BAMBU	-4609 (-34.42%)	-5017 (-37.47%)
	GRAS	-5616 (-41.94%)	-6091 (-45.49%)
2080	SEDG	-3967 (-29.63%)	-4888 (-36.51%)
	BAMBU	-6493 (-48.5%)	-7131 (-53.26%)
	GRAS	-7151 (-53.41%)	-7854 (-58.66%)

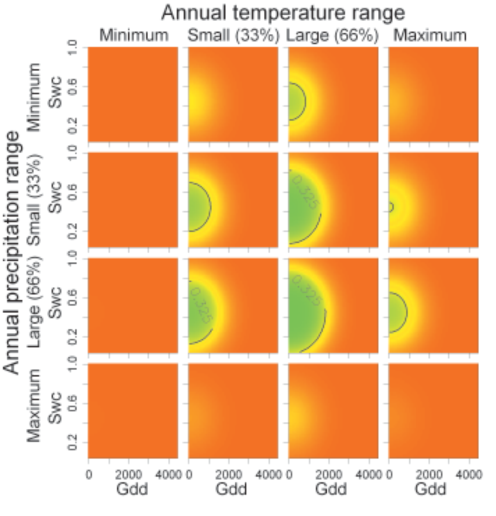
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 13389)

The Geranium Argus occurs locally, in meadows, stream valleys, and at woodland edges.
The female lays her eggs in the flowers of crane's-bills (*Geranium* spp.), at the base of the ovary into which the small caterpillar bores its way on hatching out. It stays there for a little more than a week. It then starts feeding on leaves, first gnawing on the stems, which causes them to wilt. When half-grown, the caterpillars hibernate in the litter layer, but pupate on the foodplant. They are sometimes attended by ants of the genera *Myrmica*, *Lasius* and *Tapinoma*. The Geranium Argus has only one generation a year.

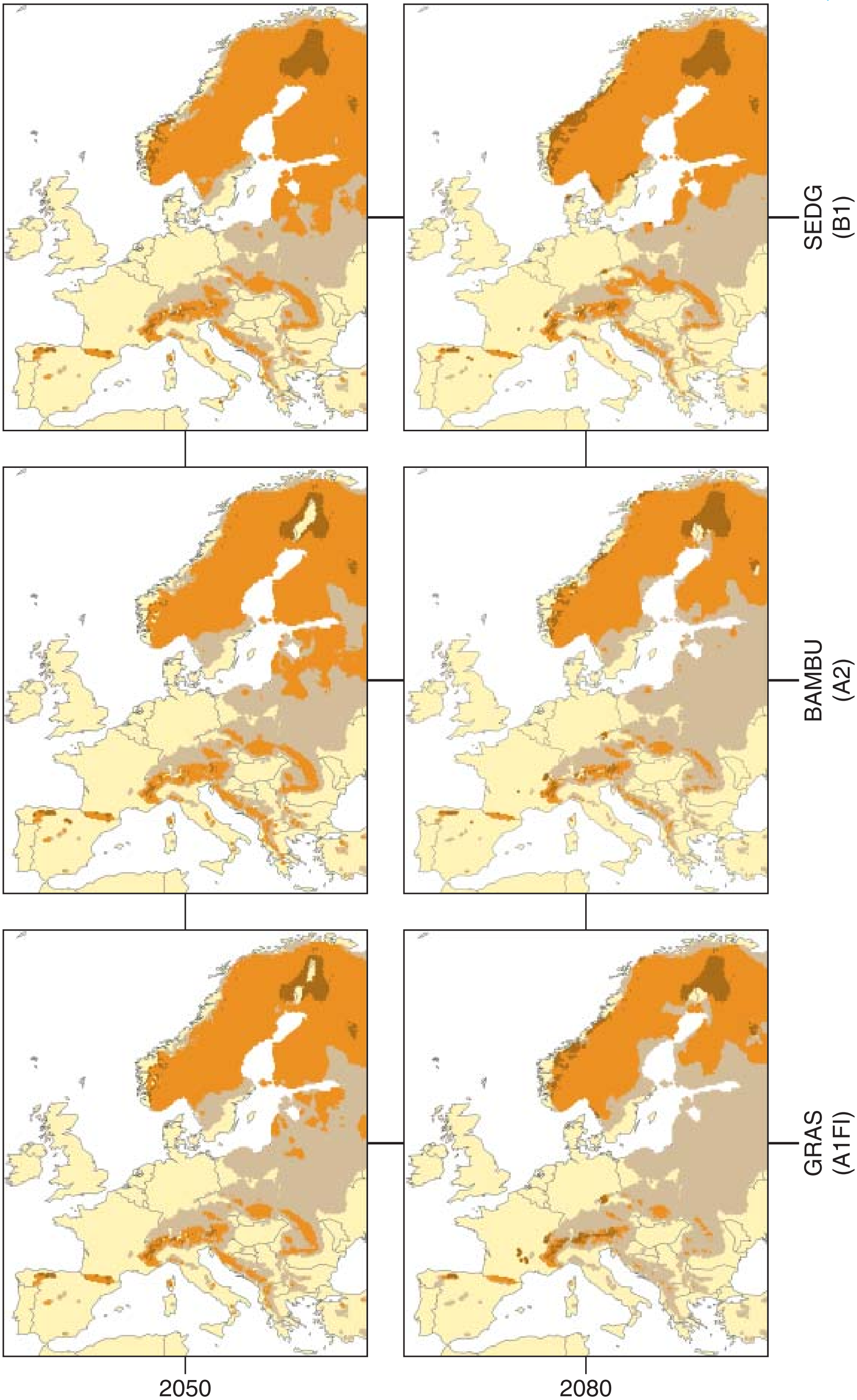
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.8).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Aricia cramera (Eschscholtz, 1821)

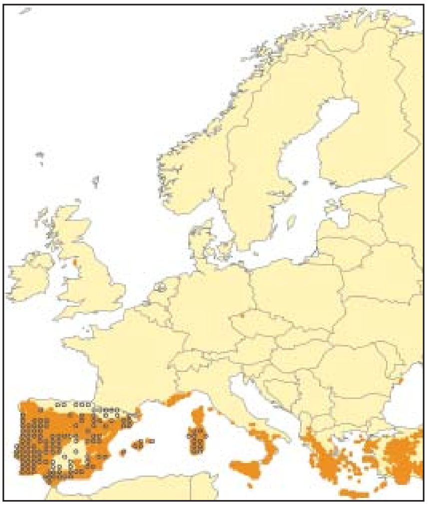
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-1273 (-51.52%)	-1505 (-60.91%)
	BAMBU	-1563 (-63.25%)	-1648 (-66.69%)
	GRAS	-1591 (-64.39%)	-1843 (-74.59%)
2080	SEDG	-1692 (-68.47%)	-2033 (-82.27%)
	BAMBU	-2054 (-83.12%)	-2346 (-94.94%)
	GRAS	-1950 (-78.92%)	-2448 (-99.07%)

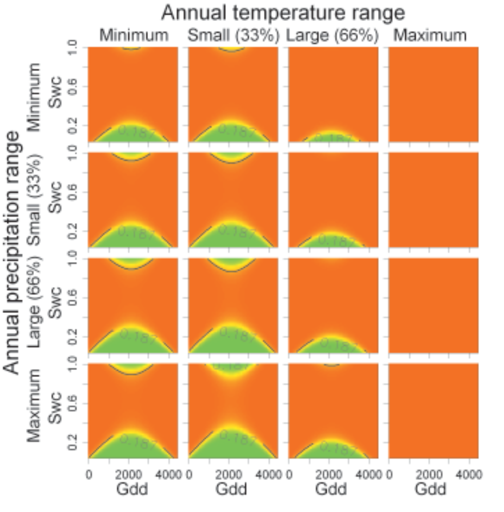
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 2471)

This butterfly species can be found in flower-rich, places, in scrub or at woodland edges. The most important foodplants are stork’s-bills (*Erodium* spp.) and crane’s-bills (*Geranium* spp.), of which the caterpillars eat the leaves. Knapweeds (*Centaurea* spp.), rockroses (*Helianthemum* spp.), and Leguminous plants, such as clovers (*Trifolium* spp.) and brooms (*Cytisus* spp.) have also been mentioned. This species has two to three generations a year and is often found together with ants of the genera *Myrmica* and *Lasius*. Hibernation takes place as larva.

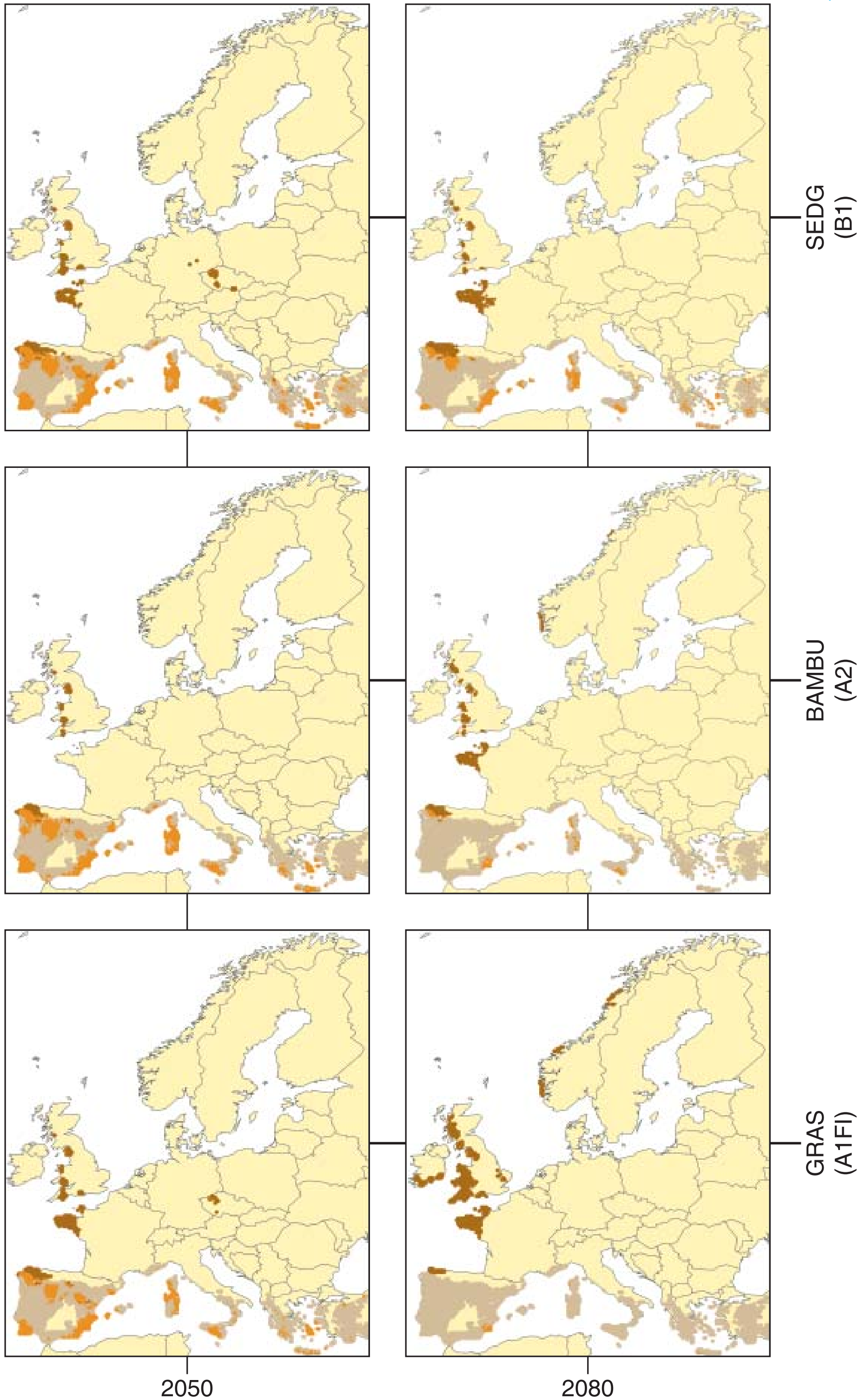
Present distribution can be well explained by climatic variables (AUC = 0.91).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Aricia agestis ([Schiffermüller], 1775) – Brown Argus

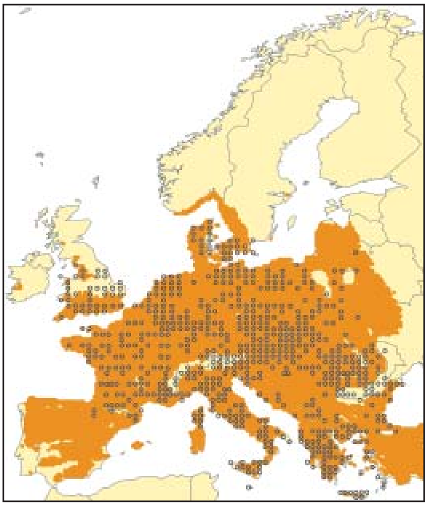
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	299 (1.96%)	-2499 (-16.38%)
	BAMBU	-354 (-2.32%)	-3124 (-20.48%)
	GRAS	-837 (-5.49%)	-3631 (-23.81%)
2080	SEDG	-2279 (-14.94%)	-4933 (-32.34%)
	BAMBU	-3463 (-22.7%)	-6939 (-45.49%)
	GRAS	-4787 (-31.38%)	-8715 (-57.14%)

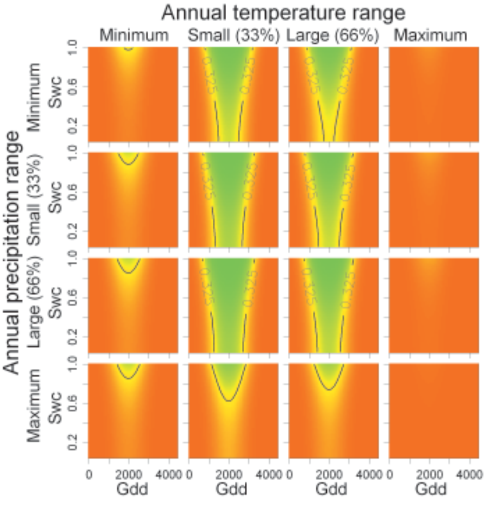
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 15253)

The Brown Argus occurs on warm grasslands, in heaths, and in dunes. It can also be found on sandy, pioneer vegetation, as for example in sand-pits, or where houses are being built. It lays its eggs on small crane’s-bill (*Geranium* spp.) and rockroses (*Helianthemum* spp.). It may build up numerous, small populations. At first, the small caterpillars only scrape off the undermost layer of the leaves making little “windows” in the leaves. Later, the bigger caterpillars feed on the whole leaf. They are often attended by *Lasius* and *Myrmica* ants. The caterpillars can hibernate at any stage. Pupation takes place in the litter layer. The Brown Argus has two to three generations depending on the geographical location.

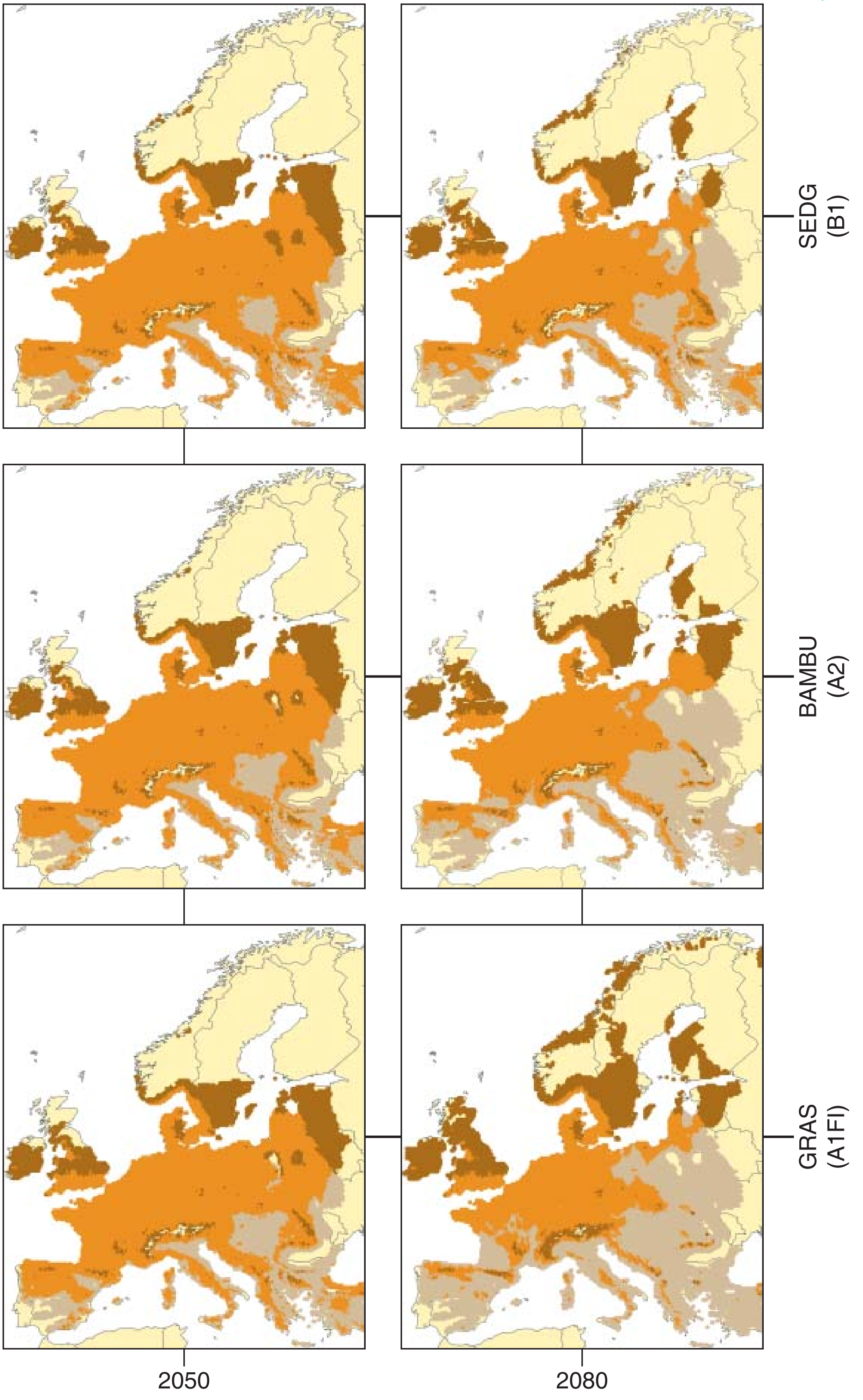
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.7).
Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


2050
2080
SEDG (B1)
BAMBU (A2)
GRAS (A1FI)

Aricia artaxerxes (Fabricius, 1793) – Northern Brown Argus

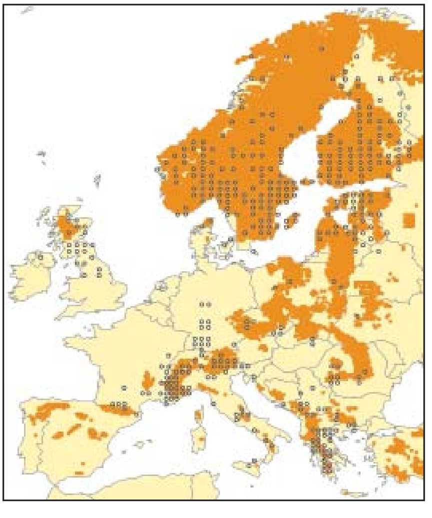
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-3340 (-34.55%)	-3708 (-38.35%)
	BAMBU	-4891 (-50.59%)	-4985 (-51.56%)
	GRAS	-4476 (-46.3%)	-4601 (-47.59%)
2080	SEDG	-4943 (-51.13%)	-5186 (-53.64%)
	BAMBU	-7110 (-73.54%)	-7262 (-75.11%)
	GRAS	-7886 (-81.57%)	-8037 (-83.13%)

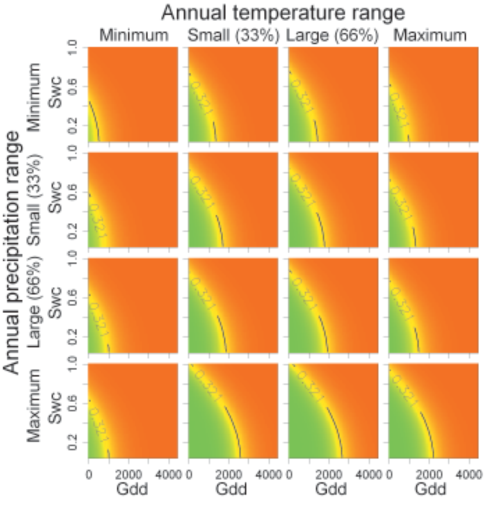
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 9668)

The Northern Brown Argus likes open grasslands or dry vegetation at the edges of woods. It is more closely bound to calcareous soil than the Brown Argus. The eggs are laid on various rockroses (*Helianthemum* spp.), as well as on various crane's-bills (*Geranium* spp.). The caterpillars feed on the leaves, often attended by *Lasius* ants. When the caterpillars are half-grown, they hibernate. Pupation takes place in the litter layer. There is always only one generation.

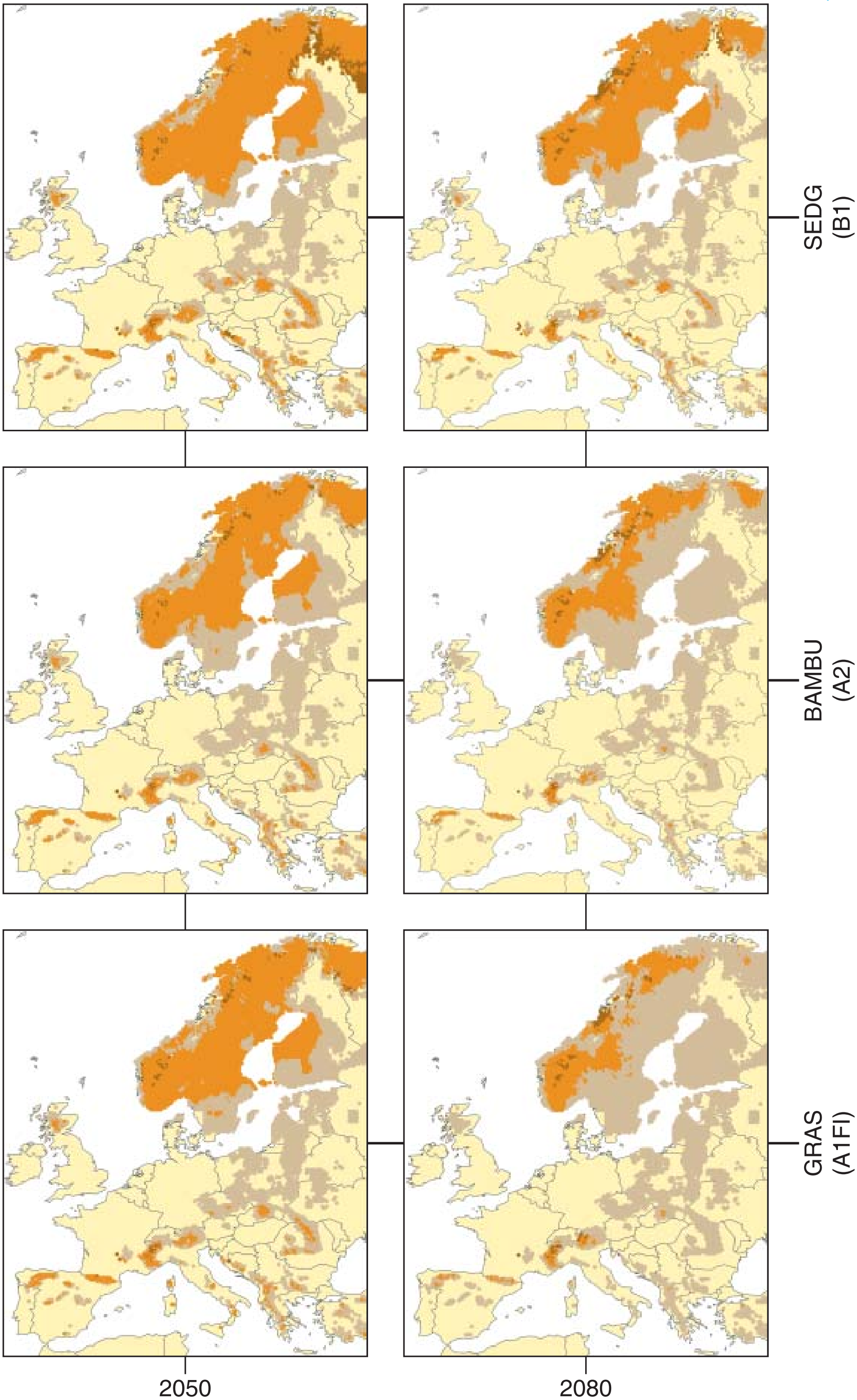
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.72). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Aricia montensis (Verity, 1928) – Southern Mountain Argus

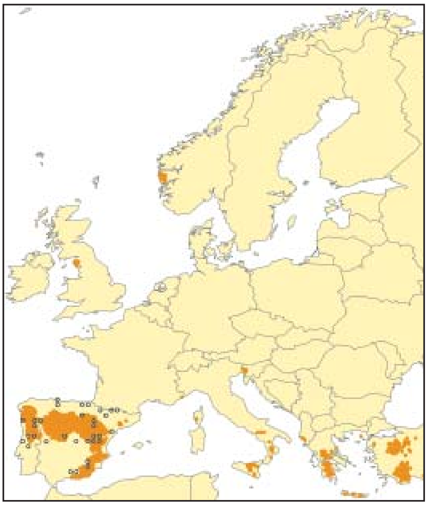
© Matt Rowlings

		Full dispersal	No dispersal
2050	SEDG	-458 (-53.32%)	-618 (-71.94%)
	BAMBU	-606 (-70.55%)	-683 (-79.51%)
	GRAS	-593 (-69.03%)	-755 (-87.89%)
2080	SEDG	-591 (-68.8%)	-804 (-93.6%)
	BAMBU	-605 (-70.43%)	-819 (-95.34%)
	GRAS	-464 (-54.02%)	-840 (-97.79%)

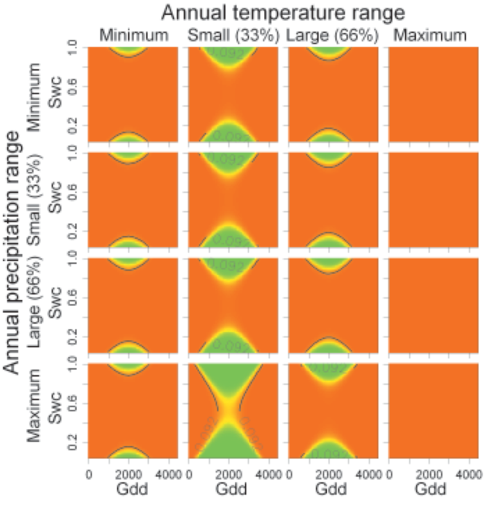
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 859)

The taxonomic relationship of several *Aricia* species is not yet clear. *Aricia montensis* is often regarded as a subspecies of *A. artaxerxes*. In the context of this atlas the species has been modeled independently, but there also would have been good reasons to keep it within *A. artaxerxes*. It occurs on the mountains south of the range or *A. artaxerxes*, it has no white spots on the upperside of the wings and distinct black spots underneath them (like the subspecies *A. a. allous*, but it is bigger than those).

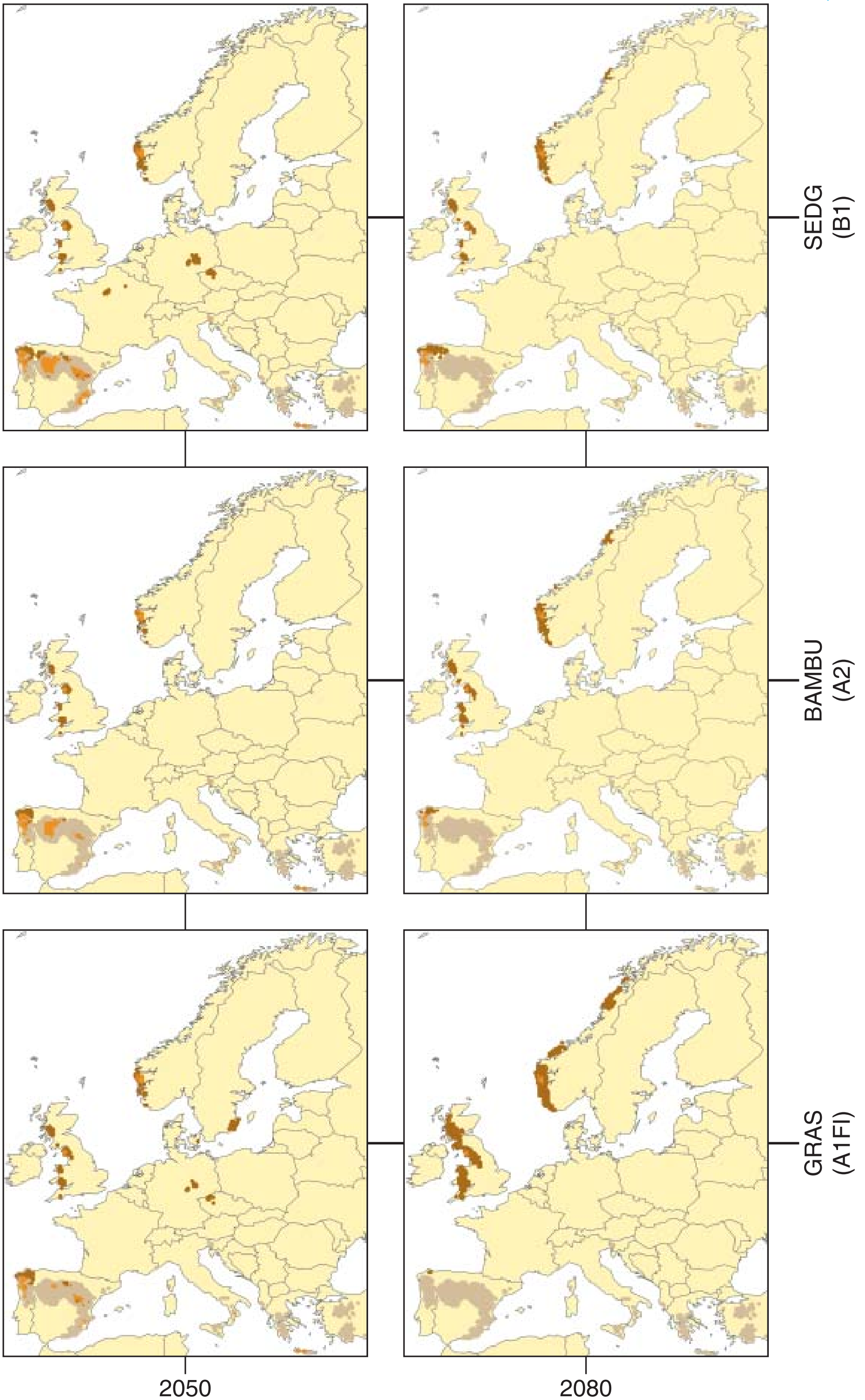
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.7). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold



SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Aricia anteros (Freyer, 1838) – Blue Argus

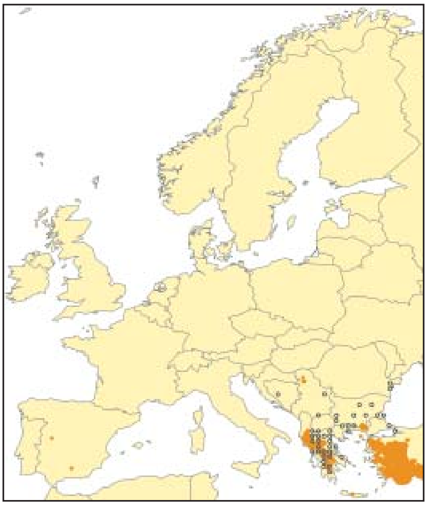
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	63 (12.52%)	-252 (-50.1%)
	BAMBU	-64 (-12.72%)	-300 (-59.64%)
	GRAS	-70 (-13.92%)	-335 (-66.6%)
2080	SEDG	113 (22.47%)	-285 (-56.66%)
	BAMBU	-300 (-59.64%)	-445 (-88.47%)
	GRAS	-355 (-70.58%)	-488 (-97.02%)

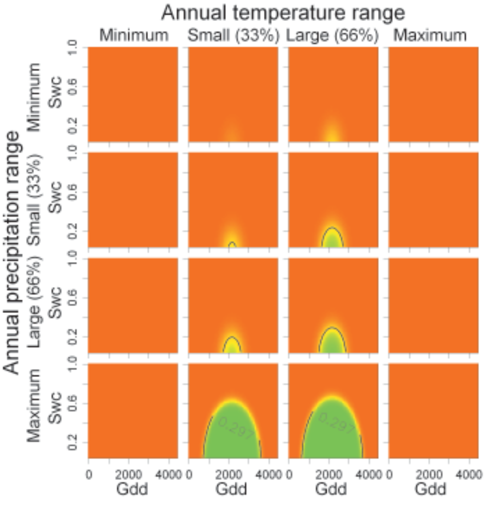
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 503)

The Blue Argus is a species of flower-rich grasslands and rocky slopes with grassy vegetation. Sometimes, they are also seen on scrub or in woodland clearings. This butterfly it is often found where the soil is calcareous. Various sorts of crane's-bills (*Geranium* spp.) are used as foodplant, including *G. asphodeloides*, Bloody Crane's-bill (*G. sanguineum*), and Rock Crane's-bill (*G. macrorrhizum*). The caterpillars feed on the leaves and are attended by ants. Depending on the altitude, the Blue Argus has one to three generations a year.

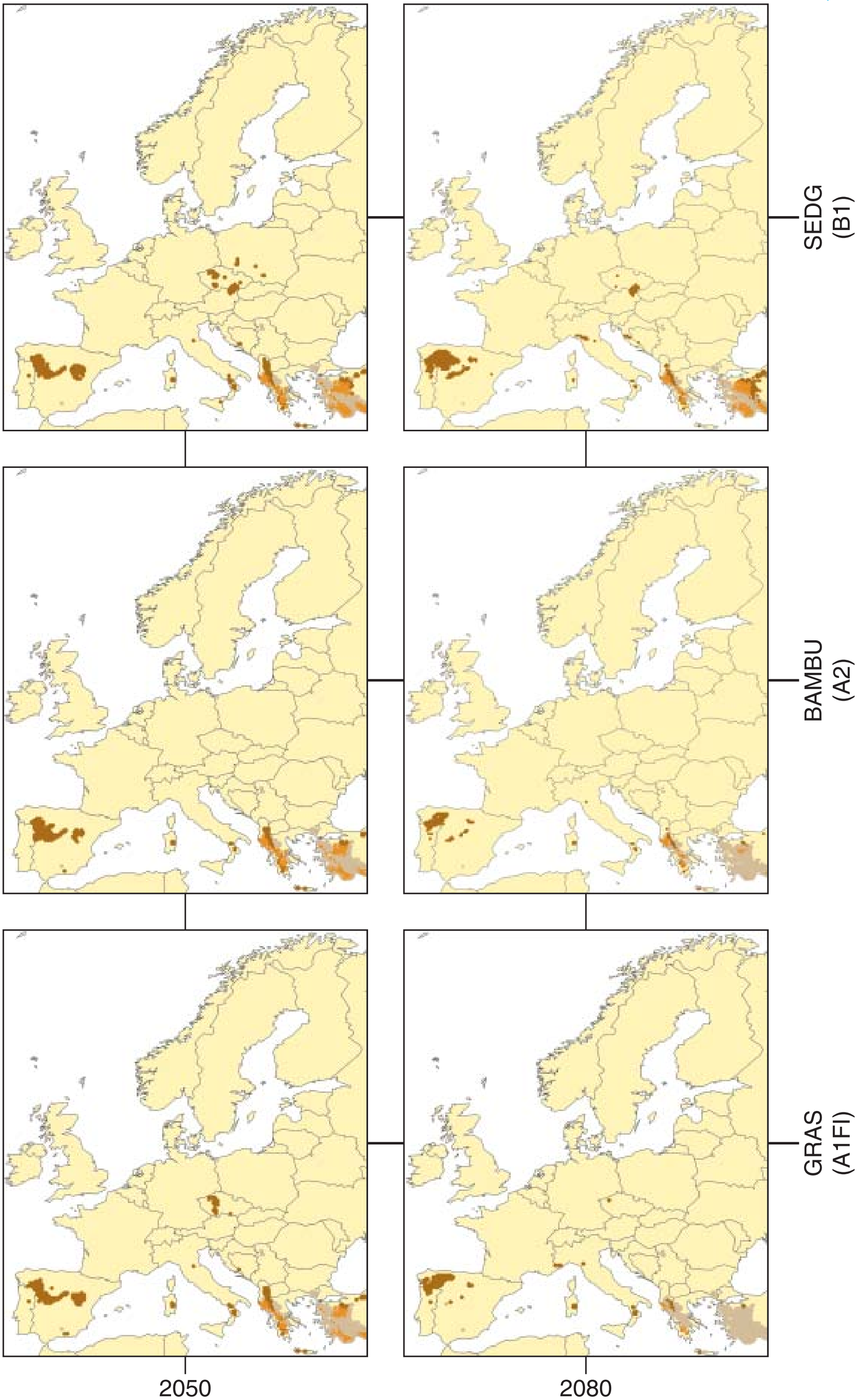
Present distribution can be very well explained by climatic variables (AUC = 0.96).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Aricia nicias (Meigen, 1829) – Silvery Argus

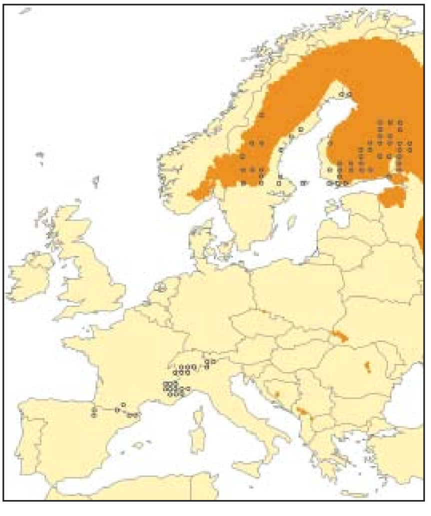
© Bernard Fransen

		Full dispersal	No dispersal
2050	SEDG	-434 (-10.09%)	-814 (-18.93%)
	BAMBU	-1380 (-32.09%)	-1528 (-35.53%)
	GRAS	-1255 (-29.18%)	-1467 (-34.11%)
2080	SEDG	-207 (-4.81%)	-1031 (-23.97%)
	BAMBU	-1611 (-37.46%)	-2242 (-52.13%)
	GRAS	-1952 (-45.38%)	-2625 (-61.03%)

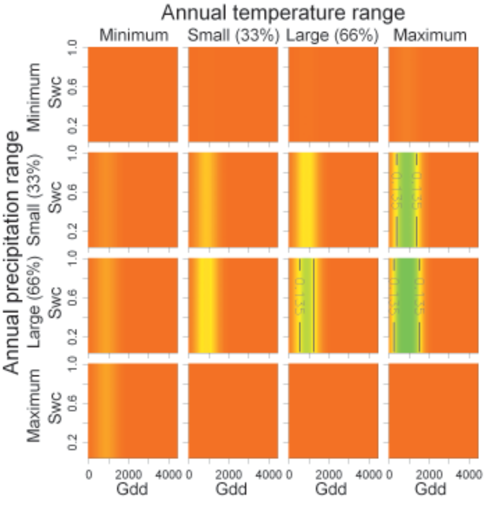
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 4301)

The Silvery Argus occurs on flower-rich grasslands with some bushes or trees, in grass along the hedges, at the edge of woodland, and in sunny, grassy woodland clearings. The grassland on which the Silvery Argus occurs is usually damp with rather tall vegetation, but it is also seen on dry grassland. The female lays her eggs on the flowers of Wood Crane's-bill (*Geranium sylvaticum*) and Meadow Crane's-bill (*G. pratense*). The caterpillars eat the leaves as well as the flowers. They are attended by ants. This butterfly hibernates as a larva, but in Scandinavia it is said to overwinter in the egg stage.

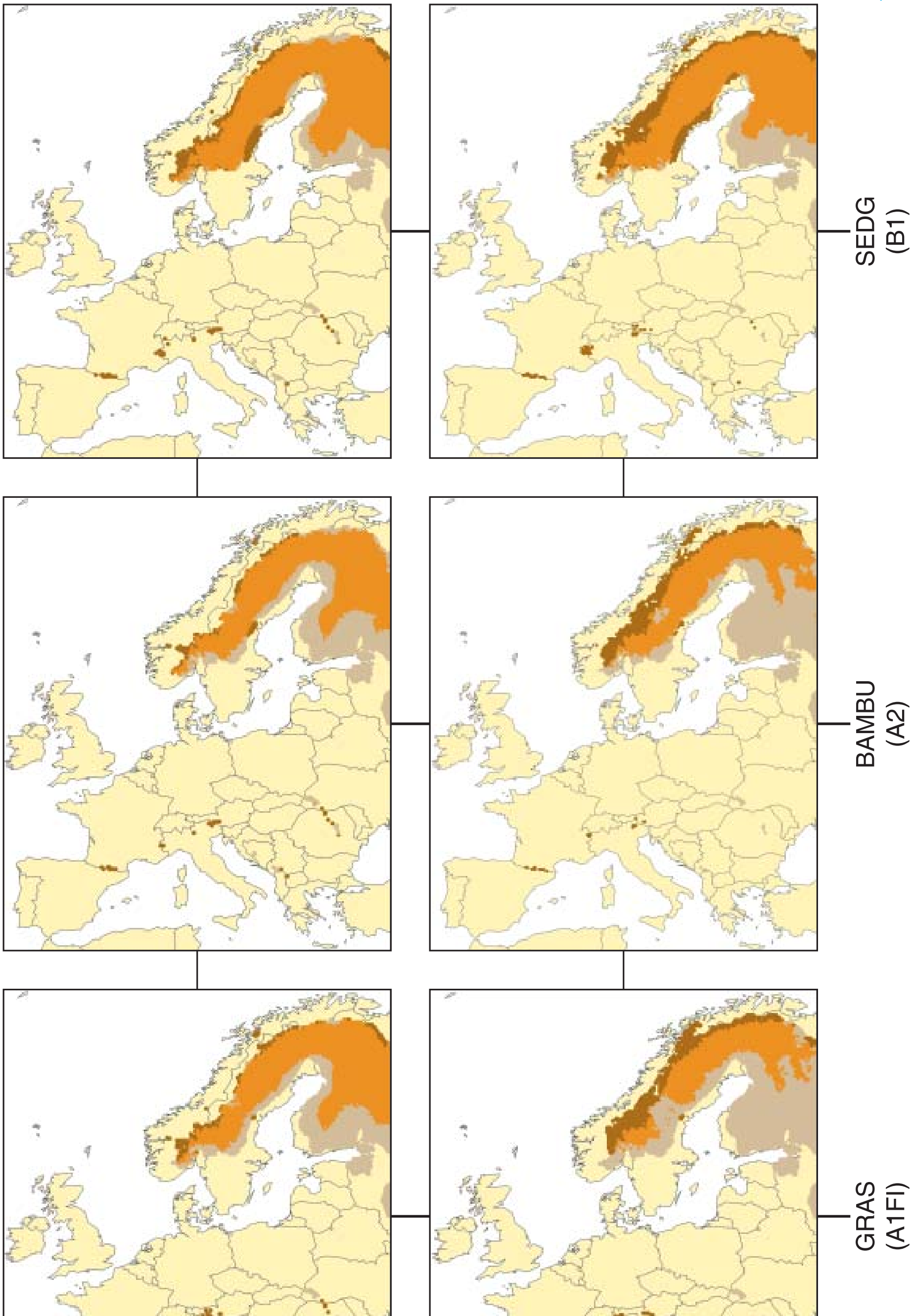
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.82).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Cyaniris semiargus (Rottemburg, 1775) – Mazarine Blue

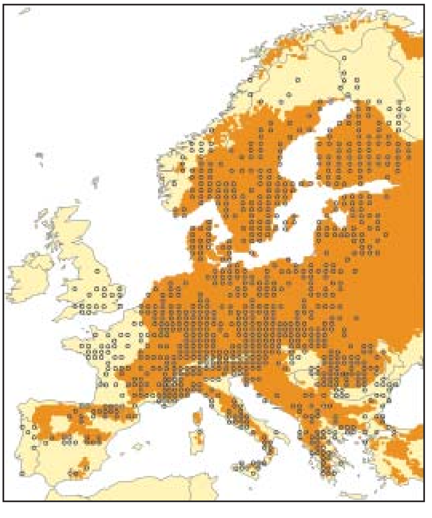
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-131 (-0.75%)	-2574 (-14.83%)
	BAMBU	-349 (-2.01%)	-2498 (-14.39%)
	GRAS	-1510 (-8.7%)	-3763 (-21.68%)
2080	SEDG	-792 (-4.56%)	-4238 (-24.41%)
	BAMBU	-2792 (-16.08%)	-6166 (-35.52%)
	GRAS	-4868 (-28.04%)	-8323 (-47.95%)

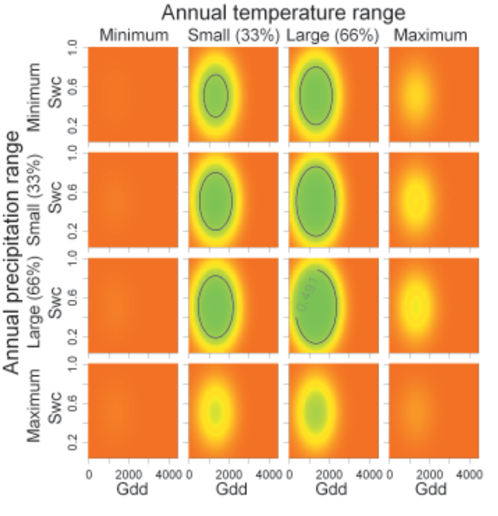
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 17359)

The Mazarine Blue usually occurs on quite damp vegetation in flower-rich meadows and pastures and at the edges of woodland. These butterflies are fond of basking together in groups and are then easy to find and to be observed. The female deposits her eggs on the flowerheads of Red Clover (*Trifolium pratense*), eating the unopened buds. The first instar caterpillar only feeds on buds and flowers, later stages also feed on leaves. The colours of the caterpillars are well adapted to their surroundings, with pink in the first instar and then green in later stages. The caterpillars can hardly be seen while feeding on the foodplants. Ants of the genera *Lasius* and *Camponotus* attend the caterpillars. Depending on the altitude and position in the range, the Mazarine Blue has one to three generations a year. The hibernation takes place as a larva.

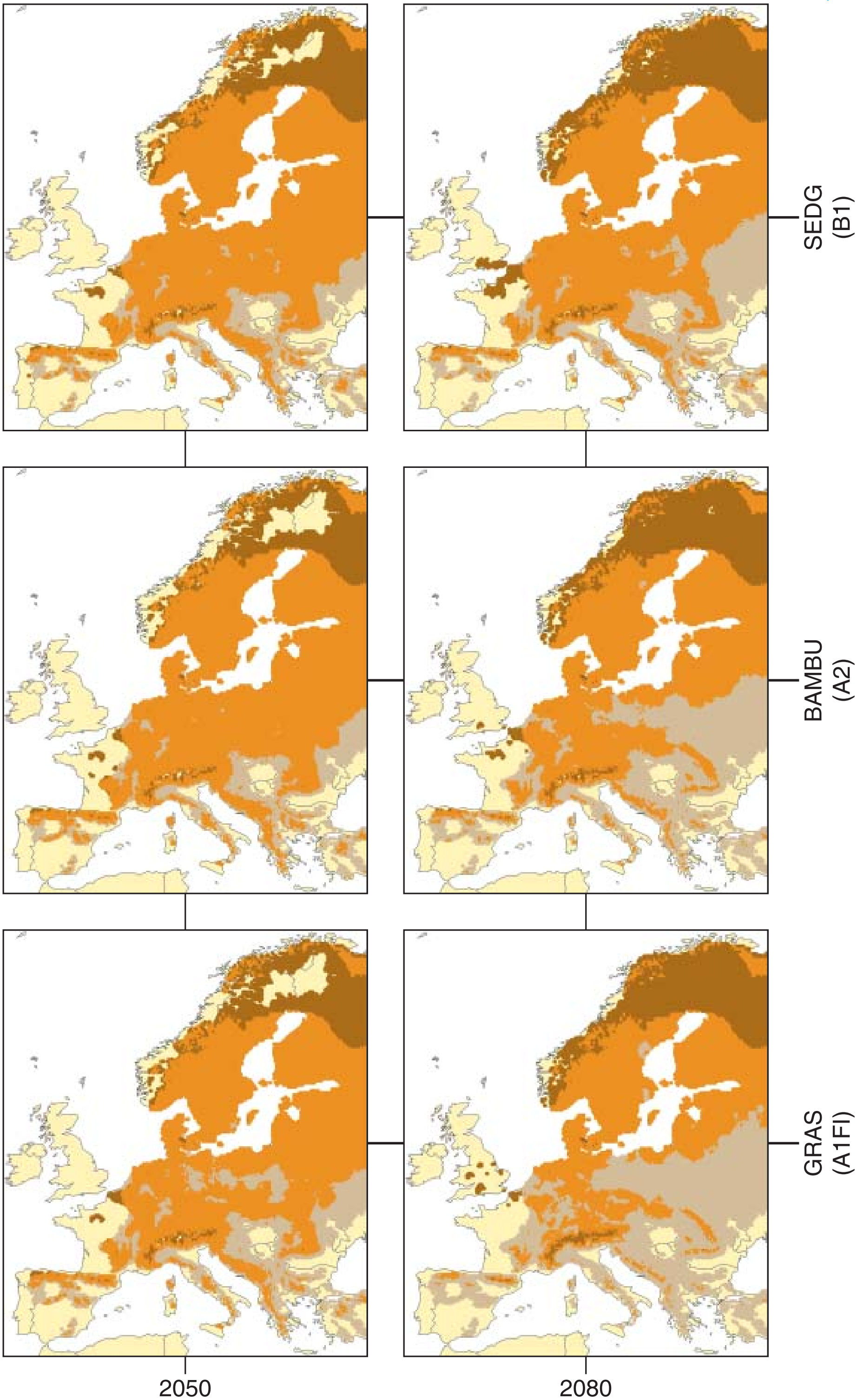
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.76). Climate risk category: LR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG (B1)
BAMBU (A2)
GRAS (A1FI)
2050
2080

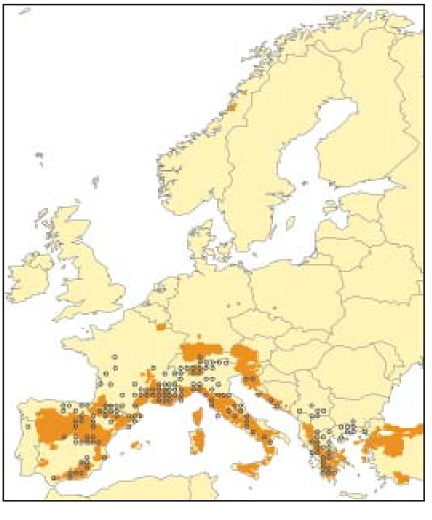
Polyommatus escheri (Hübner, 1823) – Escher's Blue

		Full dispersal	No dispersal
2050	SEDG	-889 (-38.48%)	-1562 (-67.62%)
	BAMBU	-1061 (-45.93%)	-1633 (-70.69%)
	GRAS	-1243 (-53.81%)	-1873 (-81.08%)
2080	SEDG	-788 (-34.11%)	-1988 (-86.06%)
	BAMBU	-1188 (-51.43%)	-2116 (-91.6%)
	GRAS	-1178 (-51%)	-2268 (-98.18%)

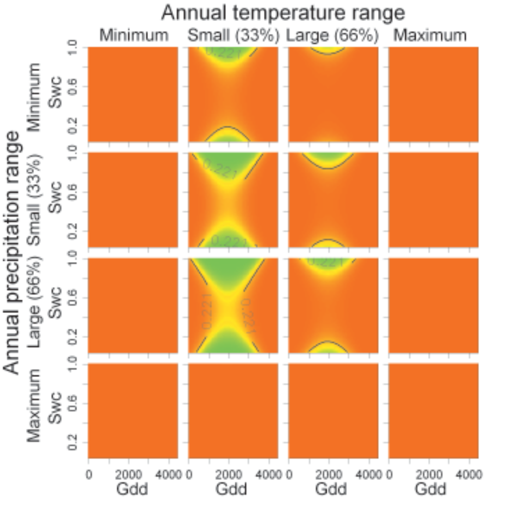
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2310)

Escher's Blue occurs on dry, and flower-rich grassland, damp rough vegetation, in flower-rich rocky places, on scrub and at woodland edges, and on agricultural land. The females lay their eggs singly on milk-vetches (*Astragalus* spp.), in particular *A. monspessulanus*. *Qxytropis helvetica* may also be a foodplant. When still small, the caterpillar goes into hibernation, and in the spring completes its growth, feeding on the leaves and flowerbuds of the foodplants. When fully grown, it leaves the foodplant and pupates under stones. Both caterpillars and pupae are attended by ants of different genera including *Myrmica*, *Formica*, *Lasius* and *Plagiolepis*. Escher's Blue is single-brooded. It hibernates as a larva.

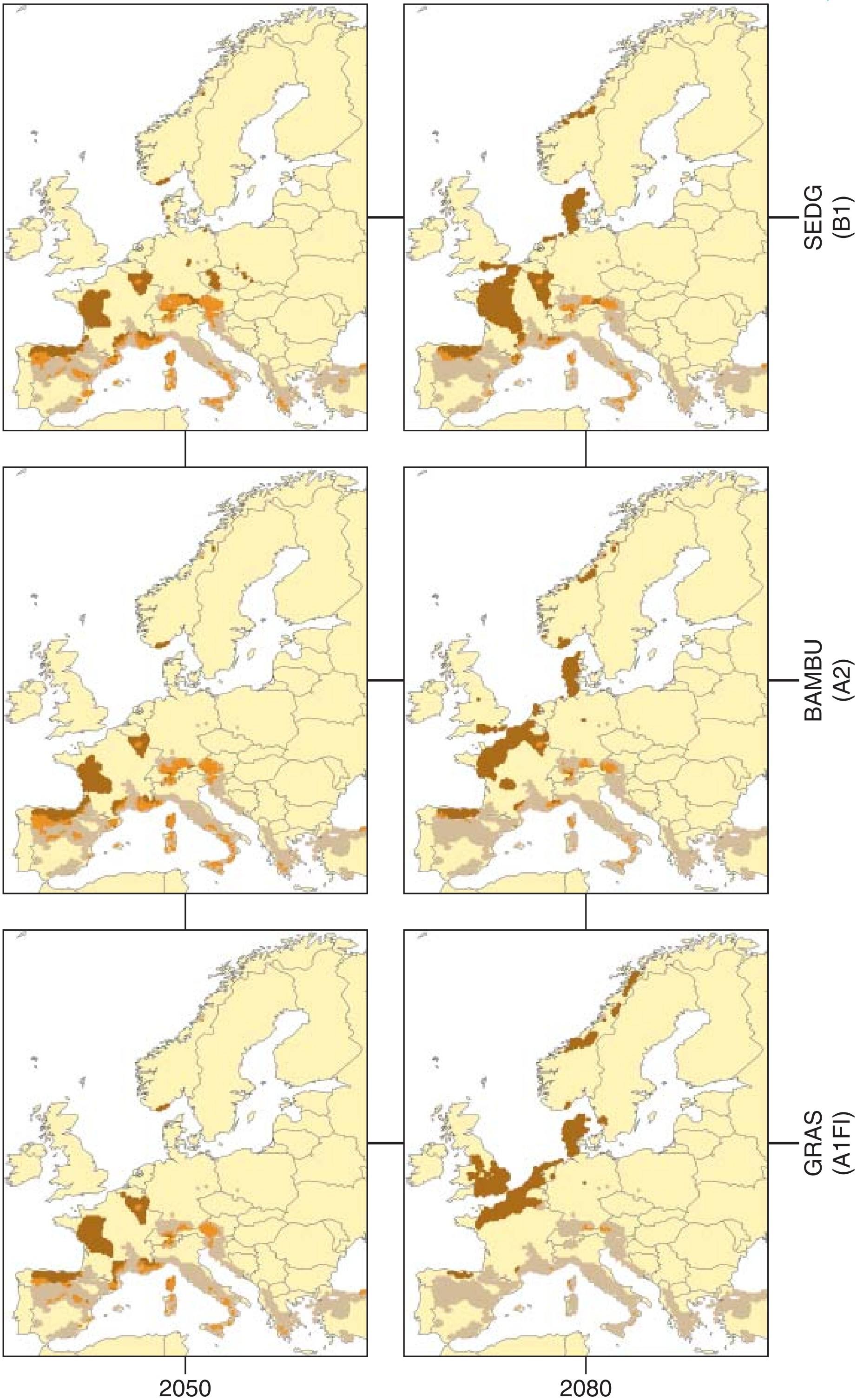
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.8).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Polyommatus dorylas ([Schiffermüller], 1775) – Turquoise Blue

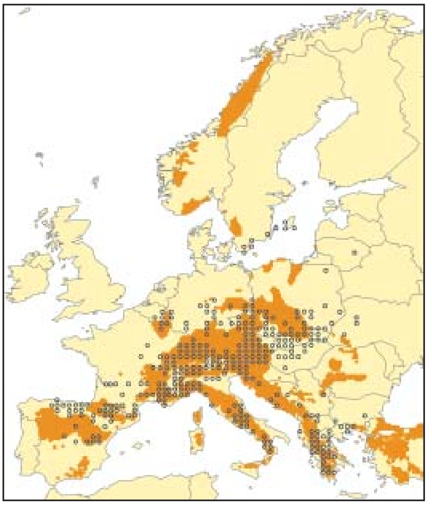
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-949 (-21%)	-2030 (-44.91%)
	BAMBU	-1526 (-33.76%)	-2328 (-51.5%)
	GRAS	-1804 (-39.91%)	-2684 (-59.38%)
2080	SEDG	-372 (-8.23%)	-2706 (-59.87%)
	BAMBU	-1383 (-30.6%)	-3262 (-72.17%)
	GRAS	-1903 (-42.1%)	-3725 (-82.41%)

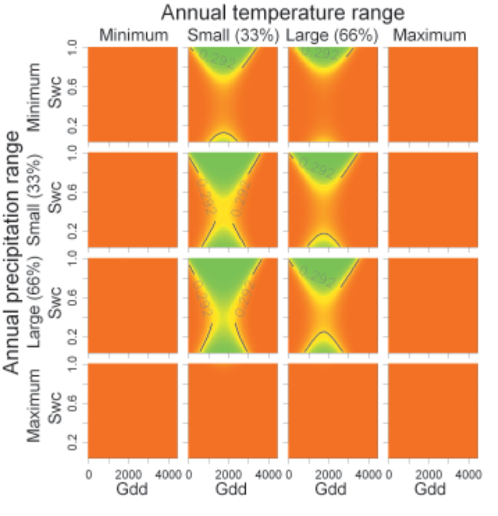
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 4520)

The Turquoise Blue likes the warmth, occurring on dry, flower-rich slopes and calcareous grassland, often where there is shelter from a wood or from bushes. The butterflies are nearly always seen on calcareous ground. The populations are usually small in mountainous areas. The female lays her eggs on Kidney-vetch (*Anthyllis vulneraria*), depositing them onto the underside of the leaves and also on the sepals. The newly-hatched caterpillars feed by scraping off the undermost layer of cells, so making little "windows" in the leaves. Later, they feed on the whole leaf. They are attended by various ant species, including those belonging to the genera *Myrmica, Lasius,* and *Formica.* The caterpillars pupate in the litter layer. The Turquoise Blue mostly has two generations, but at higher altitudes and in the north of its range, it is single-brooded. Hibernation takes place as a small larva.

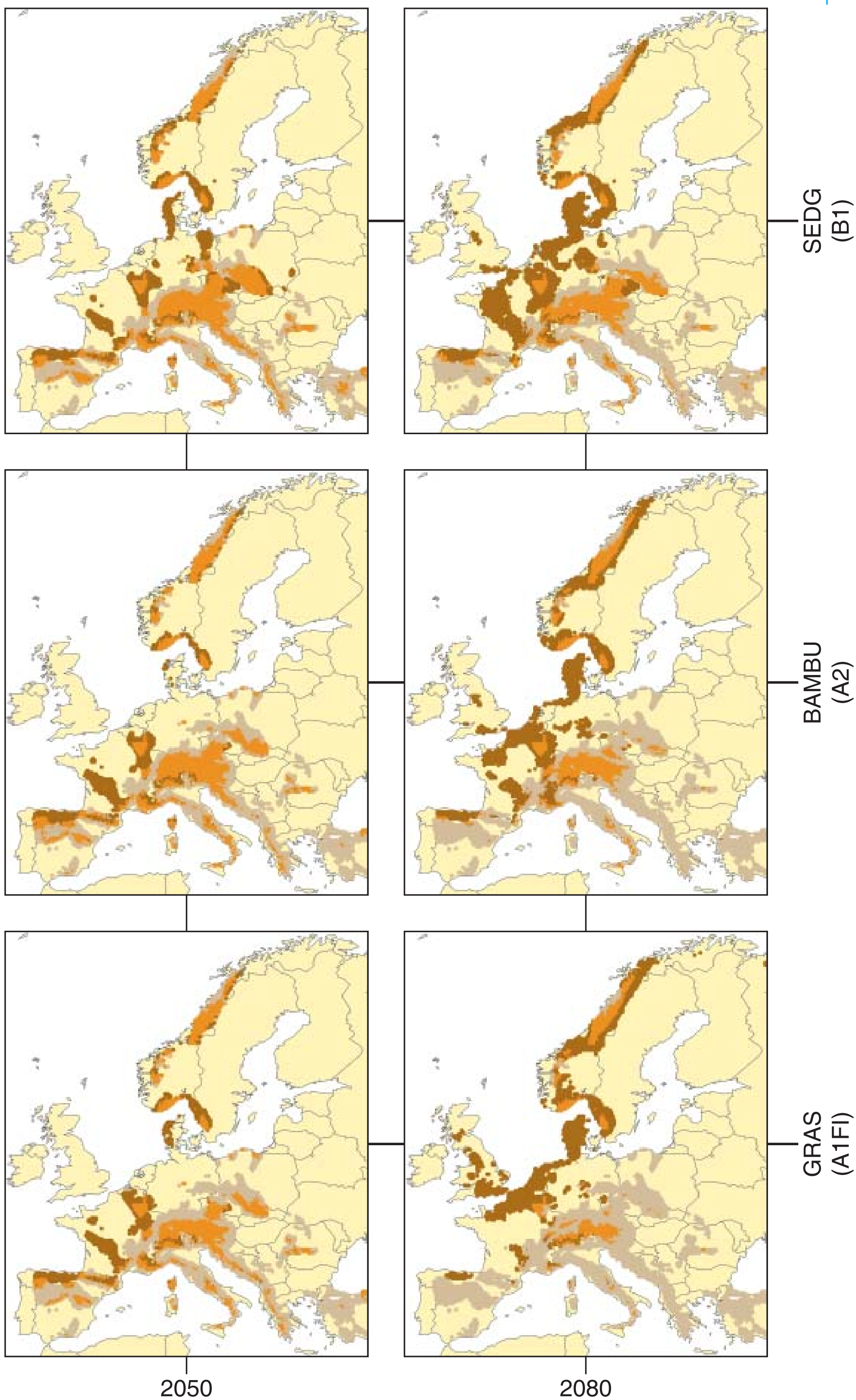
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.81).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Polyommatus nivescens (Keferstein, 1851) – Mother-of-pearl Blue

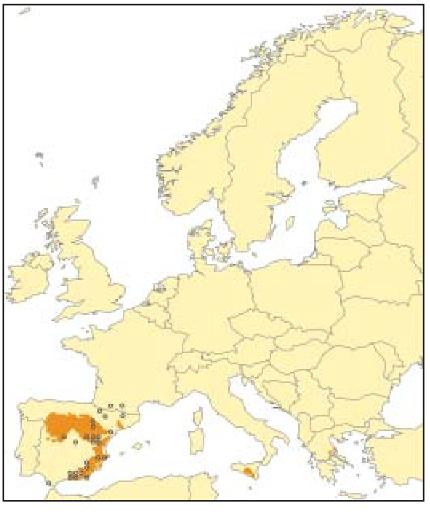
© Hermann Haas

		Full dispersal	No dispersal
2050	SEDG	-378 (-80.94%)	-392 (-83.94%)
	BAMBU	-434 (-92.93%)	-434 (-92.93%)
	GRAS	-446 (-95.5%)	-448 (-95.93%)
2080	SEDG	-466 (-99.79%)	-466 (-99.79%)
	BAMBU	-467 (-100%)	-467 (-100%)
	GRAS	-467 (-100%)	-467 (-100%)

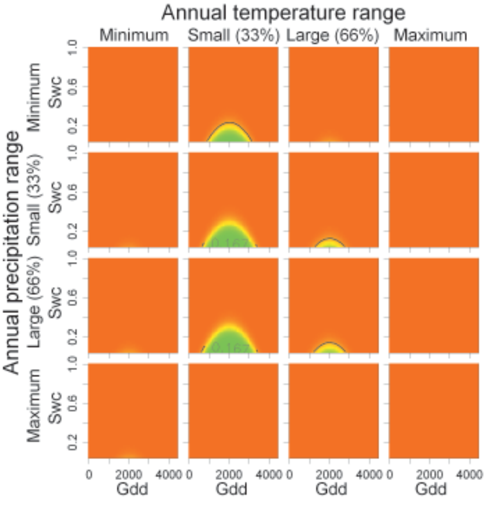
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 467)

The Mother-of-pearl Blue occurs in flower-rich grasslands and on warm, dry chalk rocks with scattered patches of grassy vegetation and an occasional bush. The female lays her eggs on the leaves of Kidney-vetch (*Anthyllis vulneraria*), seeming to prefer smaller plants. Other leguminous plants, such as clovers (*Trifolium* spp.) and birdsfoot-trefoils (*Lotus* spp.) are possibly also used as foodplants. The small caterpillars go into hibernation, and after feeding and growing further, they pupate at the end of the spring on the ground. The caterpillars are attended by ants of the species *Tapinoma erraticum*. The Mother-of-pearl Blue has one generation a year.

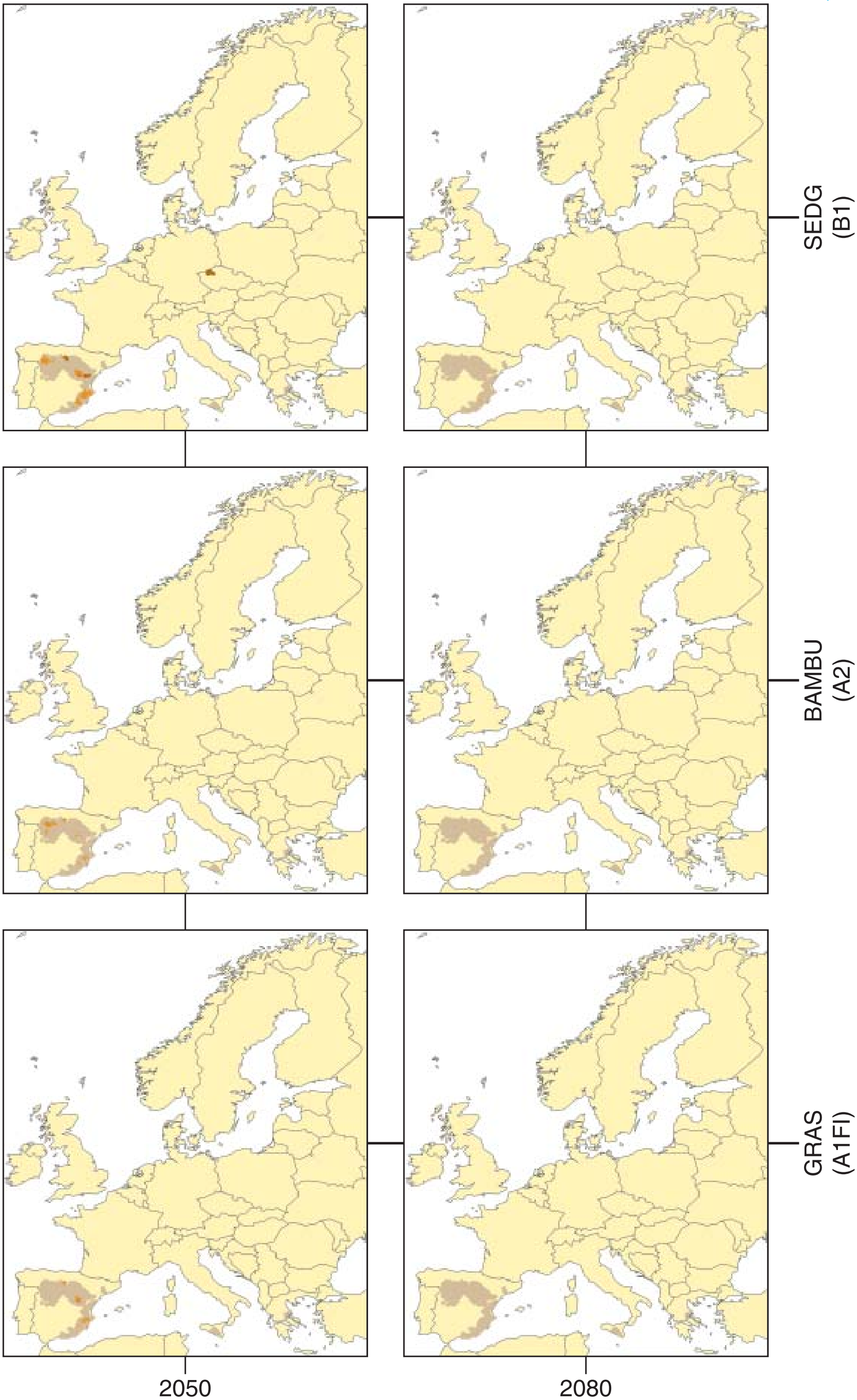
Present distribution can be very well explained by climatic variables (AUC = 0.98).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Polyommatus amandus (Schneider, 1792) – Amanda's Blue

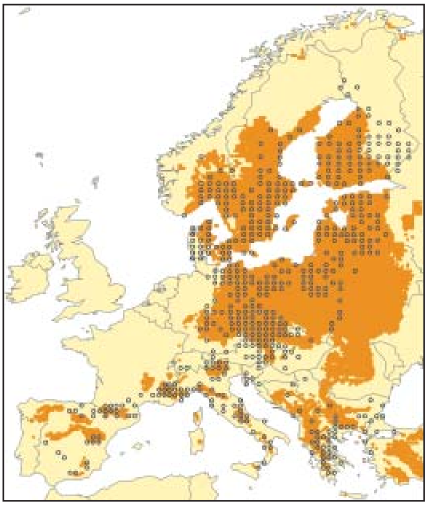
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-2889 (-28.64%)	-3583 (-35.52%)
	BAMBU	-5353 (-53.07%)	-5575 (-55.27%)
	GRAS	-4505 (-44.66%)	-5013 (-49.7%)
2080	SEDG	-6907 (-68.47%)	-7321 (-72.58%)
	BAMBU	-8257 (-81.86%)	-8426 (-83.53%)
	GRAS	-8935 (-88.58%)	-9088 (-90.1%)

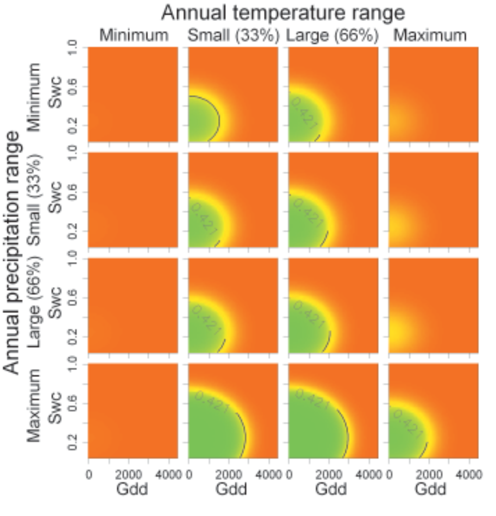
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 10087)

The German name for this butterfly, "Prächtiger Blauling" (Magnificent Blue), is well chosen, if only for the colour of the males. They are a bright sky-blue, and they also attract attention by their territorial behaviour. The females' are modest brown in most of their distribution area and have a greenish-blue sheen. Amanda's Blue occurs on flower-rich grassland with damp patches, that has some shelter from bushes or a nearby woodland edge. The female lays her eggs on the leaves of vetches (*Vicia* spp.) and possibly also vetchlings (*Lathyrus* spp.). The caterpillars hibernate in the litter layer and are attended by ants of the genera *Lasius, Myrmica, Formica,* and *Tapinoma*. They also pupate in the litter layer. Amanda's Blue is single-brooded.

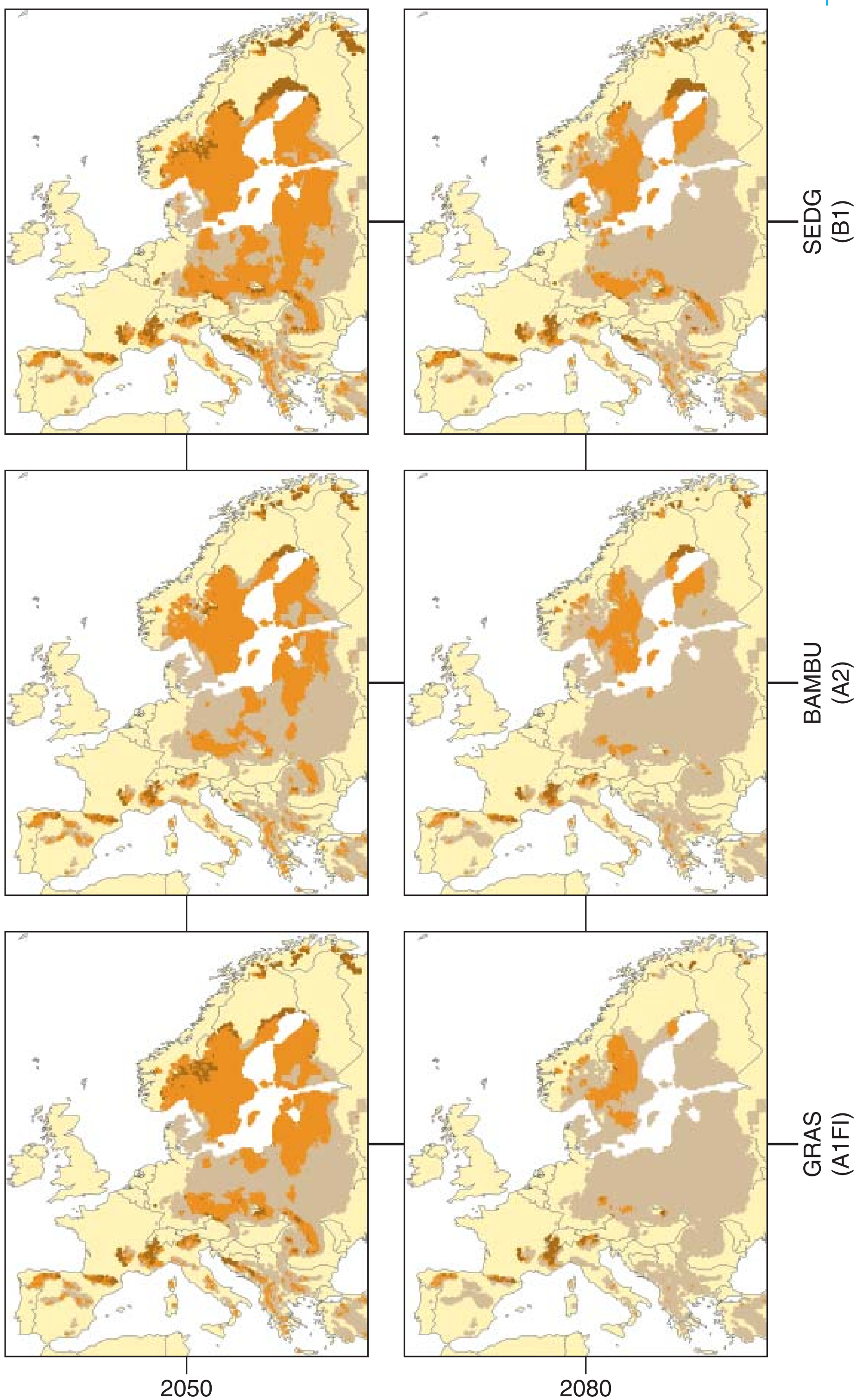
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.83).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Polyommatus thersites (Cantener, 1834) – Chapman's Blue

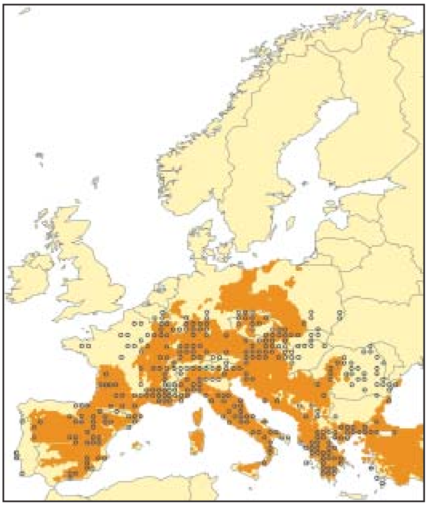
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	787 (11.31%)	-2140 (-30.75%)
	BAMBU	-278 (-3.99%)	-2569 (-36.92%)
	GRAS	-140 (-2.01%)	-2824 (-40.58%)
2080	SEDG	279 (4.01%)	-3388 (-48.69%)
	BAMBU	-746 (-10.72%)	-4622 (-66.42%)
	GRAS	-1437 (-20.65%)	-5673 (-81.52%)

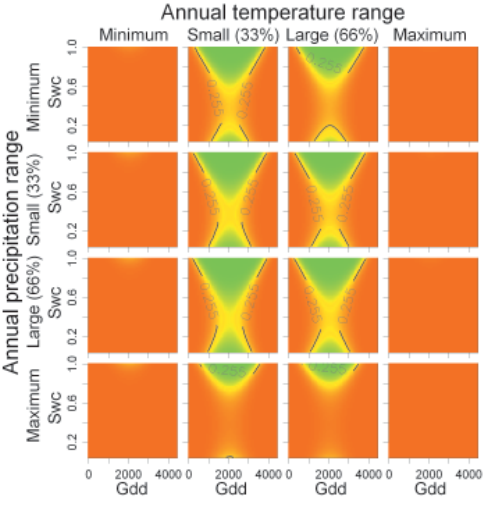
Changes in climatic niche distribution (in 10'×10' grid cells; present niche space: 6959)

The Chapman's Blue looks very much like the Common Blue (*P. icarus*). However, the two black spots in the cell on the underside of the forewing are absent. It occurs in warm, dry places, such as calcareous and poor grasslands, fields of sainfoin, and abandoned agricultural land. Eggs are laid on Sainfoin (*Onobrychis viciifolia*), and in Greece also on Cockscomb Sainfoin (*O. caput-galli*). The caterpillars feed on soft parts of the leaflets, leaving the veins. The small caterpillars go into hibernation, and in those parts of the range with hot climates, the egg or undeveloped larva possibly goes into aestivation. The caterpillars are attended by ants of the genera *Lasius, Formica, Myrmica,* and *Tapinoma,* and hide themselves in the litter layer and pupate. The Chapman's Blue usually has two generations a year, but in the south of the range also three.

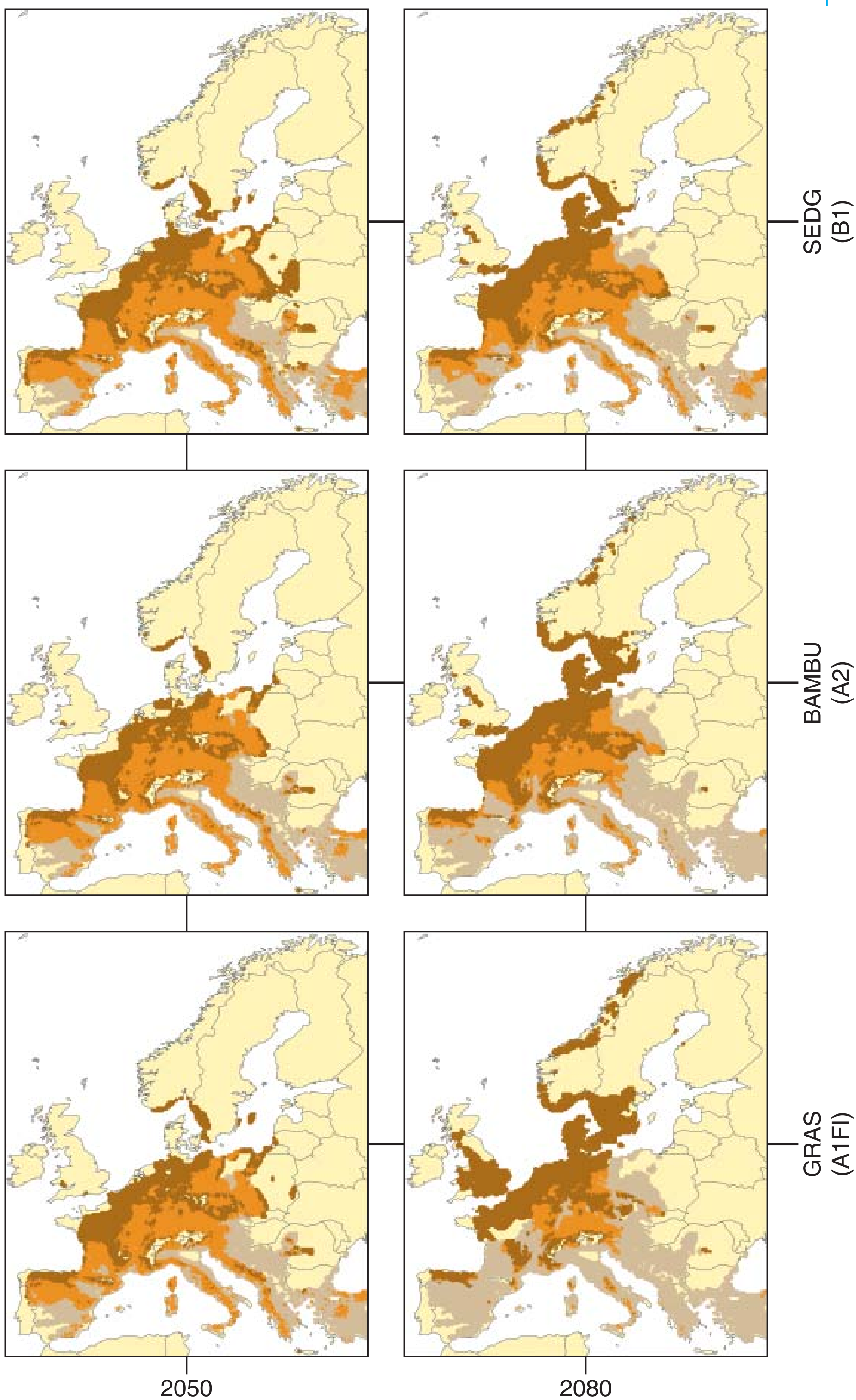
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.75). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Polyommatus icarus (Rottemburg, 1775) – Common Blue

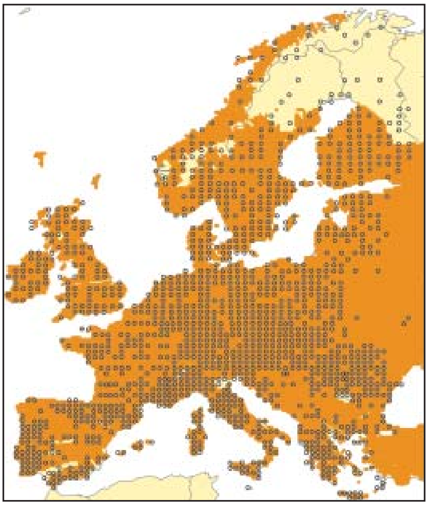
© Martin Wiemers

		Full dispersal	No dispersal
2050	SEDG	-1508 (-5.96%)	-3252 (-12.84%)
	BAMBU	-2902 (-11.46%)	-3836 (-15.15%)
	GRAS	-3054 (-12.06%)	-4374 (-17.27%)
2080	SEDG	-2279 (-9%)	-5242 (-20.7%)
	BAMBU	-5208 (-20.57%)	-7950 (-31.4%)
	GRAS	-7231 (-28.56%)	-10608 (-41.9%)

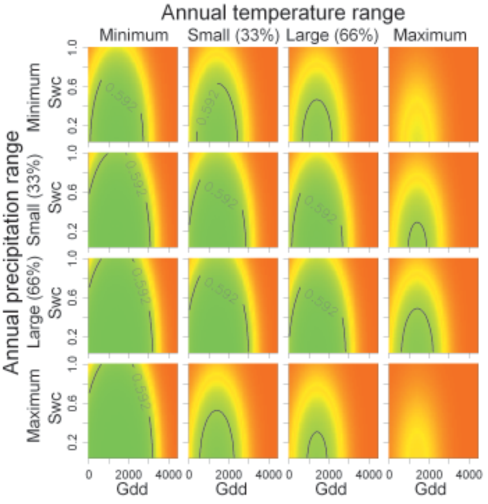
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 25320)

The Common Blue is a very common butterfly. It looks rather like Chapman's Blue (*P. thersites*), but the two black spots on the underside of its front wings distinguish it in most specimens. It can be found on most types of grassy vegetation, ranging from quite dry, poor grassland to moderately damp meadows. The female lays her eggs on a variety of leguminous plants, including Common Birdsfoot–trefoil (*Lotus corniculatus*). The caterpillars feed on the leaves. They are attended by ants of the genera *Lasius, Formica, Myrmica, Tapinoma,* and *Plagiolepis*. When half-grown, the caterpillars may hibernate in the litter layer. In hot climates, aestivation possibly also takes place, in the egg or larval stage. The caterpillars pupate in the litter layer. Depending on the geographical position and altitude of the breeding ground, the Common Blue has one to three (or even more) generations a year.

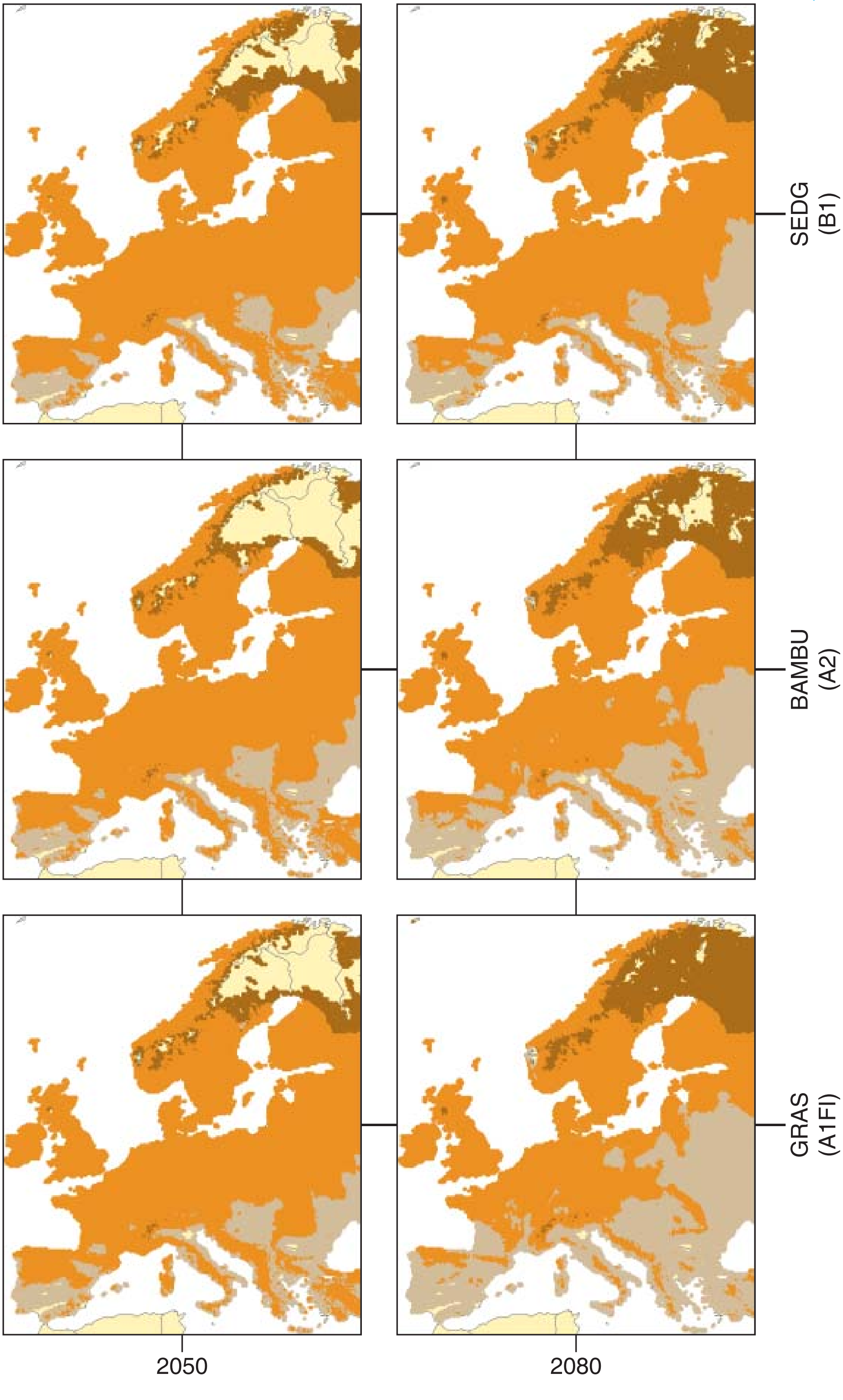
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.65). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Polyommatus eros (Ochsenheimer, 1808) – Eros Blue

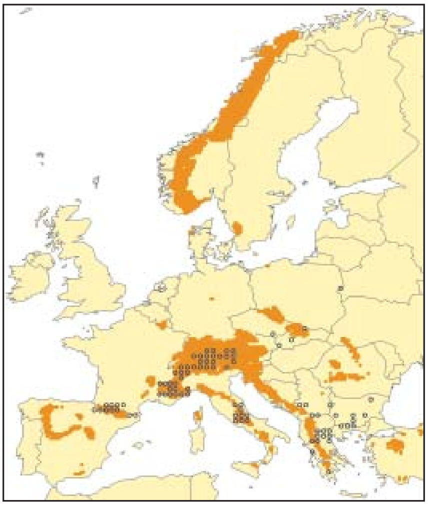
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-880 (-33.2%)	-1087 (-41%)
	BAMBU	-968 (-36.51%)	-1130 (-42.63%)
	GRAS	-1162 (-43.83%)	-1322 (-49.87%)
2080	SEDG	-1071 (-40.4%)	-1530 (-57.71%)
	BAMBU	-1167 (-44.02%)	-1570 (-59.22%)
	GRAS	-1399 (-52.77%)	-1855 (-69.97%)

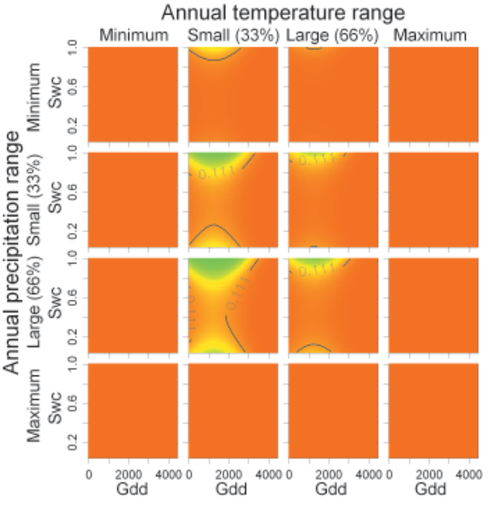
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2651)

The Eros Blue is a mountain butterfly occurring on sub-alpine and alpine grasslands, on rocky places with flower-rich vegetation and on scree slopes. Purple Beaked Milk-vetch (*Oxytropis halleri*) and *O. fetida* are probably the major foodplants but other leguminous plants such as *Astragalus sempervirens, A. leontinus*, and Common Birdsfoot-trefoil (*Lotus corniculatus*) have also been named. The caterpillars feed on the leaves of the foodplant and hibernate on it. In spring, they grow further and when fully grown, pupate at the foot of the foodplants. They are attended by ants of the genera *Myrmica*, *Formica* and *Camponotus*. The Eros Blue has one generation a year.
Polyommatus eroides, which is listed in the Annexes II and IV of the Habitats' Directive, is also is included here.

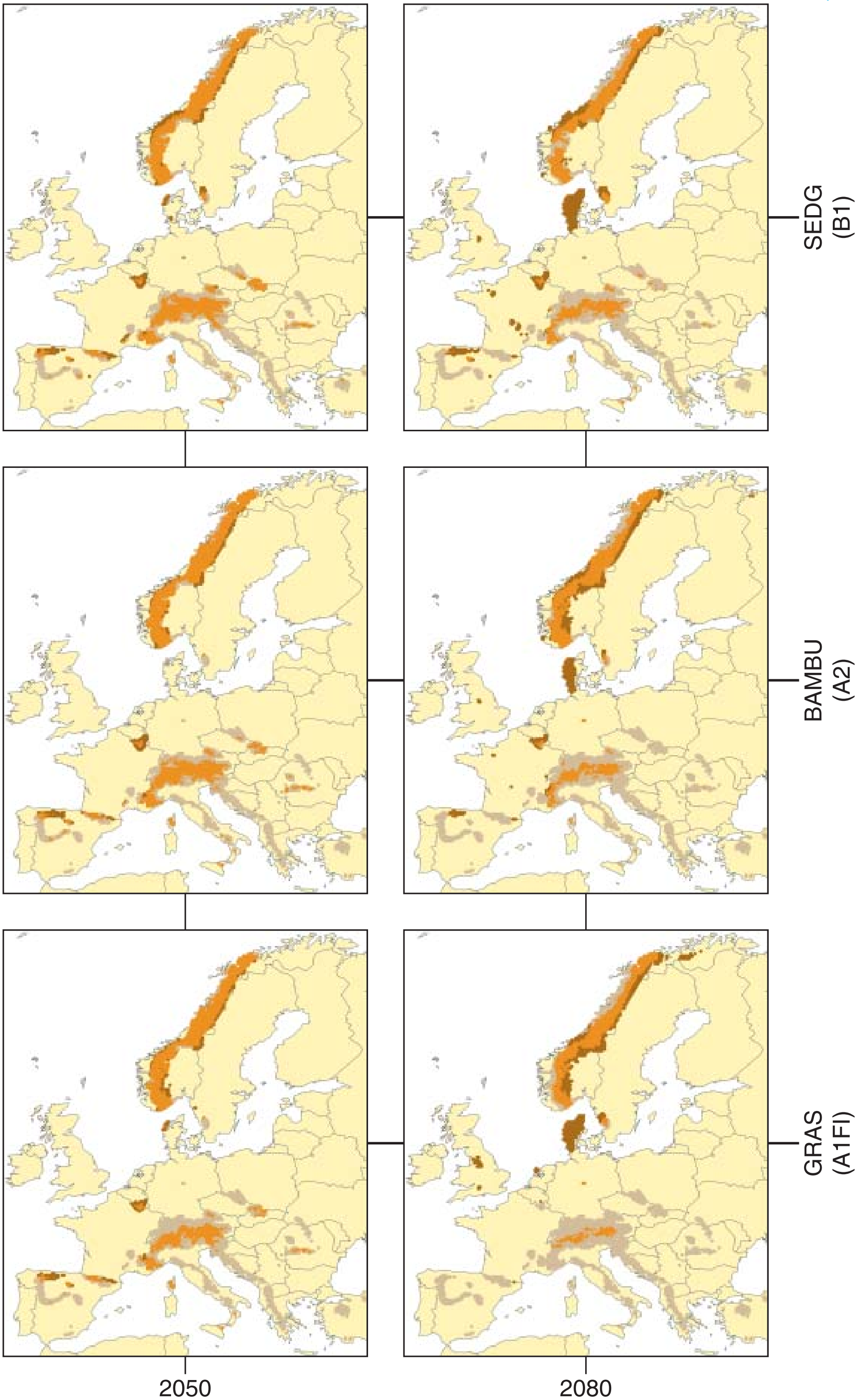
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.71).
Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold



SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Polyommatus daphnis ([Schiffermüller], 1775) – Meleager's Blue

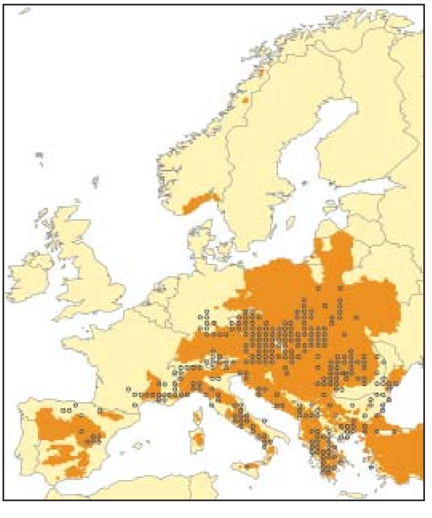
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-599 (-7.06%)	-2243 (-26.44%)
	BAMBU	-3054 (-36%)	-3575 (-42.14%)
	GRAS	-2615 (-30.83%)	-3487 (-41.11%)
2080	SEDG	-2162 (-25.49%)	-4723 (-55.68%)
	BAMBU	-4525 (-53.34%)	-6338 (-74.71%)
	GRAS	-3937 (-46.41%)	-7016 (-82.71%)

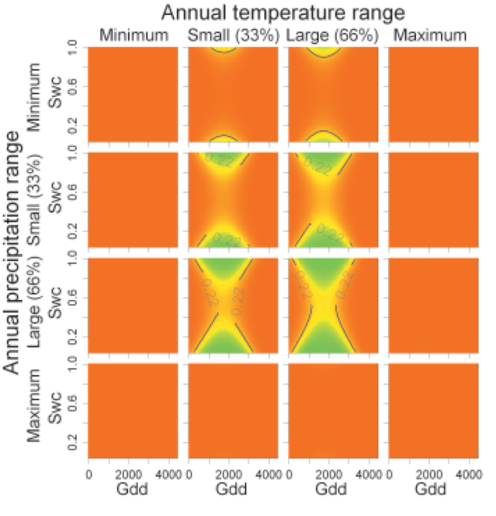
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 8483)

The Meleager's Blue is a local butterfly that occurs on poor, rough vegetation and poor grassland often near woods. The populations are usually small. The scalloped edge of the hindwing of the female distinguishes this species from all other blues. The female lays her eggs on Horseshoe Vetch (*Hippocrepis comosa*) and Crown Vetch (*Coronilla varia*), favouring plants that grow in the shade provided by rocks or woodland. The caterpillars are attended by ants, including species of *Lasius*, *Formica*, and *Tapinoma*. Either the egg or the small caterpillar hibernates, and pupation takes place in the litter layer. The Meleager's Blue has one generation a year.

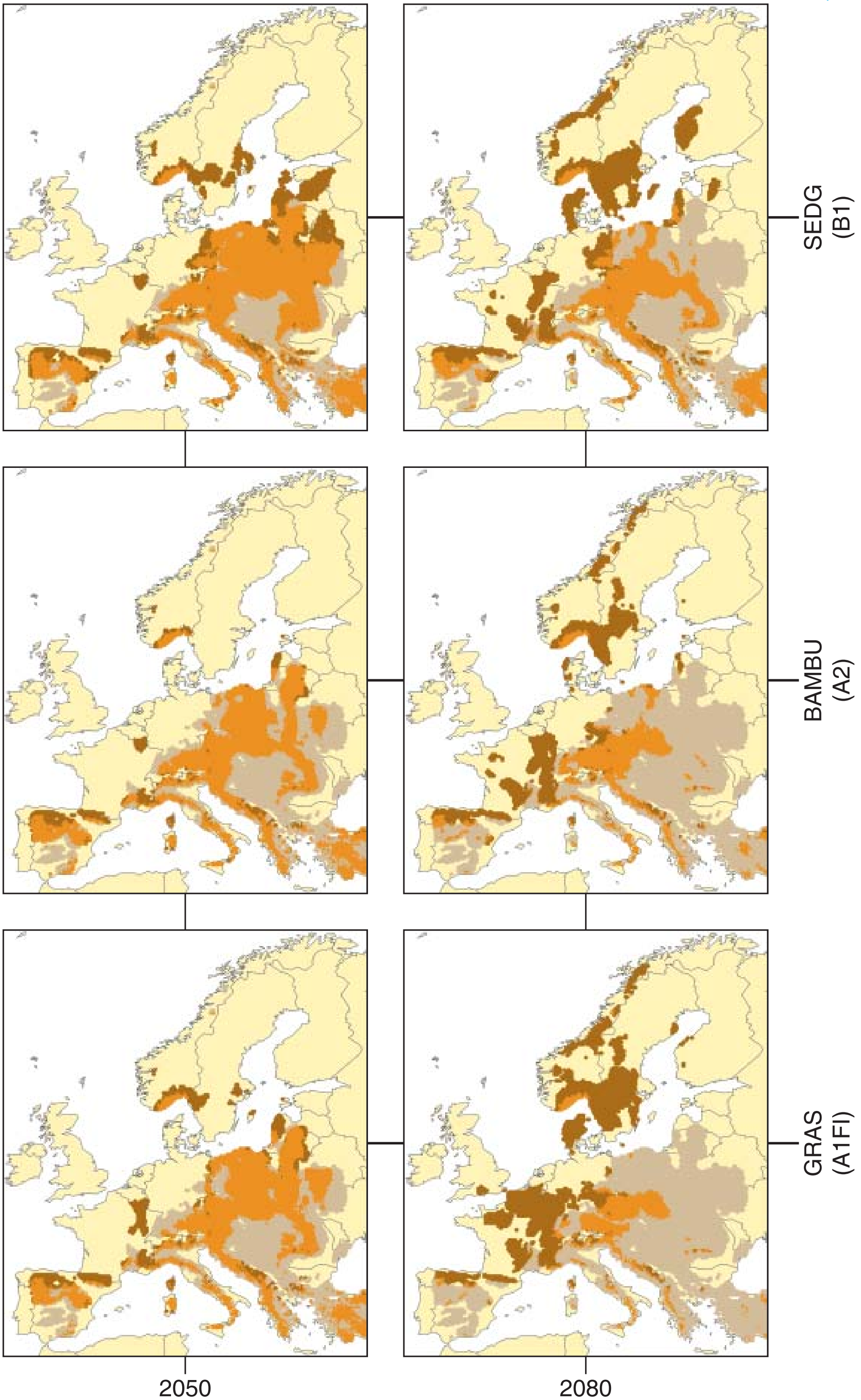
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.84).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Polyommatus bellargus (Rottemburg, 1775) – Adonis Blue

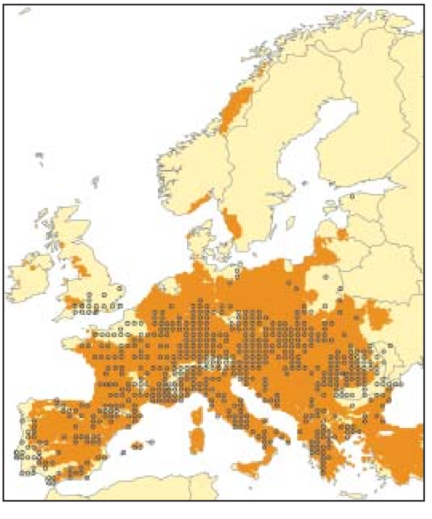
© Peter Ginzinger

		Full dispersal	No dispersal
2050	SEDG	1560 (12.74%)	-2047 (-16.72%)
	BAMBU	1018 (8.31%)	-2600 (-21.23%)
	GRAS	285 (2.33%)	-3061 (-25%)
2080	SEDG	411 (3.36%)	-3601 (-29.41%)
	BAMBU	-405 (-3.31%)	-5496 (-44.88%)
	GRAS	-1117 (-9.12%)	-6854 (-55.97%)

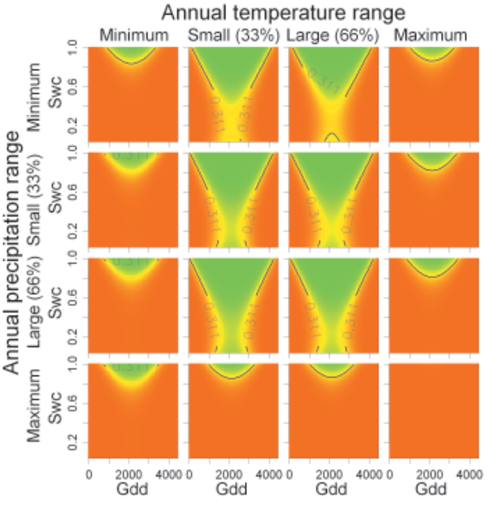
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 12245)

The Adonis Blue is found on calcareous soil on moderately to very sparse grassland, that is often sheltered by neighbouring woods or shrub. Its foodplants are Horseshoe Vetch (*Hippocrepis comosa*) and Crown Vetch (*Coronilla varia*), and the eggs are laid on the leaves. It pupates in the litter layer. The caterpillars are attended by ants of the genera *Myrmica, Lasius, Plagiolepis, Tetramorium, Formica,* and *Tapinoma.* The Adonis Blue usually has two generations a year, and the caterpillars of the second brood hibernate. There are also some single-brooded populations in the south of Greece.

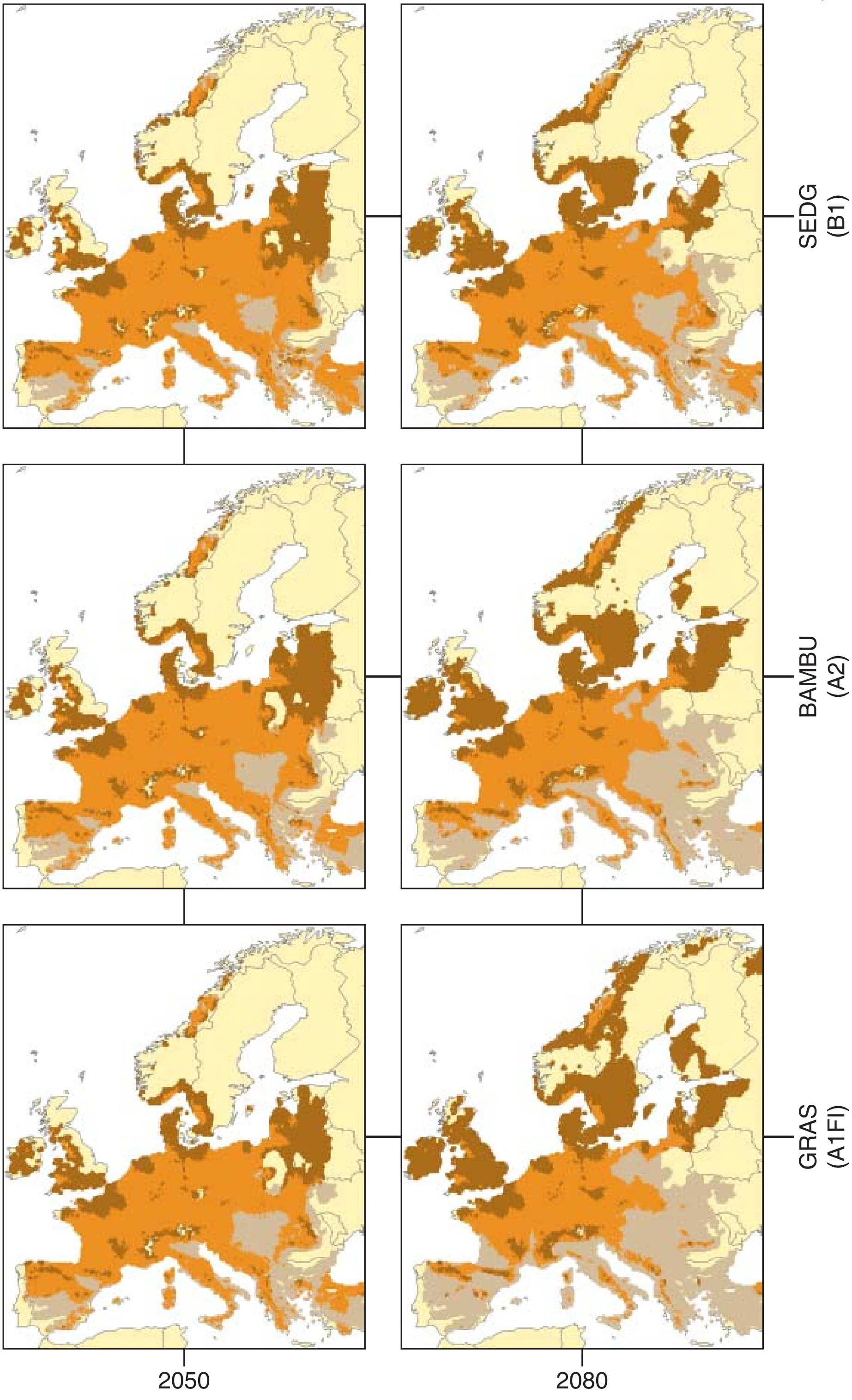
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.72). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Polyommatus coridon (Poda, 1761) – Chalkhill Blue

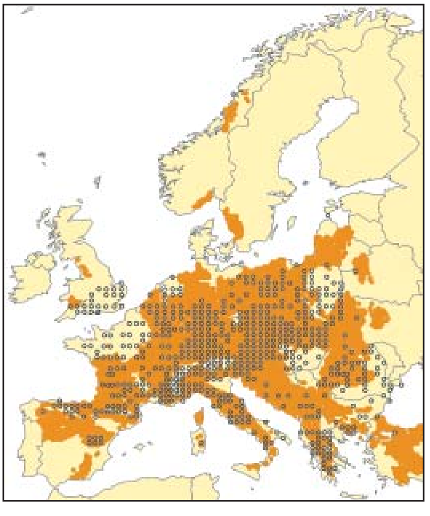
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	304 (3.45%)	-2524 (-28.66%)
	BAMBU	384 (4.36%)	-2645 (-30.04%)
	GRAS	-917 (-10.41%)	-3587 (-40.73%)
2080	SEDG	-501 (-5.69%)	-4088 (-46.42%)
	BAMBU	-838 (-9.52%)	-5197 (-59.02%)
	GRAS	-1527 (-17.34%)	-6483 (-73.62%)

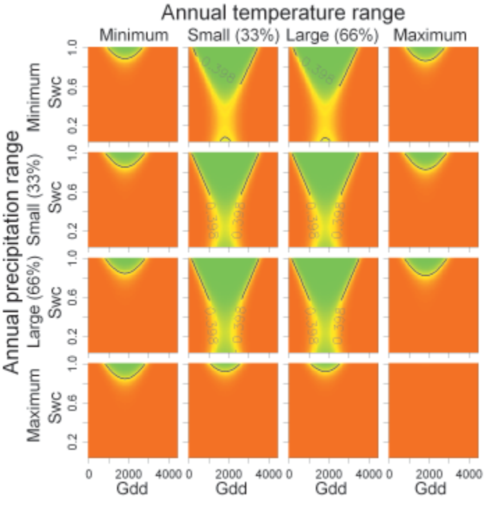
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 8806)

The Chalkhill Blue occurs on calcareous soil in dry, and flower-rich places with a short vegetation. They seem to prefer sheltered places. Sometimes, populations can be extremely large which is especially obvious in the late afternoon when the butterflies come together to roost. Hundreds of butterflies can be seen, their heads pointing downwards into the vegetation, wings upright, the light-coloured underwings gleaming in the evening sun. Horseshoe Vetch (*Hippocrepis comosa*) is its only foodplant, the female laying her eggs on the leaves. The eggs hibernate. The caterpillars are attended by ants of the genera *Myrmica, Lasius, Formica, Plagiolepis, Tetramorium, Aphaenogaster,* and *Tapinoma*. The Chalk-hill Blue pupates in the litter layer. It usually only has one generation a year.

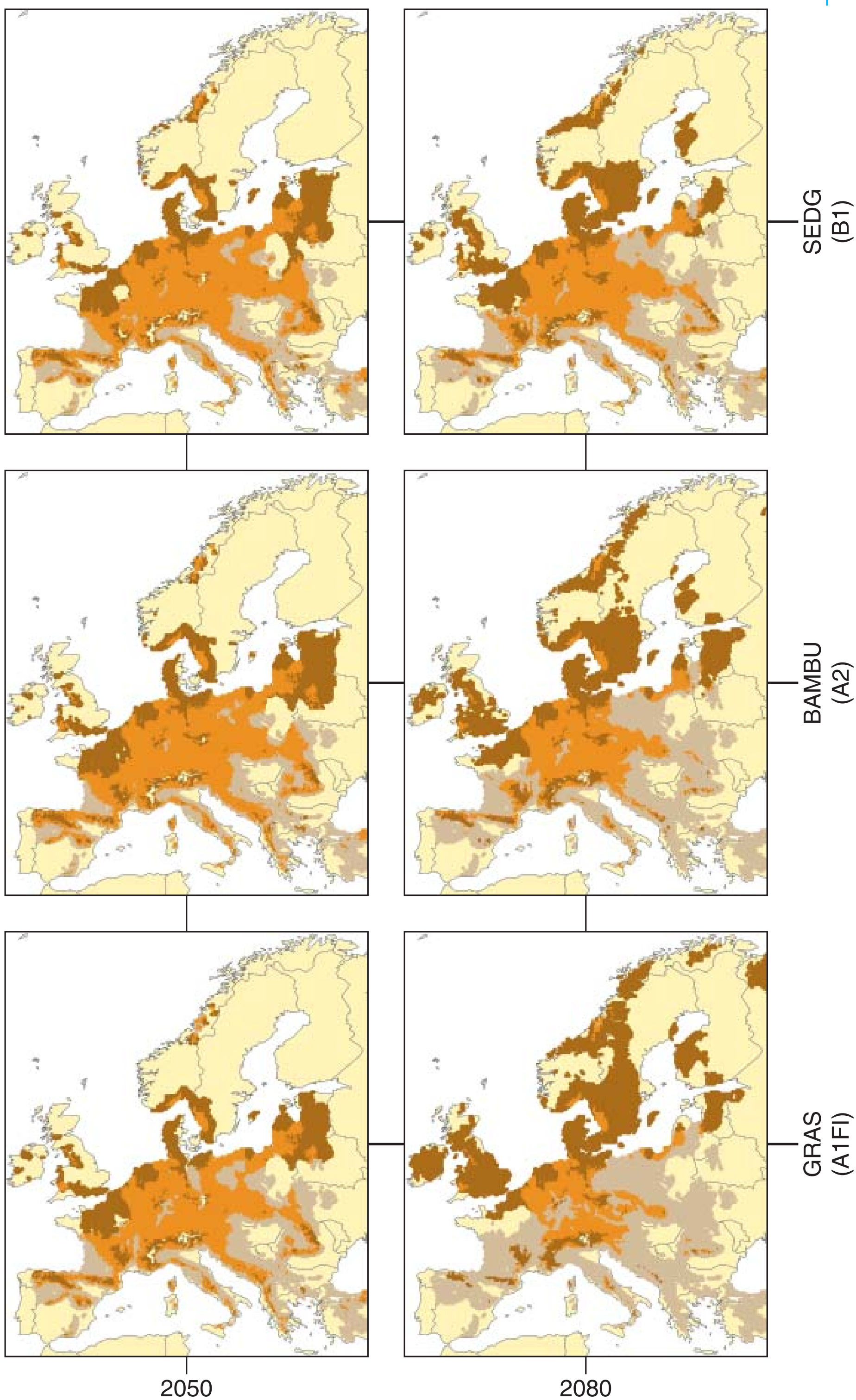
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.82).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Polyommatus hispanus (Herrich-Schäffer, 1851) – Provence Chalkhill Blue

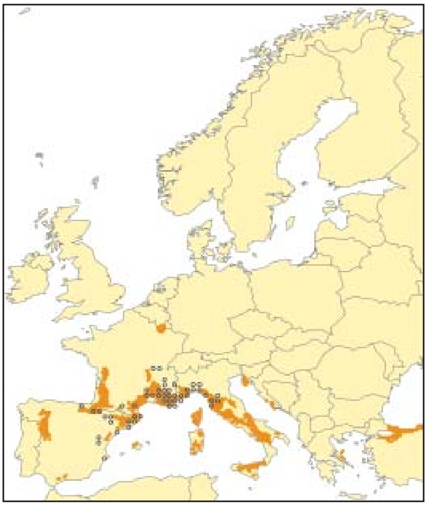
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	170 (21.46%)	-557 (-70.33%)
	BAMBU	68 (8.59%)	-559 (-70.58%)
	GRAS	145 (18.31%)	-608 (-76.77%)
2080	SEDG	500 (63.13%)	-656 (-82.83%)
	BAMBU	214 (27.02%)	-739 (-93.31%)
	GRAS	151 (19.07%)	-787 (-99.37%)

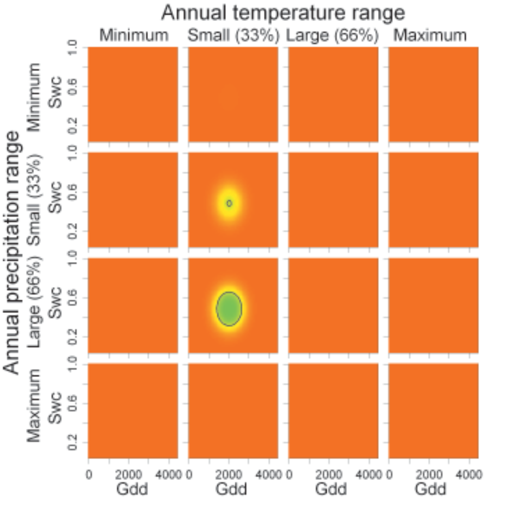
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 792)

The Provence Chalkhill Blue occurs on dry, calcareous soils covered with a flower-rich grassy vegetation, often with scattered bushes. Eggs are laid on Horseshoe-vetch (*Hippocrepis comosa*). The caterpillars are attended by ants of the genera *Plagiolepis* and *Crematogaster*. The Provence Chalkhill Blue has two generations a year and the butterflies can be seen as late as October.

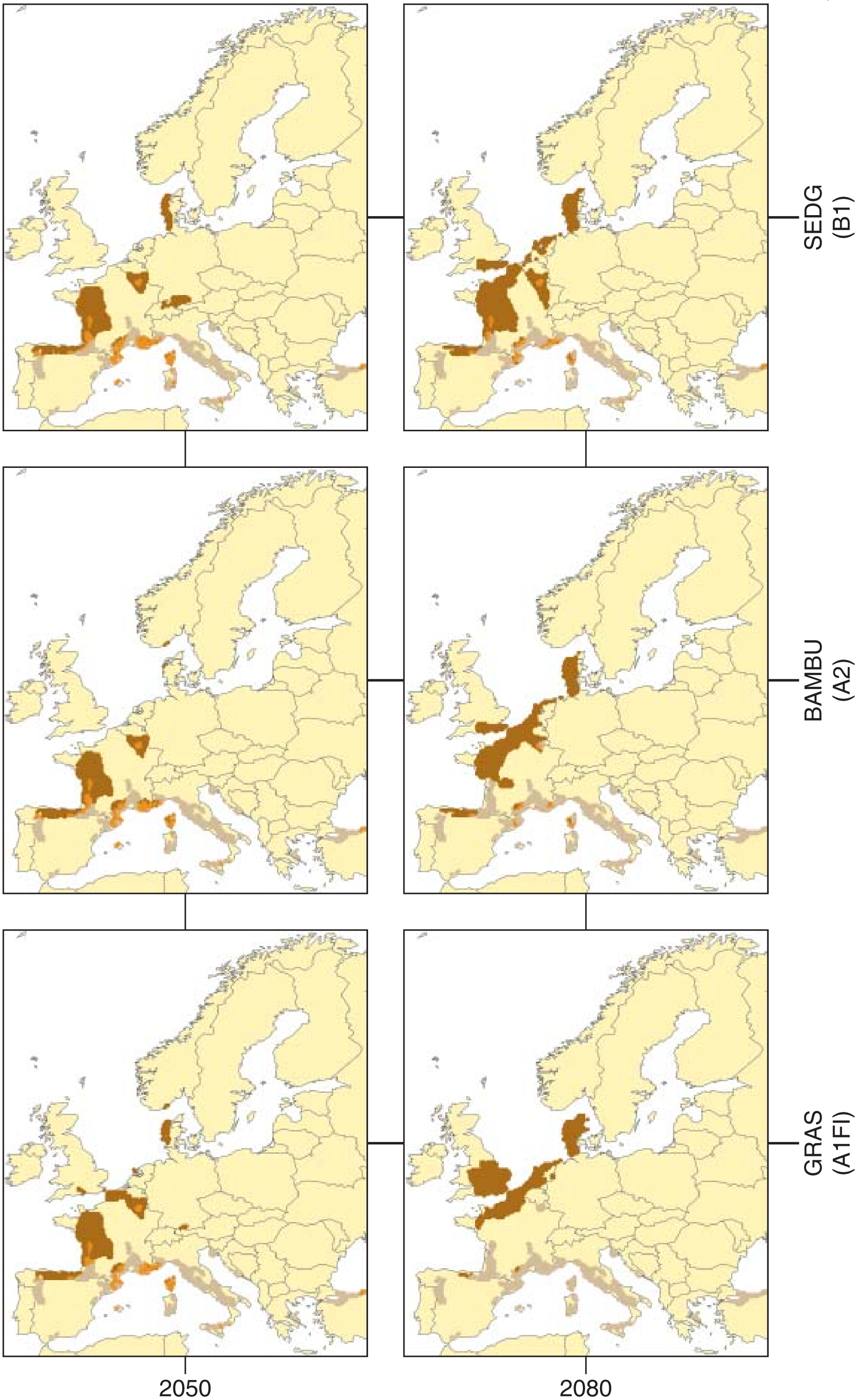
Present distribution can be well explained by climatic variables (AUC = 0.95).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Polyommatus albicans (Herrich-Schäffer, 1851) – Spanish Chalkhill Blue

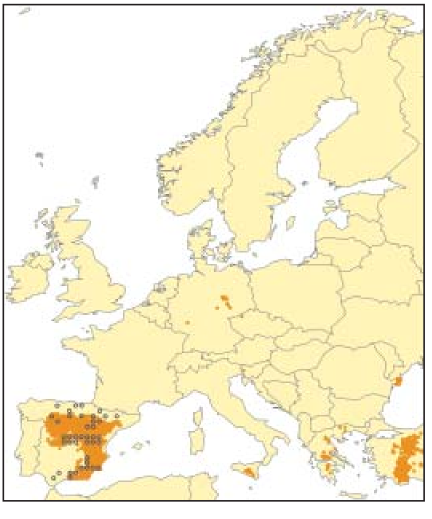
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-457 (-48.11%)	-598 (-62.95%)
	BAMBU	-691 (-72.74%)	-700 (-73.68%)
	GRAS	-498 (-52.42%)	-707 (-74.42%)
2080	SEDG	-924 (-97.26%)	-926 (-97.47%)
	BAMBU	-946 (-99.58%)	-950 (-100%)
	GRAS	-922 (-97.05%)	-950 (-100%)

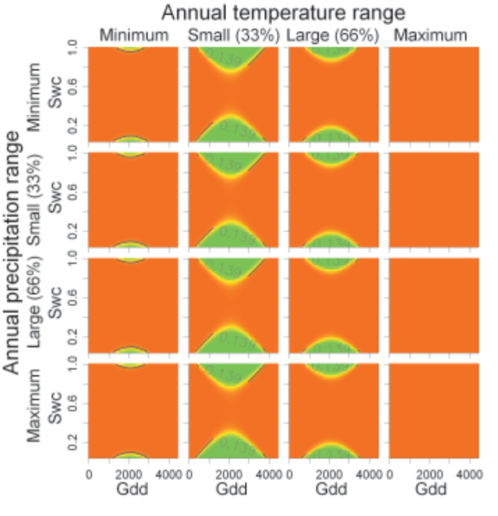
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 950)

The Spanish Chalkhill Blue can be seen in dry, calcareous rocky places with grassy vegetation, and in dry, open scrub. Its most important foodplant is Horseshoe Vetch (*Hippocrepis comosa*), although *H. multisiliquosa* is possibly also used. The female lays her eggs on the leaves. The caterpillars are often found accompanied by *Tapinoma* ants. This butterfly species is single-brooded.

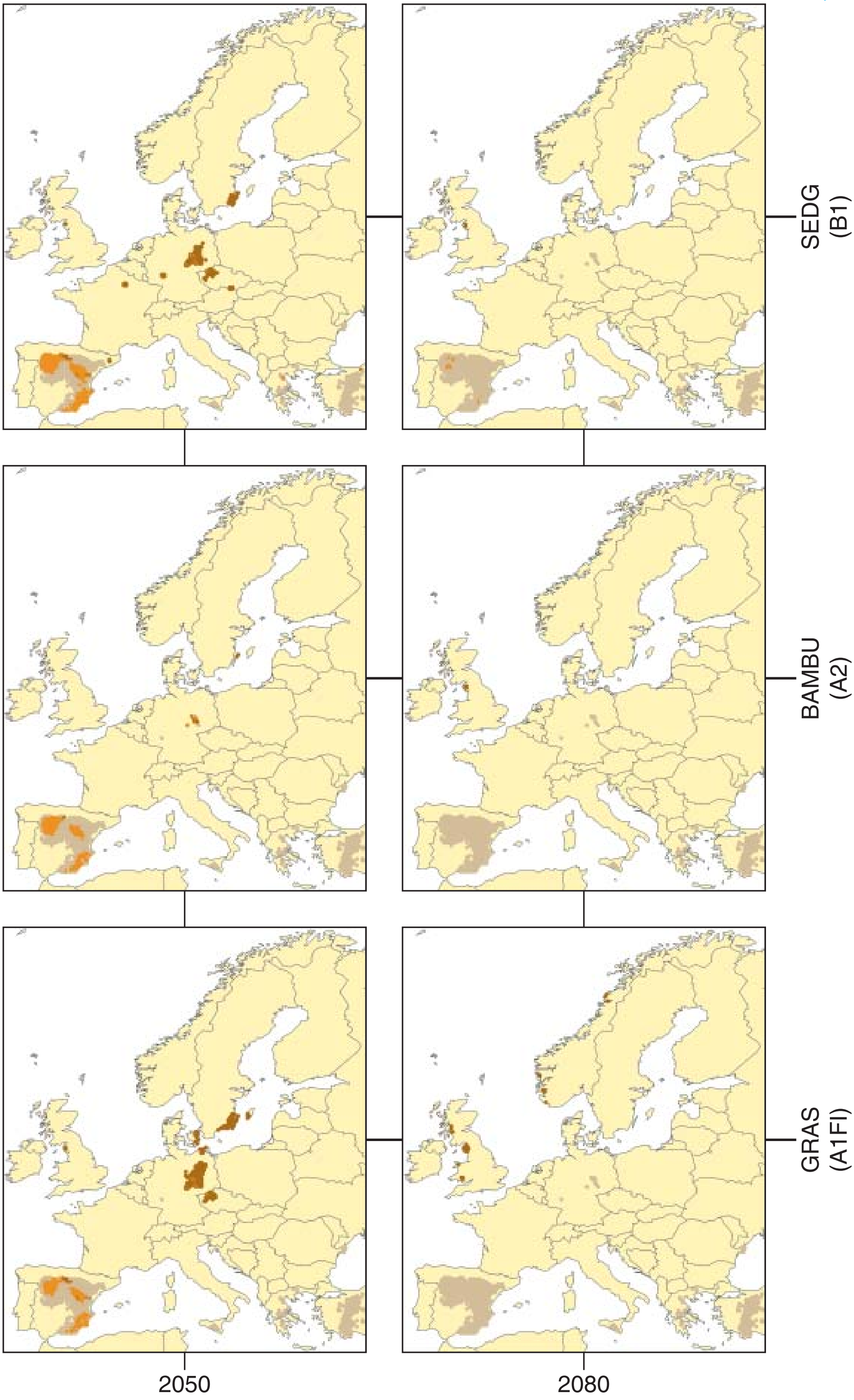
Present distribution can be well explained by climatic variables (AUC = 0.88).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Polyommatus admetus (Esper, 1785) – Anomalous Blue

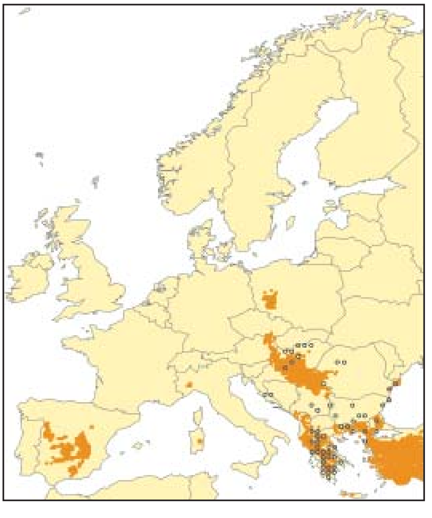
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	568 (36.96%)	-842 (-54.78%)
	BAMBU	-452 (-29.41%)	-1020 (-66.36%)
	GRAS	-39 (-2.54%)	-1076 (-70.01%)
2080	SEDG	-150 (-9.76%)	-1016 (-66.1%)
	BAMBU	-1004 (-65.32%)	-1357 (-88.29%)
	GRAS	-915 (-59.53%)	-1464 (-95.25%)

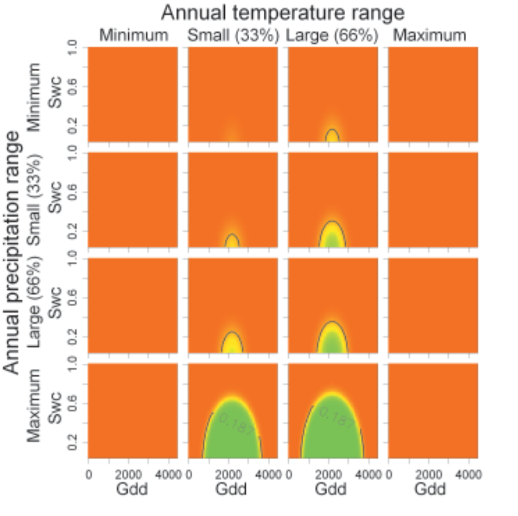
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 1537)

The Anomalous Blue occurs in woodland clearings, open scrub, on sheltered slopes and in agricultural areas. All the places are warm and have a flower-rich grassy vegetation. The females lay their eggs on the flowers of Sainfoin (*Onobrychis viciifolia*) and Cockscomb Sainfoin (*O. caput-galli*). The caterpillars are attended by ants of the genera *Crematogaster*, *Camponotus*, and *Tapinoma*. The Anomalous Blue has one generation a year and hibernation takes place on the ground, the small caterpillars hiding under stones.

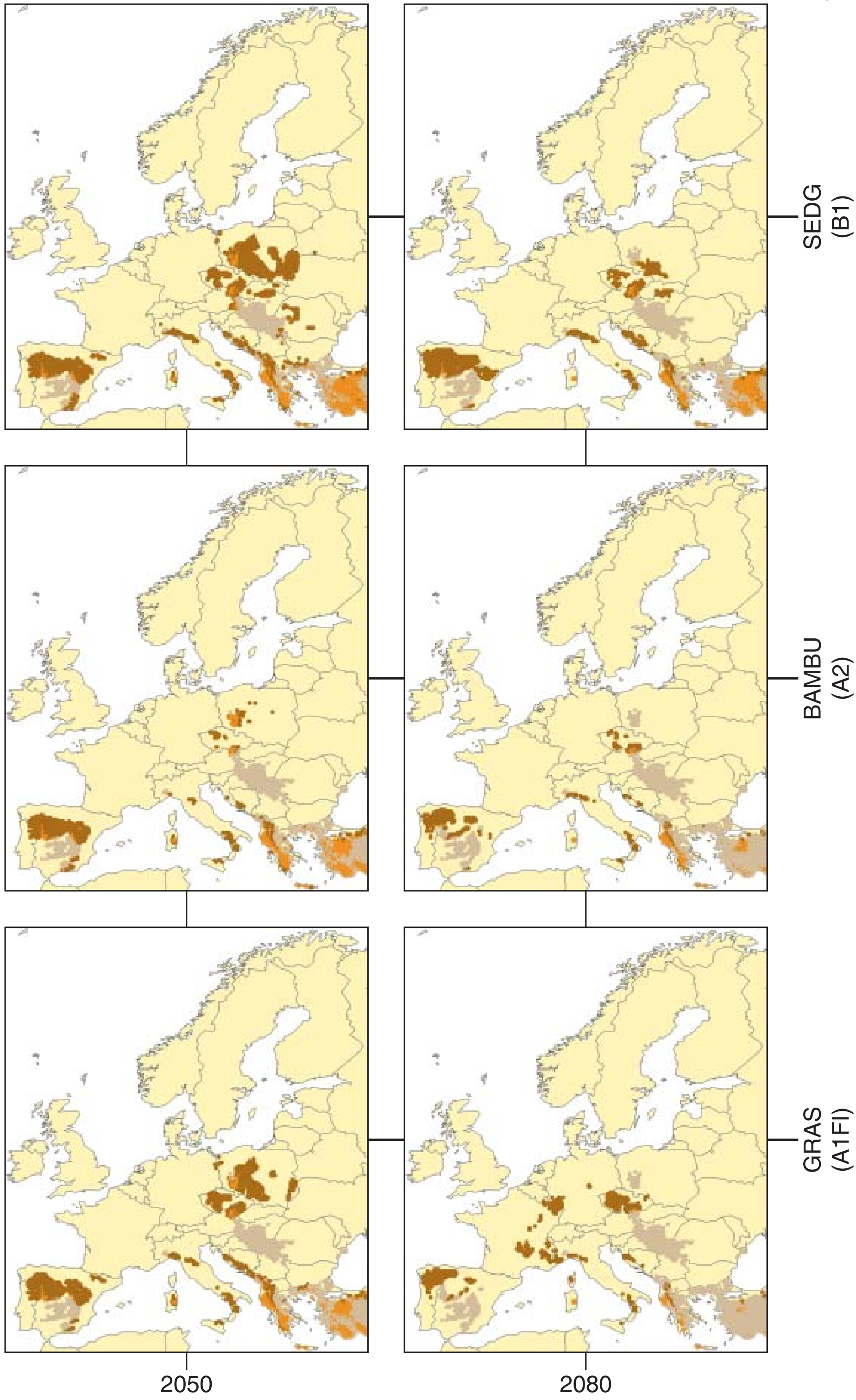
Present distribution can be well explained by climatic variables (AUC = 0.88).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Polyommatus ripartii (Freyer, 1830) – Ripart's Anomalous Blue

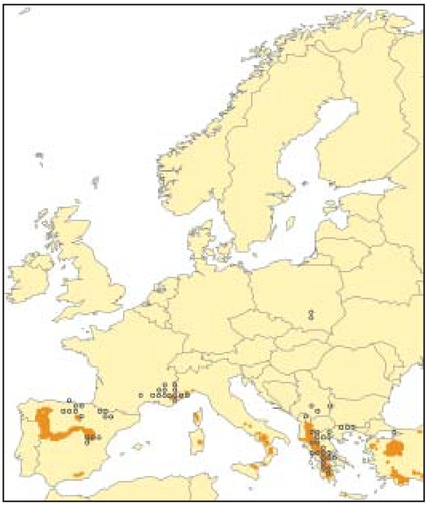
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-290 (-63.04%)	-336 (-73.04%)
	BAMBU	-342 (-74.35%)	-372 (-80.87%)
	GRAS	-349 (-75.87%)	-384 (-83.48%)
2080	SEDG	-359 (-78.04%)	-408 (-88.7%)
	BAMBU	-406 (-88.26%)	-433 (-94.13%)
	GRAS	-447 (-97.17%)	-456 (-99.13%)

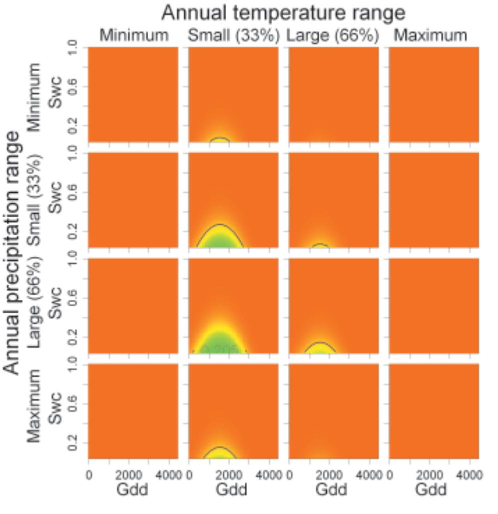
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 460)

Ripart's Anomalous Blue is mostly found on dry, grassy places with bushes. Different sainfoins are used as foodplant, such as Sainfoin (*Onobrychis viciifolia*), *O. arenaria*, Rock Sainfoin (*O. saxatilis*), and *O. alba*. The female lays her eggs on the flowers. The caterpillars hibernate when still small. They are often attended by ants of the genera *Crematogaster*, *Camponotus*, and *Lasius*. The Ripart's Anomalous Blue has one generation a year.

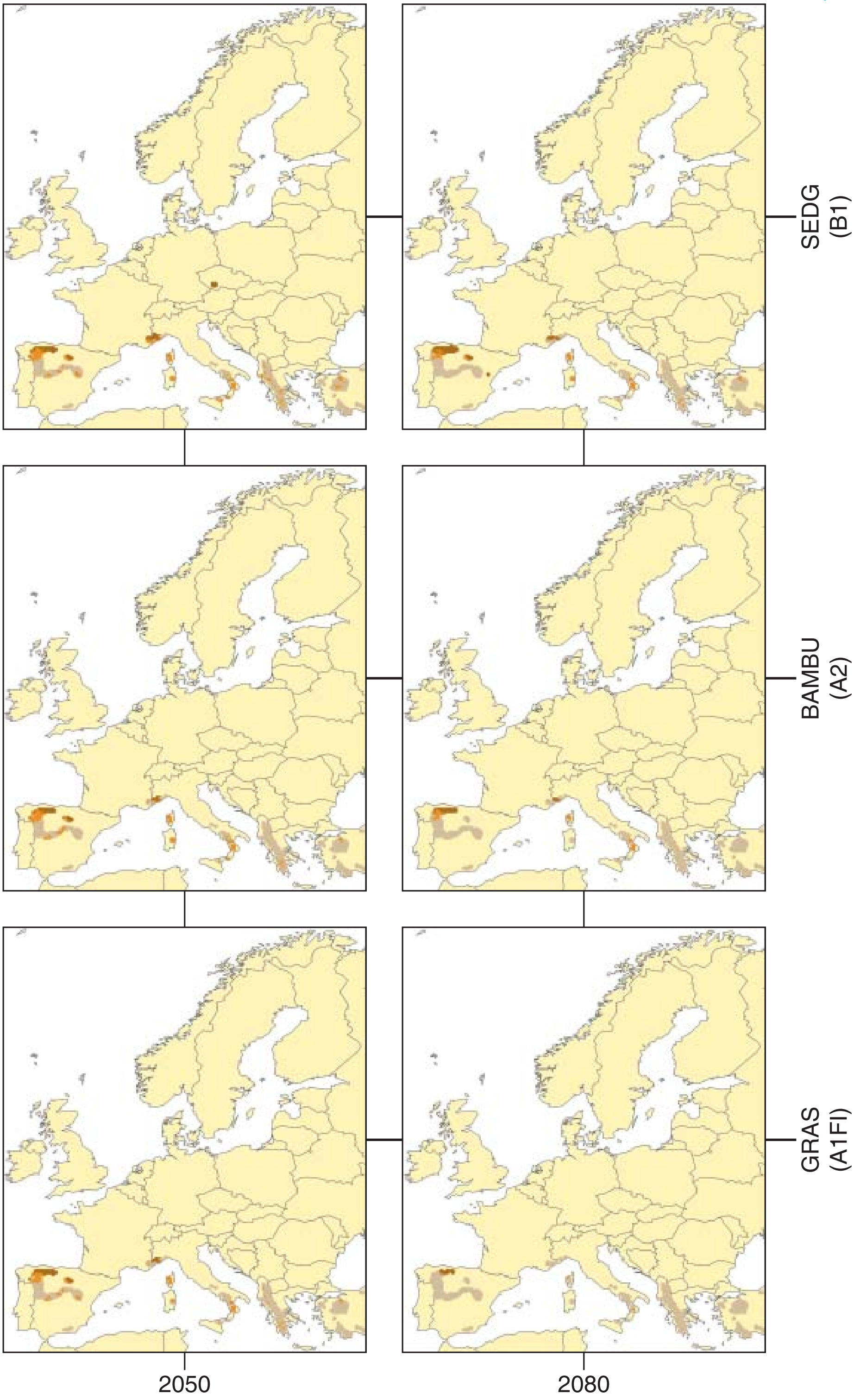
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.75). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Polyommatus dolus (Hübner, 1823) – Furry Blue

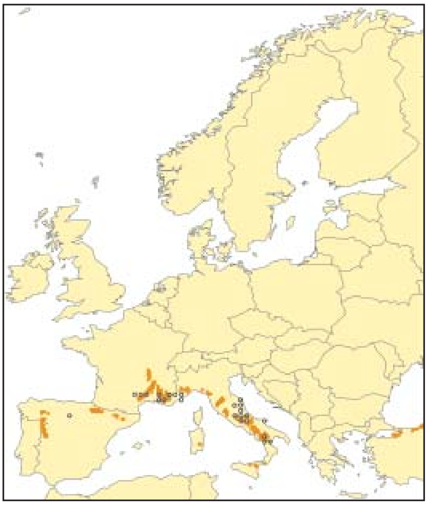
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-58 (-27.1%)	-190 (-88.79%)
	BAMBU	-90 (-42.06%)	-192 (-89.72%)
	GRAS	-34 (-15.89%)	-202 (-94.39%)
2080	SEDG	105 (49.07%)	-208 (-97.2%)
	BAMBU	-97 (-45.33%)	-214 (-100%)
	GRAS	-79 (-36.92%)	-214 (-100%)

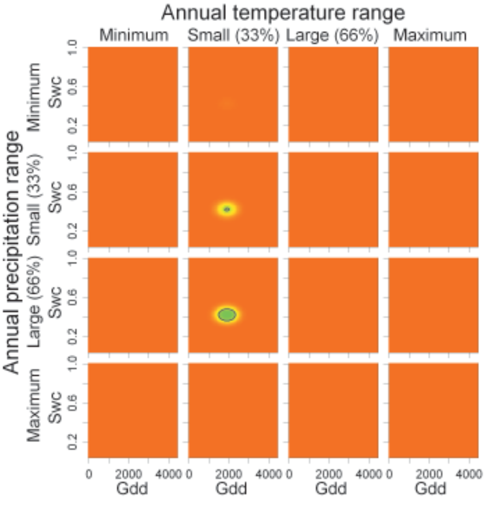
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 214)

The Furry Blue occurs on dry, flower-rich, grassy vegetation with scrub, on waste ground, and in clearings in deciduous or coniferous woods. The female lays her eggs on Sainfoin (*Onobrychis viciifola*). The butterflies are attended by ants. Hibernation takes place when the caterpillars are still small.

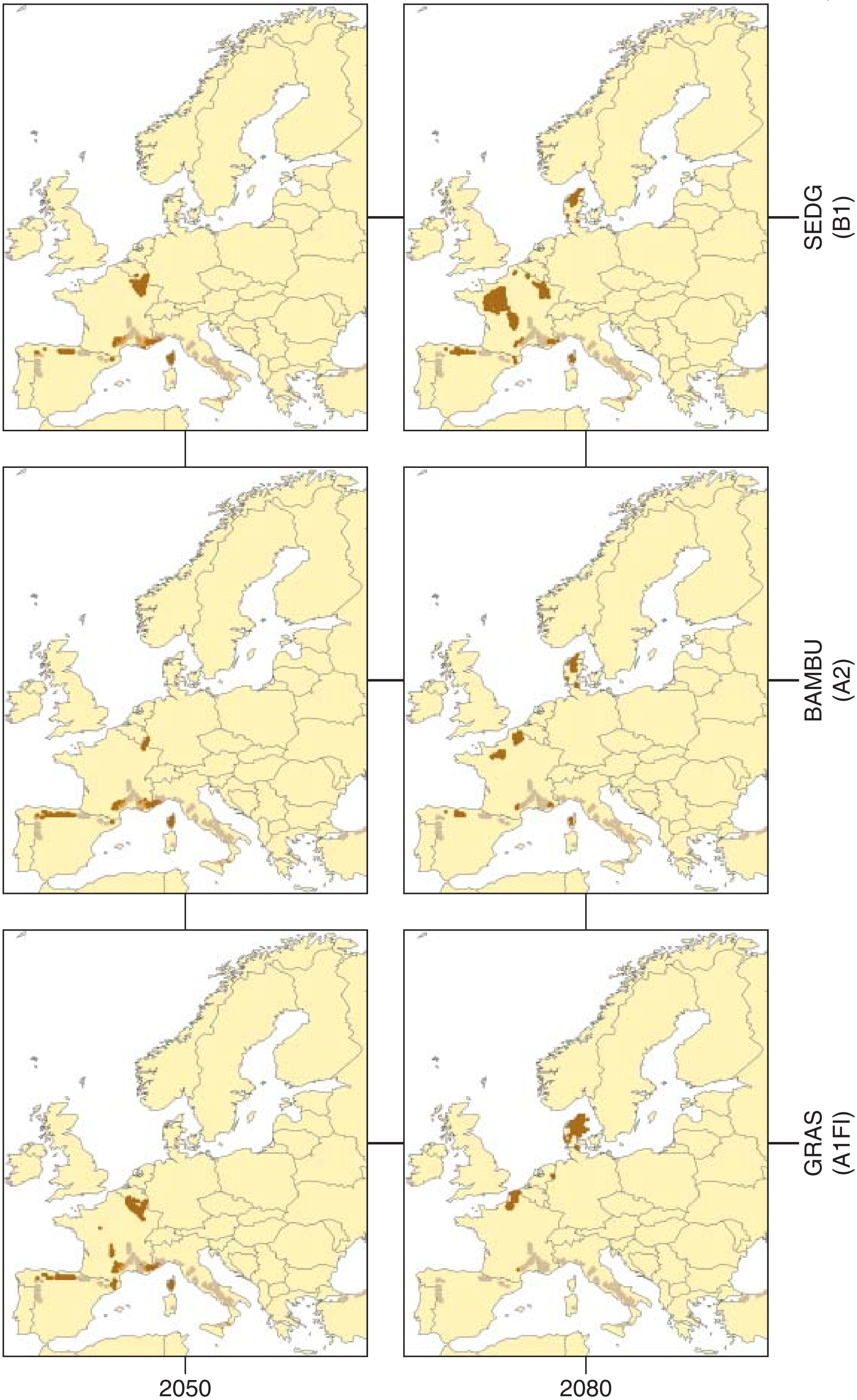
Present distribution can be very well explained by climatic variablesnt (AUC = 0.97).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Polyommatus damon ([Schiffermüller], 1775) – Damon Blue

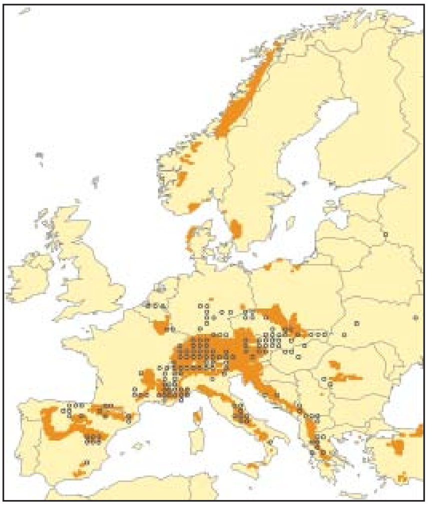
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-660 (-28.23%)	-1169 (-50%)
	BAMBU	-850 (-36.36%)	-1277 (-54.62%)
	GRAS	-1112 (-47.56%)	-1526 (-65.27%)
2080	SEDG	-857 (-36.66%)	-1653 (-70.7%)
	BAMBU	-1091 (-46.66%)	-1769 (-75.66%)
	GRAS	-1409 (-60.27%)	-2009 (-85.93%)

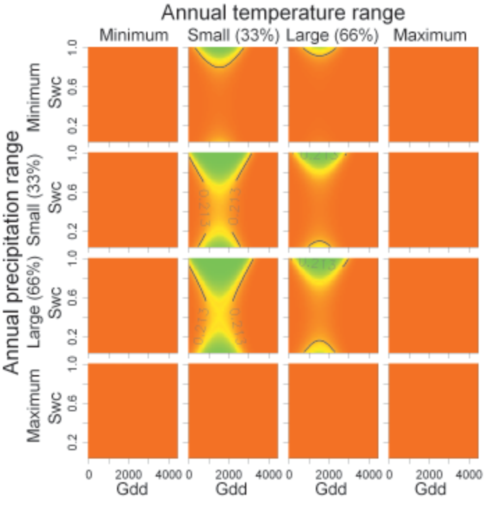
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2338)

The Damon Blue is found on calcareous soil, on grasslands, rough vegetation, such as small patches at the edge of scrub or woodland, and also on abandoned Sainfoin (*Onobrychis viciifolia*) fields. It lays its eggs on different species of *Onobrychis*, including Sainfoin (*Onobrychis viciifolia*). The caterpillars seem to like being between the flowers and only start to feed late in the afternoon. They are often attended by ants of the genera *Lasius* or *Formica*. They pupate in the litter layer. The Damon Blue has one generation a year.

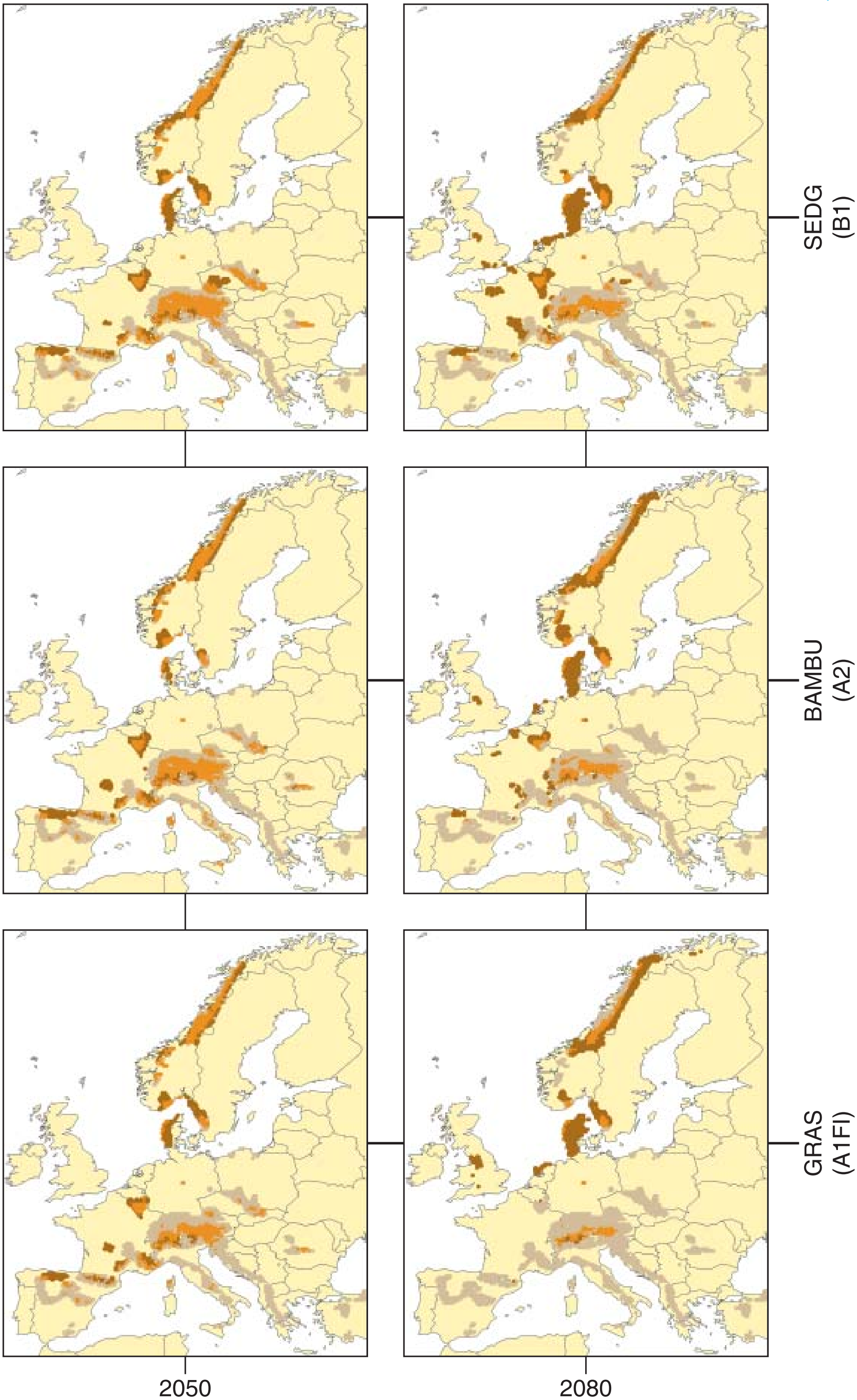
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.85). Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Hamearis lucina (Linnaeus, 1758) – Duke of Burgundy Fritillary

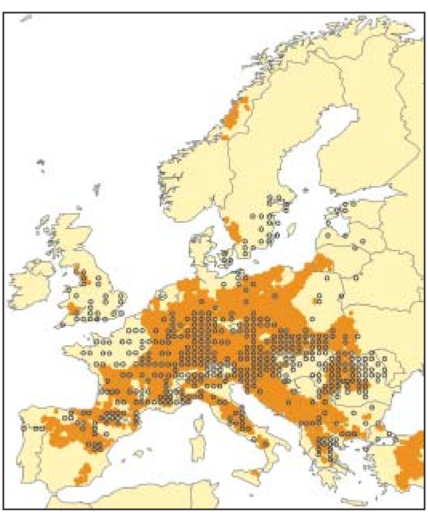
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	55 (0.89%)	-2192 (-35.31%)
	BAMBU	529 (8.52%)	-2161 (-34.82%)
	GRAS	-686 (-11.05%)	-2928 (-47.17%)
2080	SEDG	-249 (-4.01%)	-3222 (-51.91%)
	BAMBU	-452 (-7.28%)	-4008 (-64.57%)
	GRAS	-1480 (-23.84%)	-5148 (-82.94%)

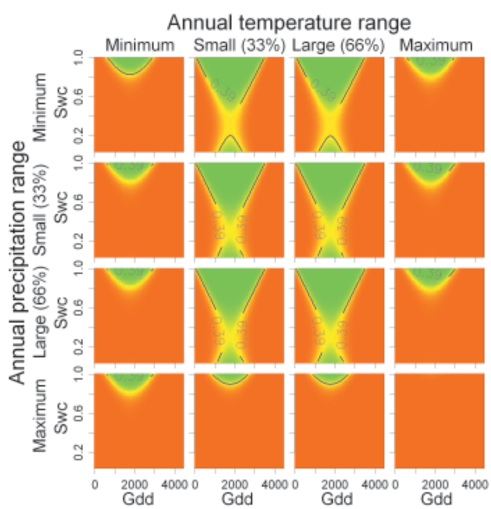
Changes in climatic niche distribution (in 10'×10' grid cells; present niche space: 6207)

The Duke of Burgundy Fritillary occurs in woodland clearings, along the edges of paths in the woods, and at woodland edges. Although the populations are often very local, the numbers of butterflies can be considerable. Eggs are laid on the underside of the leaves of *Primula* species. The caterpillars feed at night, hiding themselves during the day by lying along the main nerve of the *Primula* leaf. They leave the larval foodplants to hibernate in the litter layer. Mostly, it has only one generation a year, but in warm areas, there may be a second generation late in the year.

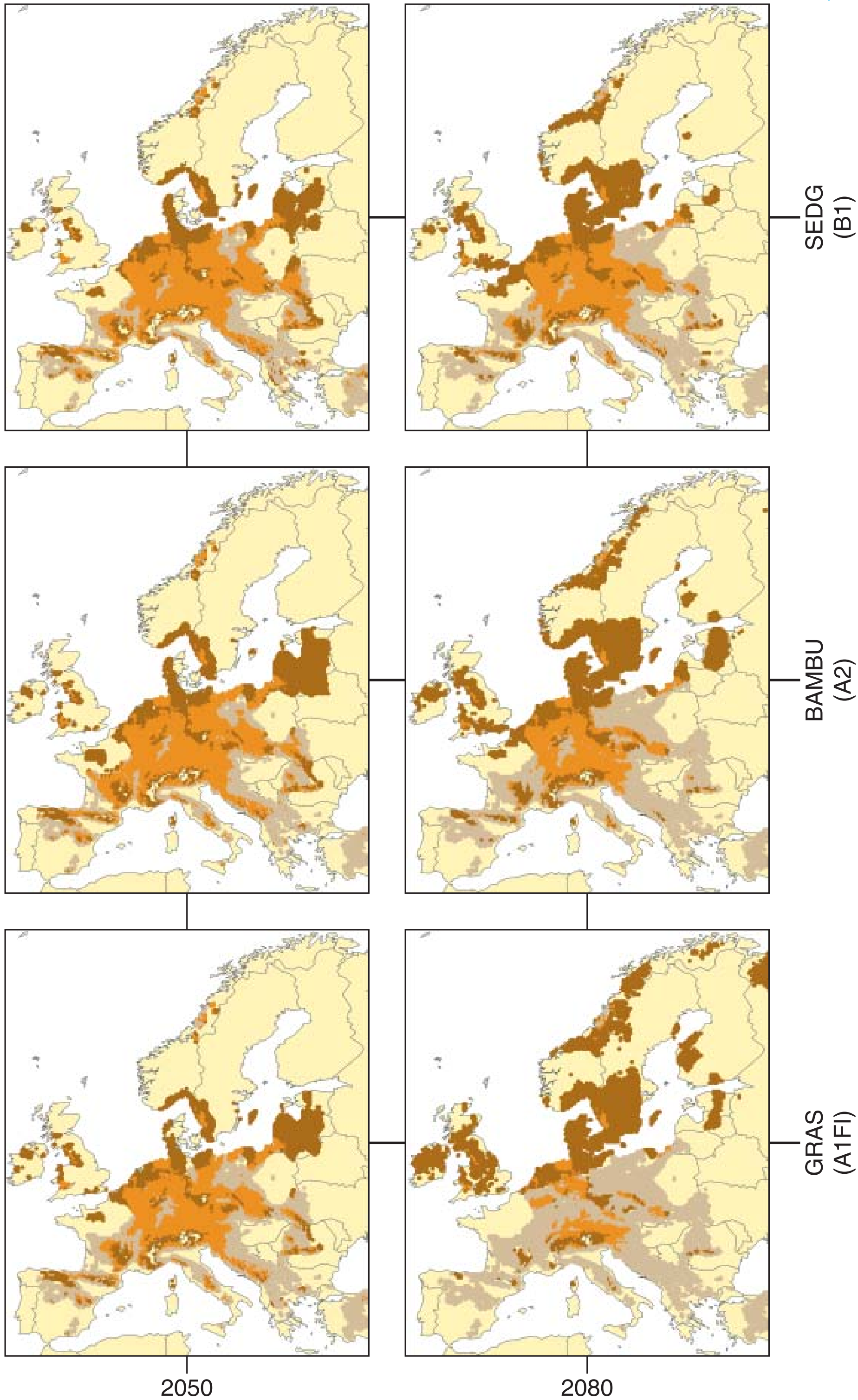
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.77). Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Libythea celtis (Laicharting, 1782) – Nettle-tree Butterfly

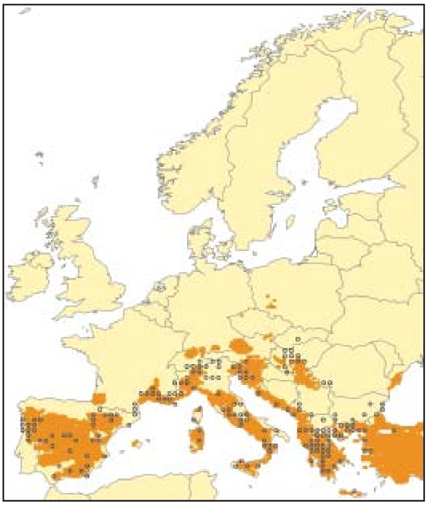
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-582 (-15.8%)	-1642 (-44.57%)
	BAMBU	-1280 (-34.74%)	-1946 (-52.82%)
	GRAS	-1165 (-31.62%)	-2165 (-58.77%)
2080	SEDG	-813 (-22.07%)	-2341 (-63.55%)
	BAMBU	-1635 (-44.38%)	-3068 (-83.28%)
	GRAS	-1312 (-35.61%)	-3409 (-92.54%)

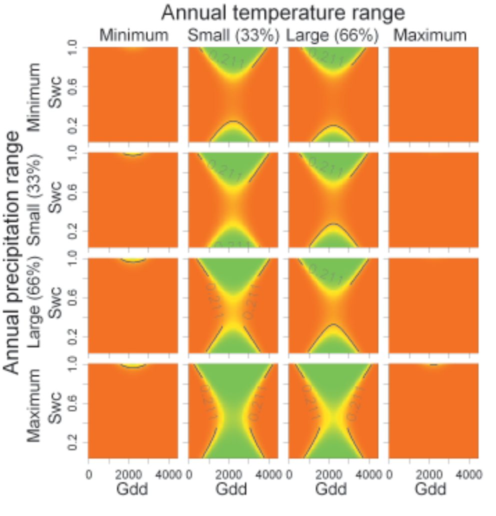
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 3684)

The Nettle-tree Butterfly is one of the snout butterflies, so-called because of its long maxillary palps, which point forward seemingly forming a snout. They are often found in scrub or woods, where the major foodplant, the Nettle Tree (*Celtis australis*) grows. The eggs are laid singly on the leaf buds, early in the year because this butterfly hibernates in the adult stage, appearing again in March. The green or brown caterpillars keep mostly to the underside of the leaves, and also pupate there. The Nettle-tree Butterfly has one generation a year. The adult enters hibernation sometimes as soon as August. The brown underside of its wings provides a good camouflage in the dense undergrowth where it spends the winter looking very much like a dead leaf.

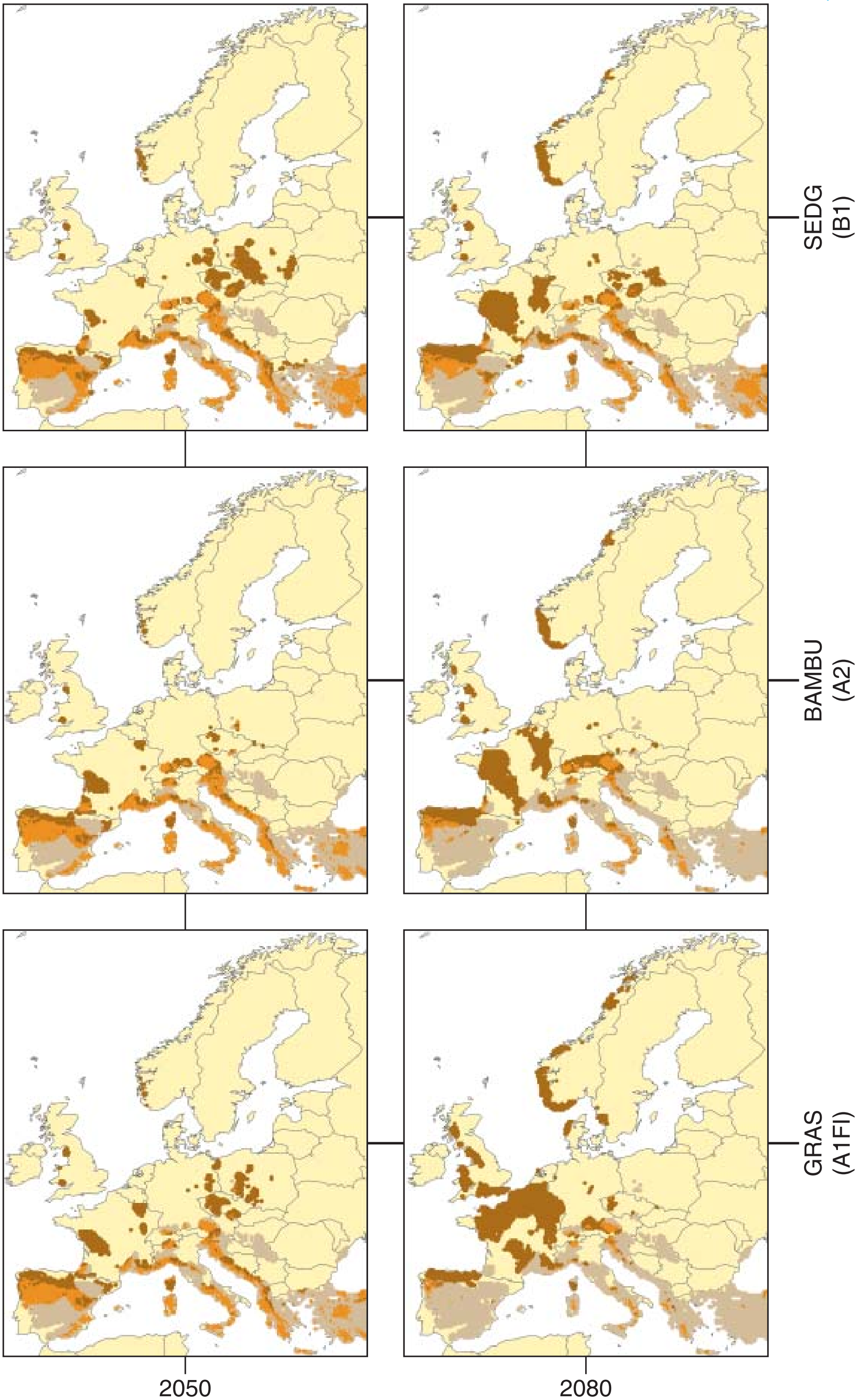
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.8).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Argynnis paphia (Linnaeus, 1758) – Silver-washed Fritillary

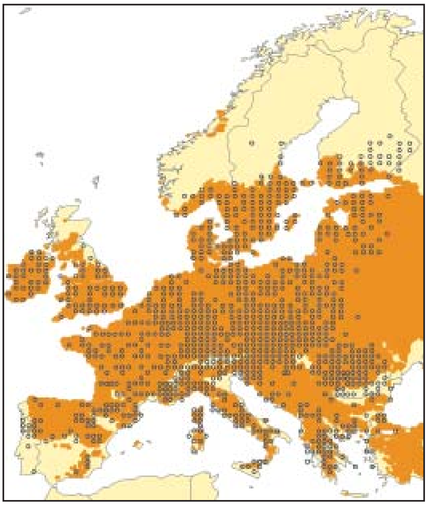
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-1366 (-7.47%)	-3351 (-18.34%)
	BAMBU	-2110 (-11.55%)	-3766 (-20.61%)
	GRAS	-2577 (-14.1%)	-4369 (-23.91%)
2080	SEDG	-2912 (-15.93%)	-5757 (-31.5%)
	BAMBU	-4872 (-26.66%)	-8253 (-45.16%)
	GRAS	-6457 (-35.33%)	-11083 (-60.64%)

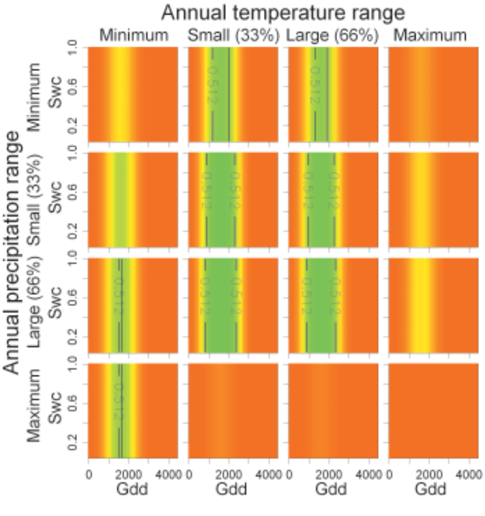
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 18276)

The Silver-washed Fritillary is a large, conspicuous butterfly that is often present in large numbers. Needing a lot of nectar, they are often found on thistles at the edge of woodland. They also occur on rough vegetation in woodland clearings. Unlike other butterflies, the eggs are not laid on the foodplant. Instead, the female deposits them singly on the branches and trunks of trees growing at woodland edges. As soon as they emerge from the egg in the late summer, the tiny caterpillar looks for somewhere to hibernate. In the spring it starts looking for violets (*Viola* spp.), on which it feeds at night, hiding under the leaves of the foodplant during the day. It pupates on a stalk of a violet plant, or in a crevice in the bark of a tree. The Silver-washed Fritillary has one generation a year.

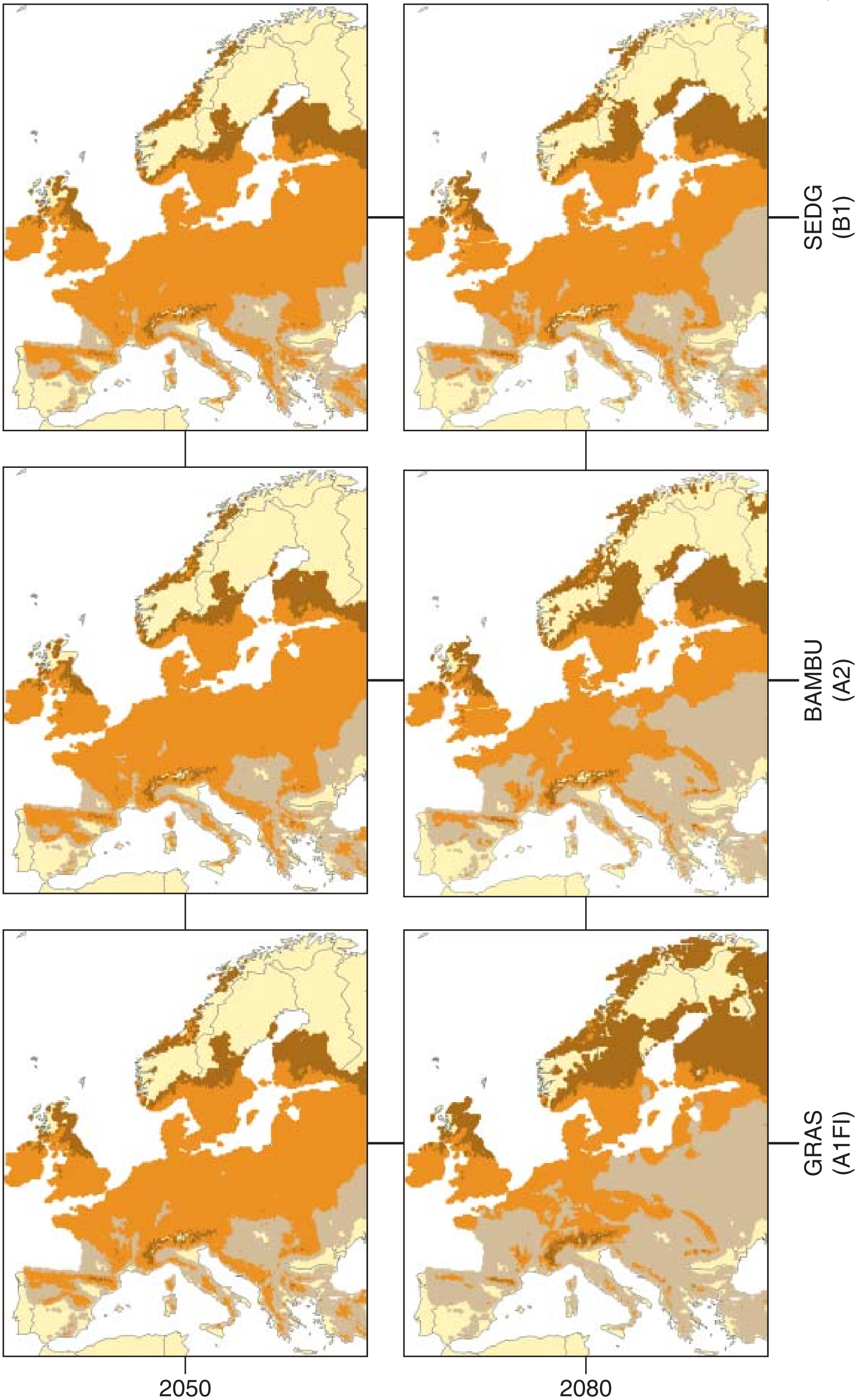
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.78).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Argynnis pandora ([Schiffermüller], 1775) – Cardinal

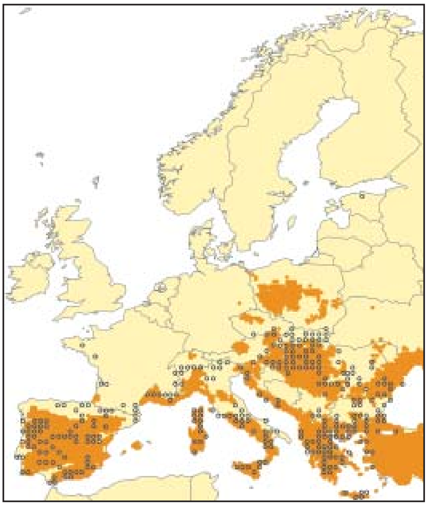
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	1193 (21.96%)	-1626 (-29.93%)
	BAMBU	-1933 (-35.58%)	-2556 (-47.05%)
	GRAS	-587 (-10.8%)	-2566 (-47.23%)
2080	SEDG	-1599 (-29.43%)	-3246 (-59.75%)
	BAMBU	-3121 (-57.45%)	-4172 (-76.79%)
	GRAS	-2148 (-39.54%)	-4744 (-87.32%)

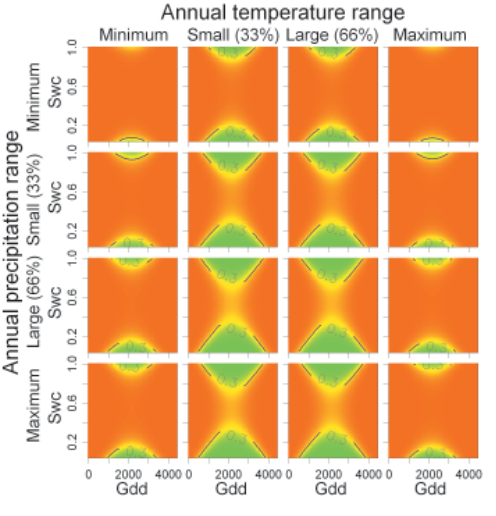
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 5433)

The Cardinal is a woodland butterfly occurring at woodland edges and in glades with bushes and grassy, flower-rich vegetations. Like the Silver-washed Fritillary (*A. paphia*), these butterflies are often seen in places where plants rich in nectar, such as thistles, are plentiful. The Cardinal is a fast and powerful flyer, vagrants being sometimes observed outside the distribution range. The eggs are laid singly on the leaves of violets (*Viola* spp.). It hibernates as a small caterpillar and pupates in the spring, suspended low down on the foodplant or on the nearby vegetation. It is single-brooded.

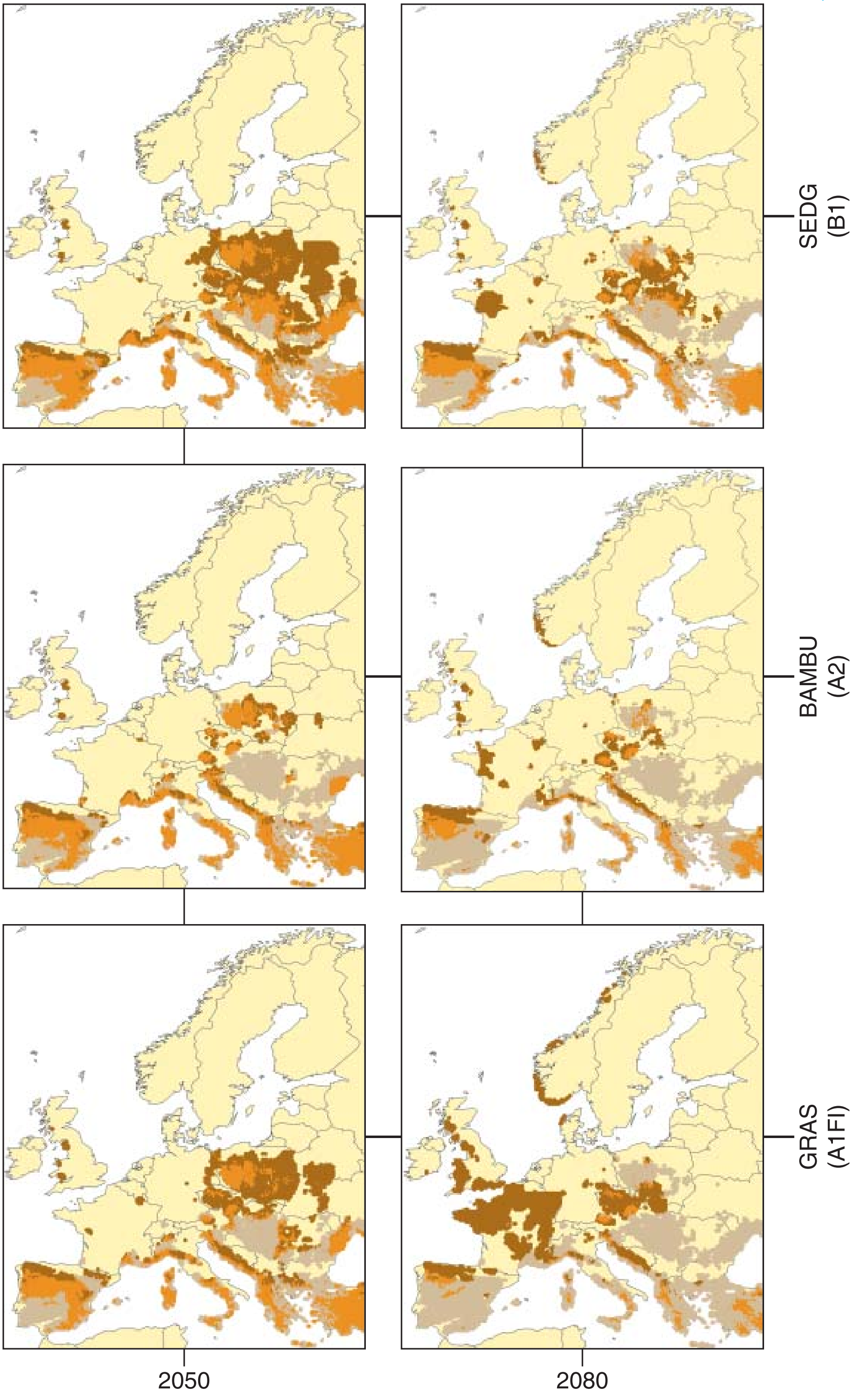
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.83). Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Argynnis aglaja (Linnaeus, 1758) – Dark Green Fritillary

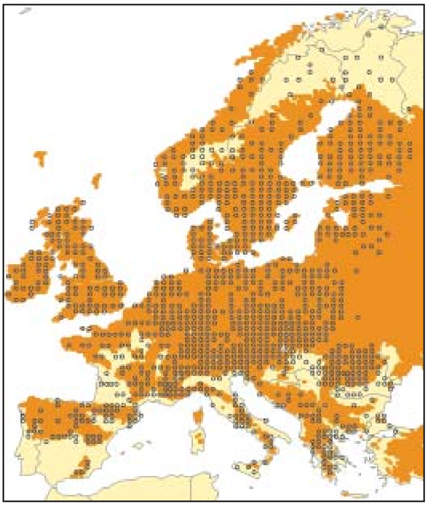
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-1213 (-5.9%)	-3328 (-16.19%)
	BAMBU	-2865 (-13.94%)	-4599 (-22.38%)
	GRAS	-2885 (-14.04%)	-4947 (-24.07%)
2080	SEDG	-4162 (-20.25%)	-7016 (-34.14%)
	BAMBU	-7493 (-36.46%)	-10512 (-51.15%)
	GRAS	-9906 (-48.2%)	-13024 (-63.37%)

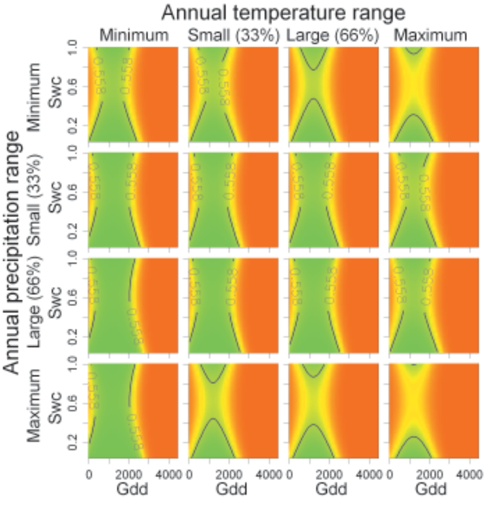
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 20551)

The Dark Green Fritillary can be found on many different types of flower-rich grasslands. The grassland is often situated in or at the edge of woodland, and may be dry, calcareous or dune grassland, or damp grasslands along the edges of bogs. The eggs are laid on the often already withered leaf-stems of violets (*Viola* spp.). Directly after hatching, the small caterpillar prepares for hibernation, hiding itself in the litter layer until the spring. It then begins to feed on the fresh, new growth of the violet plants, continuing into the summer, when it pupates either in the moss layer, or under a tussock of grass. The caterpillars are quite mobile and visit several plants when feeding. The Dark Green Fritillary is single-brooded.

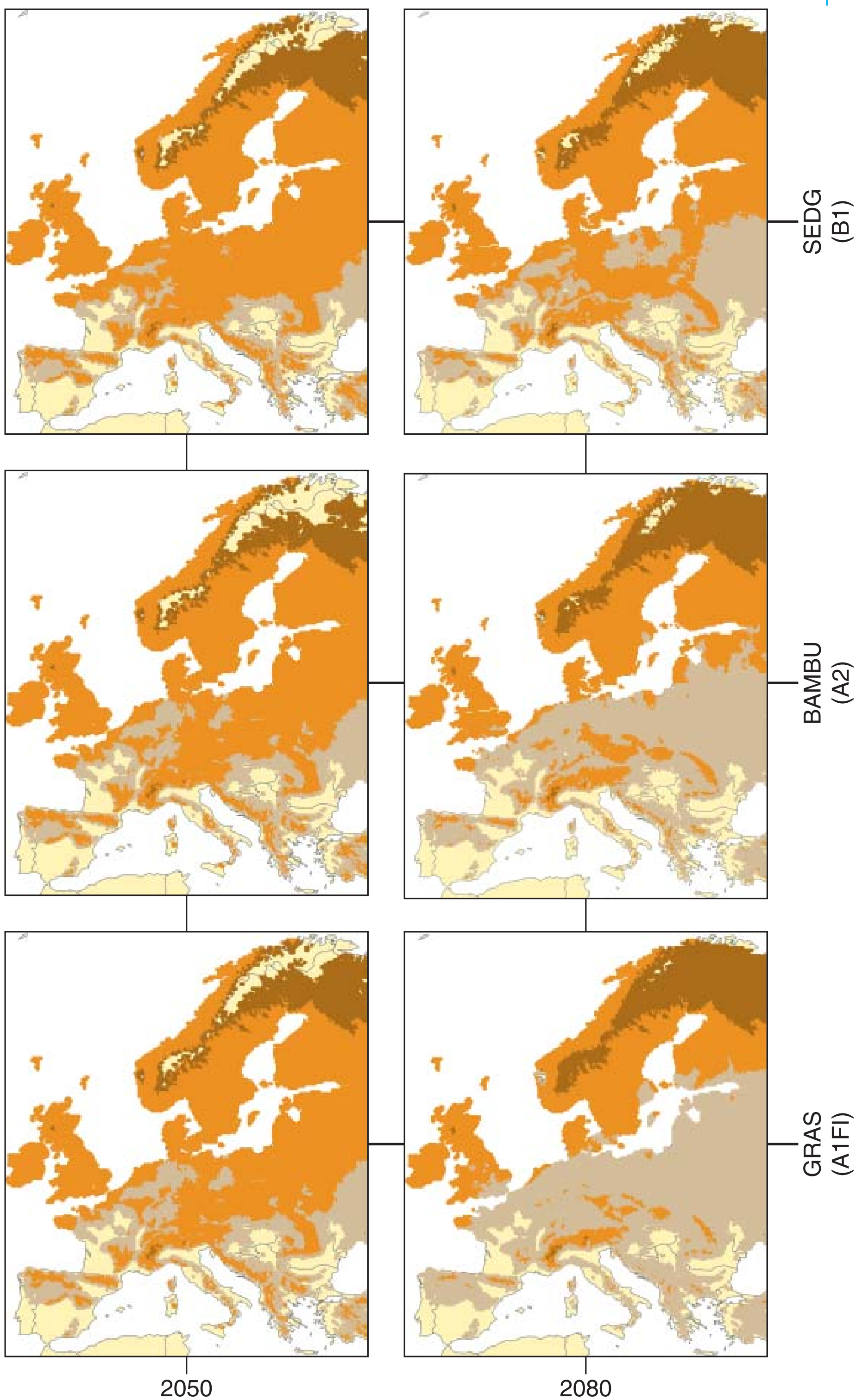
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.78).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Argynnis adippe ([Schiffermüller], 1775) – High Brown Fritillary

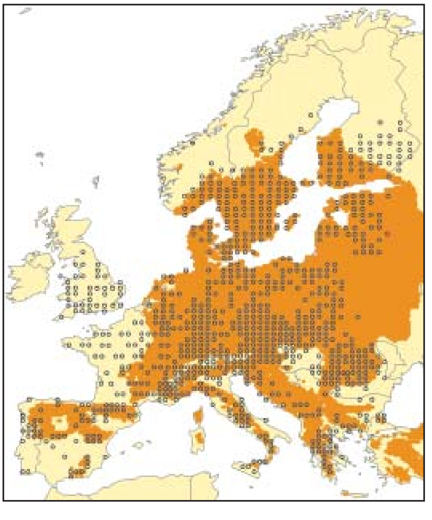
© Peter Ginzinger

		Full dispersal	No dispersal
2050	SEDG	-1589 (-11.19%)	-2919 (-20.56%)
	BAMBU	-2493 (-17.56%)	-3556 (-25.04%)
	GRAS	-3720 (-26.2%)	-4865 (-34.26%)
2080	SEDG	-3763 (-26.5%)	-5920 (-41.69%)
	BAMBU	-5935 (-41.8%)	-8143 (-57.35%)
	GRAS	-8102 (-57.06%)	-10604 (-74.68%)

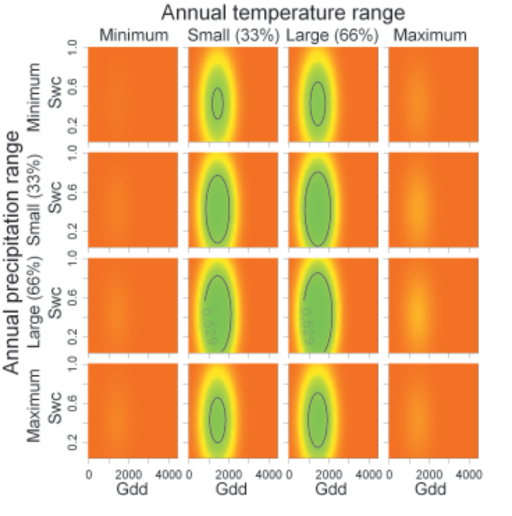
Changes in climatic niche distribution (in 10’×10’ grid cells; present niche space: 14199)

The High Brown Fritillary occurs on woodland edges and in woodland clearings, where there is lush, rough vegetation with plenty of nectar plants. The eggs are laid on the leaves of violets (*Viola* spp.) and also on the bark of trees with violets growing near them. The tiny caterpillar remains within the egg during the winter, and from about the beginning of March, leaves the egg and starts feeding on violet leaves. It pupates on a twig or on a leaf close to the ground. The High Brown Fritillary has one generation a year.

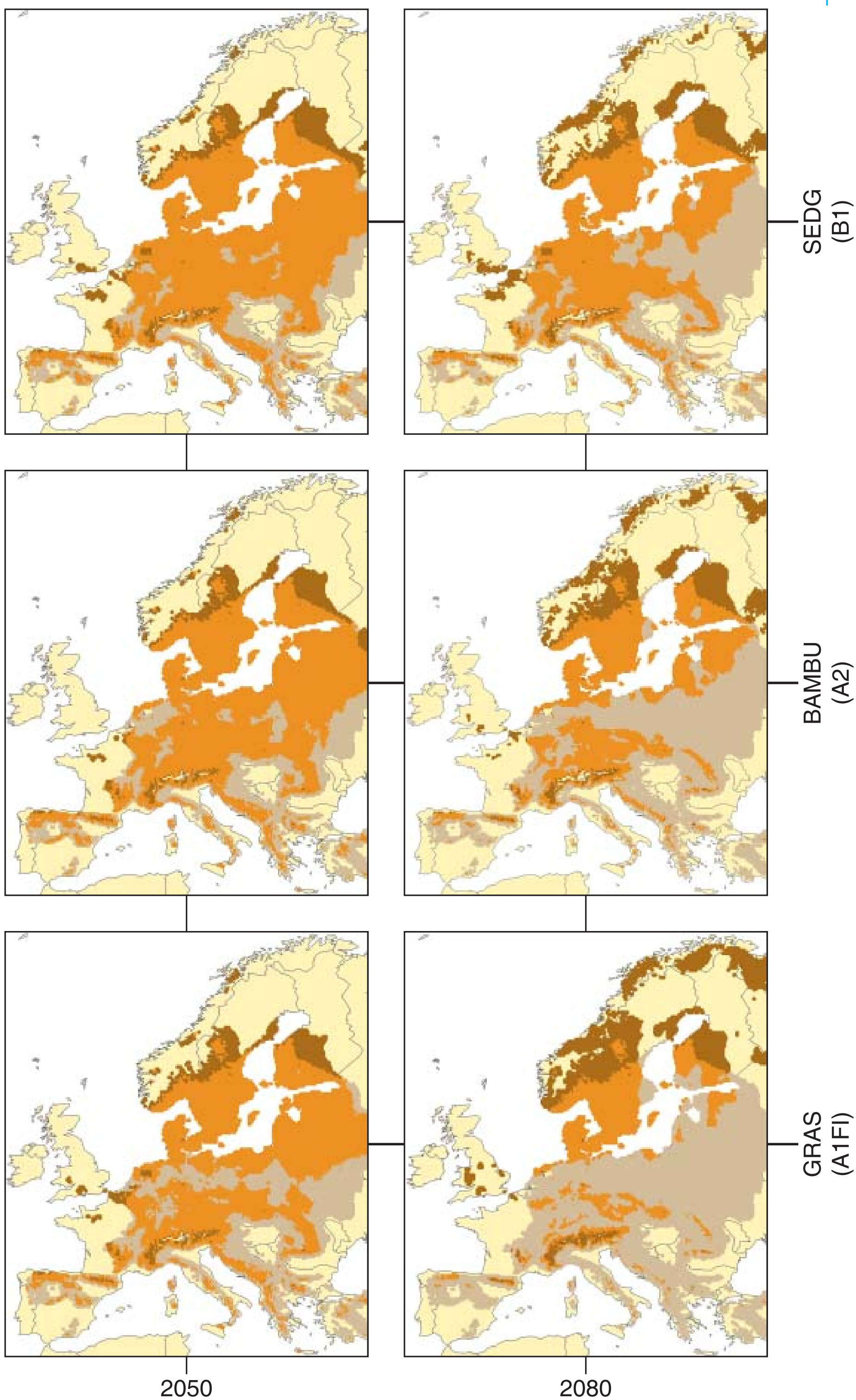
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.78). Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Argynnis niobe (Linnaeus, 1758) – Niobe Fritillary

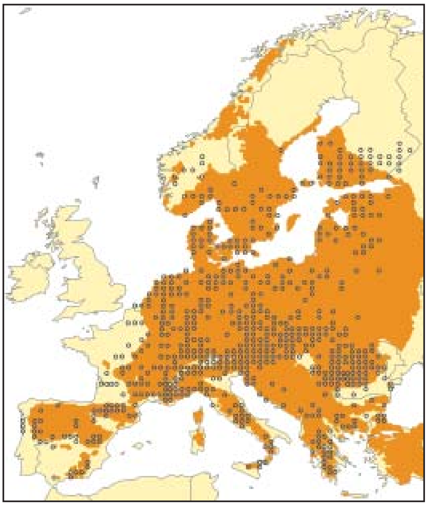
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-1295 (-7.83%)	-2967 (-17.94%)
	BAMBU	-2109 (-12.75%)	-3441 (-20.81%)
	GRAS	-2562 (-15.49%)	-3948 (-23.87%)
2080	SEDG	-3322 (-20.09%)	-6045 (-36.55%)
	BAMBU	-5110 (-30.9%)	-7946 (-48.04%)
	GRAS	-7117 (-43.03%)	-10289 (-62.21%)

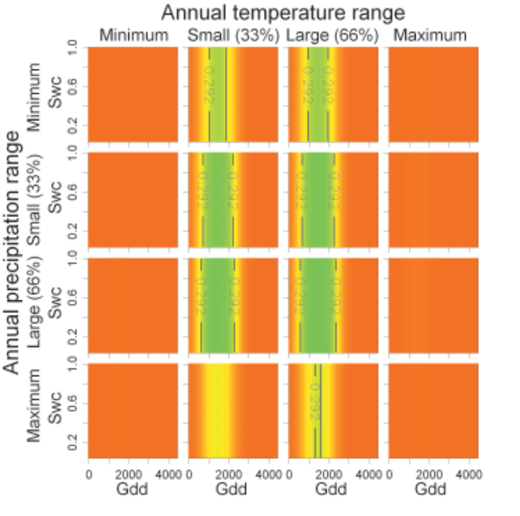
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 16539)

The Niobe Fritillary occurs on poor, dry grassland, often with woodland or scrub nearby. The eggs are laid on the woody stock of violets (*Viola* spp.). The caterpillar develops quickly within the egg, but does not hatch until after hibernation. Staying hidden during the day, it feeds on the violet plants at night. It pupates low down in the vegetation. The Niobe Fritillary has one generation a year.

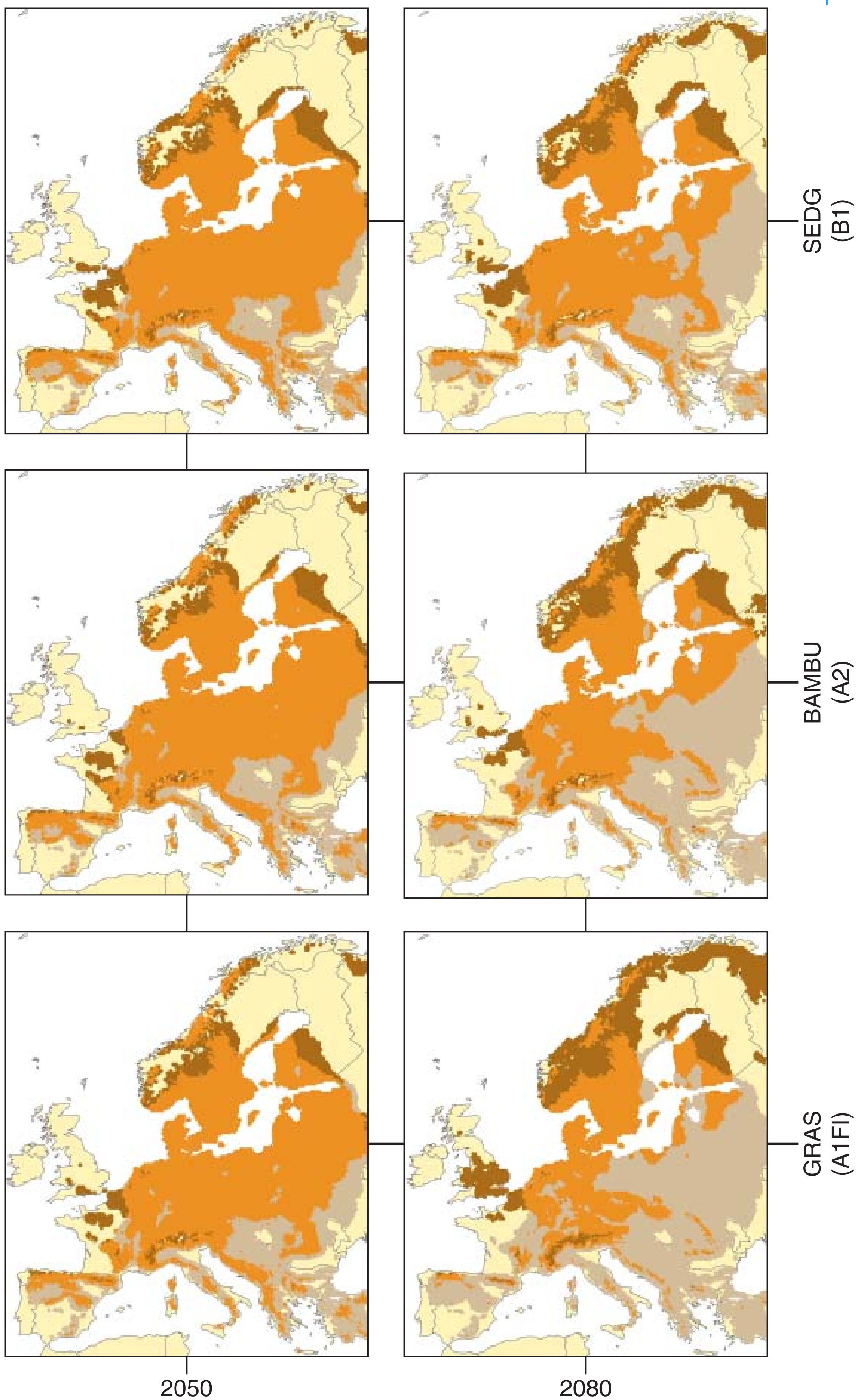
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.74). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Argynnis laodice (Pallas, 1771) – Pallas' Fritillary

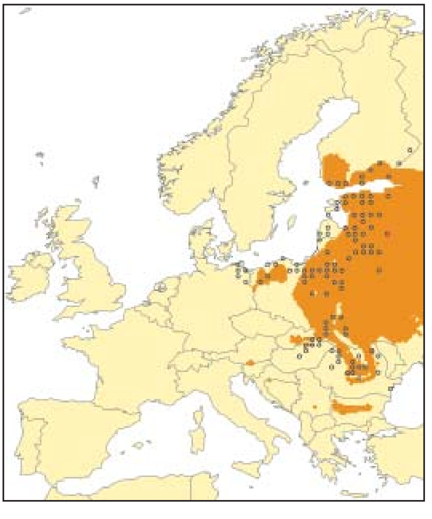
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-679 (-13.69%)	-2209 (-44.53%)
	BAMBU	201 (4.05%)	-1794 (-36.16%)
	GRAS	-443 (-8.93%)	-2242 (-45.19%)
2080	SEDG	-358 (-7.22%)	-2923 (-58.92%)
	BAMBU	960 (19.35%)	-3083 (-62.14%)
	GRAS	167 (3.37%)	-3849 (-77.59%)

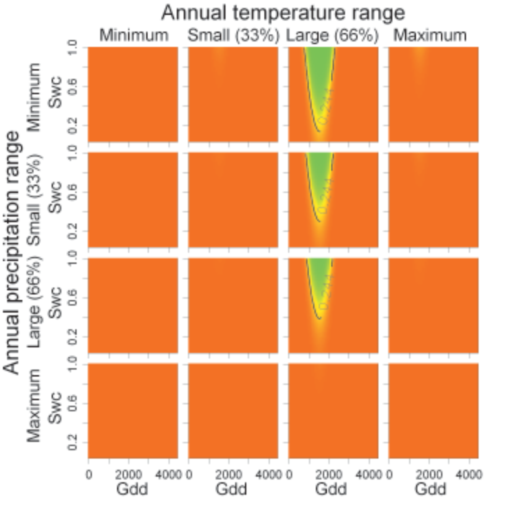
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 4961)

The Pallas's Fritillary can be easily recognized by the noticeable jagged, white line, running across the underside of the hindwing. It can be found on damp, flower-rich grassland in open or deciduous forests or mixed woods. Both males and females are fond of sucking nectar from bramble blossom. The caterpillars live on Marsh Violet (*Viola palustris*) and Heath Dog Violet (*V. canina*). It has one generation a year and passes the winter in the egg stage.

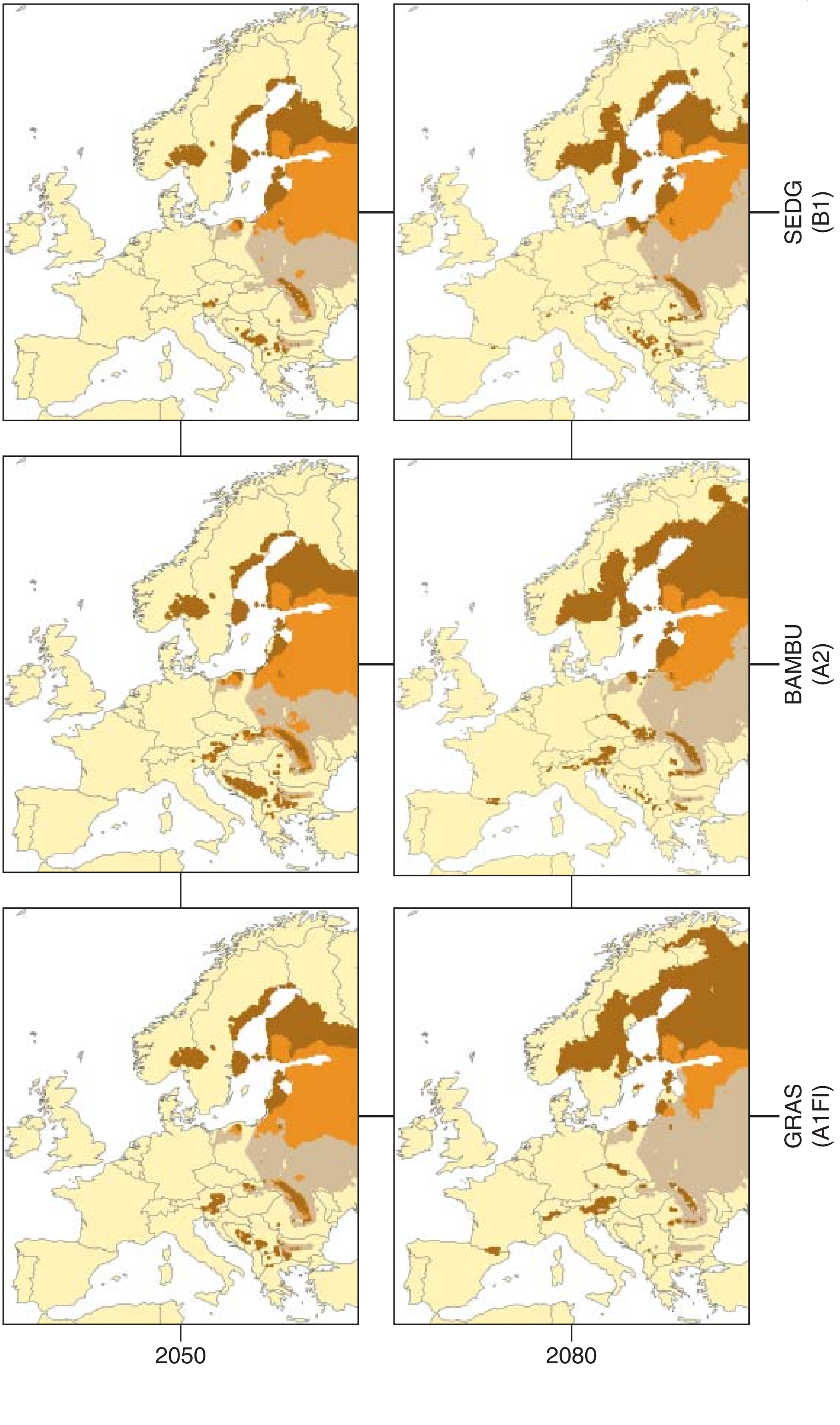
Present distribution can be well explained by climatic variables (AUC = 0.89).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Issoria lathonia (Linnaeus, 1758) – Queen of Spain Fritillary

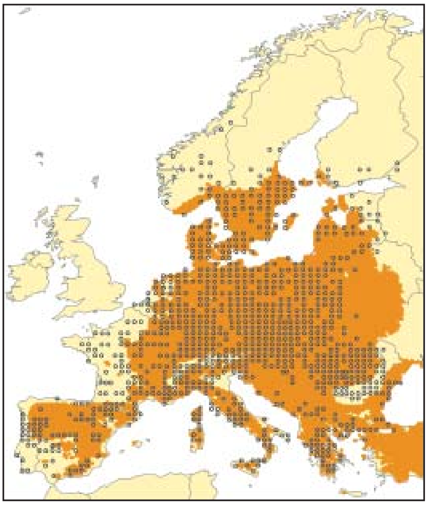
© Martin Wiemers

		Full dispersal	No dispersal
2050	SEDG	-770 (-5.48%)	2836 (-20.17%)
	BAMBU	-2545 (-18.1%)	-4088 (-29.08%)
	GRAS	-2031 (-14.45%)	-3944 (-28.05%)
2080	SEDG	-4326 (-30.77%)	-6463 (-45.97%)
	BAMBU	-6471 (-46.02%)	-8591 (-61.1%)
	GRAS	-7632 (-54.28%)	-10003 (-71.15%)

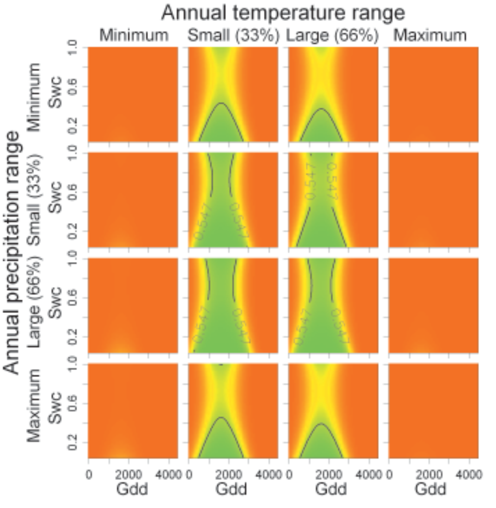
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 14060)

The large, silver-white mirrors on the underside of the hindwings, distinguish the Queen of Spain Fritillary from other fritillaries. The butterflies of the first brood that emerge at the end of the spring are quite small, but those of summer broods are often bigger. They can be found on a wide range of dry, flower-rich grasslands, wasteland and fields. The female deposits her eggs singly on the underside of the leaves of violets (*Viola* spp.) on which the caterpillars later feed. On this nutritious diet the caterpillars grow very quickly, pupating low down in the vegetation. The Queen of Spain Fritillary has two to four generations a year, depending on the altitude and geographical position of the habitat. Hibernation takes place in the larval stage in temperate areas, but probably it can overwinter in other stages as well.

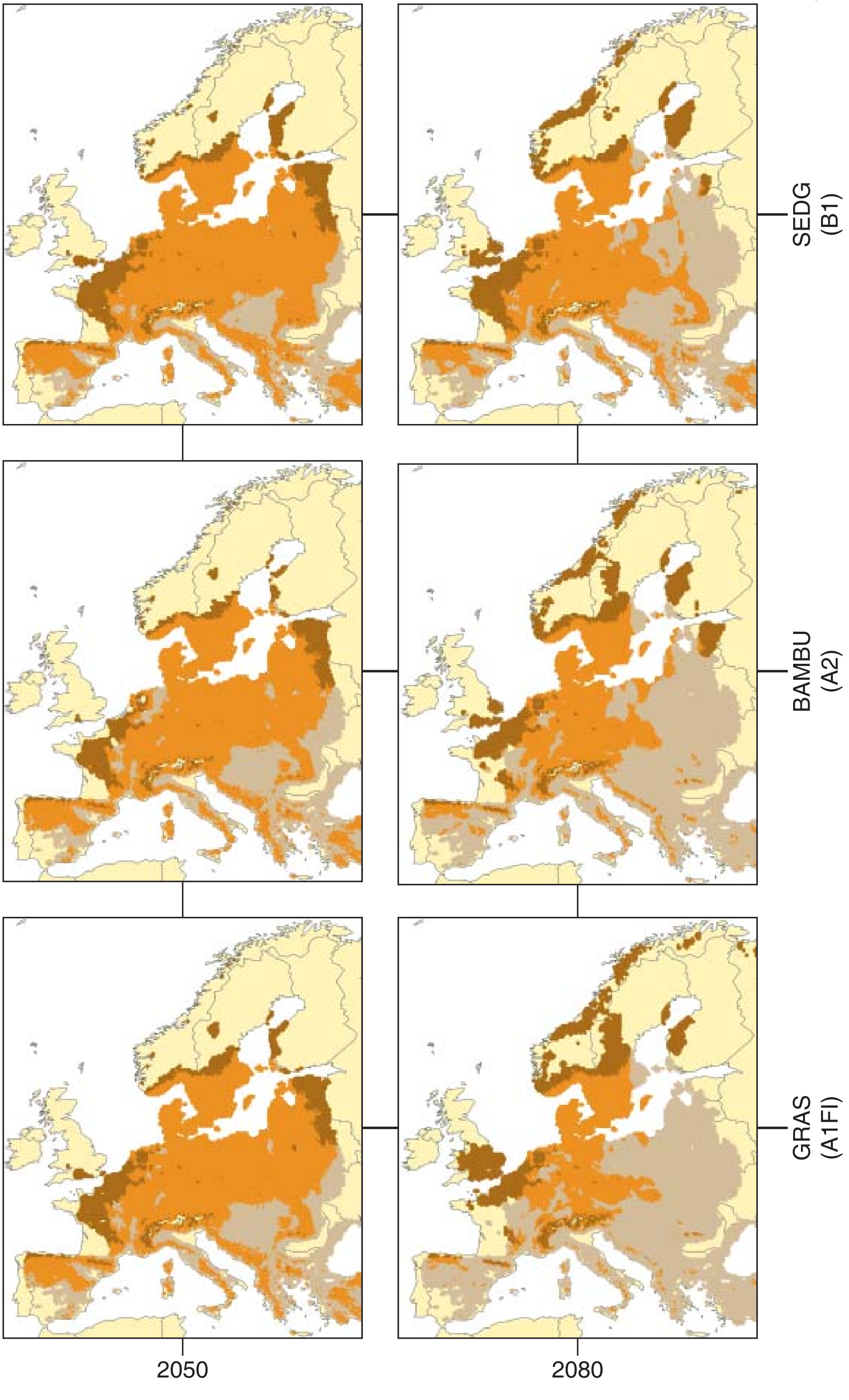
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.78). Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Brenthis ino (Rottemburg, 1775) – Lesser Marbled Fritillary

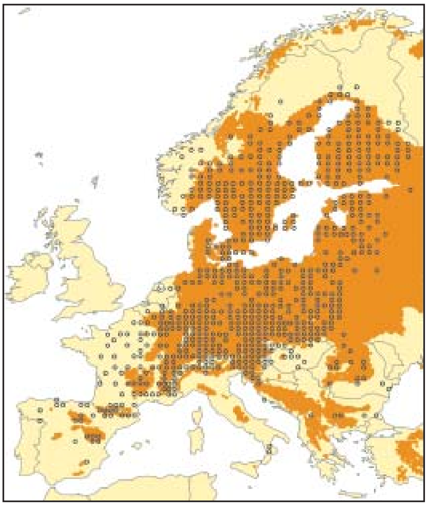
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-2157 (-15.64%)	-4631 (-33.59%)
	BAMBU	-2329 (-16.89%)	-4748 (-34.44%)
	GRAS	-2704 (-19.61%)	-5157 (-37.4%)
2080	SEDG	-4126 (-29.92%)	-7216 (-52.34%)
	BAMBU	-4906 (-35.58%)	-8460 (-61.36%)
	GRAS	-6908 (-50.1%)	-10472 (-75.95%)

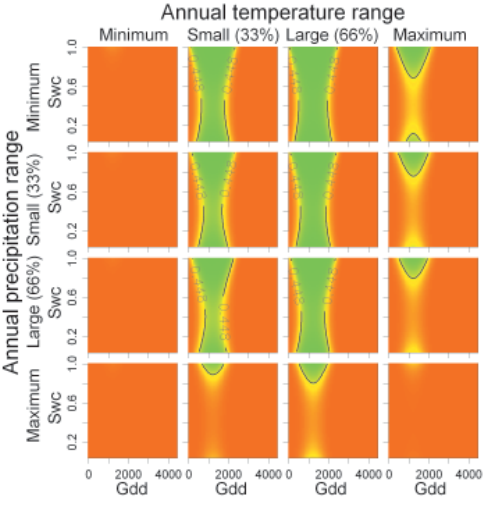
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 13788)

The Lesser Marbled Fritillary occurs on damp to wet, flower-rich, rough vegetation, growing in the shelter of woodland. This can be situated in a valley, or on the banks of a stream, in abandoned meadows and swampy habitats. Because of changes in agricultural practices, this butterfly has been able to expand into some abandoned wet meadows. After continuing succession, these meadows will get overgrown by scrub and become unsuitable for the Lesser Marbled Fritillary. Eggs are laid singly or in pairs on the leaves and flowerheads of Meadowsweet (*Filipendula ulmaria*), Goat’s-beard (*Aruncus dioicus*), Great Burnet (*Sanguisorba officinalis*) and brambles (*Rubus* spp.). It hibernates either as an egg or a caterpillar. The caterpillars feed at night, and in bad weather, also during the day. They pupate on the foodplant. The Lesser Marbled Fritillary is single-brooded.

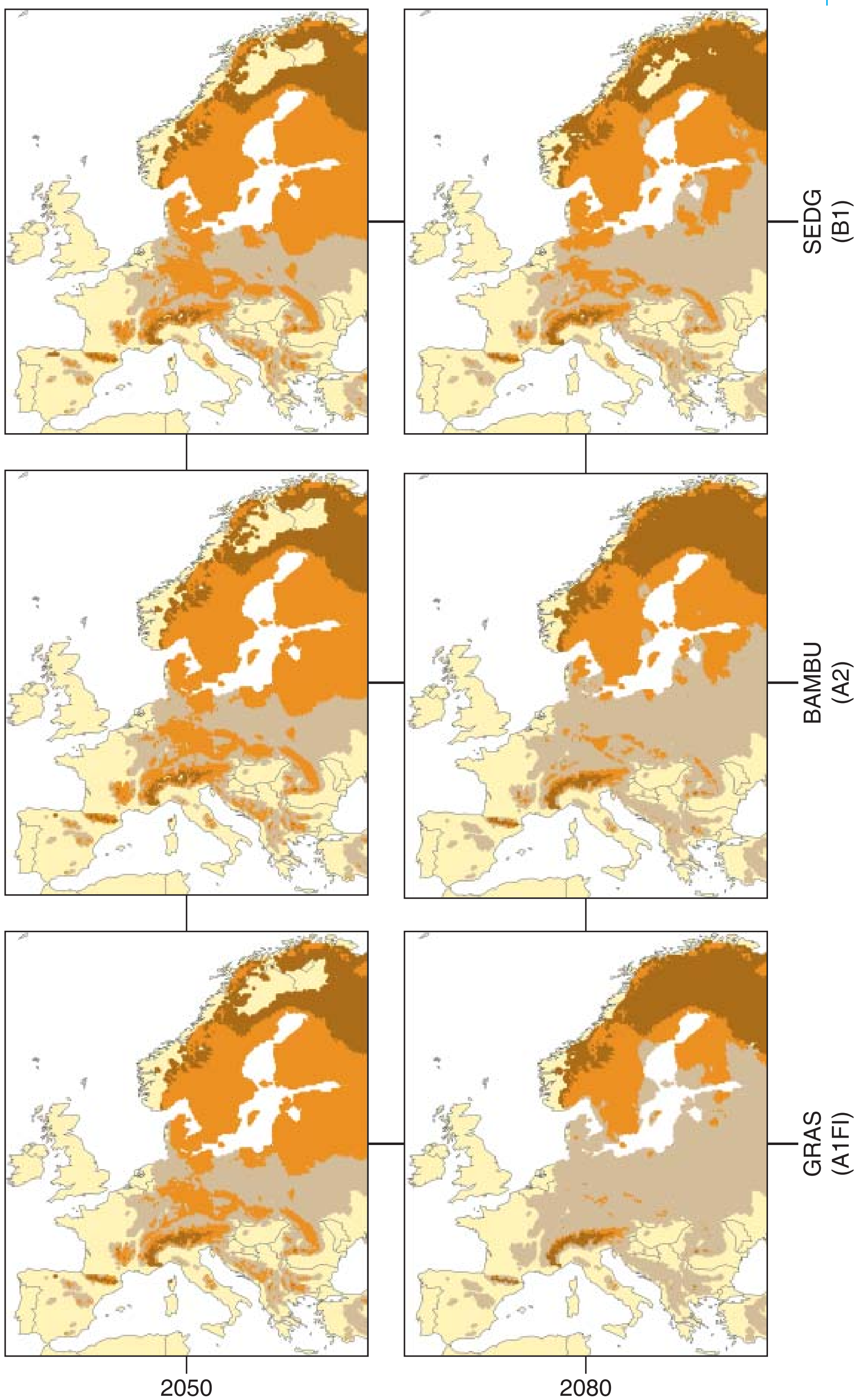
Present distribution can be well explained by climatic variables (AUC = 0.87).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Brenthis daphne (Bergsträsser, 1780) – Marbled Fritillary

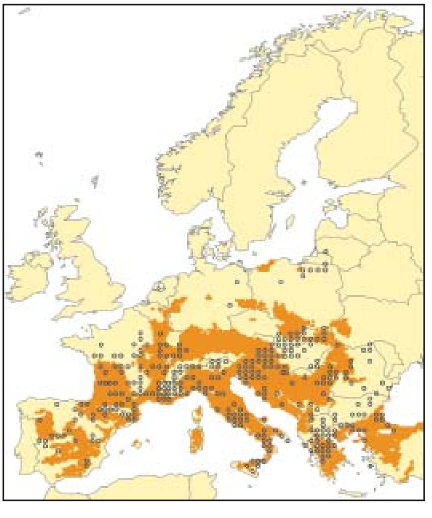
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	1518 (27.55%)	-1190 (-21.6%)
	BAMBU	1916 (34.78%)	-1365 (-24.78%)
	GRAS	763 (13.85%)	-1779 (-32.29%)
2080	SEDG	2653 (48.16%)	-1927 (-34.98%)
	BAMBU	2007 (36.43%)	-2868 (-52.06%)
	GRAS	1929 (35.02%)	-3676 (-66.73%)

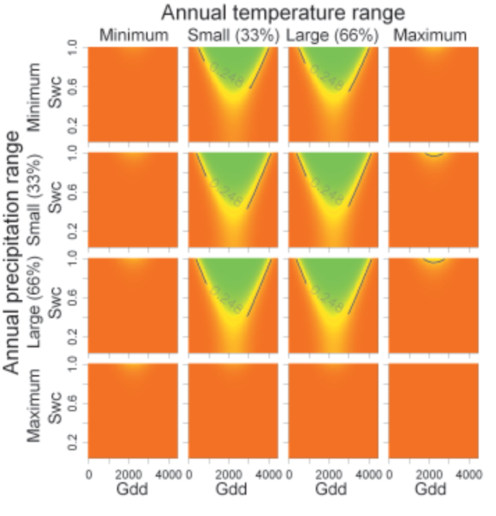
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 5509)

The Marbled Fritillary occurs at the edges of woods or in scrub where brambles are growing. It takes nectar from thistles growing in rough vegetation. Eggs are deposited singly on the leaves and sepals of brambles (*Rubus* spp.), where they pass the winter, protected by withered leaves. In the spring, the small caterpillar feeds on the new, young leaves in the leaf buds, the later larval stages eating older leaves. The pupa is suspended from a leaf or branch of the foodplant. The Marbled Fritillary is single-brooded.

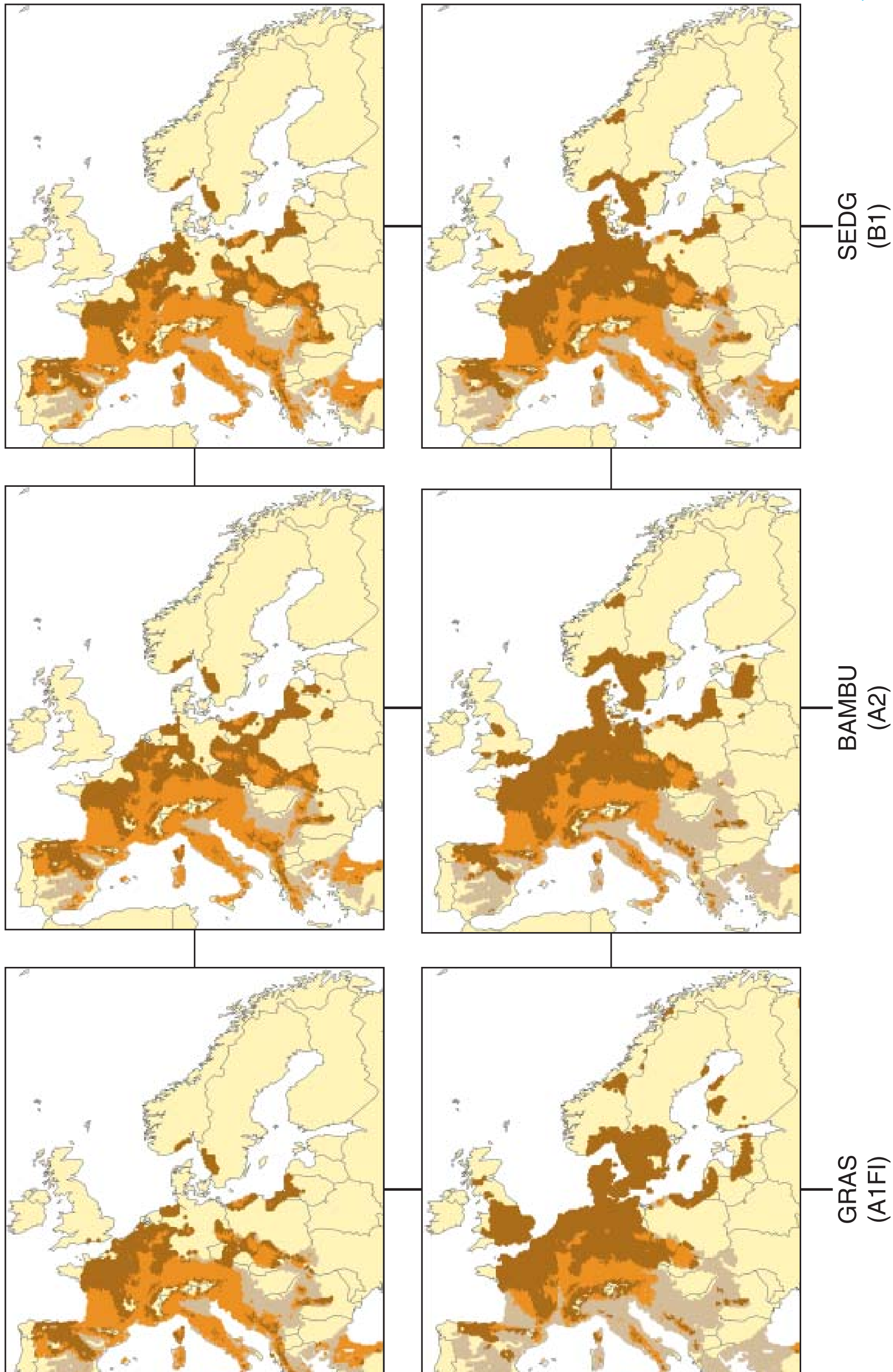
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.77).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Brenthis hecate ([Schiffermüller], 1775) – Twin-spot Fritillary

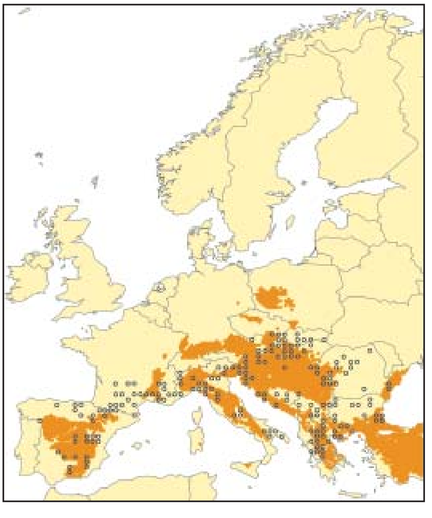
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	554 (14.53%)	-1741 (-45.65%)
	BAMBU	-589 (-15.44%)	-2135 (-55.98%)
	GRAS	-270 (-7.08%)	-2292 (-60.09%)
2080	SEDG	-217 (-5.69%)	-2542 (-66.65%)
	BAMBU	-554 (-14.53%)	-3243 (-85.03%)
	GRAS	-508 (-13.32%)	-3442 (-90.25%)

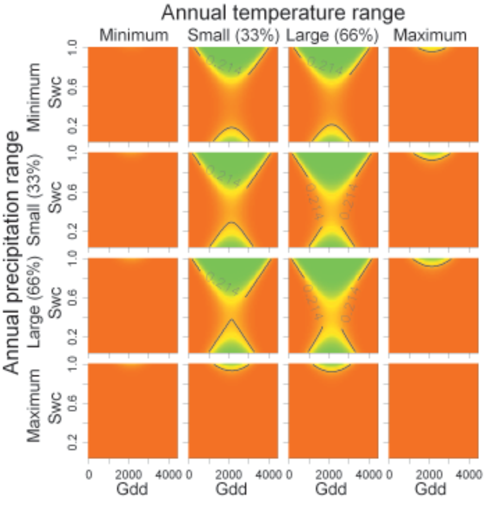
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 3814)

The Twin-spot Fritillary can be found in flower-rich grassland, situated in the shelter of a woodland edge, or in scattered bushes. The most important foodplant is Meadowsweet (*Filipendula ulmaria*), although different species of *Dorycnium*, a leguminous plant, are named as a foodplant in Spain. It is single-brooded, and passes the winter in the egg or caterpillar stage.

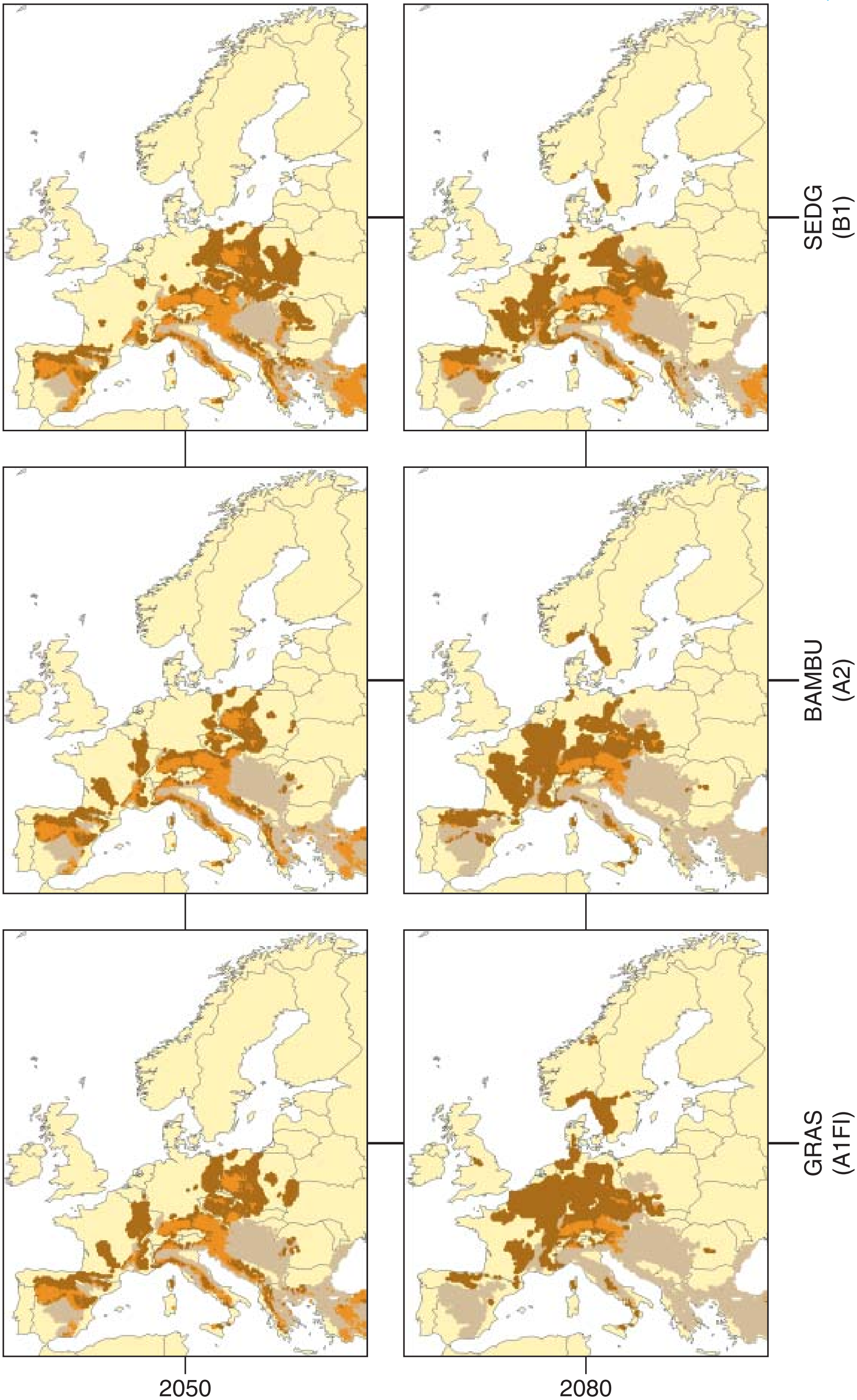
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.79).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Boloria eunomia (Esper, 1799) – Bog Fritillary

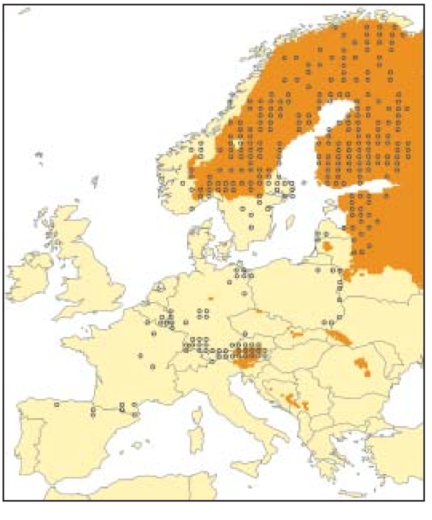
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-1589 (-19.98%)	-1783 (-22.42%)
	BAMBU	-1220 (-15.34%)	-1399 (-17.59%)
	GRAS	-1564 (-19.66%)	-1760 (-22.13%)
2080	SEDG	-1843 (-23.17%)	-2291 (-28.8%)
	BAMBU	-2410 (-30.3%)	-2747 (-34.54%)
	GRAS	-3171 (-39.87%)	-3443 (-43.29%)

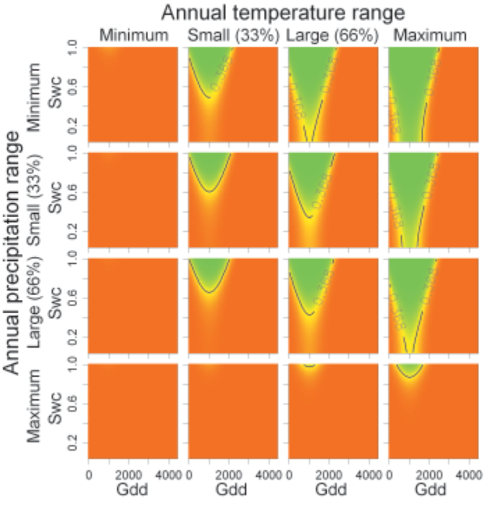
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 7954)

The Bog Fritillary occurs on wet grasslands and marshy ground by streams, rivers, or lakes, and at the edges of raised bogs. Sometimes, the area they occupy is very small. They can be seen beside streams, flying slowly back and forth between small patches where its foodplant Common Bistort (*Polygonum bistorta*) is growing. The small caterpillars live together in a loosely spun nest, and hibernate when half-grown. However, the larger, later caterpillars are solitary and considerably more mobile, frequently leaving their foodplants in order to bask in the sun on another plant. The Bog Fritillary has one generation a year. There are two subspecies in Europe. The species' range in central Europe is highly fragmented.

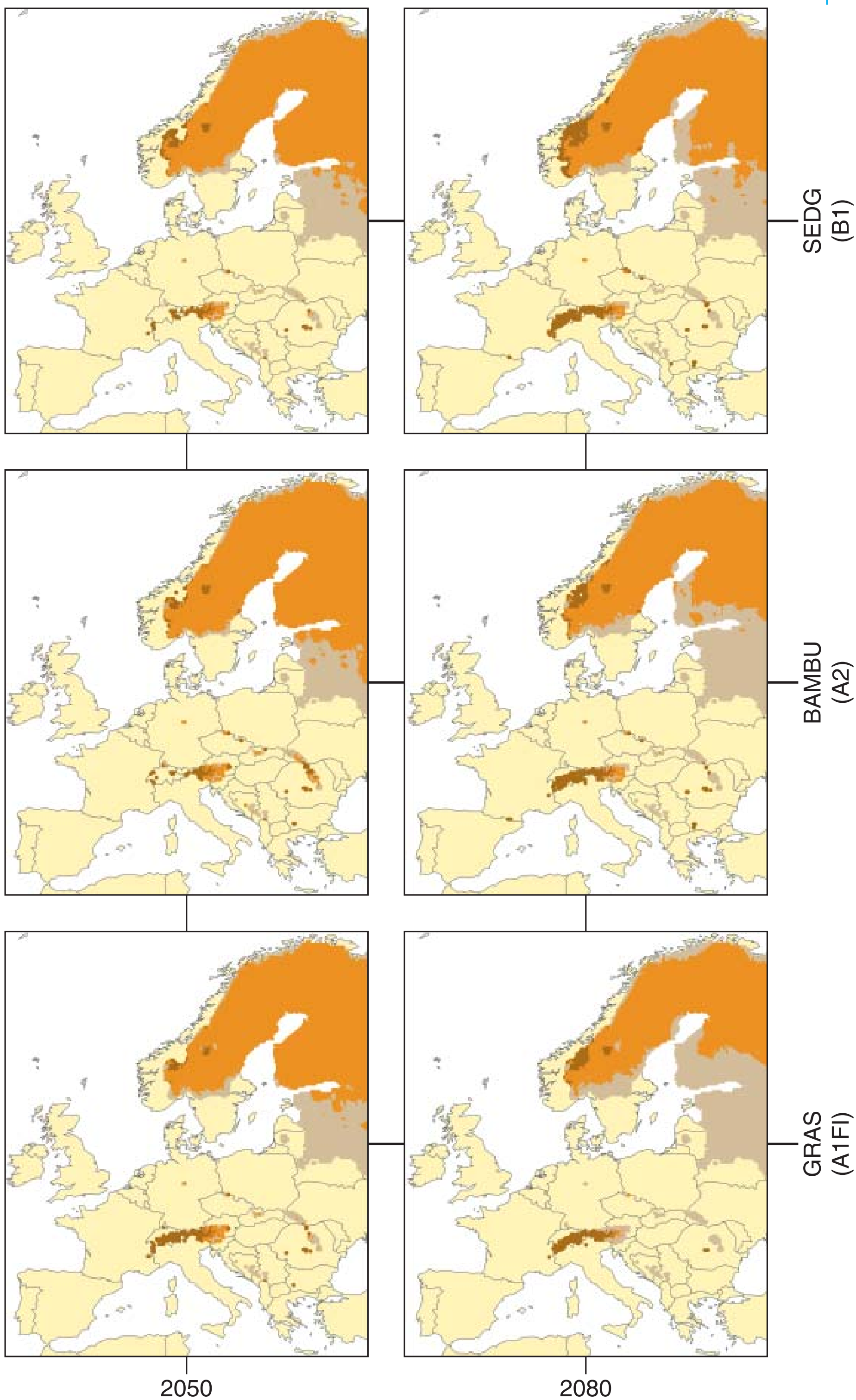
Present distribution can be well explained by climatic variables (AUC = 0.89).
Climate risk category: LR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Boloria euphrosyne (Linnaeus, 1758) – Pearl-bordered Fritillary

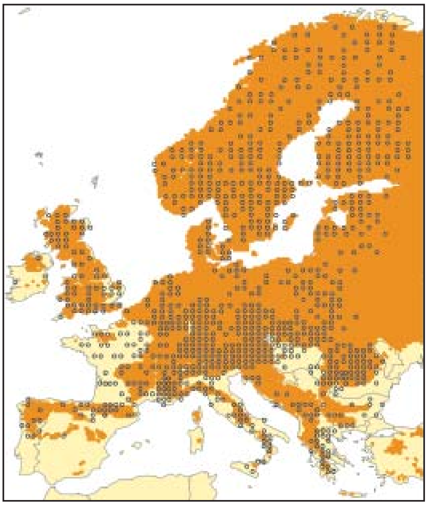
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-4042 (-18.77%)	-4132 (-19.19%)
	BAMBU	-3553 (-16.5%)	-3587 (-16.66%)
	GRAS	-5707 (-26.51%)	-5782 (-26.86%)
2080	SEDG	-4372 (-20.31%)	-4649 (-21.59%)
	BAMBU	-7044 (-32.72%)	-7118 (-33.06%)
	GRAS	-8912 (-41.4%)	-9059 (-42.08%)

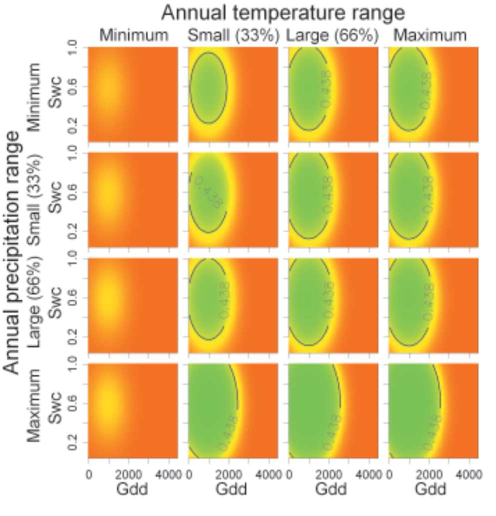
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 21529)

The Pearl-bordered Fritillary occurs at the edges of woods and in clearings, in meadows and on pastures near scrub. Its habitats are usually dry and moderately rich in nutrients. The butterflies are quite mobile, leaving the habitat in search of nectar, visiting vegetation that ranges from very dry to wet. Most species of violet (*Viola* spp.) can be used as a foodplant. The female lays her eggs singly, either on a foodplant or on a neighbouring plant. The caterpillars feed on the violet leaves, hibernating in a rolled-up, withered leaf, when half-grown. The species pupates on the foodplant, close to the ground. It has one to two broods per year.

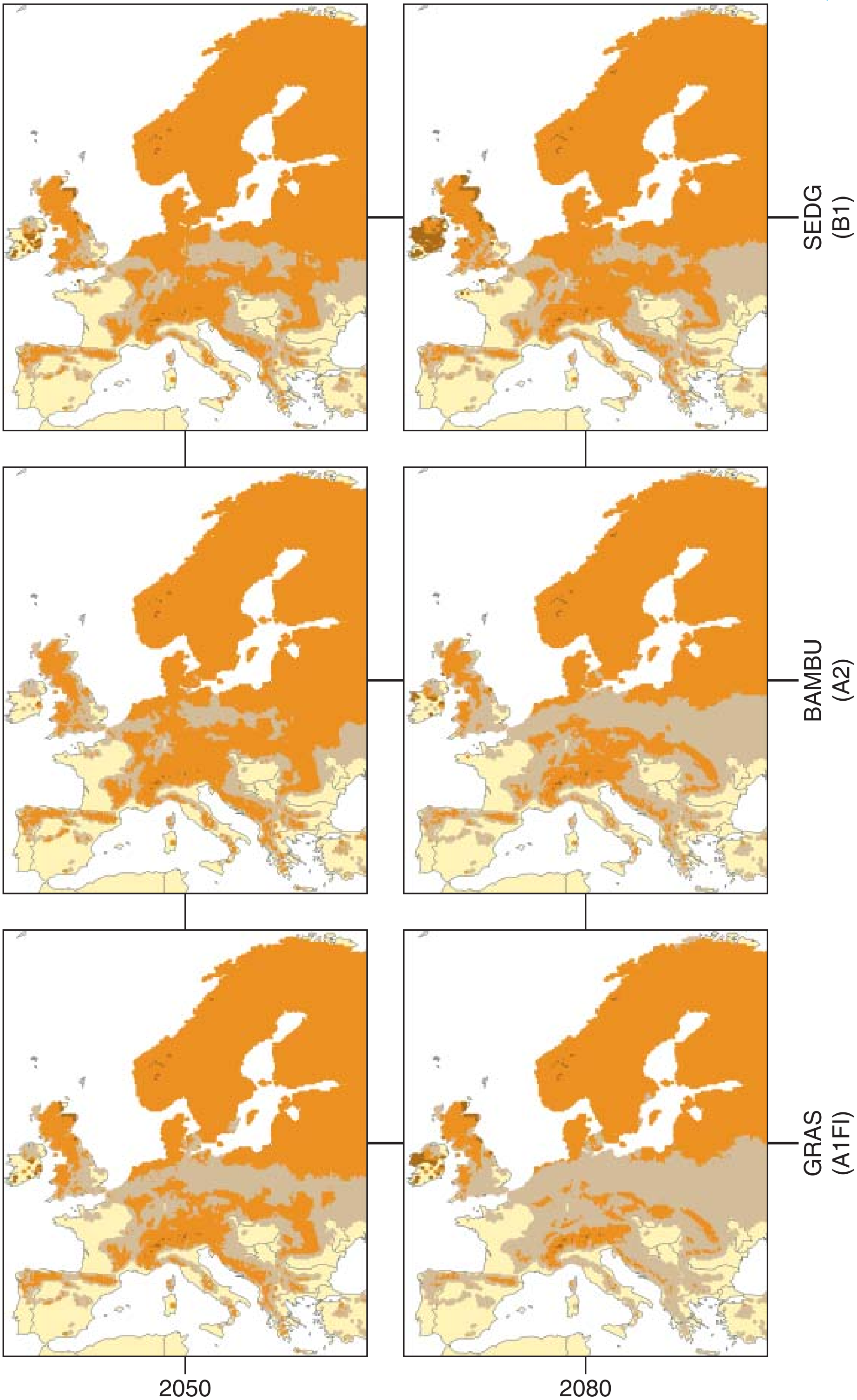
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.73).
Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Boloria titania (Esper, 1793) – Titania's Fritillary

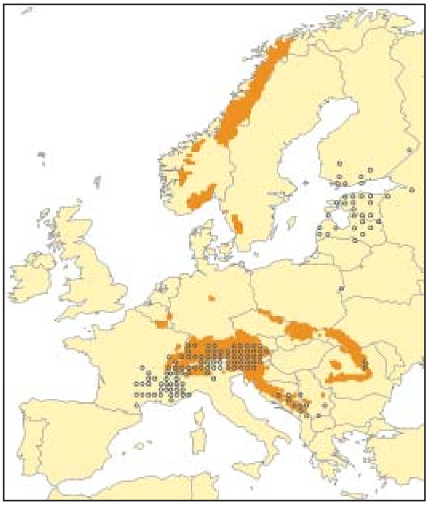
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-377 (-19.74%)	-766 (-40.1%)
	BAMBU	-151 (-7.91%)	-525 (-27.49%)
	GRAS	-580 (-30.37%)	-874 (-45.76%)
2080	SEDG	116 (6.07%)	-863 (-45.18%)
	BAMBU	570 (29.84%)	-926 (-48.48%)
	GRAS	492 (25.76%)	-1181 (-61.83%)

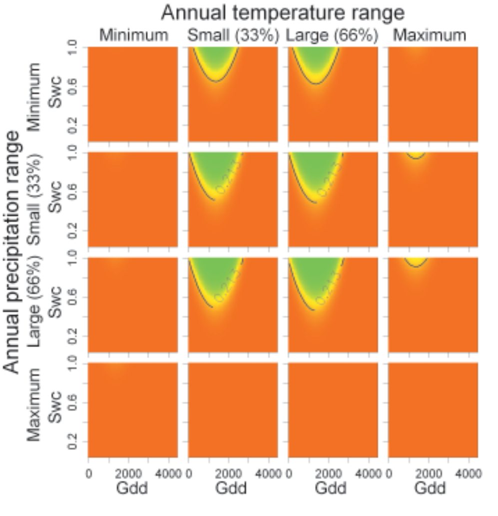
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1910)

Titania's Fritillary occurs in grassy, open places at the edges of woodland, or in woodland clearings, or on grassland with scattered trees, mostly on damp to swampy ground, where its foodplant Snake-root or Common Bistort (*Polyganum bistorta*) is growing among tall flower-rich vegetation. Various violets (*Viola* spp.) are also used as a foodplant. The female deposits her rather large eggs singly on either the foodplant, or on a plant nearby. The caterpillars go into hibernation in an early stage, and pupate at the end of the spring on a stalk, near to the ground. The species is single-brooded.

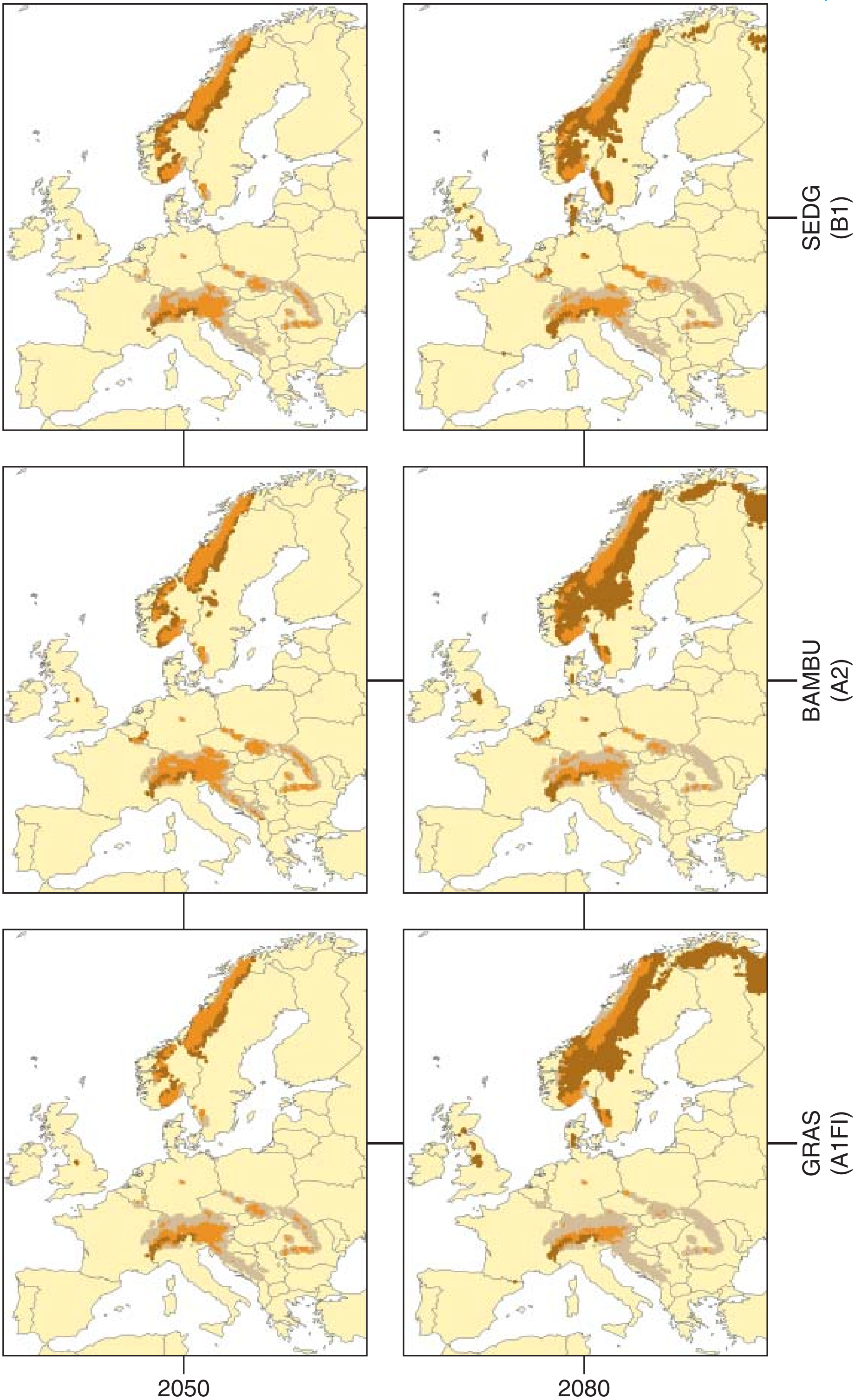
Present distribution can be well explained by climatic variables (AUC = 0.9).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


2050
2080
SEDG (B1)
BAMBU (A2)
GRAS (A1FI)

Boloria selene ([Schiffermüller], 1775) – Small Pearl-bordered Fritillary

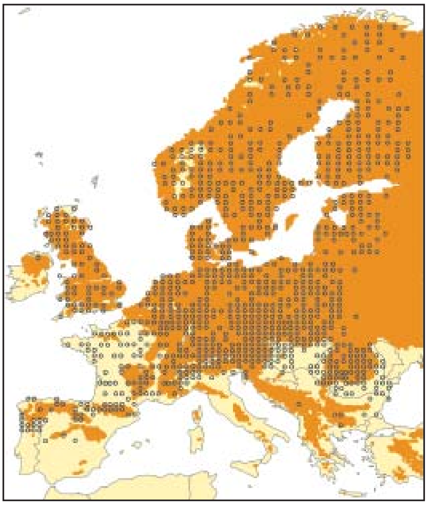
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-4708 (-23%)	-5037 (-24.61%)
	BAMBU	-5114 (-24.99%)	-5424 (-26.5%)
	GRAS	-6093 (-29.77%)	-6442 (-31.47%)
2080	SEDG	-6291 (-30.74%)	-6771 (-33.08%)
	BAMBU	-8549 (-41.77%)	-8996 (-43.95%)
	GRAS	-10443 (-51.02%)	-10927 (-53.39%)

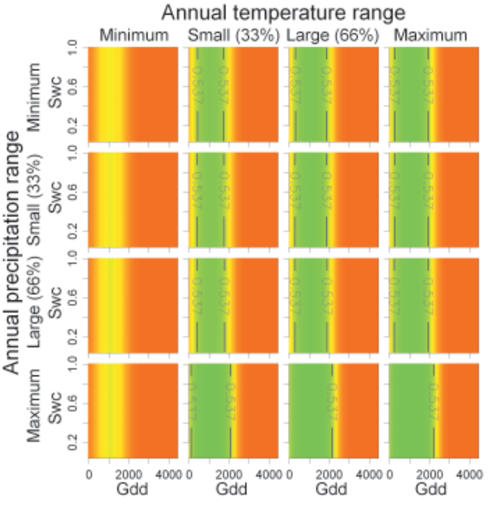
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 20468)

The Small Pearl-bordered Fritillary, is found in damp to wet meadows or on lightly-grazed pastures. It is also found on raised bogs and in swampy habitats. Populations may occur in small, sheltered locations, but also in an open landscape. The butterflies can often be seen taking nectar, seeming to prefer thistles of various kinds. The eggs are laid on violets (*Viola* spp.). When half-grown, the caterpillars hibernate in a rolled-up leaf of the foodplant. They pupate low down on a stalk in the litter layer. At high altitudes and in the north, the Small Pearl-bordered Fritillary is single-brooded, but has two generations a year elsewhere.

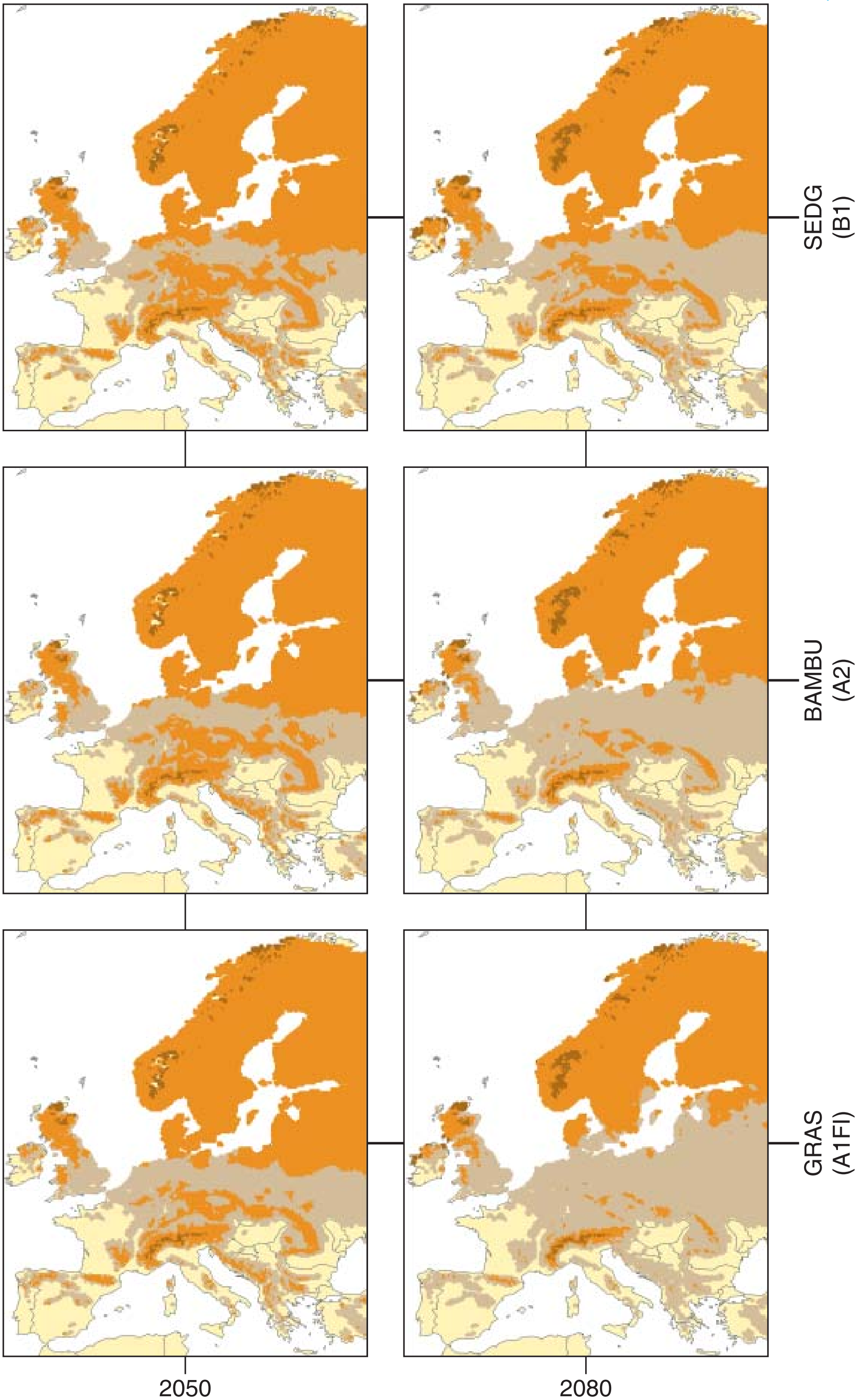
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.73). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Boloria chariclea (Schneider, 1794) – Arctic Fritillary

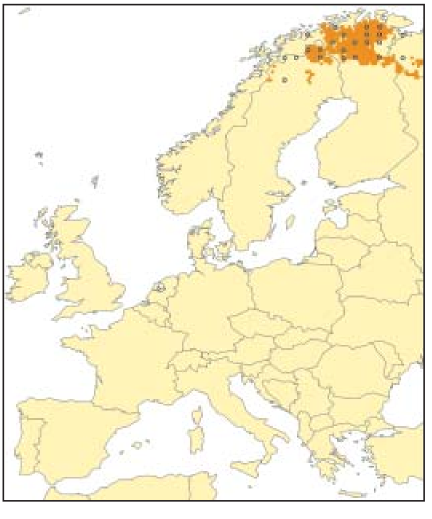
© Jostein Engdal

		Full dispersal	No dispersal
2050	SEDG	-519 (-98.3%)	-523 (-99.05%)
	BAMBU	-518 (-98.11%)	-521 (-98.67%)
	GRAS	-518 (-98.11%)	-524 (-99.24%)
2080	SEDG	-512 (-96.97%)	-528 (-100%)
	BAMBU	-526 (-99.62%)	-528 (-100%)
	GRAS	-528 (-100%)	-528 (-100%)

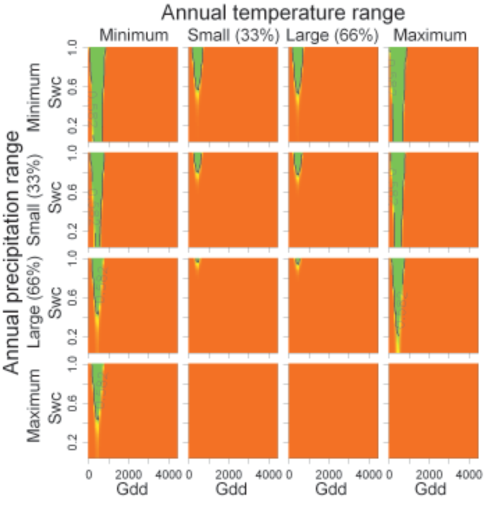
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 528)

The Arctic Fritillary occurs in a harsh environment, the windy, dry, rocky tundra in the far north of Europe, with a vegetation of grass and dwarf shrubs. The foodplant is not certain, but *Cassiope tetragon* (Ericaceae) and violets (*Viola* spp.) may be used. The butterflies, which only appear for about two weeks a year, fly close to the ground, seeking the shelter of rocks or hollows.

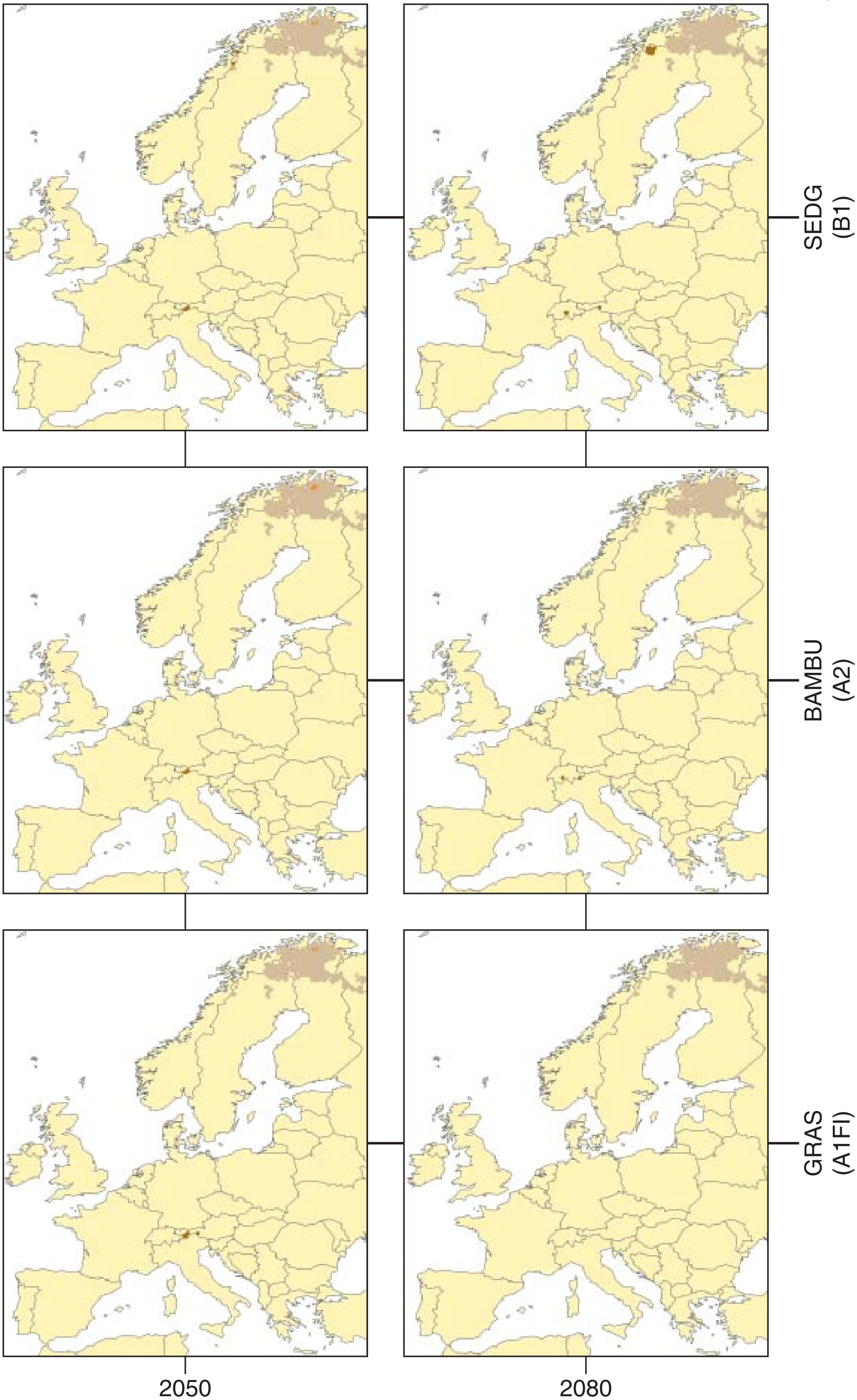
Present distribution can be very well explained by climatic variables (AUC = 1).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Boloria freija (Becklin, 1791) – Frejya's Fritillary

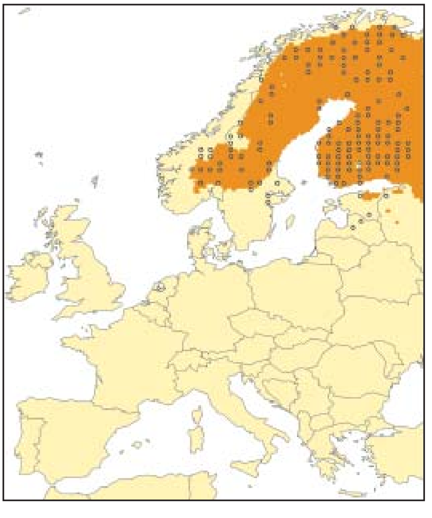
© Jostein Engdal

		Full dispersal	No dispersal
2050	SEDG	-1904 (-34.57%)	-1930 (-35.05%)
	BAMBU	-1434 (-26.04%)	-1446 (-26.26%)
	GRAS	-1581 (-28.71%)	-1593 (-28.93%)
2080	SEDG	-3654 (-66.35%)	-3670 (-66.64%)
	BAMBU	-3324 (-60.36%)	-3340 (-60.65%)
	GRAS	-4189 (-76.07%)	-4197 (-76.21%)

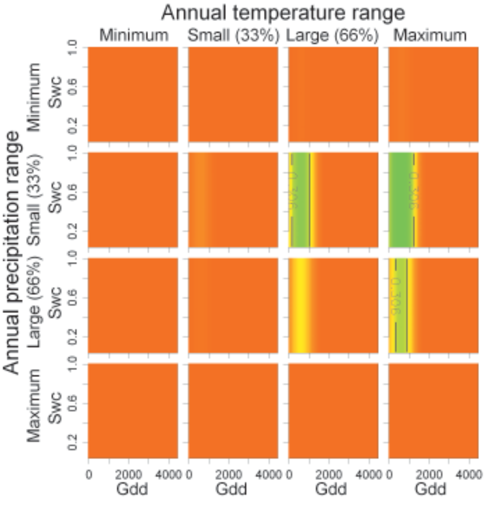
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 5507)

Frejya's Fritillary occurs in damp, peatland habitats. The female lays her eggs singly on Bog Whortleberry (*Vaccinium uliginosum*), and possibly also on Cloudberry (*Rubus chamaemorus*), Bearberry (*Arctostaphylos uva-ursi*), Alpine Bearberry (*A. alpinus*), and Crowberry (*Empetrum nigrum*). The butterflies can also be seen on drier, grassy vegetation, searching for nectar, visiting Moss Campion (*Silene acaulis*) frequently. Frejya's Fritillary is single-brooded.

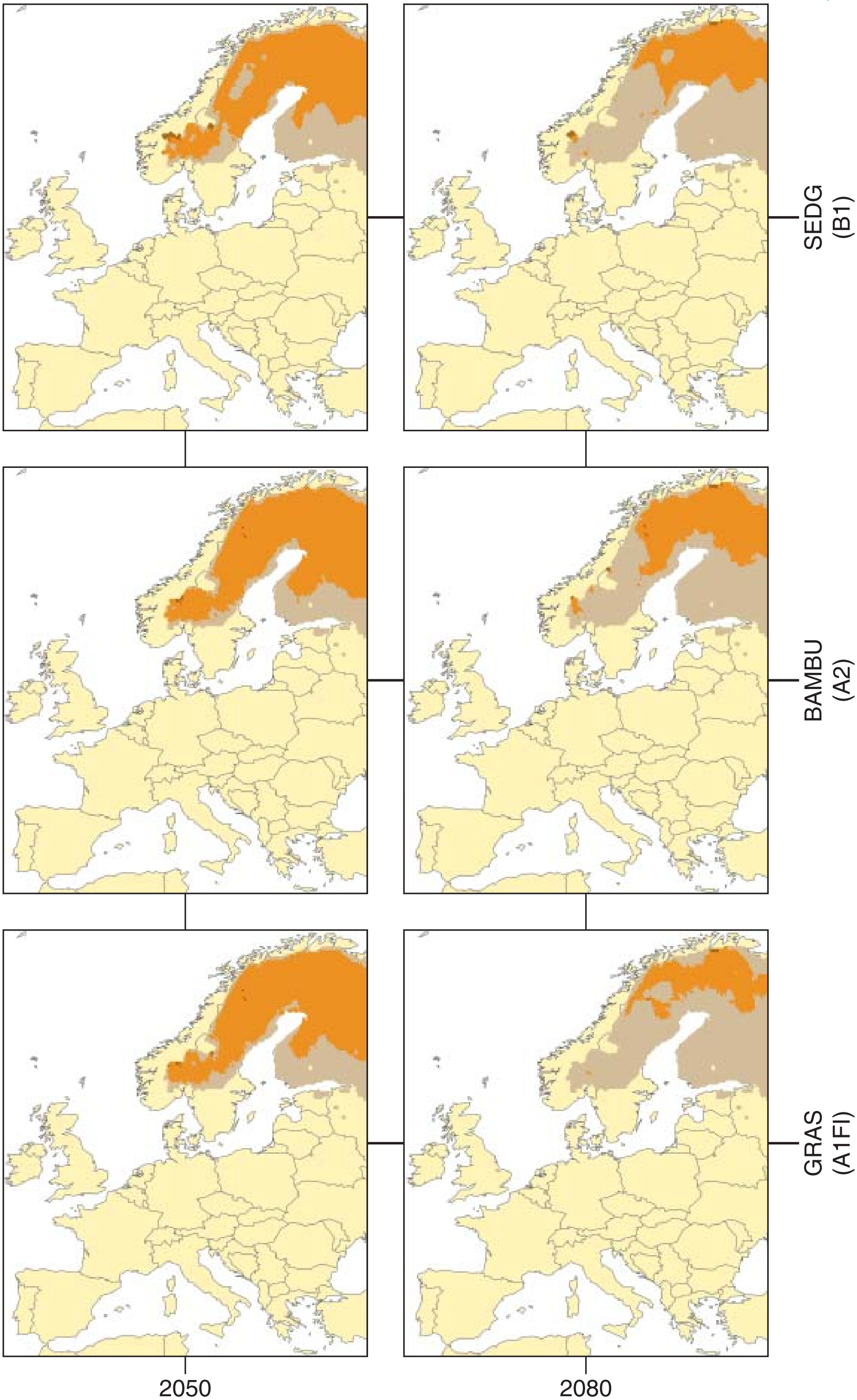
Present distribution can be well explained by climatic variables (AUC = 0.95).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Boloria dia (Linnaeus, 1767) – Weaver's Fritillary

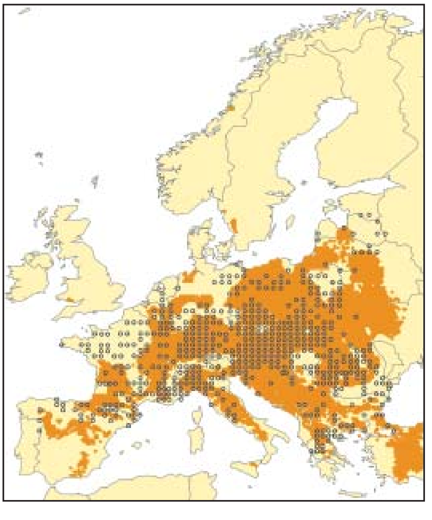
© Karl Heyde

		Full dispersal	No dispersal
2050	SEDG	1212 (14.54%)	-2342 (-28.09%)
	BAMBU	1436 (17.22%)	-2450 (-29.38%)
	GRAS	-2 (-0.02%)	-3190 (-38.26%)
2080	SEDG	1325 (15.89%)	-4030 (-48.33%)
	BAMBU	892 (10.7%)	-5229 (-62.71%)
	GRAS	605 (7.26%)	-6394 (-76.69%)

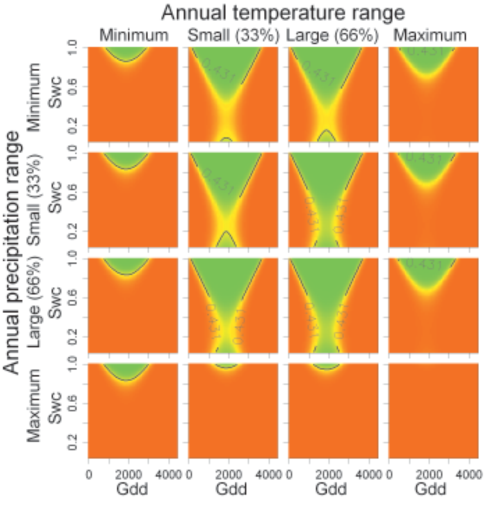
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 8338)

In the northern part of its range, the Weaver's Fritillary can be found on warm slopes with open woodland, scrub, and flower-rich grassland. More to the south, it is also found in damp, shady places. It can be very common in a traditional South-European agricultural landscape. The eggs are laid singly on various violets (*Viola* spp.). The caterpillars hibernate when half-grown in the litter layer. They pupate deep down in the vegetation. Weaver's Fritillary has two to three broods a year.

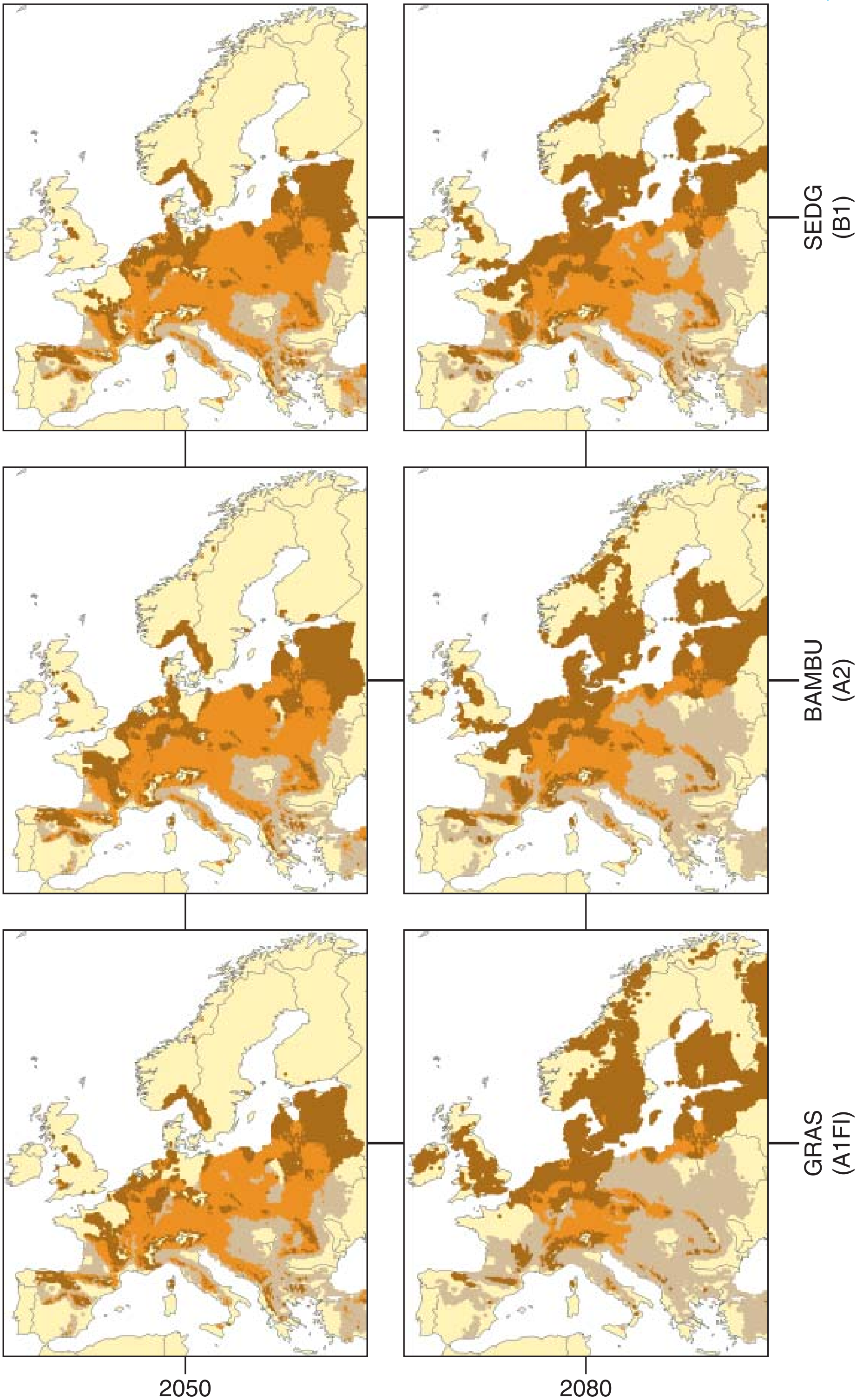
Present distribution can be well explained by climatic variables (AUC = 0.86).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Boloria thore (Hübner, 1806) – Thor's Fritillary

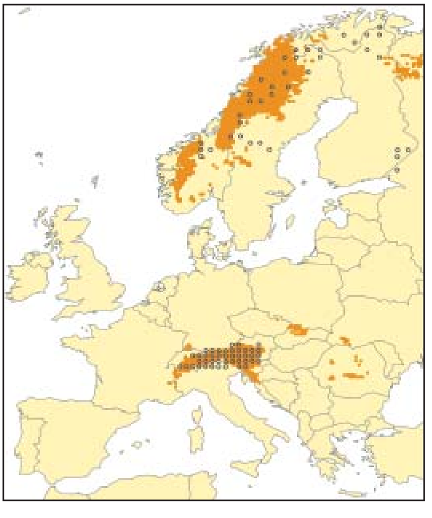
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	-200 (-12.32%)	-396 (-24.38%)
	BAMBU	-237 (-14.59%)	-370 (-22.78%)
	GRAS	-365 (-22.48%)	-471 (-29%)
2080	SEDG	579 (35.65%)	-405 (-24.94%)
	BAMBU	229 (14.1%)	-437 (-26.91%)
	GRAS	388 (23.89%)	-549 (-33.81%)

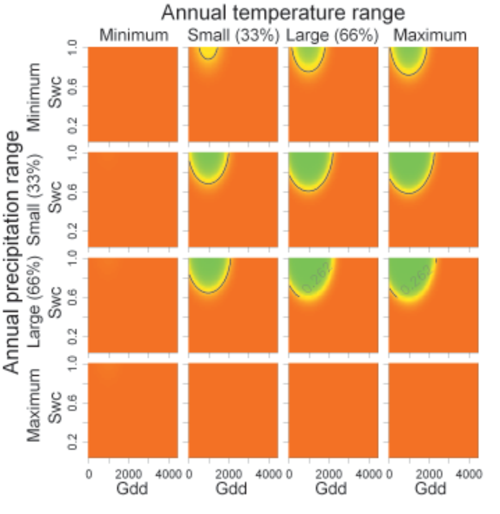
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1624)

In the Alps, Thor's Fritillary can be found in flower-rich places, in clearings, or in sheltered "alcoves" at the edges of woods. It prefers damp, north-facing slopes, and is often found beside streams or in ravines. In the Scandinavian part of its range, the butterflies can be seen in clearings in birch woods and coniferous forests, and near mountain lakes, swampy places, in gullies, and river beds. The Yellow Wood Violet (*Viola biflora*) is its major foodplant, but other violets are used as well. The female lays her eggs either on the foodplant, or on a neighbouring plant, and the caterpillars take nearly two years to develop.

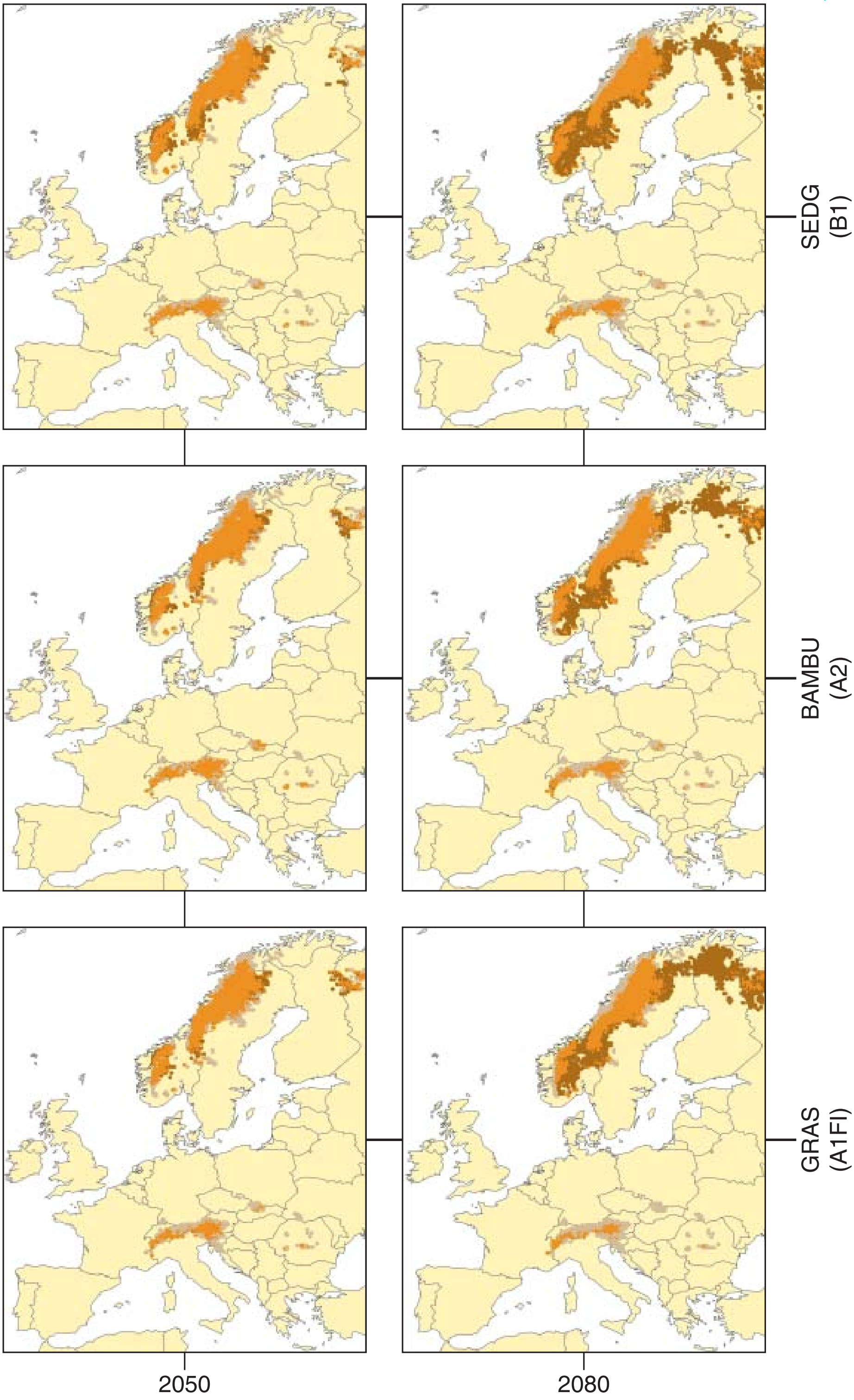
Present distribution can be well explained by climatic variables (AUC = 0.95).
Climate risk category: LR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Boloria frigga (Becklin, 1791) – Frigga's Fritillary

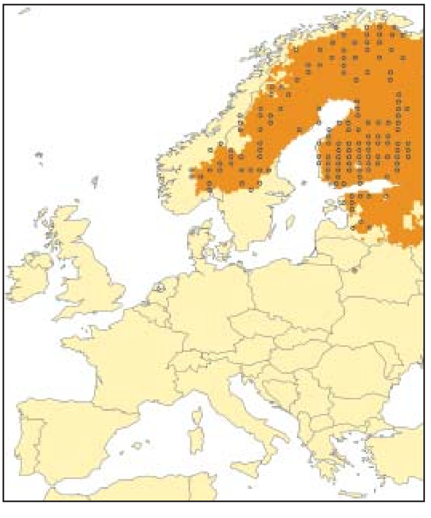
© Jostein Engdal

		Full dispersal	No dispersal
2050	SEDG	-1825 (-30.7%)	-1919 (-32.28%)
	BAMBU	-1331 (-22.39%)	-1457 (-24.51%)
	GRAS	-1842 (-30.98%)	-1949 (-32.78%)
2080	SEDG	-3317 (-55.79%)	-3406 (-57.29%)
	BAMBU	-2550 (-42.89%)	-2690 (-45.25%)
	GRAS	-3189 (-53.64%)	-3323 (-55.9%)

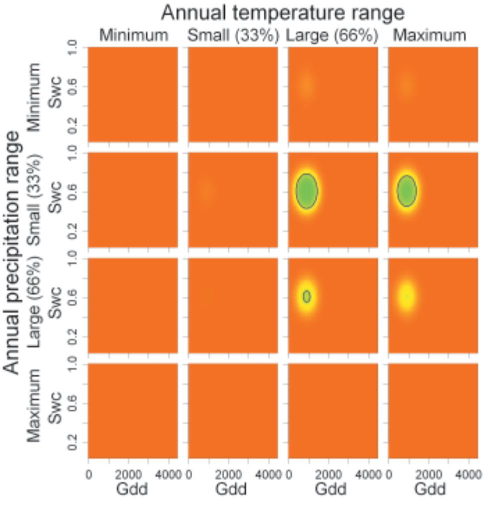
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 5945)

Frigga's Fritillary is mostly found on open bogs and in swampy areas with shrubs of Birches (*Betula* spp.) and willows (*Salix* spp.) scrub, in swampy areas in birch woods, and on bogs in coniferous forests. It is a rare fritillary that occurs locally and always in low to very low numbers. Despite its size, it is inconspicuous and can suddenly seem to vanish. The eggs are laid singly on Cloudberry (*Rubus chamaemorus*).

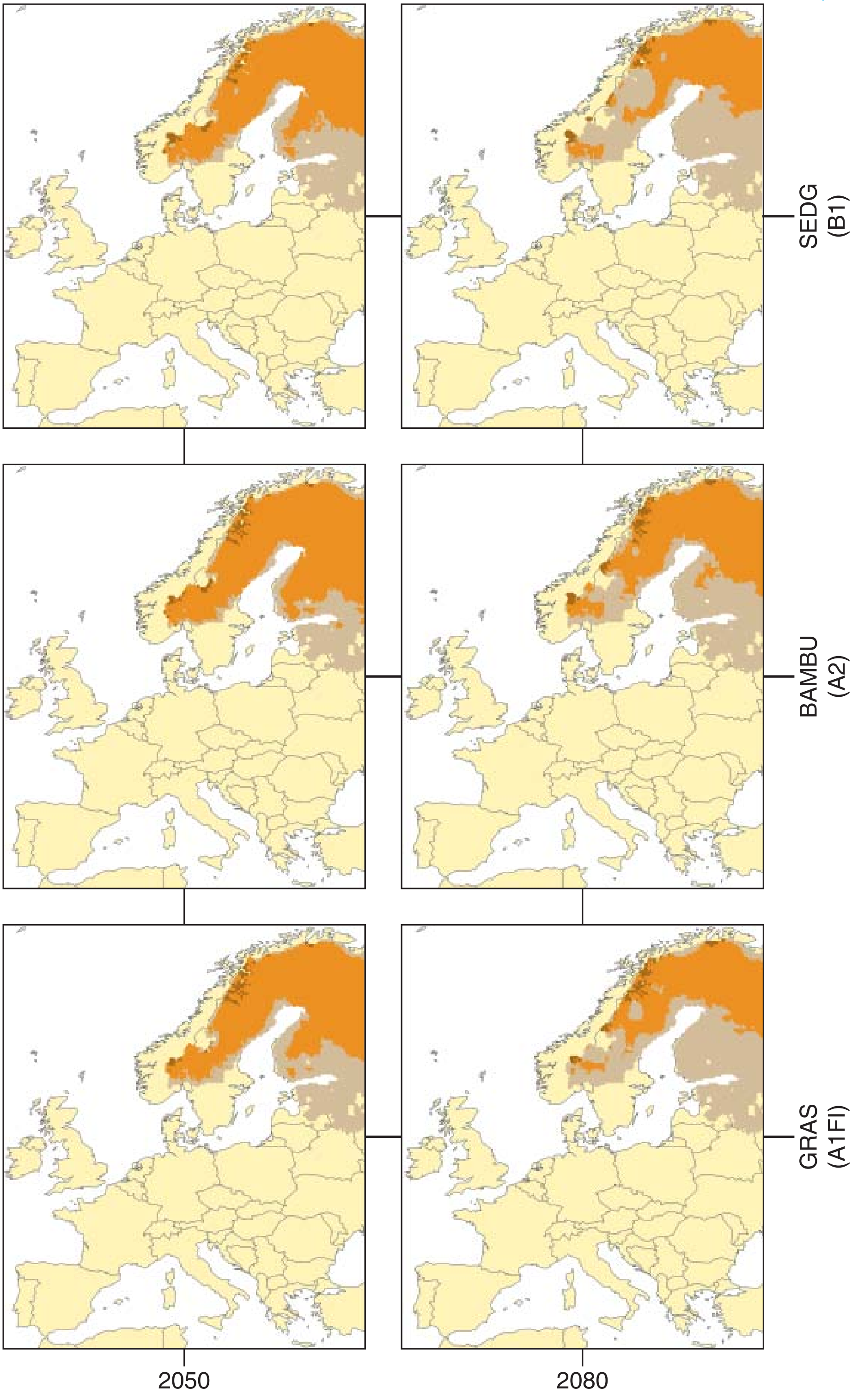
Present distribution can be well explained by climatic variables (AUC = 0.96).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Boloria pales ([Schiffermüller], 1775) – Shepherd's Fritillary

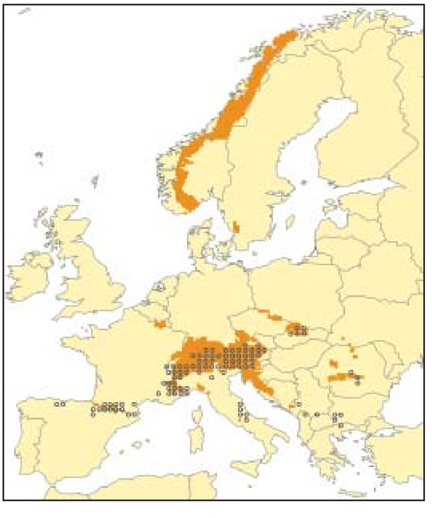
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-359 (-23.68%)	-493 (-32.52%)
	BAMBU	-286 (-18.87%)	-463 (-30.54%)
	GRAS	-520 (-34.3%)	-631 (-41.62%)
2080	SEDG	-533 (-35.16%)	-808 (-53.3%)
	BAMBU	-417 (-27.51%)	-782 (-51.58%)
	GRAS	-631 (-41.62%)	-1002 (-66.09%)

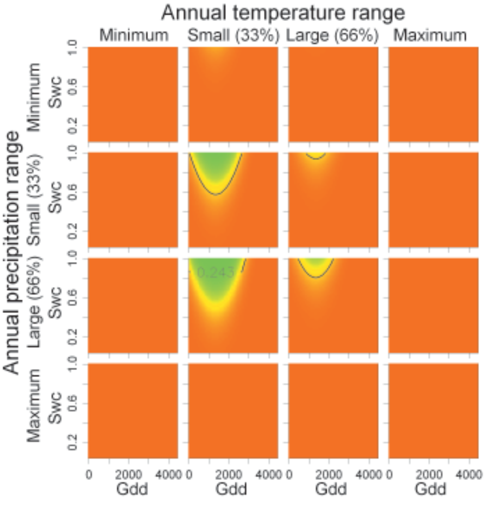
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1516)

The Shepherd's Fritillary is a characteristic species of flower-rich sub-alpine and alpine grasslands and can even be found on quite heavily grazed pastures. They can occur in high numbers. At the end of the day, they often roost communally in damp vegetation with tall plants. Long-spurred Pansy (*Viola calcarata*) is the major foodplant, but Alpine Plantain (*Plantago alpina*) and valerians (*Valeriana*) are probably also used. Caterpillars are mostly found on plants growing in dry, rocky places. The Shepherd's Fritillary has one generation a year and passes the winter in the larval stage.

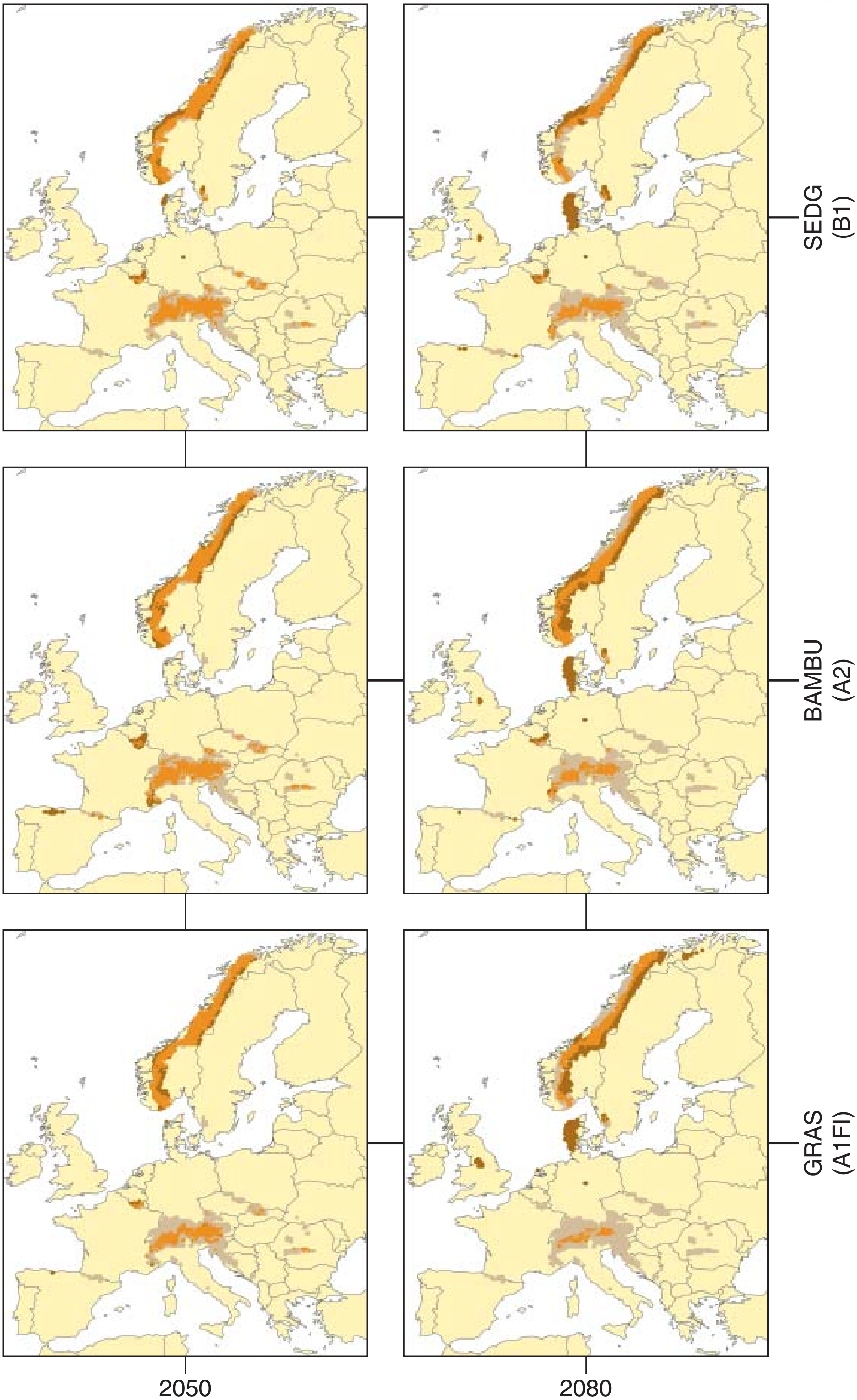
Present distribution can be well explained by climatic variables (AUC = 0.89).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Boloria aquilonaris (Stichel, 1908) – Cranberry Fritillary

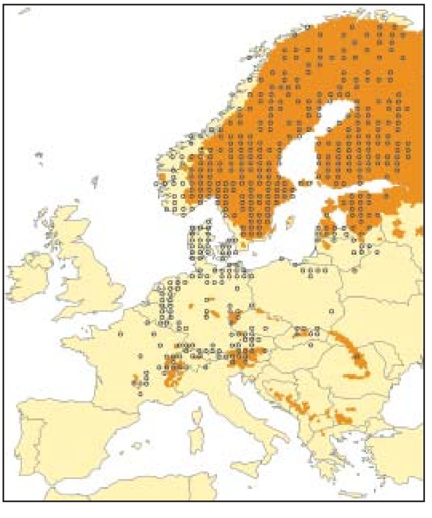
© Peter Ginzinger

		Full dispersal	No dispersal
2050	SEDG	-2371 (-29%)	-2668 (-32.63%)
	BAMBU	-1964 (-24.02%)	-2230 (-27.27%)
	GRAS	-2362 (-28.89%)	-2625 (-32.1%)
2080	SEDG	-3359 (-41.08%)	-3768 (-46.08%)
	BAMBU	-3717 (-45.46%)	-4025 (-49.22%)
	GRAS	-4789 (-58.57%)	-5019 (-61.38%)

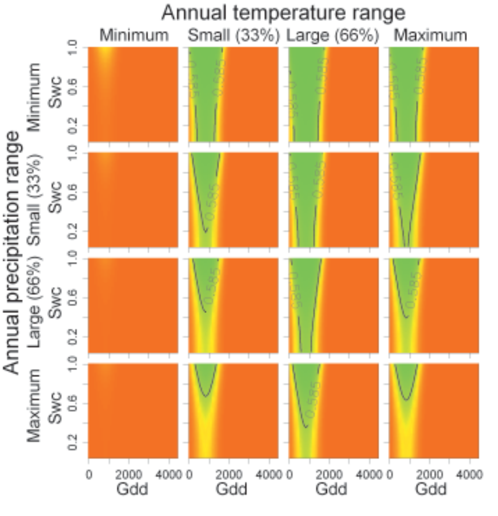
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 8177)

The Cranberry Fritillary inhabits raised bogs and wet heaths, mostly in sheltered places at the edges of woods, or in clearings. The female lays her eggs singly on the leaves of Cranberry (*Vaccinium oxycoccos*) and Marsh Andromeda (*Andromeda polifolia*). The caterpillar goes into hibernation in the moss layer just after hatching, only beginning to feed and grow the following year. However, in adverse conditions, the caterpillar may hibernate a second time. It pupates low down in the vegetation. It is usually single-brooded.

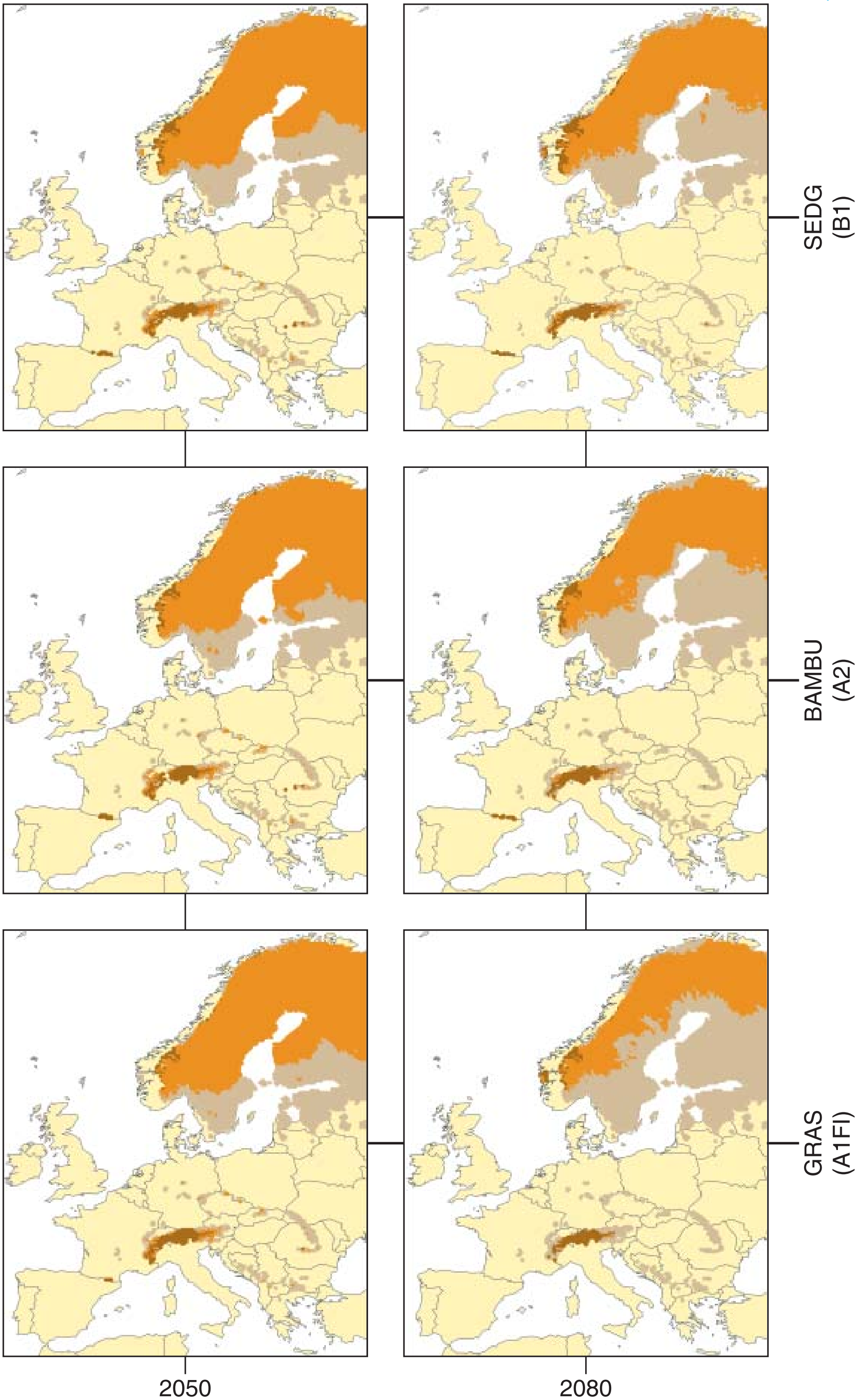
Present distribution can be well explained by climatic variables (AUC = 0.89).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Boloria graeca (Staudinger, 1870) – Balkan Fritillary

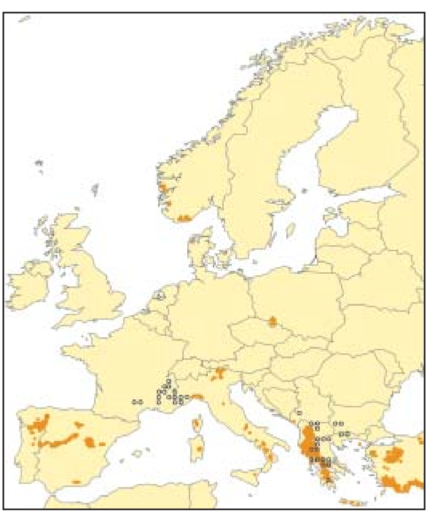
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-239 (-49.69%)	-353 (-73.39%)
	BAMBU	-281 (-58.42%)	-370 (-76.92%)
	GRAS	-271 (-56.34%)	-378 (-78.59%)
2080	SEDG	-197 (-40.96%)	-370 (-76.92%)
	BAMBU	-330 (-68.61%)	-418 (-86.9%)
	GRAS	-259 (-53.85%)	-433 (-90.02%)

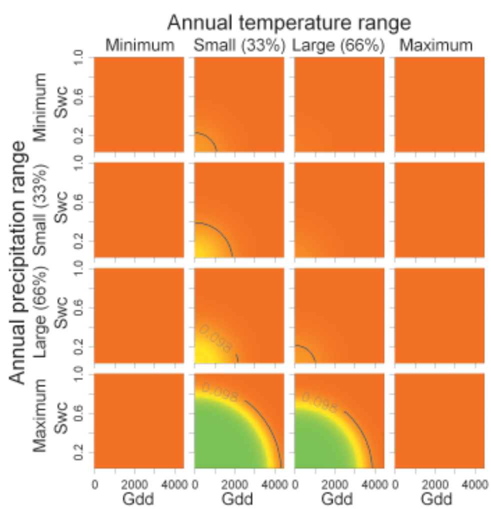
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 481)

The Balkan Fritillary can be found in the mountains on flower-rich grasslands, or on grassland with scattered bushes, and in clearings in woods. These butterflies usually fly close to the ground. Various violets (*Viola* spp.) are used as foodplant. The female lays her eggs either on the foodplant, or on a plant nearby. The Balkan Fritillary has one generation a year and hibernates as a small caterpillar.

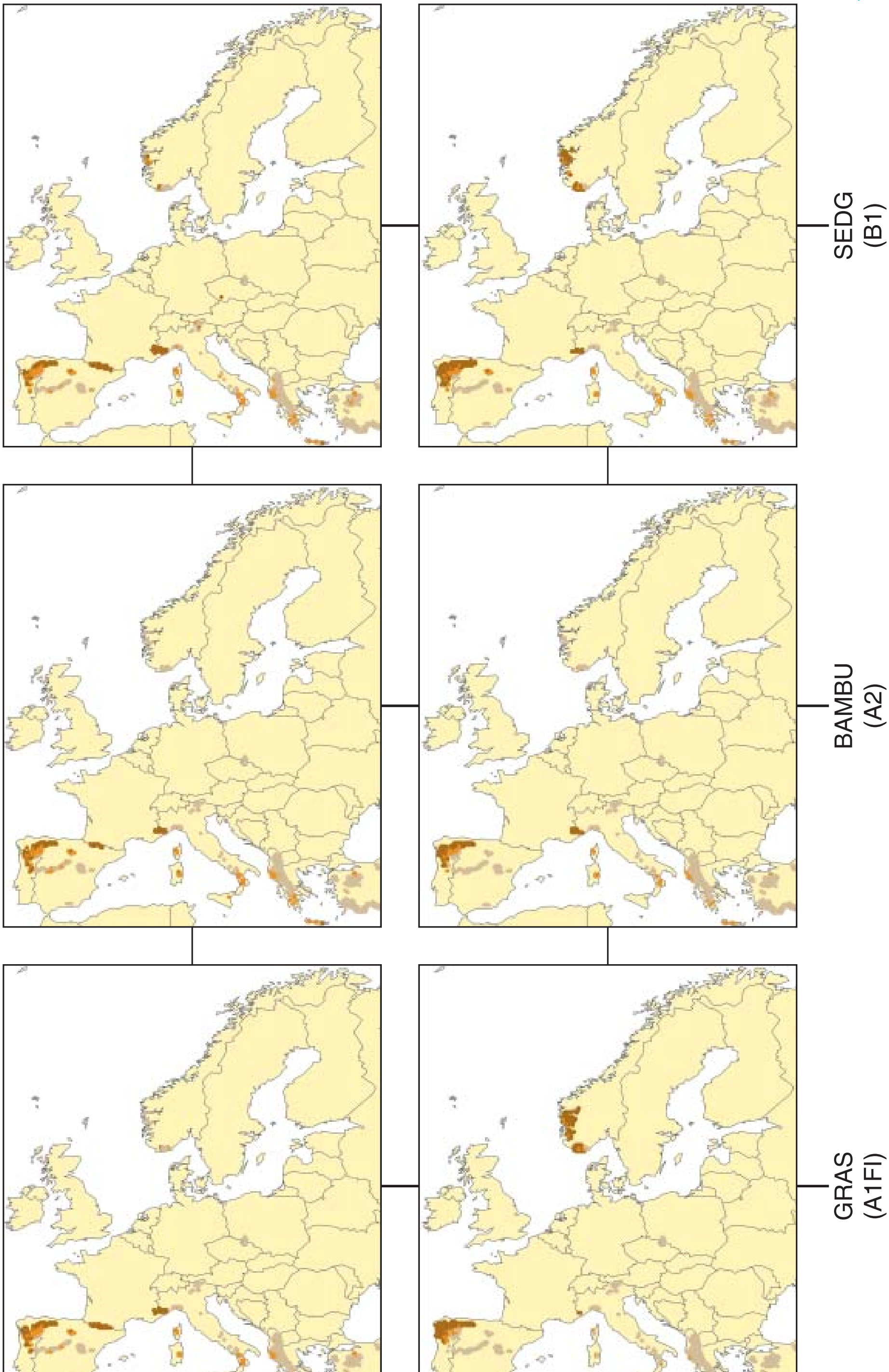
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.75). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Vanessa atalanta (Linnaeus, 1758) – Red Admiral

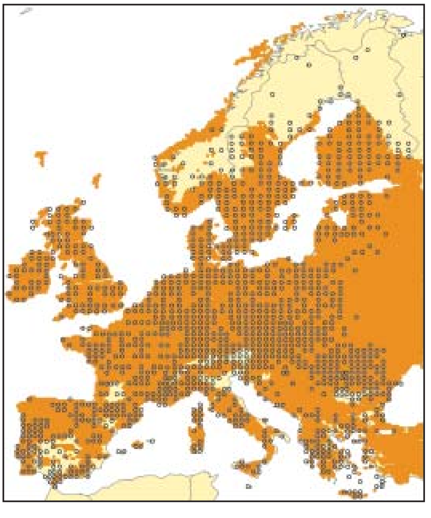
© Peter Ginzinger

		Full dispersal	No dispersal
2050	SEDG	-2683 (-11.89%)	-3874 (-17.16%)
	BAMBU	-4288 (-19%)	-4857 (-21.52%)
	GRAS	-4073 (-18.04%)	-5063 (-22.43%)
2080	SEDG	-5008 (-22.18%)	-6755 (-29.92%)
	BAMBU	-8963 (-39.7%)	-10381 (-45.99%)
	GRAS	-11874 (-52.6%)	-13684 (-60.62%)

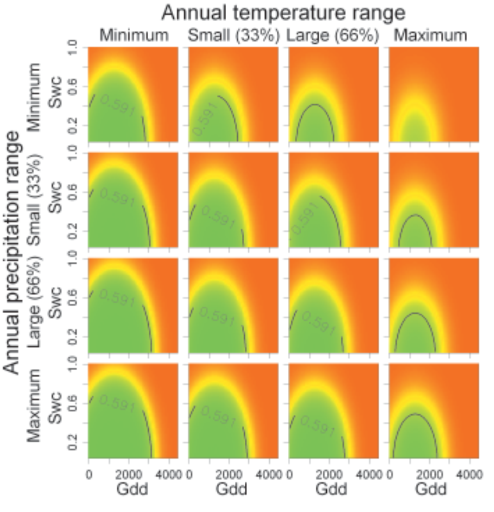
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 22574)

The Red Admiral is a wide-ranging, migratory butterfly that in temperate areas can only survive mild winters. Each year, butterflies from southern Europe fly northwards, and in good years Red Admirals can be seen practically everywhere. The butterflies need a lot of nectar, which they get from flowers. They also feed on rotting fruit and at harvest time are often seen in orchards. They are also attracted to the resin oozing from trees. The Red Admiral lays its eggs on Stinging Nettle (*Urtica dioica*) and Pellitory (*Parietaria* spp.) in sunny, but not all too dry places. The caterpillars live alone or in small groups in small tent-like shelters made by spinning leaves together. The caterpillars pupate in a little tent of spun leaves.

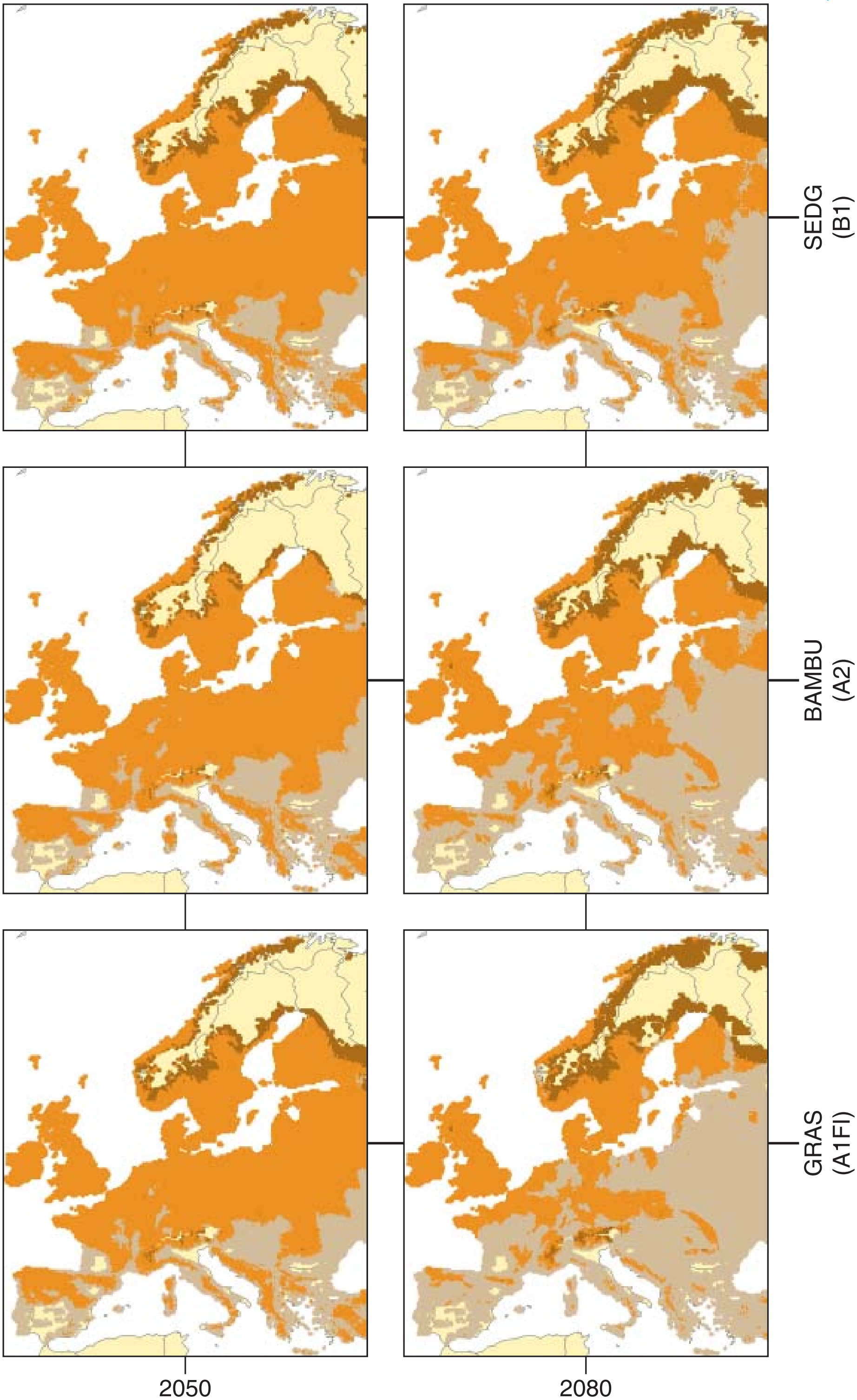
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.65). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Vanessa cardui (Linnaeus, 1758) – Painted Lady

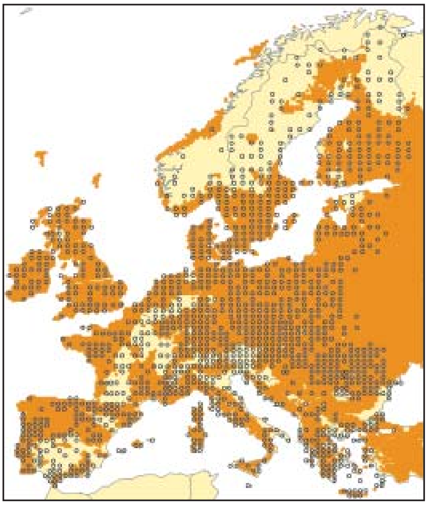
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-1792 (-8.9%)	-3883 (-19.28%)
	BAMBU	-4224 (-20.98%)	-5073 (-25.19%)
	GRAS	-3350 (-16.64%)	-5180 (-25.73%)
2080	SEDG	-2799 (-13.9%)	-5567 (-27.65%)
	BAMBU	-7054 (-35.03%)	-9170 (-45.54%)
	GRAS	-9272 (-46.05%)	-11805 (-58.63%)

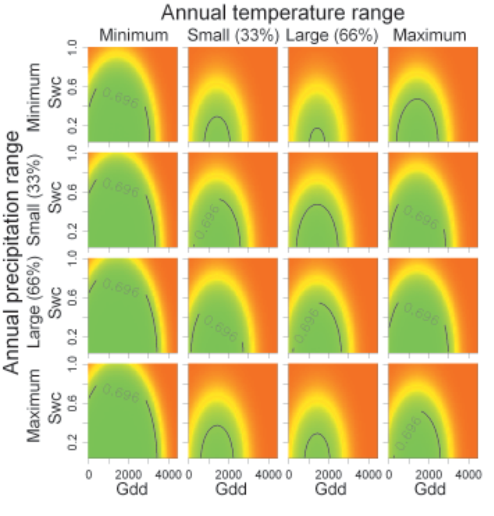
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 20136)

The Painted Lady is a visitor from the south, which is difficult to confuse with other butterflies. The black triangle on the tip of the forewing distinguishes it from the proper fritillaries. It is a migrant and cannot survive the winter in temperate climates. Each year, Western Europe is recolonized by butterflies from the south of Spain and Africa. In good years, the Painted Lady can be seen nearly everywhere, but otherwise seems to be absent. It visits a variety of flowers for nectar. The Painted Lady lays its eggs on very different foodplants. It prefers various thistles (*Cirsium* spp., *Carduus* spp., and *Onopordum* spp.), but also uses mallows (*Malva* spp.) especially in the south, Viper's Bugloss (*Echium vulgare*), and Stinging Nettle (*Urtica dioica*). The eggs are laid singly on the upperside of the leaves. The caterpillars feed in a shelter of loosely spun leaves. They pupate on the foodplant.

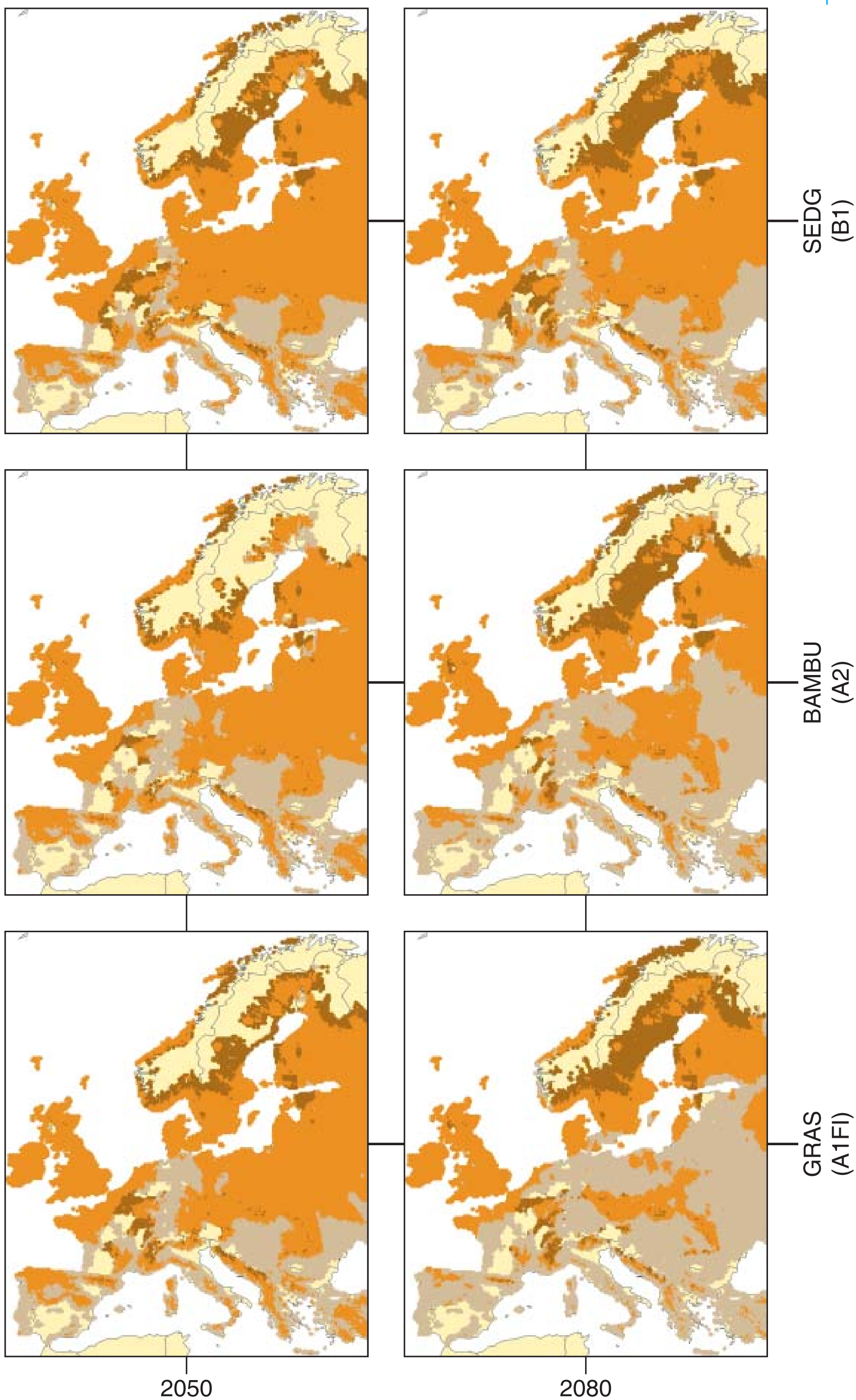
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.63). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Aglais io (Linnaeus, 1758) – Peacock

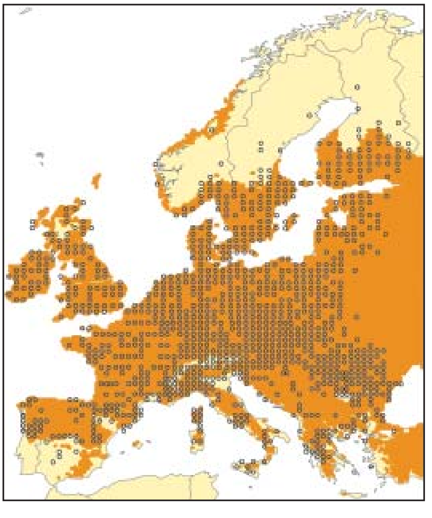
© Peter Ginzinger

		Full dispersal	No dispersal
2050	SEDG	-1220 (-5.96%)	-3269 (-15.96%)
	BAMBU	-1744 (-8.51%)	-3602 (-17.59%)
	GRAS	-2035 (-9.94%)	-4094 (-19.99%)
2080	SEDG	-1718 (-8.39%)	-5136 (-25.07%)
	BAMBU	-3006 (-14.68%)	-7383 (-36.04%)
	GRAS	-5130 (-25.05%)	-10412 (-50.83%)

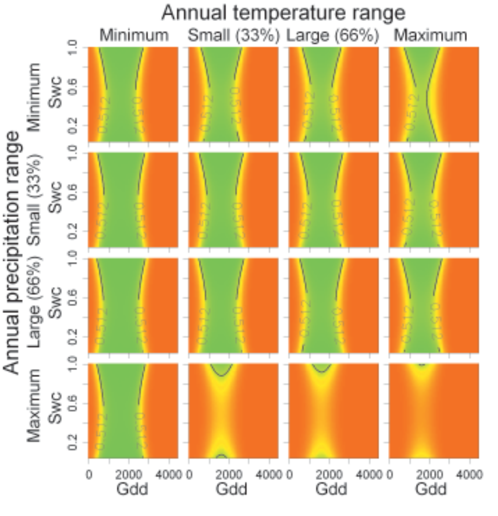
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 20483)

In temperate Europe, the Peacock is one of the best-known butterflies, because of its striking appearance and common occurrence. There is no other diurnal butterfly with such noticeable eye-spots on the upperside of its wings. It is often seen in gardens and parks on herbaceous borders and flowering shrubs, looking for nectar. Eggs are laid on Stinging Nettle (*Urtica dioica*) in damp, shady places, sometimes at edges of woodland. Occasionally, Hop (*Humulus lupulus*) is also used. The caterpillars live gregariously in flimsy webs. Sometimes, plants are completely covered with spun silk, which serves as a home for tens of caterpillars. They leave the web to pupate on the foodplant. The adult butterfly goes into hibernation, hiding itself away in cold lofts and sheds. The species usually has one and sometimes a partial second generation per year.

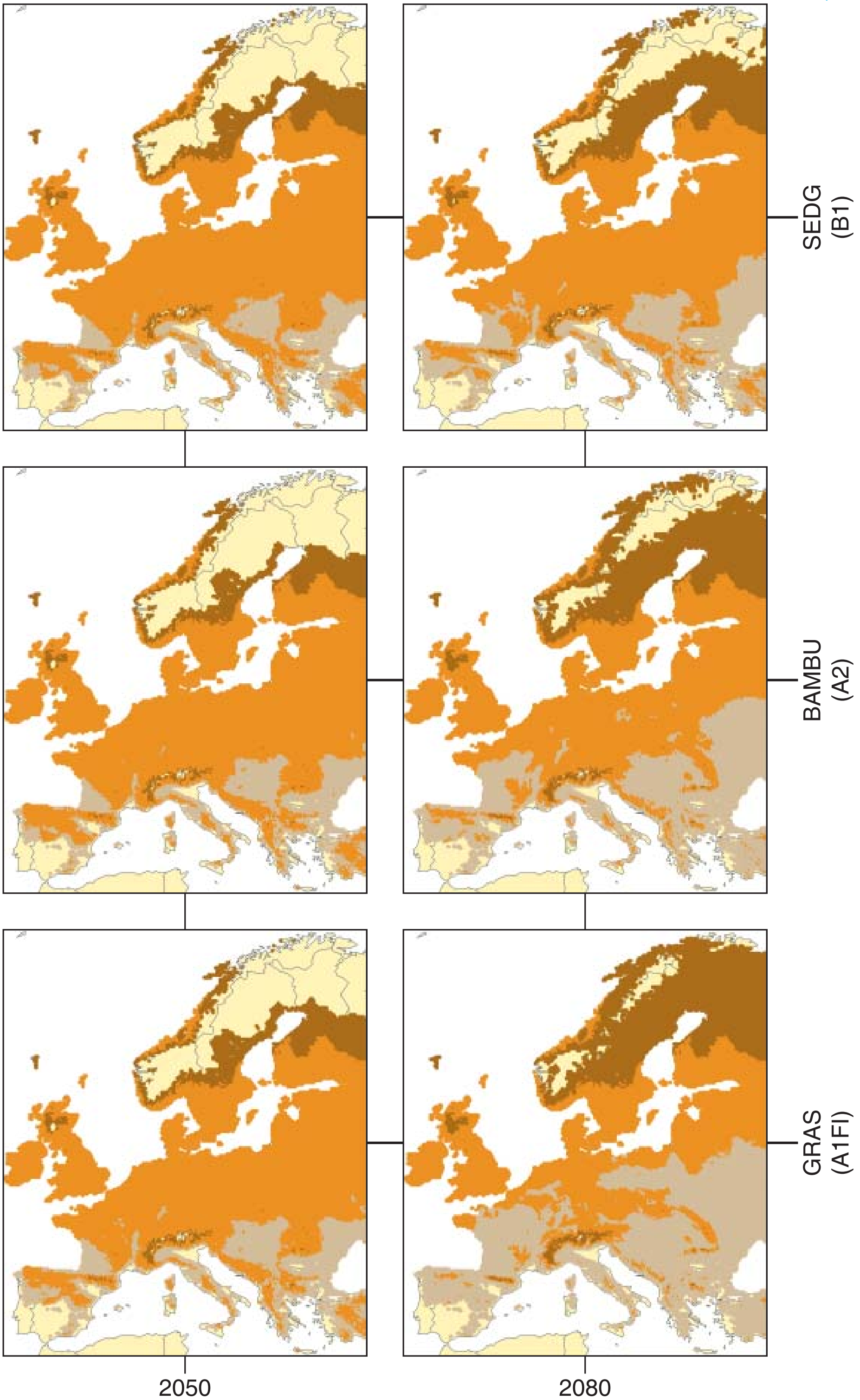
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.8).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Aglais urticae (Linnaeus, 1758) – Small Tortoiseshell

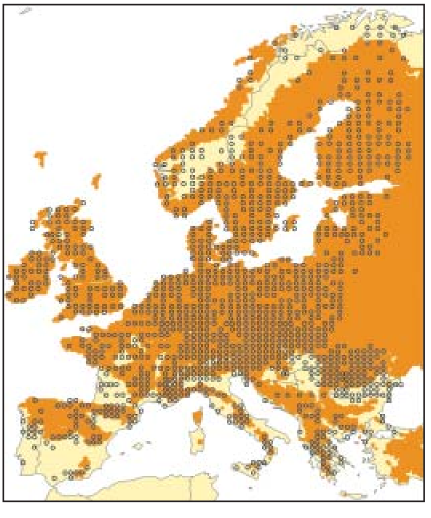
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-2522 (-11.56%)	-3317 (-15.2%)
	BAMBU	-3394 (-15.56%)	-4153 (-19.03%)
	GRAS	-3835 (-17.58%)	-4718 (-21.62%)
2080	SEDG	-4391 (-20.13%)	-5898 (-27.03%)
	BAMBU	-7863 (-36.04%)	-9692 (-44.42%)
	GRAS	-10097 (-46.28%)	-12111 (-55.51%)

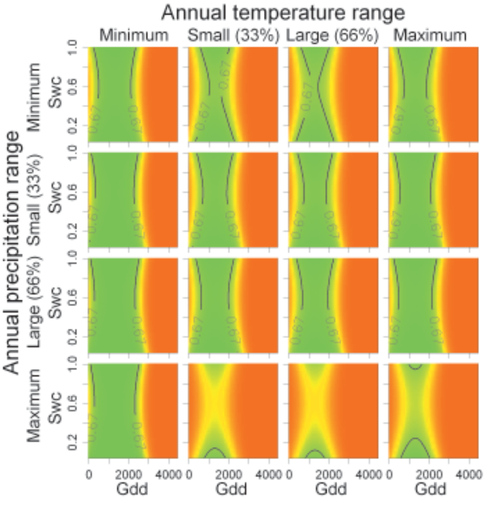
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 21818)

The Small Tortoiseshell is a common and welcome guest in parks and gardens, and is sometimes very abundant. It occurs in low numbers in nearly all habitats. Its only foodplant is Stinging Nettle (*Urtica dioica*). The foodplants are often growing on nutrient-rich, disturbed ground in the sun, such as in rough vegetation at the edges of meadows treated with manure or fertilizer. The eggs are laid in large batches on the underside of the nettle leaves. The caterpillars are gregarious, living in flimsy webs until they go their separate ways in the last larval instar. The species forms its pupa on the foodplants. The Small Tortoiseshell hibernates as a butterfly, and can often be found in the cold months hiding in houses or sheds. It is one of the first butterflies to be seen in the spring.

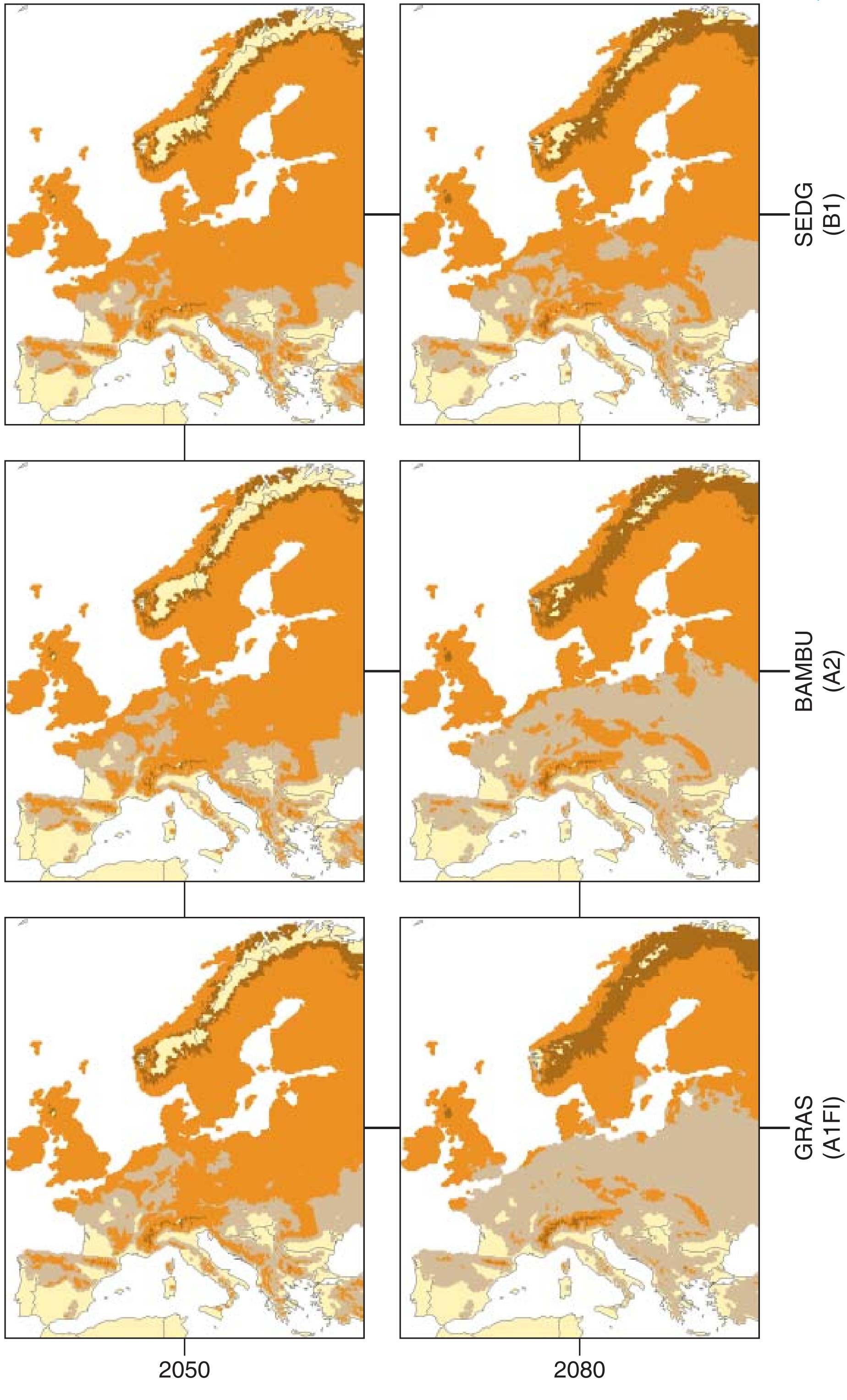
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.8).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Nymphalis c-album (Linnaeus, 1758) – Comma

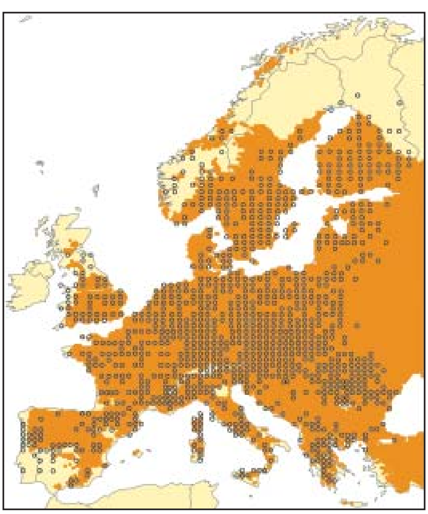
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-811 (-3.79%)	-2936 (-13.72%)
	BAMBU	-1830 (-8.55%)	-3404 (-15.91%)
	GRAS	-1943 (-9.08%)	-3916 (-18.3%)
2080	SEDG	-1279 (-5.98%)	-5032 (-23.52%)
	BAMBU	-3567 (-16.67%)	-7489 (-35%)
	GRAS	-5154 (-24.09%)	-9934 (-46.42%)

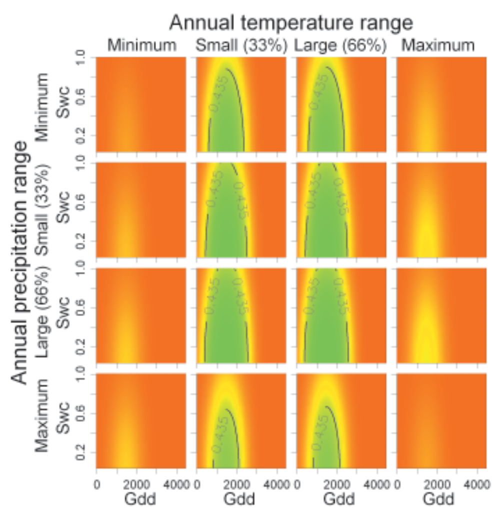
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 21399)

The Comma is a butterfly of wood edges and clearings in wood, except in very dry places. It is easily recognized by the deep indentations in the margins of its wings, and the small white comma on the otherwise dusky underside of the hindwing. Eggs are laid on many different plant species, like Stinging Nettle (*Urtica dioica*), bramble (*Rubus* spp.), elm (*Ulmus* spp.), willow (*Salix* spp.), Hazel (*Corylus avellana*), and Hop (*Humulus lupulus*). The caterpillar is solitary, brownish-black with long spines and a broad white stripe on his back towards the rear, making it look like a bird dropping. The pupa hangs from the foodplant on a small stalk. The butterflies hibernate in hollow trees, hedgerows, and shrubs. In large parts of Europe it is double-brooded. However, in Scandinavia it only has one generation, and in warm locations in Spain and Greece, it can have three.

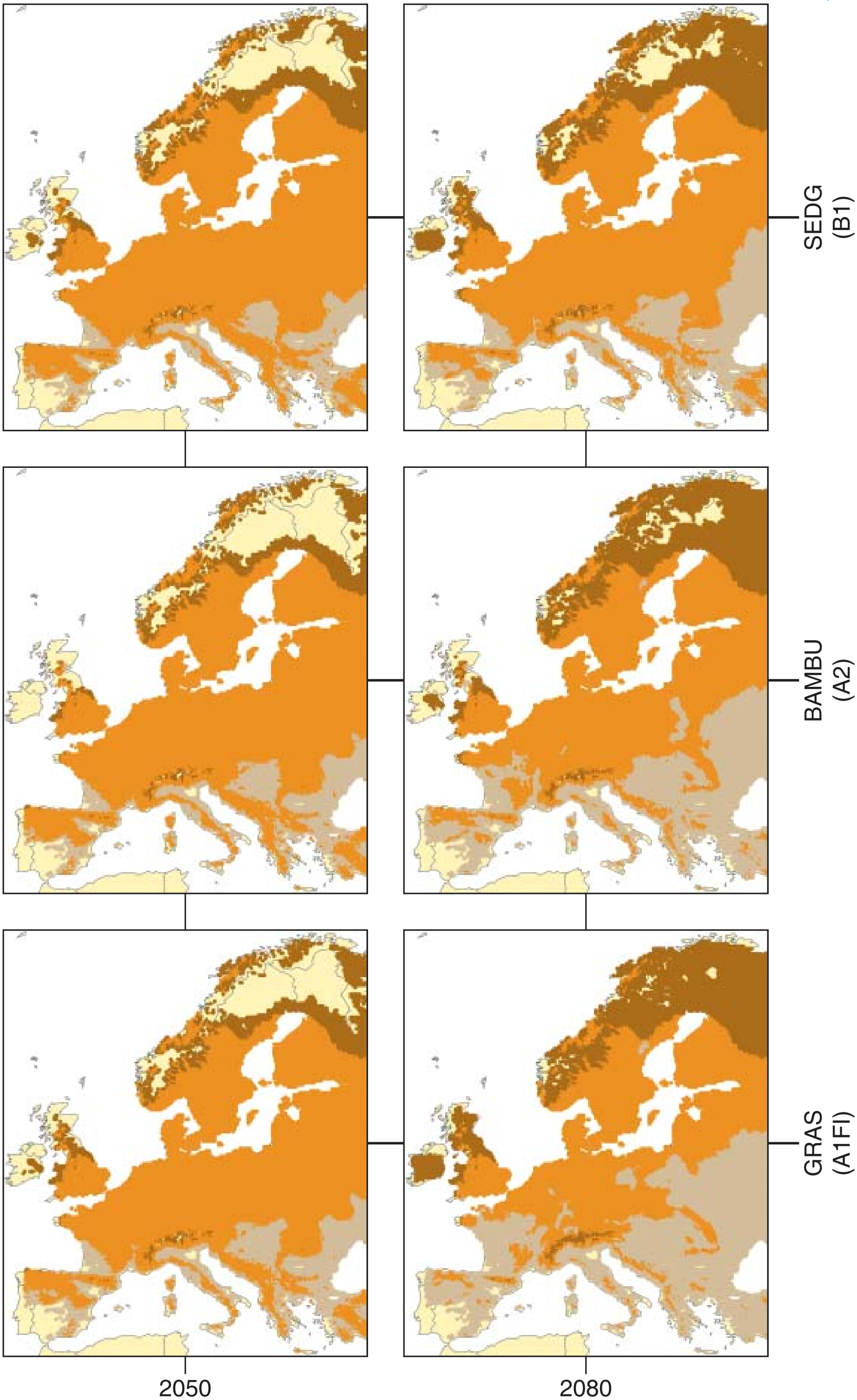
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.77).
Climate risk category: LR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Nymphalis egea (Cramer, 1775) – Southern Comma

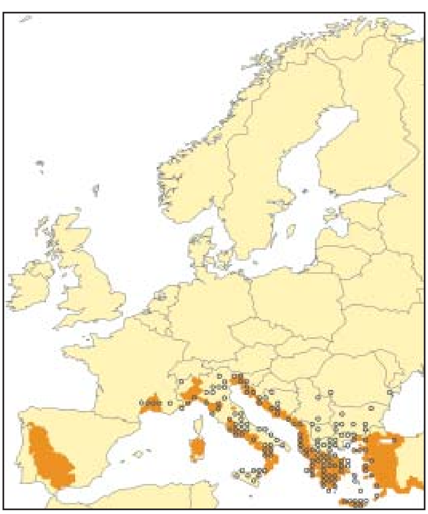
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	283 (15.9%)	-368 (-20.67%)
	BAMBU	309 (17.36%)	-330 (-18.54%)
	GRAS	348 (19.55%)	-414 (-23.26%)
2080	SEDG	937 (52.64%)	-471 (-26.46%)
	BAMBU	709 (39.83%)	-784 (-44.04%)
	GRAS	1380 (77.53%)	-1161 (-65.22%)

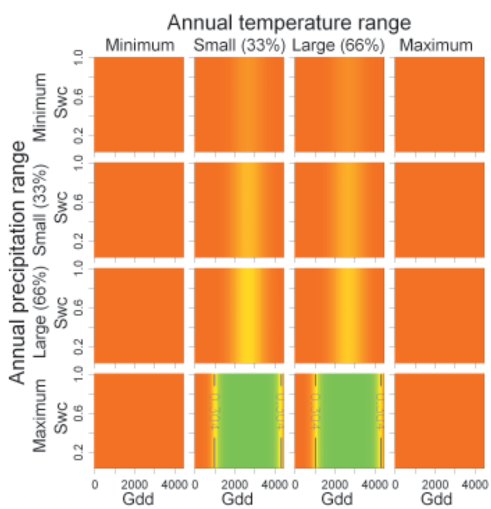
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1780)

The Southern Comma is a species of dry grasslands and dry scrub. The major foodplant is Common Pellitory (*Parietaria officinalis*), a plant that often grows on old walls, so that these butterflies are often found near buildings. They can often be seen, wings widespread, basking in the sun on walls and rocks, or on the ground. The caterpillars probably also feed on Stinging Nettle (*Urtica dioica*), willows (*Salix* spp.), and elms (*Ulmus* spp.). The Southern Comma has two to three generations a year, and just as the ordinary Comma (*P. c-album*), hibernates as an adult butterfly. It can therefore be seen early in the spring.

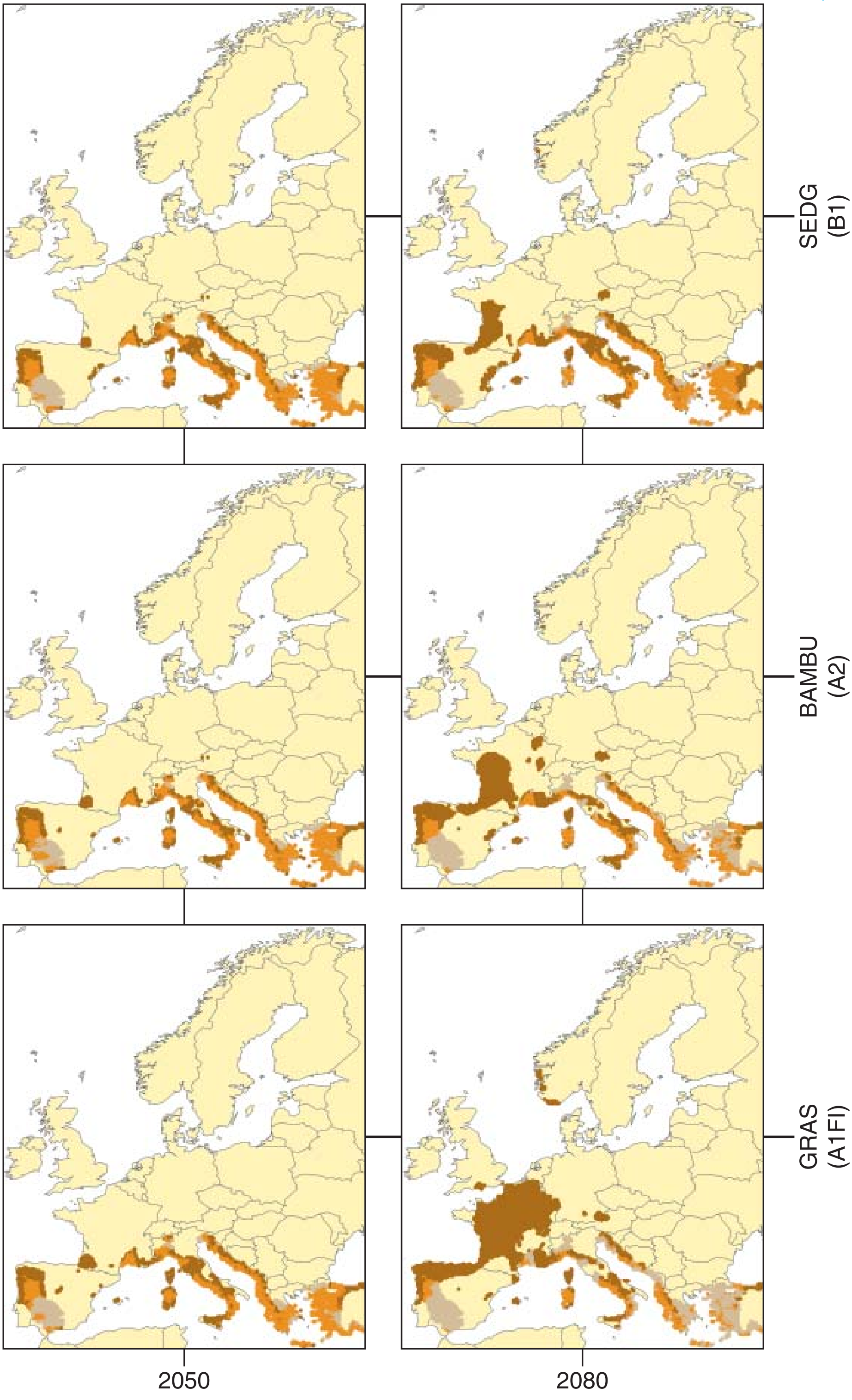
Present distribution can be well explained by climatic variables (AUC = 0.94).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Nymphalis antiopa (Linnaeus, 1758) – Camberwell Beauty

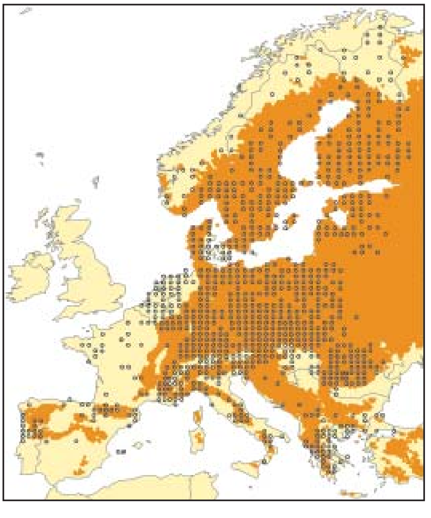
© Peter Ginzinger

		Full dispersal	No dispersal
2050	SEDG	-886 (-5.5%)	-2806 (-17.43%)
	BAMBU	-1047 (-6.5%)	-2840 (-17.64%)
	GRAS	-2083 (-12.94%)	-3979 (-24.71%)
2080	SEDG	-805 (-5%)	-3615 (-22.45%)
	BAMBU	-3635 (-22.57%)	-6079 (-37.75%)
	GRAS	-5251 (-32.61%)	-8017 (-49.79%)

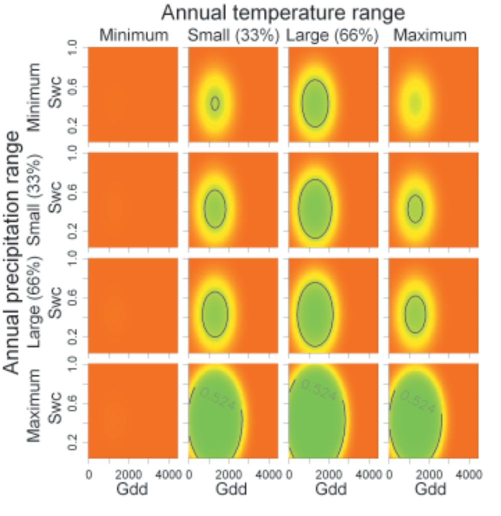
Changes in climatic niche distribution (in 10'×10' grid cells; present niche space: 16102)

The Camberwell Beauty is an imposing butterfly, which can fly large distances, although this only happens in some years. It occurs near patches of woodland in stream valleys, gullies, along woodland edges and on scrub. Because they are fairly mobile, they can be seen in open countryside far away from their foodplants. The female lays her eggs in large clusters around the twigs of birches (*Betula* spp.), willows (*Salix* spp.), and poplars (*Populus* spp.). At first, the caterpillars live together in a communal web, becoming solitary when nearly fully-grown. The caterpillar is easily recognized, black and spiny with a double row of red spots on its back. They pupate on the bark of the foodplants. The adult butterflies hibernate in a hollow tree, wood pile or just hidden in the vegetation, and wait for spring before mating. The Camberwell Beauty has one generation a year.

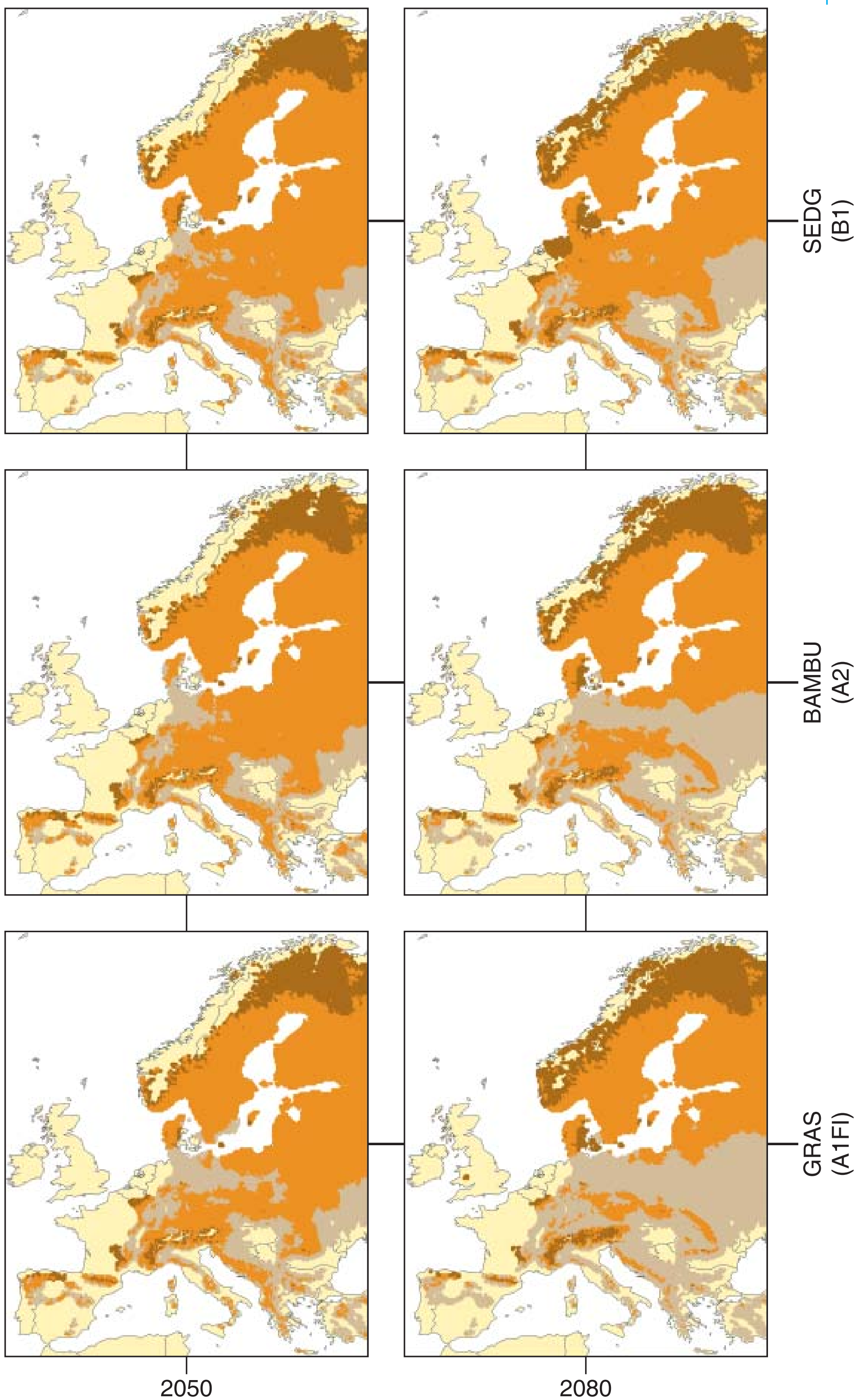
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.76). Climate risk category: LR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Nymphalis polychloros (Linnaeus, 1758) – Large Tortoiseshell

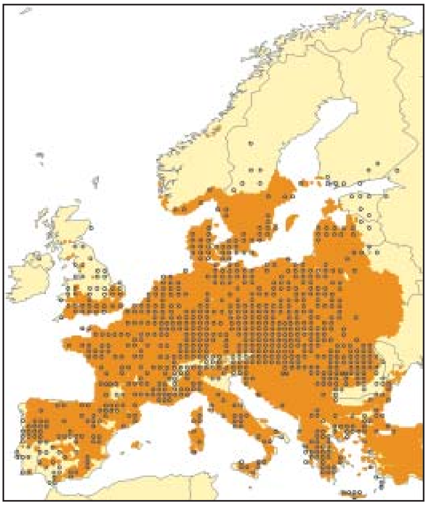
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-1494 (-9.42%)	-3210 (-20.24%)
	BAMBU	-2991 (-18.86%)	-4236 (-26.71%)
	GRAS	-2864 (-18.06%)	-4403 (-27.76%)
2080	SEDG	-4926 (-31.06%)	-6669 (-42.05%)
	BAMBU	-6995 (-44.1%)	-8952 (-56.44%)
	GRAS	-8220 (-51.83%)	-10595 (-66.8%)

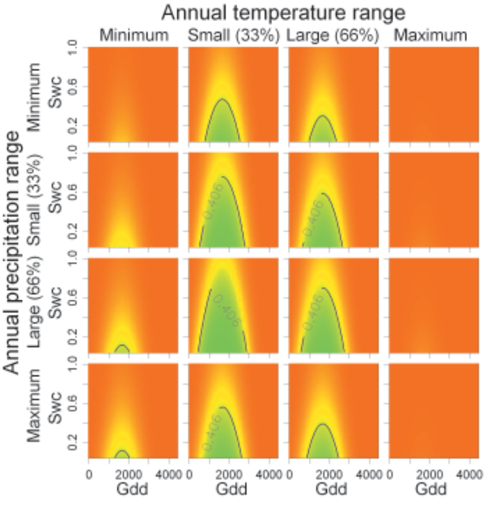
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 15861)

The Large Tortoiseshell is found in warm, sunny places in deciduous woods and near groups of trees. Elms (*Ulmus* spp.), willows (*Salix* spp.) and sometimes fruit trees or Hawthorn (*Crataegus monogyna*) are used as foodplants. The female, usually choosing a twig from the previous year, deposits a large group of eggs in a band around it. The caterpillars live together in silken tents until the last larval instar when they become solitary. They are fond of sitting on the sunny side of the foodplant or on branches in the sun. The caterpillar is dull, dark-grey with rust-coloured stripes along its back and sides, and long rust-brown spines. The pupa hangs from a twig in the foodplant, looking very like a withered leaf. The newly-emerged butterflies often roam. The Large Tortoiseshell hibernates as a butterfly in cool, dark places such as in a hollow tree. It has one generation a year.

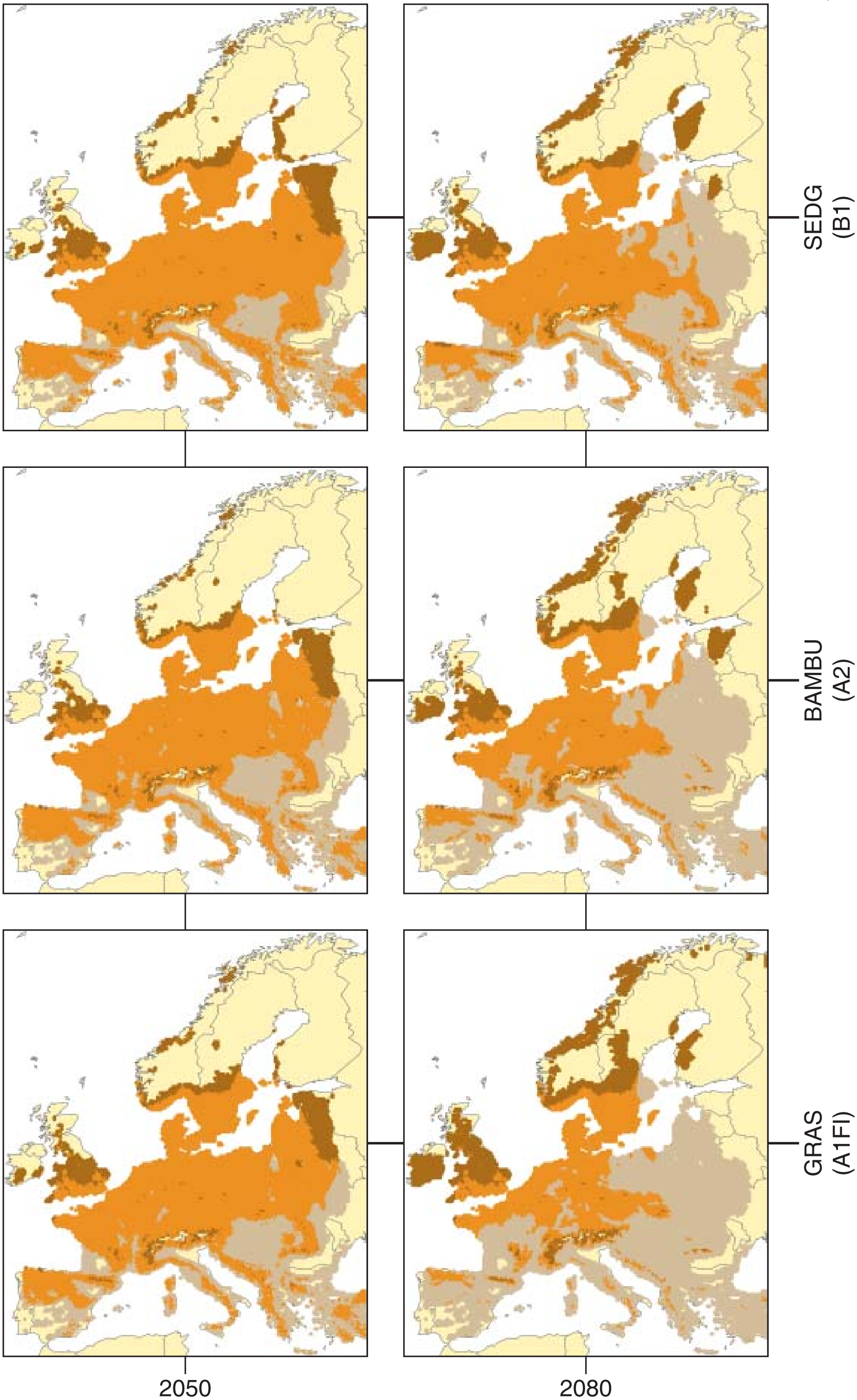
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.7). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Nymphalis xanthomelas (Esper, 1781) – Yellow-legged Tortoiseshell

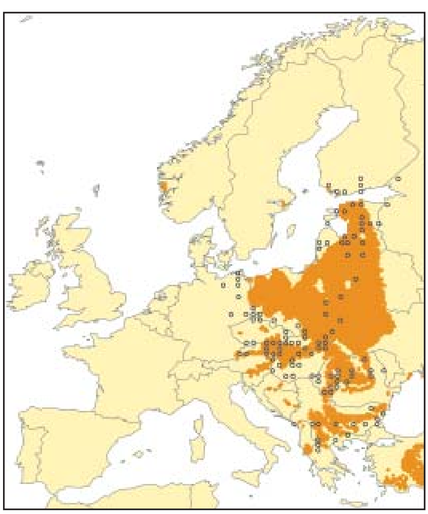
© Heiner Ziegler

		Full dispersal	No dispersal
2050	SEDG	-292 (-7.1%)	-1789 (-43.52%)
	BAMBU	-155 (-3.77%)	-1981 (-48.19%)
	GRAS	-272 (-6.62%)	-2183 (-53.1%)
2080	SEDG	-2210 (-53.76%)	-3846 (-93.55%)
	BAMBU	-1738 (-42.28%)	-3683 (-89.59%)
	GRAS	-2297 (-55.87%)	-4031 (-98.05%)

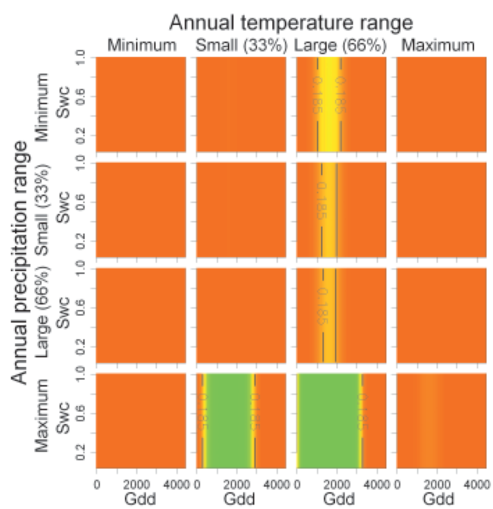
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 4111)

The Yellow-legged Tortoiseshell occurs in lowland woodland in Eastern Europe, in damp, deciduous woods growing on flood plains, or on the wooded banks of streams and rivers. Different trees are used as foodplants, including willows (*Salix* spp.), poplars (*Populus* spp.), elms (*Ulmus* spp.), and Nettle Tree (*Celtis australis*). Until nearly fully-grown, the caterpillars inhabit large communal nests, which they spin in branches that hang over the water. The Yellow-legged Tortoiseshell hibernates as a butterfly hidden away in such places as hollow trees or wood piles. It is single-brooded.

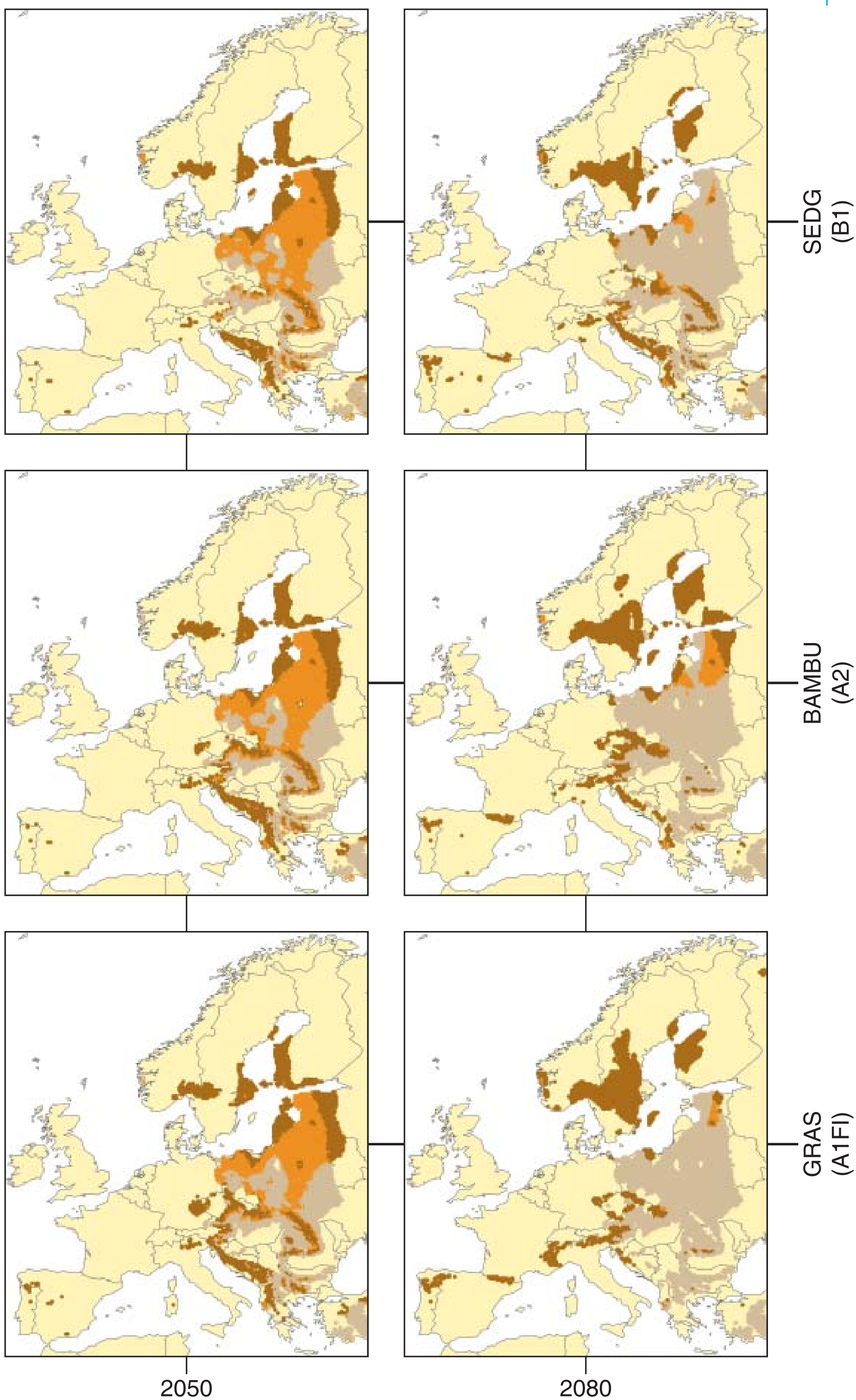
Present distribution can be well explained by climatic variables (AUC = 0.87).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Nymphalis l-album (Esper, 1780) – False Comma

© Zdravko Kolev

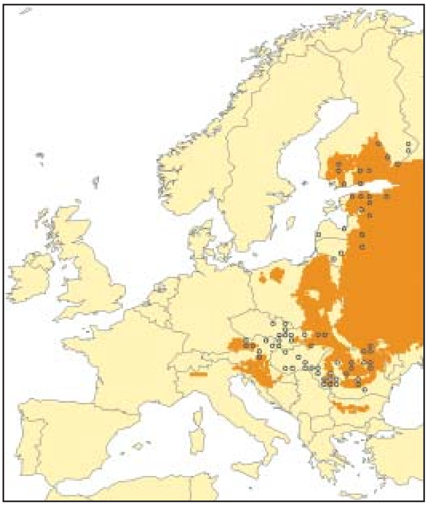
		Full dispersal	No dispersal
2050	SEDG	101 (1.93%)	-1761 (-33.63%)
	BAMBU	1514 (28.91%)	-850 (-16.23%)
	GRAS	90 (1.72%)	-1836 (-35.06%)
2080	SEDG	3311 (63.22%)	-1611 (-30.76%)
	BAMBU	3350 (63.97%)	-2324 (-44.38%)
	GRAS	3035 (57.95%)	-2884 (-55.07%)

Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 5237)

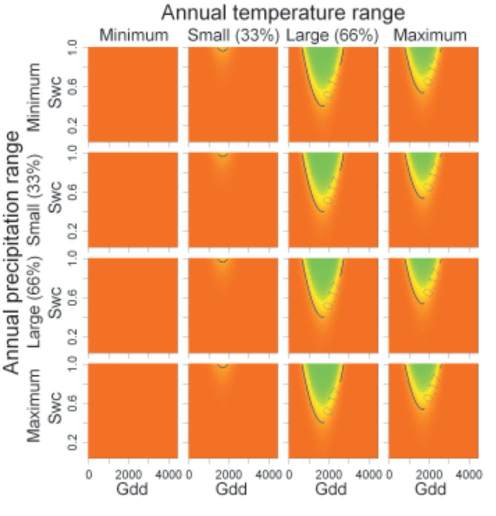
The False Comma occurs in the lowlands of Eastern Europe, in deciduous or mixed woods. It prefers damp woods, and is found in clearings or at the wood edge. It is a mobile butterfly and a strong migrant. The female lays her eggs in the spring, clustered around the twigs of the foodplants which may be birches (*Betula* spp.), willows (*Salix* spp.), poplars (*Populus* spp.), or elms (*Ulmus* spp.). The False Comma has one generation a year, and because it hibernates as a butterfly, can be seen for much of the year.

This species is listed in Annexes II and IV of the Habitats' Directive, where it erroneously is named *N. vaualbum*.

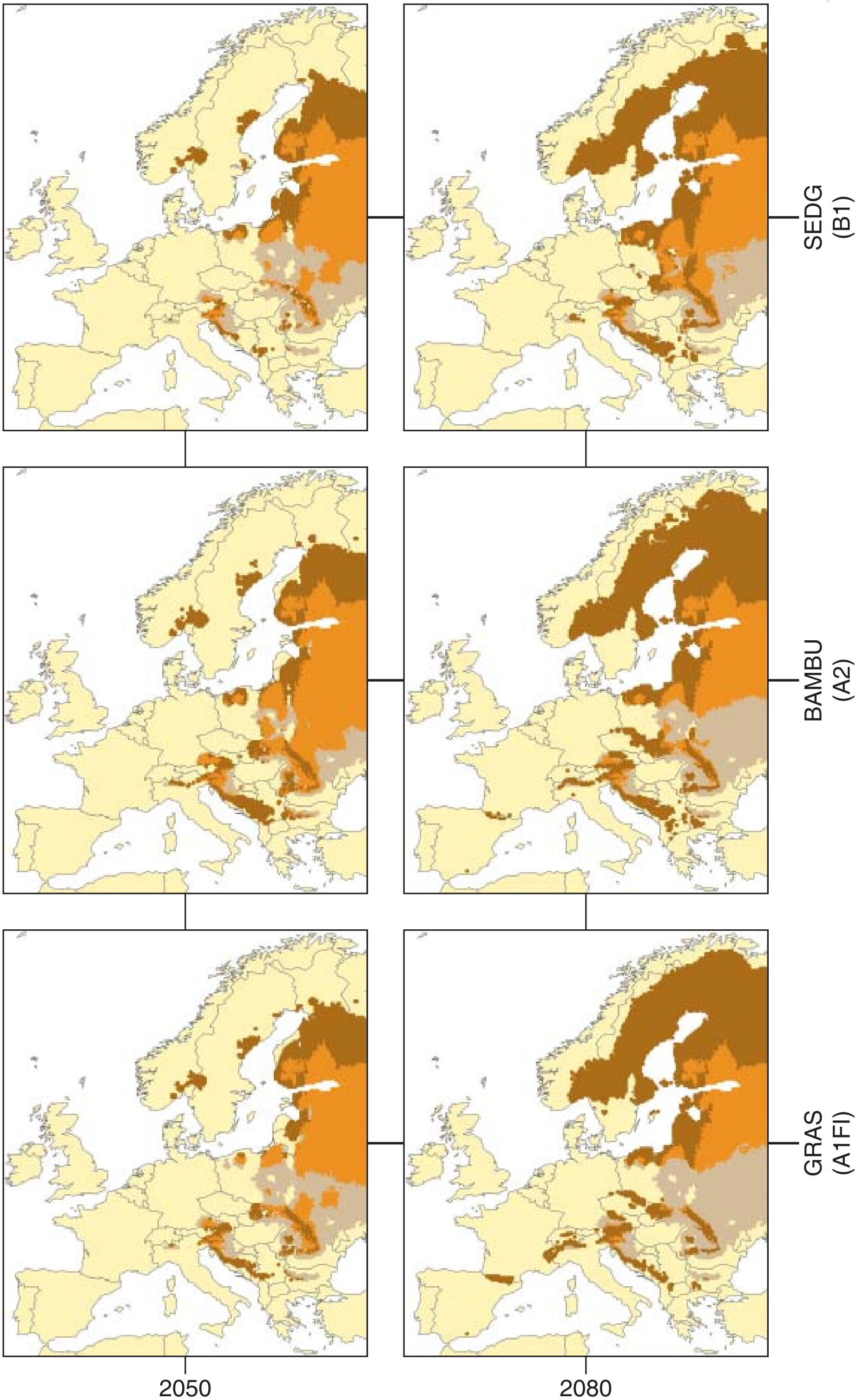
Present distribution can be well explained by climatic variables (AUC = 0.89).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG (B1)
BAMBU (A2)
GRAS (A1FI)
2050
2080

Araschnia levana (Linnaeus, 1758) – Map

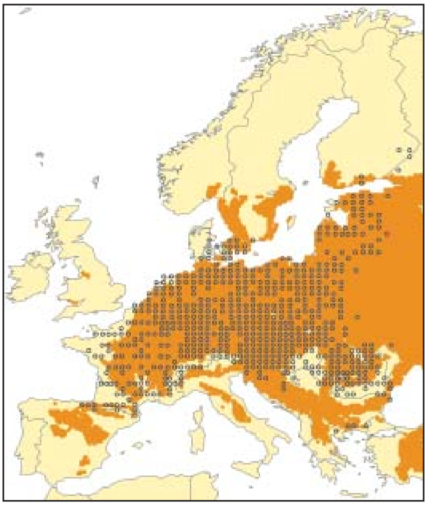
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-750 (-5.89%)	-3045 (-23.93%)
	BAMBU	-231 (-1.82%)	-2980 (-23.42%)
	GRAS	-1214 (-9.54%)	-3737 (-29.37%)
2080	SEDG	-2108 (-16.57%)	-5787 (-45.48%)
	BAMBU	-1661 (-13.05%)	-7261 (-57.06%)
	GRAS	-2943 (-23.13%)	-9390 (-73.79%)

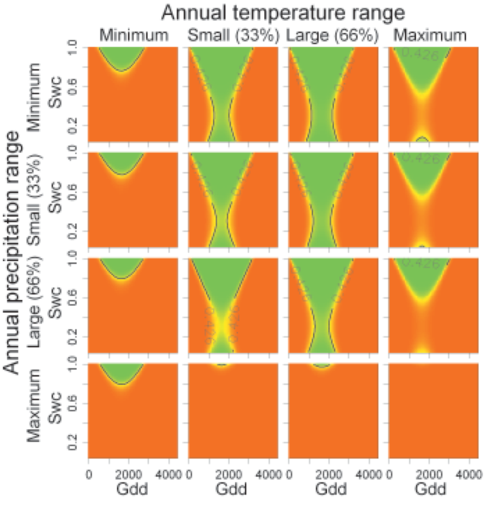
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 12725)

The Map is a common butterfly of woodland edges, coppices, hedgerows and wood banks. It normally has two generations a year, and the butterflies of the spring brood are predominantly orange, and those of the summer brood predominantly black on the upperside of the wings. The Map gets its name from the intricate pattern on the underside of its wings. These butterflies enjoy basking in the sun with their wings wide open, often on the ground. The Map has a dainty floating flight, but it settles again quite quickly. The foodplants are Stinging Nettle (*Urtica dioica*) and Small Nettle (*U. urens*). The eggs are deposited in short chains on the underside of the nettle leaves and look very much like threaded pearls. The caterpillars are gregarious, but do not spin a nest. They pupate on the foodplants, and pass the winter as a pupa.

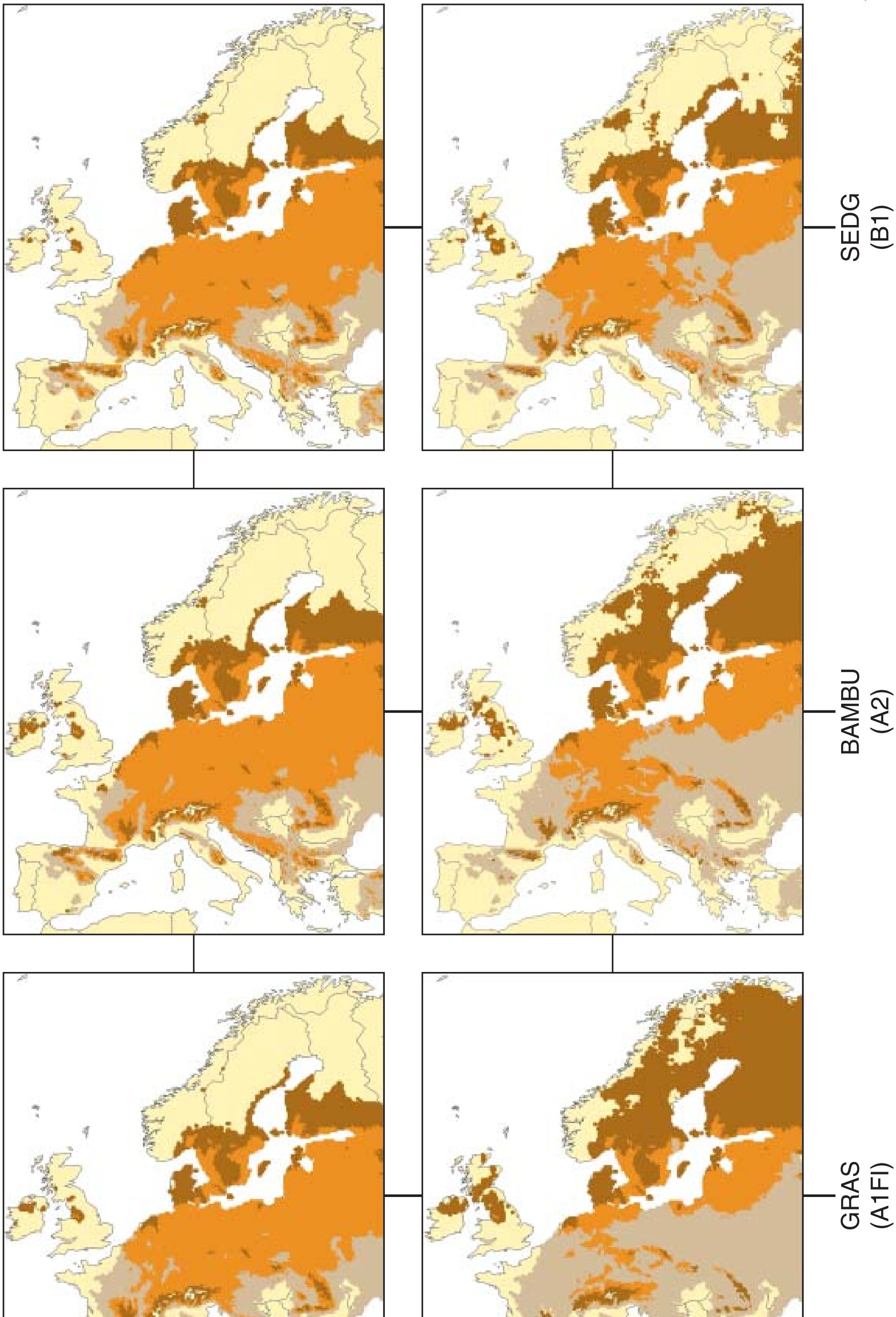
Present distribution can be well explained by climatic variables (AUC = 0.87).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Euphydryas iduna (Dalman, 1816) – Lapland Fritillary

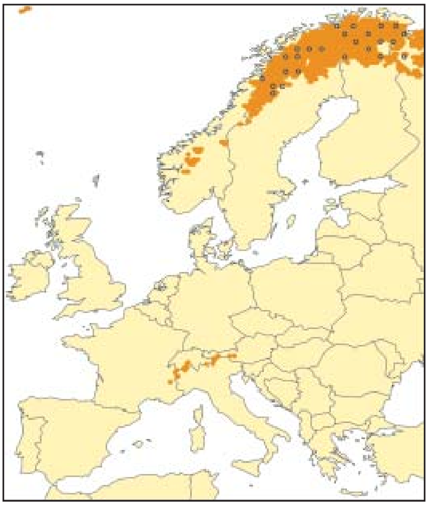
© Otakar Kudrna

		Full dispersal	No dispersal
2050	SEDG	-1047 (-79.32%)	-1062 (-80.45%)
	BAMBU	-1047 (-79.32%)	-1057 (-80.08%)
	GRAS	-1086 (-82.27%)	-1095 (-82.95%)
2080	SEDG	-1211 (-91.74%)	-1223 (-92.65%)
	BAMBU	-1276 (-96.67%)	-1280 (-96.97%)
	GRAS	-1315 (-99.62%)	-1315 (-99.62%)

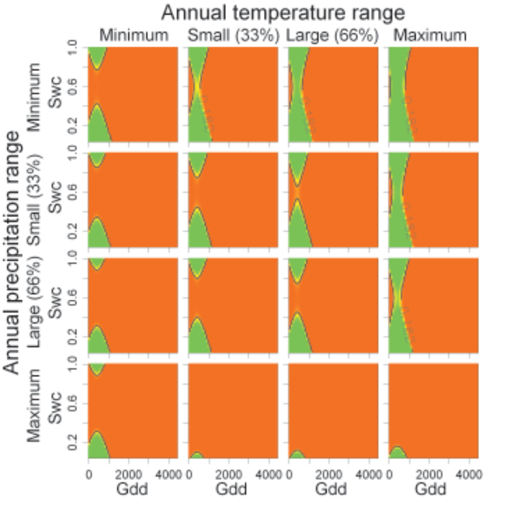
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1320)

At lower altitudes in Lapland, this lovely fritillary occurs on flower-rich swampy areas and wet slopes with scattered birches. Above 500 m, it is found in drier rocky places. Compared to the other fritillaries that occur in Lapland, the Lapland Fritillary is remarkably colourful. It is one of the first arctic species to be seen, appearing practically as soon as the snow has melted. It flies quickly, zigzagging low over the vegetation. The female lays her eggs in small groups on plantains (*Plantago* spp.), Alpine Speedwell (*Veronica alpina*), Rock Speedwell (*V. fruticans*), and species of *Vaccinium*. The caterpillars live communally in small silken webs and hibernate there. They pupate in the spring. It has one brood a year.

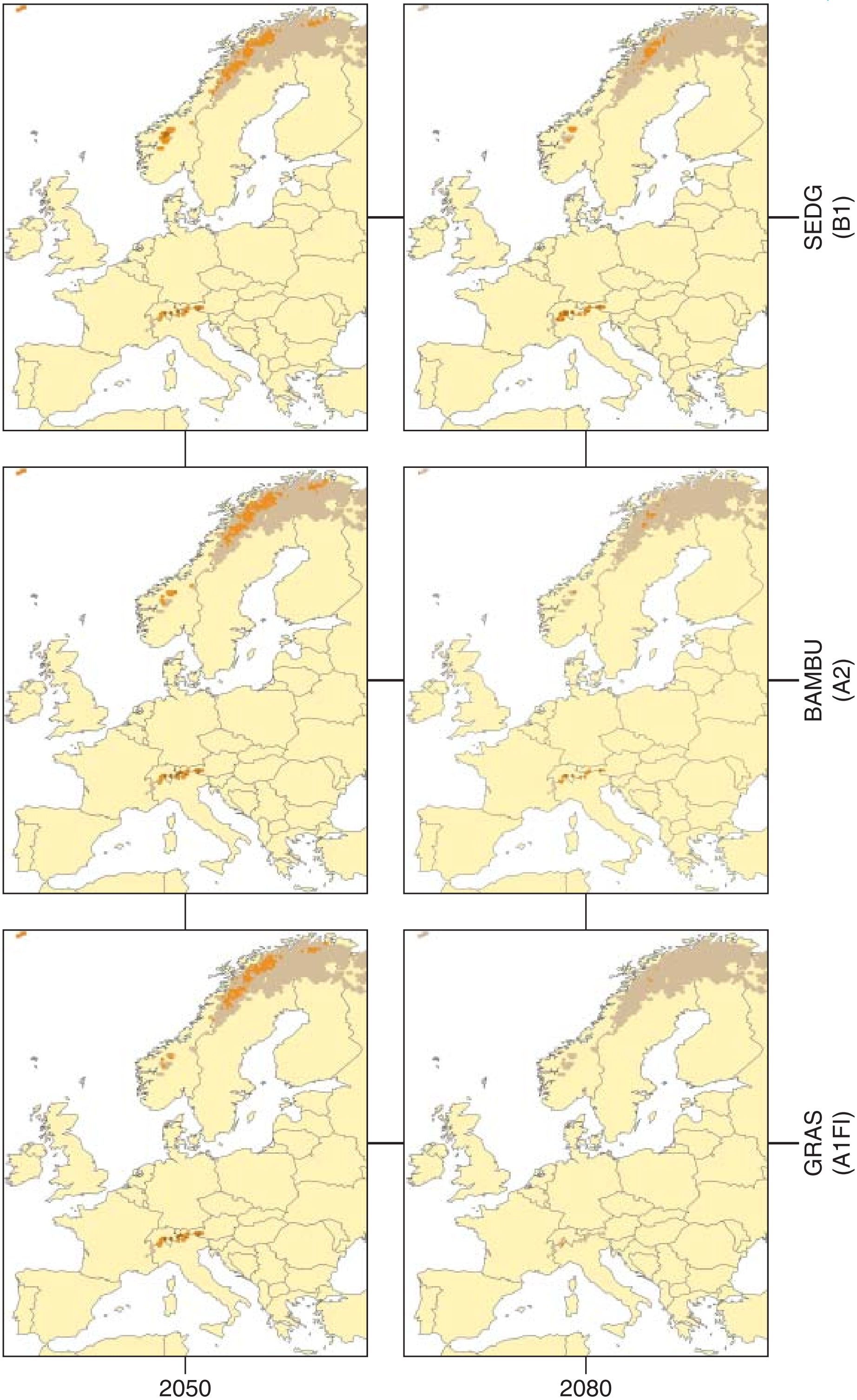
Present distribution can be very well explained by climatic variables (AUC = 1).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Euphydryas cynthia ([Schiffermüller], 1775) – Cynthia's Fritillary

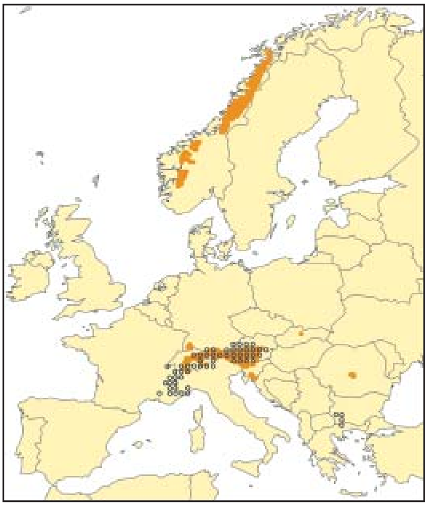
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-77 (-19.49%)	-147 (-37.22%)
	BAMBU	-80 (-20.25%)	-149 (-37.72%)
	GRAS	-132 (-33.42%)	-180 (-45.57%)
2080	SEDG	-233 (-58.99%)	-285 (-72.15%)
	BAMBU	-165 (-41.77%)	-249 (-63.04%)
	GRAS	-210 (-53.16%)	-327 (-82.78%)

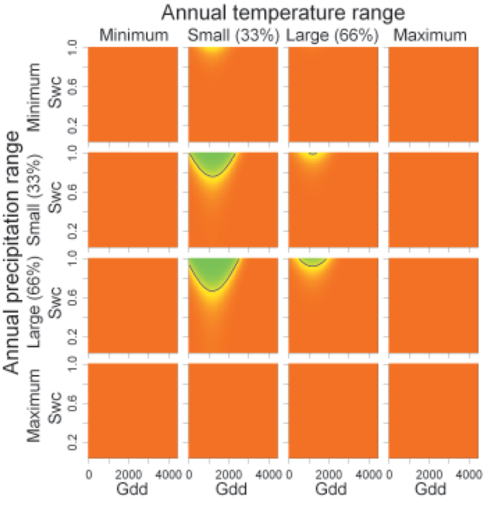
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 395)

Cynthia's Fritillary distinguishes itself from other fritillaries by the large amount of white on the basal parts of the upperside of the wings of the male. The butterflies occur on sub-alpine and alpine grassland with short, grassy vegetation and low-growing shrubs and in rocky areas. They fly quickly, close to the ground, and are fond of basking in the sun on rocks or bare patches of ground. The female lays her eggs in clusters under leaves of Alpine Plantain (*Plantago alpina*) and Long-spurred Pansy (*Viola calcarata*). The caterpillars are black and bristly with yellow bands between each segment. They can be very numerous and take two years to develop. The first hibernation takes place communally in a silken web. In the fourth larval instar, they hibernate a second time, solitarily under stones, where they later pupate.

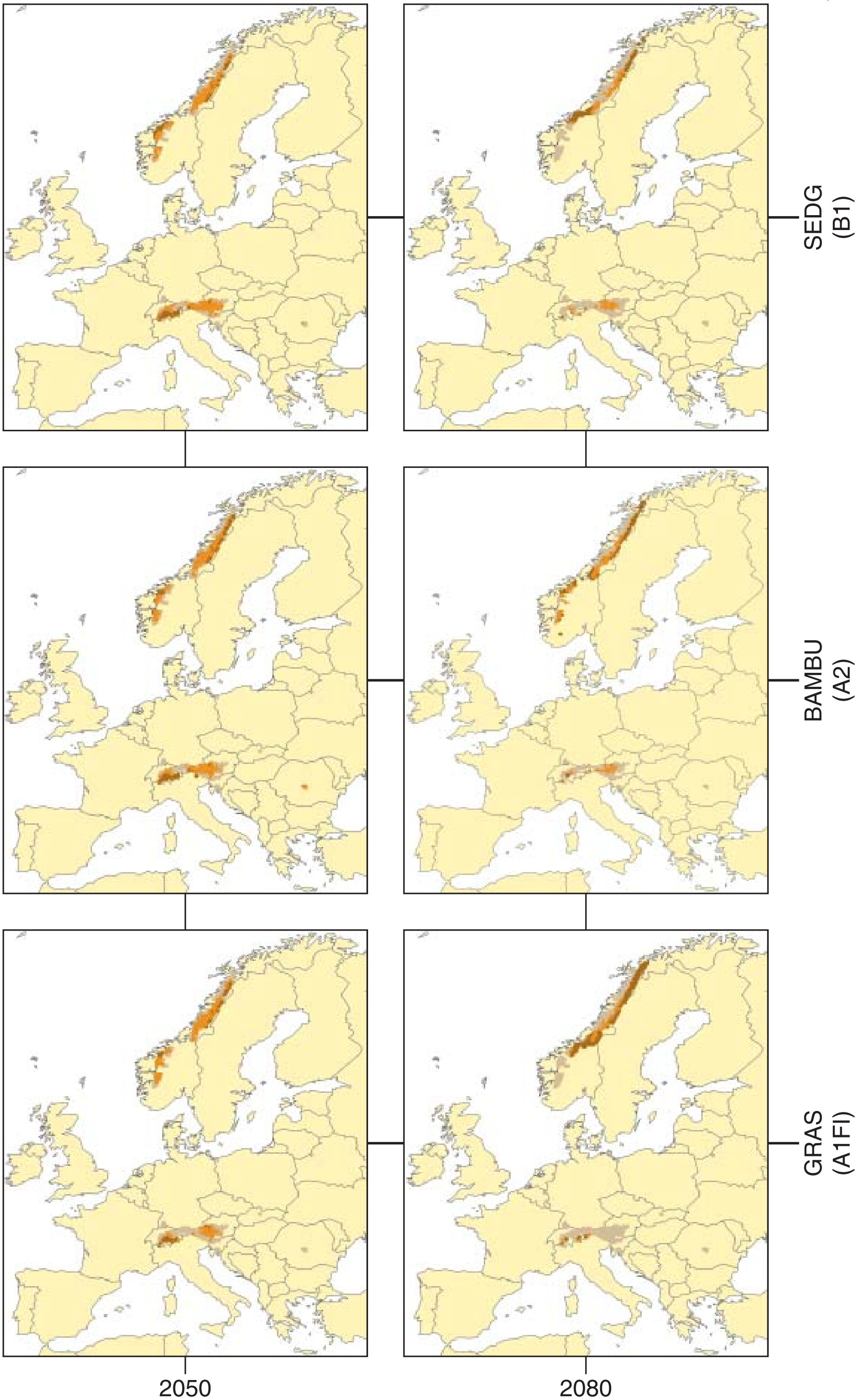
Present distribution can be very well explained by climatic variables (AUC = 0.98).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Euphydryas intermedia (Menetries, 1859) – Asian Fritillary

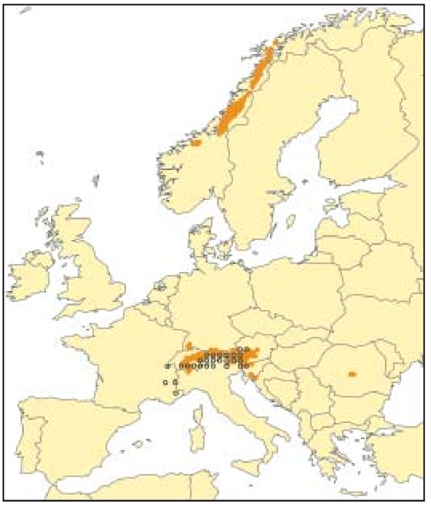
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-24 (-8.92%)	-127 (-47.21%)
	BAMBU	-11 (-4.09%)	-123 (-45.72%)
	GRAS	-69 (-25.65%)	-155 (-57.62%)
2080	SEDG	-157 (-58.36%)	-231 (-85.87%)
	BAMBU	-45 (-16.73%)	-193 (-71.75%)
	GRAS	-105 (-39.03%)	-233 (-86.62%)

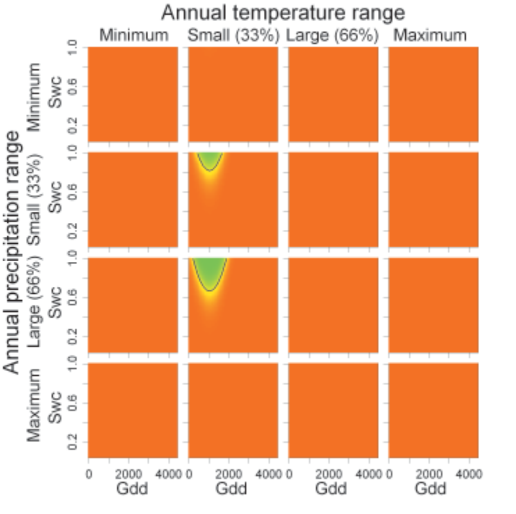
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 269)

The Asian Fritillary can be seen searching for nectar or foodplants on open scrub, rich in herbaceous plants, or in clearings in open woodland, in flower-rich grassland, and on vegetation of dwarf shrubs above the tree-line. These butterflies only occur locally, although at times in large numbers. The female lays all her eggs at once, on the underside of a leaf of its foodplant, Blue Honeysuckle (*Lonicera caerulea*). The caterpillars live in communal webs, and in the autumn make a more substantial shelter of leaves, spun together with silk, in which to hibernate. They take two years to develop and have to hibernate twice. The fully-grown caterpillar leaves the nest after the second hibernation, and pupates on the foodplant or adjacent rocks.

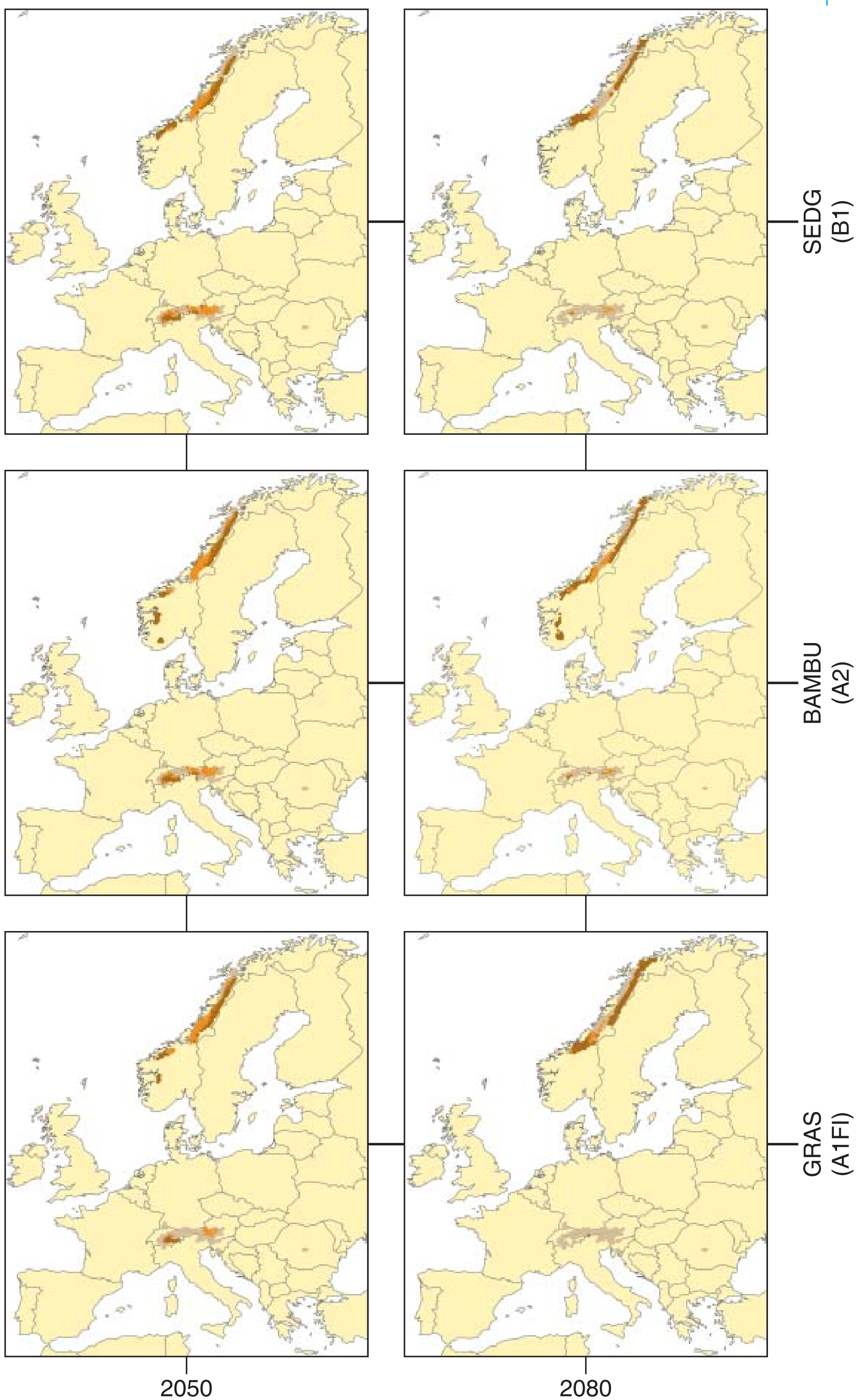
Present distribution can be very well explained by climatic variables (AUC = 0.98).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Euphydryas maturna (Linnaeus, 1758) – Scarce Fritillary

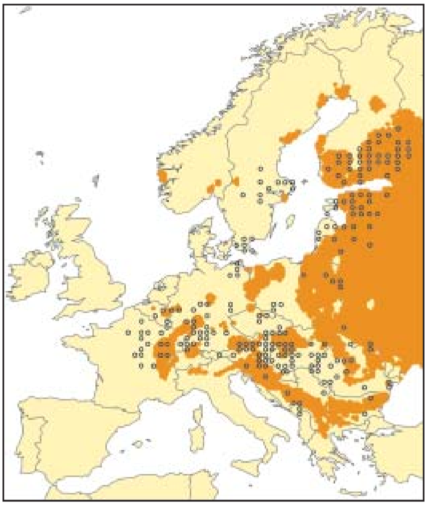
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	296 (4.13%)	-2439 (-34.05%)
	BAMBU	3998 (55.81%)	-981 (-13.69%)
	GRAS	2526 (35.26%)	-1754 (-24.48%)
2080	SEDG	3354 (46.82%)	-1971 (-27.51%)
	BAMBU	3987 (55.65%)	-2446 (-34.14%)
	GRAS	2476 (34.56%)	-3429 (-47.86%)

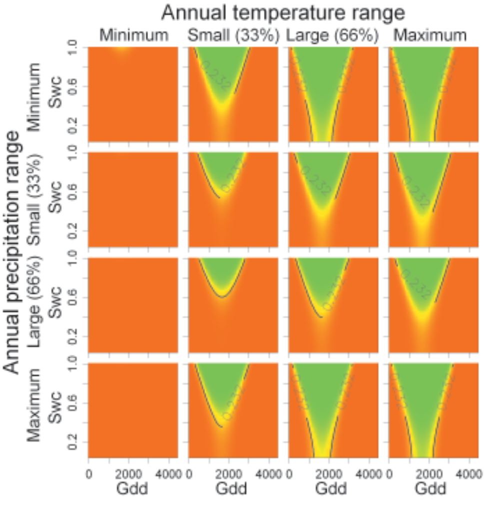
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 7164)

The Scarce Fritillary occurs in clearings, where young ash trees are growing in open, mixed woodland. The eggs are laid in one batch on a leaf of Ash (*Fraxinus excelsior*) or Aspen (*Populus tremula*), preferably at a height of around 4 m. The caterpillars build a nest of silk and leaves, and feed together at first, while still quite small. They go into hibernation, remaining in the nest, which usually falls onto the woodland floor. In spring, they leave the nest and separate, spreading out in search of food. They use a variety of larval foodplants at this stage, including honeysuckle (*Lonicera* spp.), plantains (*Plantago* spp.), or privets (*Ligustrum* spp.). They pupate in the litter layer. The species has one generation a year although some of the caterpillars hibernate a second time before pupating. This species is listed in Annexes II and IV of the Habitats' Directive.

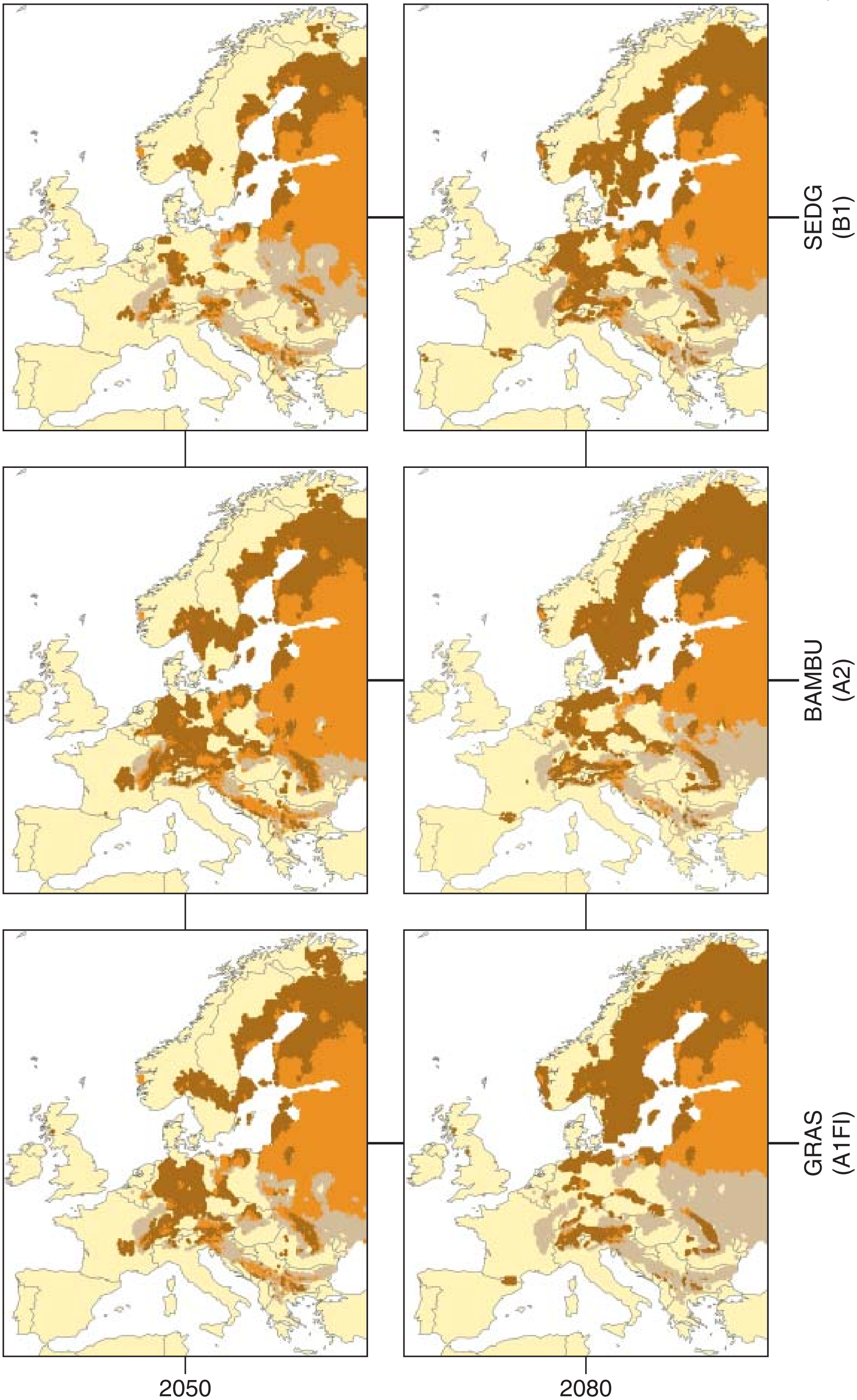
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.79). Climate risk category: LR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Euphydryas desfontainii (Godart, 1819) – Spanish Fritillary

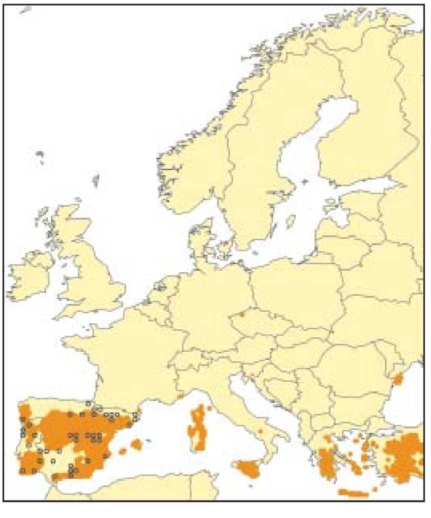
© Bernard Fransen

		Full dispersal	No dispersal
2050	SEDG	-1003 (-61.12%)	-1132 (-68.98%)
	BAMBU	-1226 (-74.71%)	-1256 (-76.54%)
	GRAS	-1202 (-73.25%)	-1314 (-80.07%)
2080	SEDG	-1406 (-85.68%)	-1481 (-90.25%)
	BAMBU	-1593 (-97.07%)	-1622 (-98.84%)
	GRAS	-1624 (-98.96%)	-1640 (-99.94%)

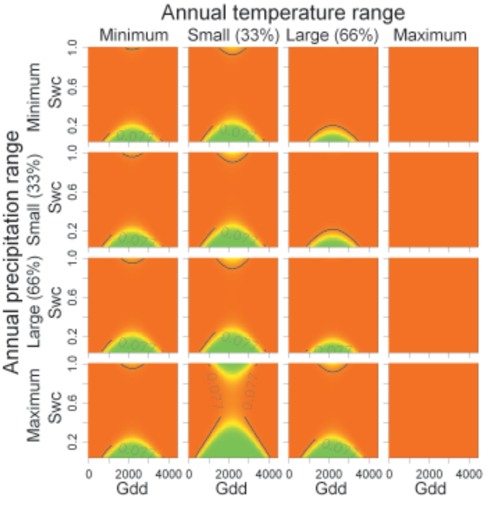
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 1641)

The Spanish Fritillary occurs on open, grassy places with stony soil and lots of shrubs. It uses various foodplants, such as *Cephalaria leucantha* and *C. syriaca*, the teasels *Dipsacus fullonum* and *D. comasus*, scabious (*Scabiosa* and *Knautia* spp.) and possibly knapweeds (*Centaurea* spp.). The female lays her eggs in small batches on the underside of leaves. The caterpillars live in a communal spun nest, also hibernating there. There is one brood a year.

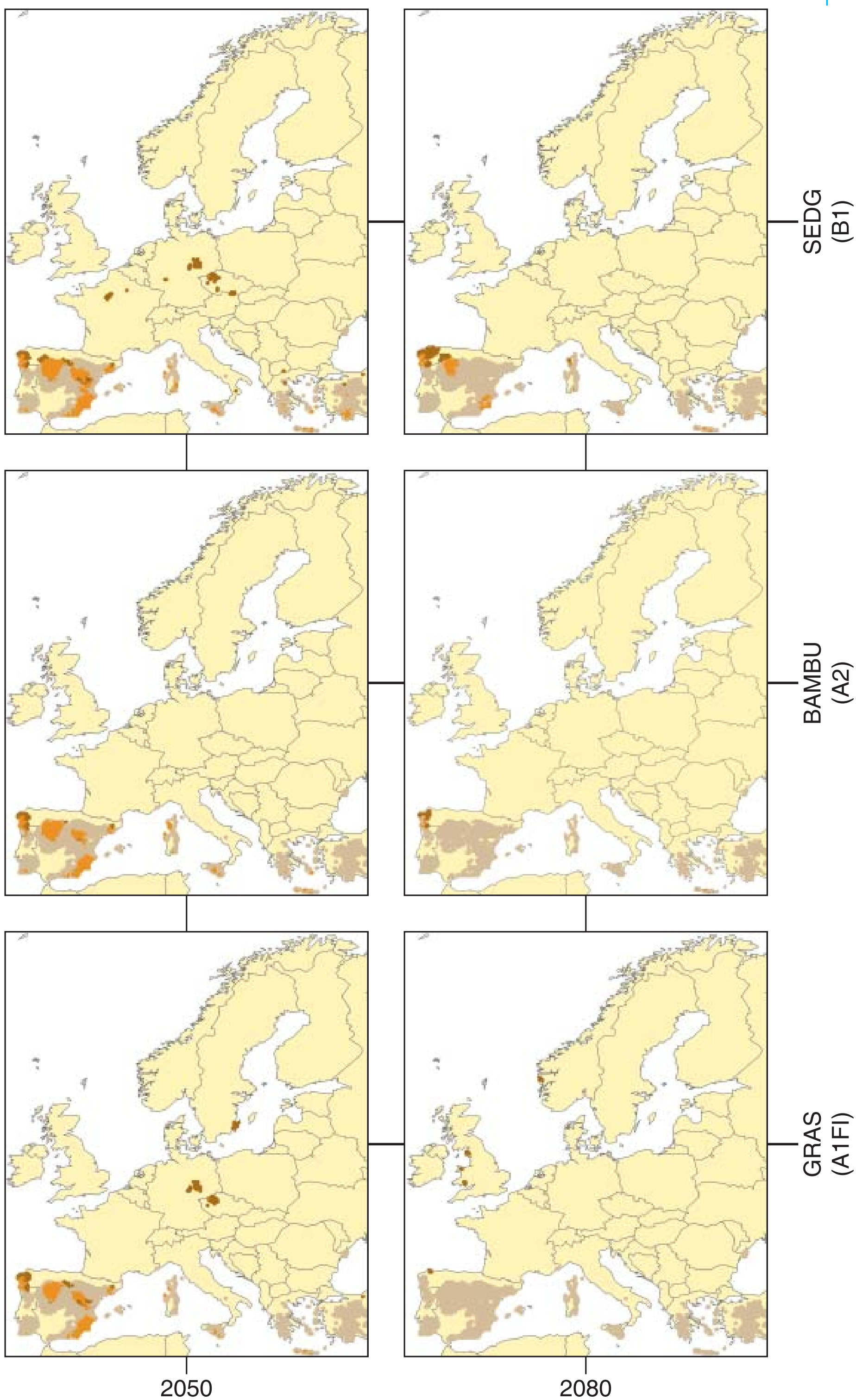
Present distribution can be well explained by climatic variables (AUC = 0.88).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Euphydryas aurinia (Rottemburg, 1775) – Marsh Fritillary

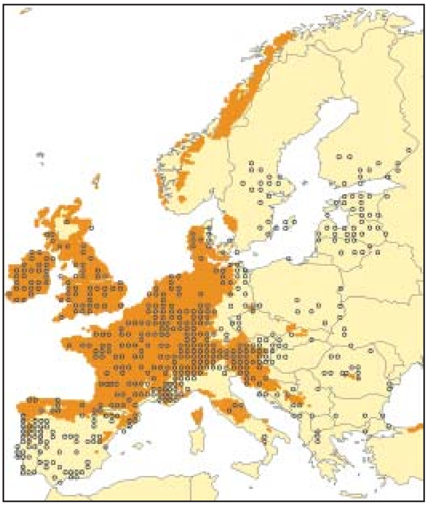
© Peter Ginzinger

		Full dispersal	No dispersal
2050	SEDG	-276 (-4.24%)	-976 (-14.99%)
	BAMBU	335 (5.14%)	-786 (-12.07%)
	GRAS	-543 (-8.34%)	-1292 (-19.84%)
2080	SEDG	-1055 (-16.2%)	-1908 (-29.3%)
	BAMBU	-1115 (-17.12%)	-2365 (-36.31%)
	GRAS	-2488 (-38.2%)	-3659 (-56.18%)

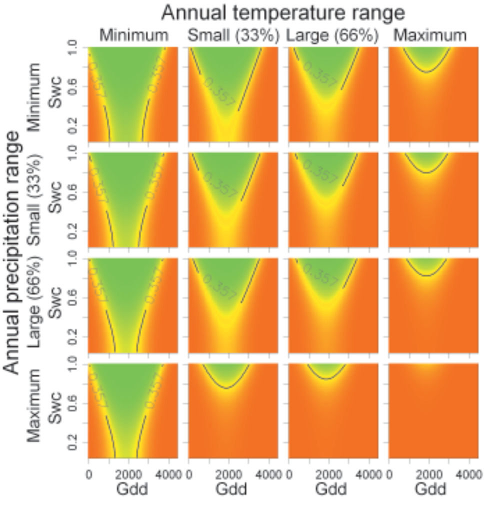
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 6513)

The Marsh Fritillary occurs in very different types of habitat, like moist, sheltered grasslands, along the edges of raised bogs and on dry, calcareous grasslands. The foodplants are Devil’s-bit Scabious (*Succisa pratense*), Small Scabious (*Scabiosa columbaria*), Field Scabious (*Knautia arvensis*), and teasels (*Dipsacus* spp.). The eggs are laid in large clumps under the leaves. The caterpillars spin a substantial nest between the leaves of the foodplants, feeding in it, and also hibernating communally there. However, later they are solitary, and look for places deep in the vegetation in which to pupate. The Marsh Fritillary has one brood a year.
This species is listed in Annex II of the Habitats’ Directive.

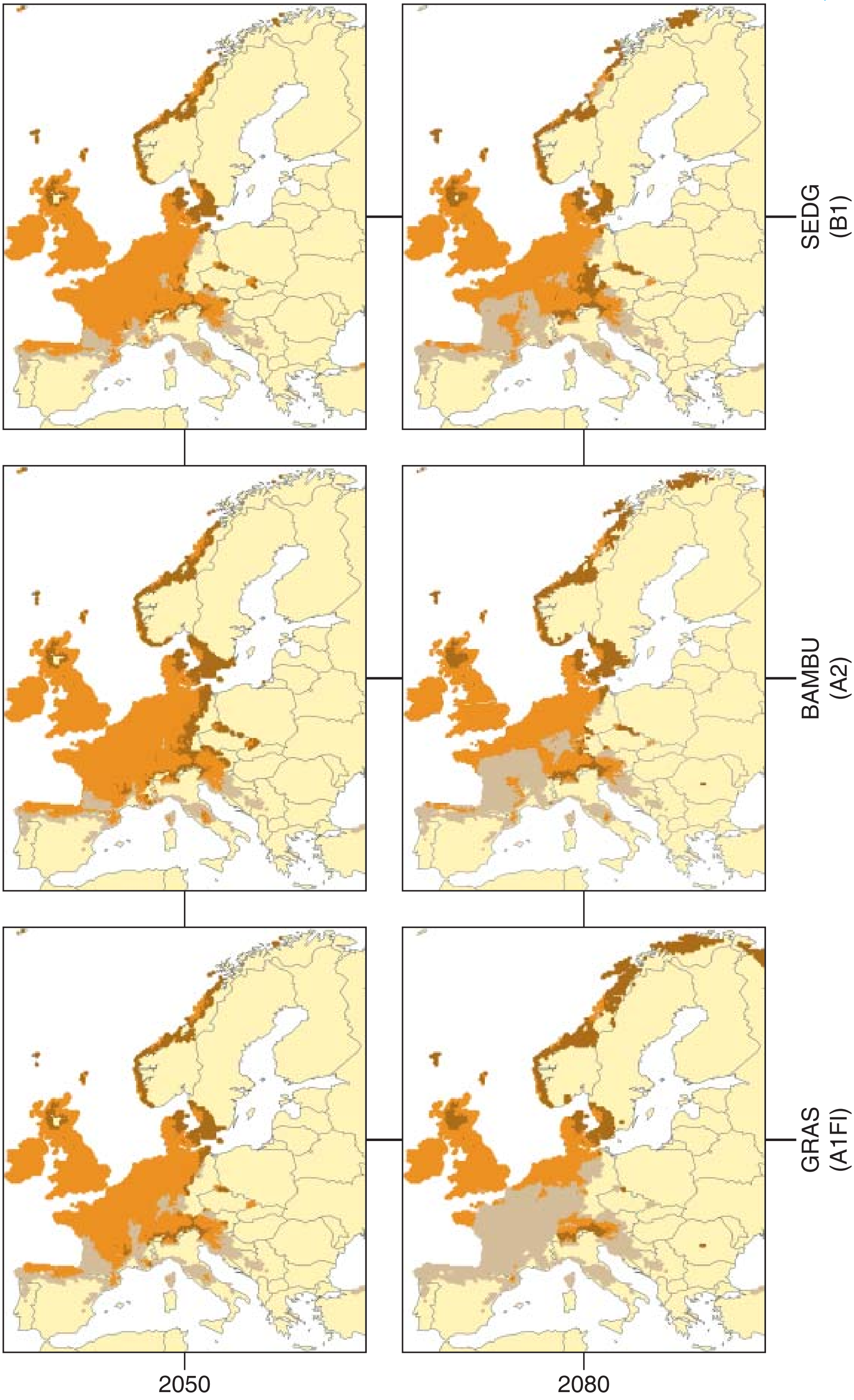
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.72).
Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melitaea cinxia (Linnaeus, 1758) – Glanville Fritillary

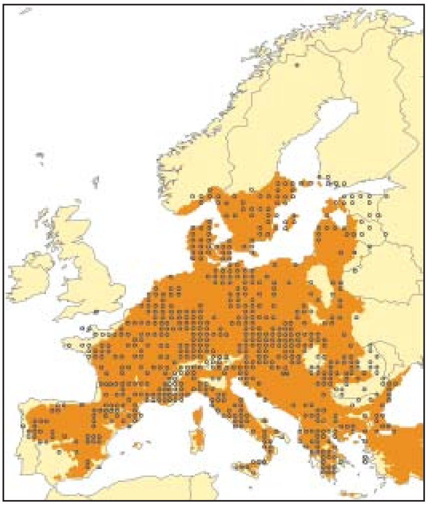
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-1505 (-11.41%)	-2787 (-21.12%)
	BAMBU	-2602 (-19.72%)	-3692 (-27.98%)
	GRAS	-2647 (-20.06%)	-3961 (-30.02%)
2080	SEDG	-4653 (-35.26%)	-5935 (-44.98%)
	BAMBU	-5706 (-43.24%)	-7293 (-55.27%)
	GRAS	-6896 (-52.26%)	-8941 (-67.76%)

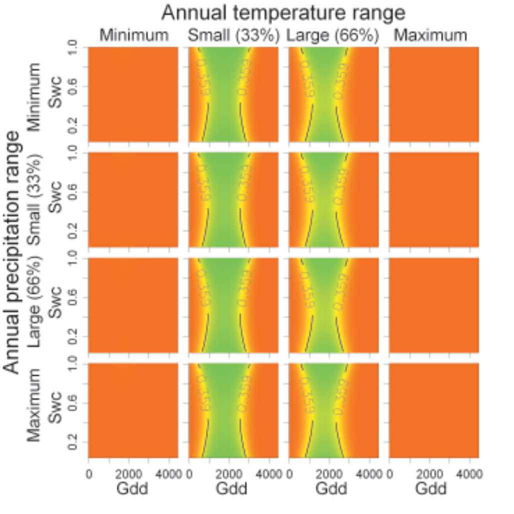
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 13195)

The Glanville Fritillary is found on many different types of flower-rich grasslands, both on calcareous and acid soils. This butterfly can survive on meadows and pastures, as well as on road verges and forgotten patches of vegetation, sometimes small habitats supporting large populations. Various plantains (*Plantago* spp.), speedwells (*Veronica* spp,), and knapweeds (*Centaurea* spp.) are used as foodplants. The eggs are laid in large batches on the underside of the leaves. The caterpillars live gregariously in a spun nest, also hibernating in a thicker one when half-grown. The Glanville Fritillary, usually has one generation a year, partially a second one under favourable conditions.

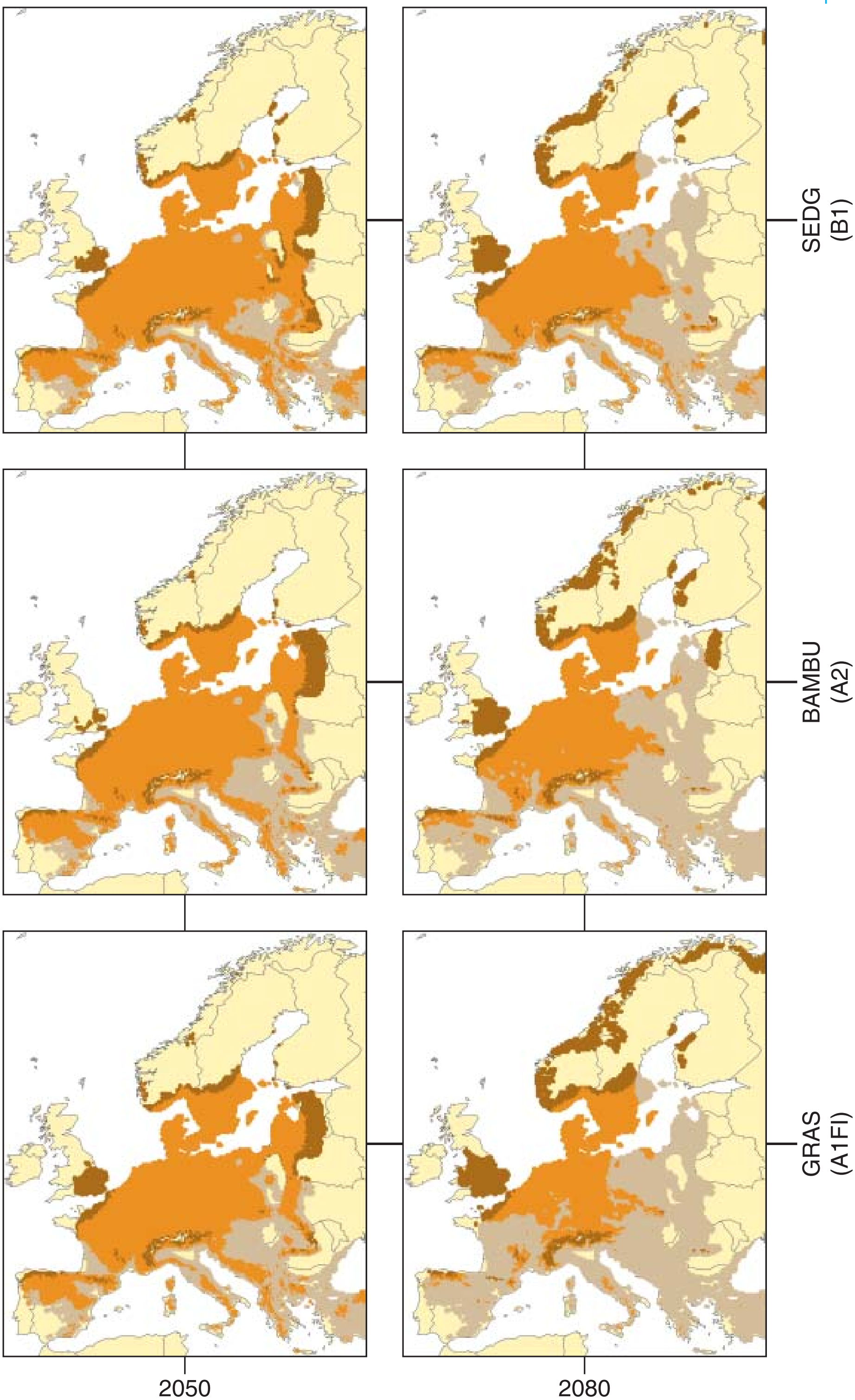
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.75). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melitaea phoebe (Goeze, 1779) – Knapweed Fritillary

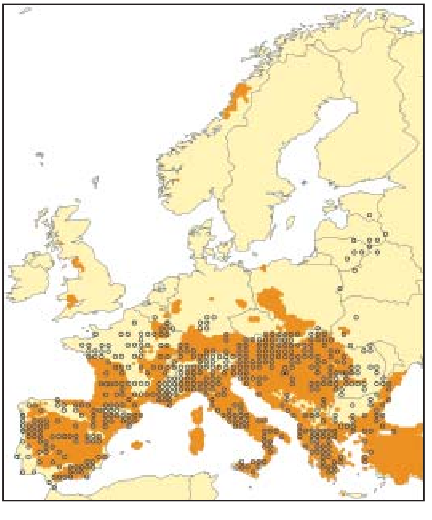
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	2383 (30.98%)	-1579 (-20.53%)
	BAMBU	1413 (18.37%)	-2181 (-28.35%)
	GRAS	1267 (16.47%)	-2473 (-32.15%)
2080	SEDG	2605 (33.86%)	-2630 (-34.19%)
	BAMBU	1417 (18.42%)	-4209 (-54.71%)
	GRAS	1843 (23.96%)	-5324 (-69.21%)

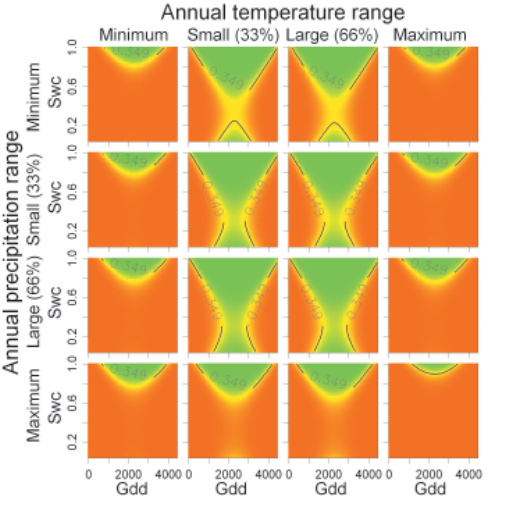
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 7693)

The Knapweed Fritillary occurs in dry, open places with flower-rich vegetation. These grasslands are often in a sheltered situation at the edge of woodland, or of groups of shrubs. In the north of its range, the grasslands are mostly calcareous. The larval foodplants are knapweeds (*Centaurea* spp.). The female lays her eggs in large batches on the undersides of the leaves. The small caterpillars live gregariously in a silken nest, also hibernating together. Later, they become solitary, and when ready to pupate, choose somewhere close to the ground. The Knapweed Fritillary usually has two broods, but at higher altitudes and in the north of its range only one.

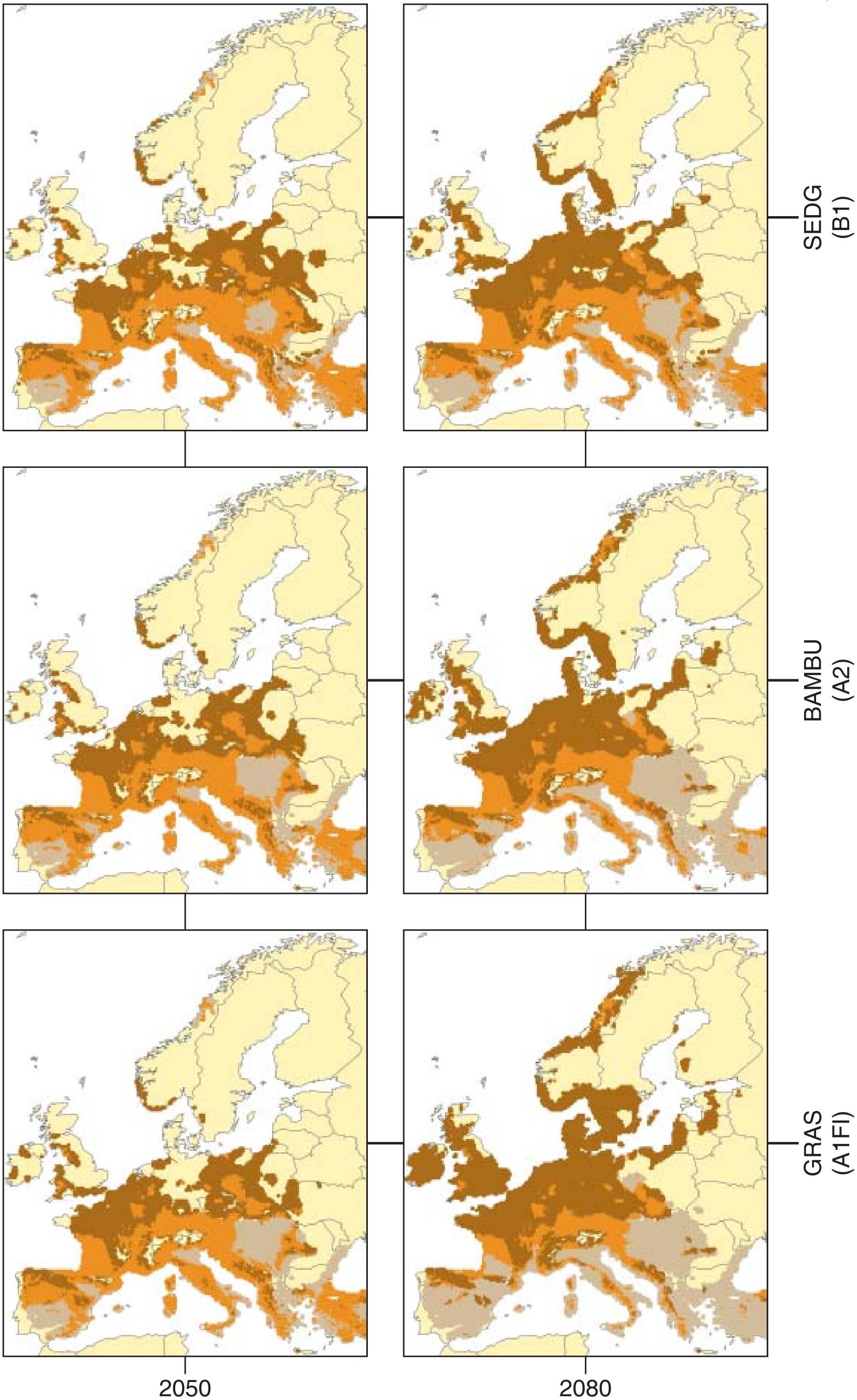
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.77).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melitaea aetherie (Hübner, 1826) – Aetherie Fritillary

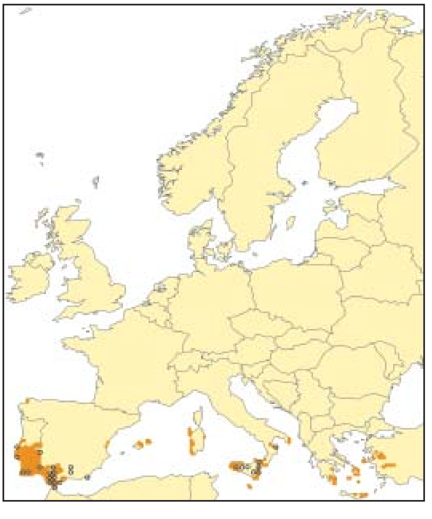
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	51 (13.01%)	-215 (-54.85%)
	BAMBU	261 (66.58%)	-184 (-46.94%)
	GRAS	214 (54.59%)	-248 (-63.27%)
2080	SEDG	642 (163.78%)	-318 (-81.12%)
	BAMBU	2480 (632.65%)	-351 (-89.54%)
	GRAS	4348 (1109.18%)	-386 (-98.47%)

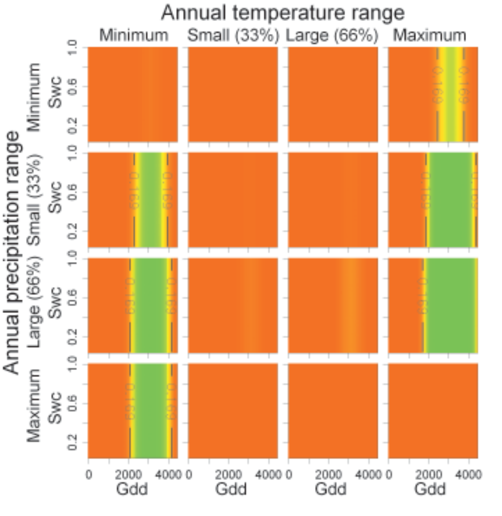
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 392)

In Spain, the Aetherie Fritillary is found in clearings in disturbed Holm Oak (*Quercus ilex*) woodlands, where its foodplants, thistles (*Cirsium* spp.) and knapweeds (*Centaurea* spp.), such as Star Thistle (*Centaurea calcitrapa*), Brown Knapweed (*C. jacea*), and *C. carratracensis* grow. The female lays her eggs in batches on the foodplants. The Aetherie Fritillary normally has one brood a year, and hibernates as a caterpillar.

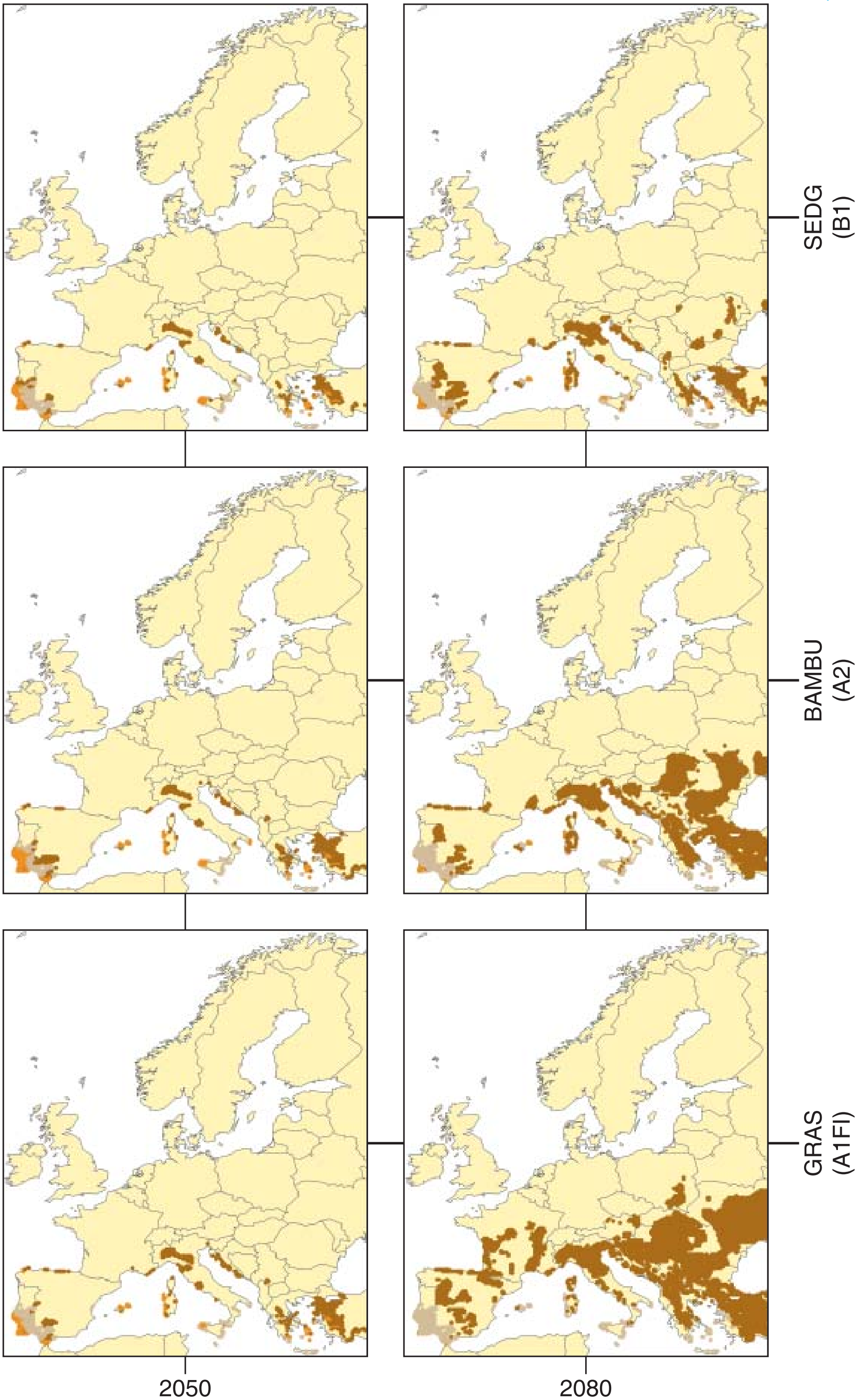
Present distribution can be well explained by climatic variables (AUC = 0.95).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melitaea trivia ([Schiffermüller], 1775) – Lesser Spotted Fritillary

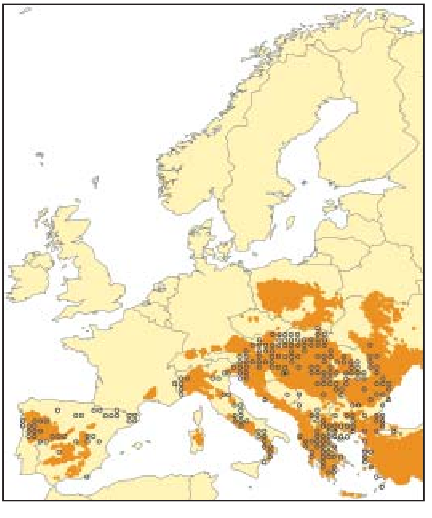
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	1635 (31.47%)	-1421 (-27.35%)
	BAMBU	-715 (-13.76%)	-2237 (-43.06%)
	GRAS	299 (5.76%)	-2154 (-41.46%)
2080	SEDG	-75 (-1.44%)	-2656 (-51.13%)
	BAMBU	-1820 (-35.03%)	-3718 (-71.57%)
	GRAS	-1070 (-20.6%)	-4285 (-82.48%)

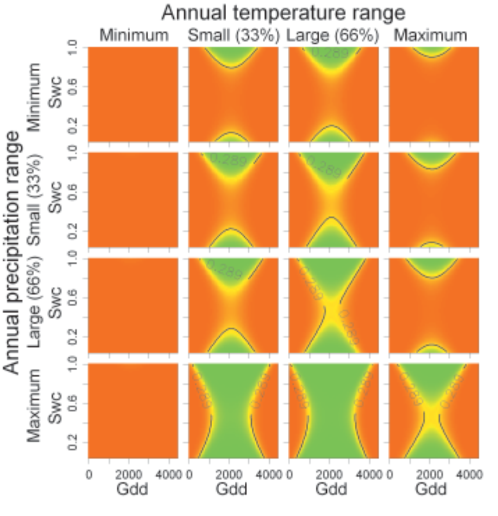
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 5195)

The Lesser Spotted Fritillary occurs on flower-rich, grassy vegetation, in both dry and damp places, and on waste ground. Various mulleins (*Verbascum* spp.) are used as foodplants, including Aaron's Rod (*Verbascum thapsus*), *V. densiflorum* and *V. longifolium*. The eggs are laid in batches on the underside of the leaves. The young caterpillars feed, gregariously in a communal web, where they also hibernate. After hibernation, they form smaller groups, and are often seen on the upper surface of the leaves. This species has one or two broods a year, depending on the climatic zone of its flight area.

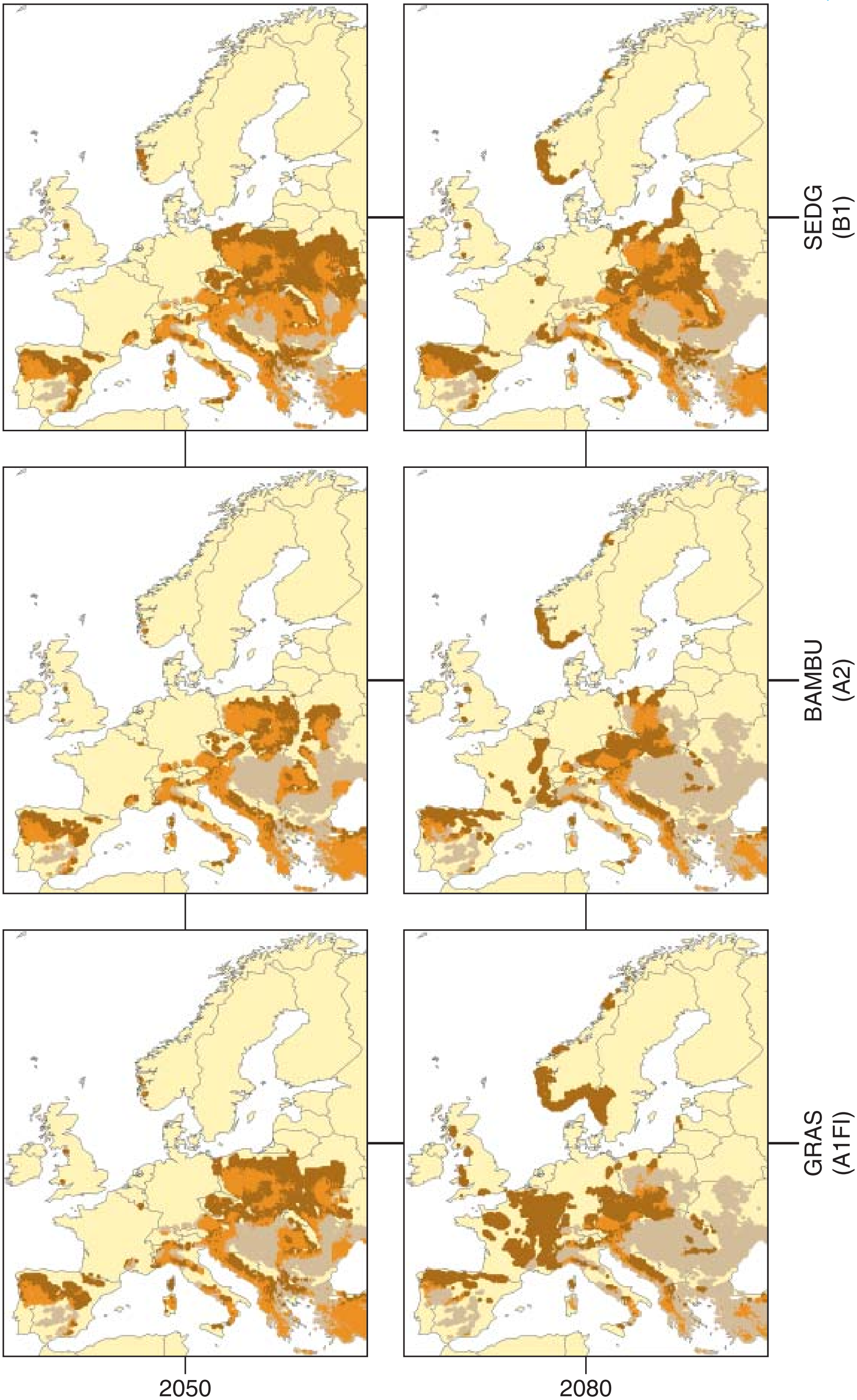
Present distribution can be well explained by climatic variables (AUC = 0.86).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melitaea didyma (Esper, 1779) – Spotted Fritillary

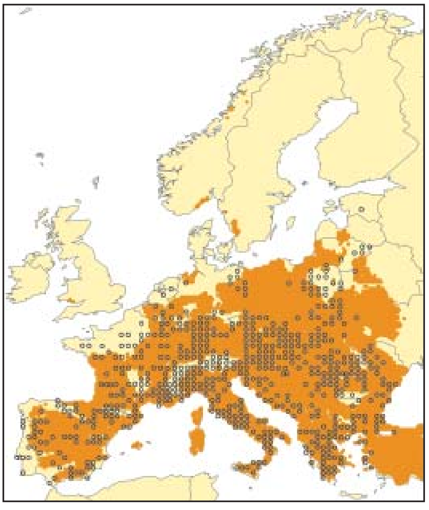
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	2540 (20.48%)	-1554 (-12.53%)
	BAMBU	1759 (14.19%)	-2270 (-18.31%)
	GRAS	1374 (11.08%)	-2686 (-21.66%)
2080	SEDG	1522 (12.27%)	-3397 (-27.4%)
	BAMBU	-73 (-0.59%)	-5816 (-46.9%)
	GRAS	-347 (-2.8%)	-7258 (-58.53%)

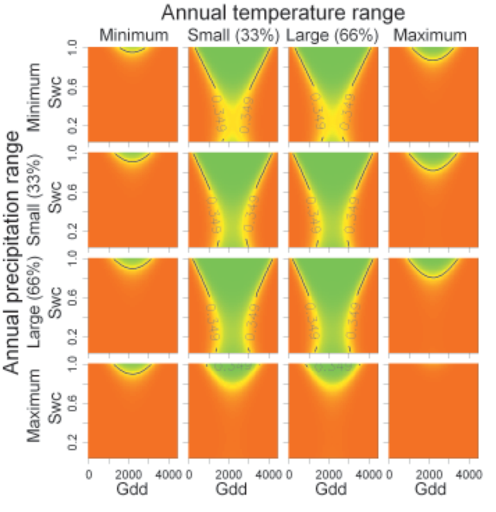
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 12400)

The Spotted Fritillary can be found on poor grasslands, steppe-like vegetation, and dry, rough vegetation near rocks and on slopes. Further, it is also seen on fallow agricultural land, or at the edges of fields. It uses a wide variety of plants as foodplant, plantains (*Plantago* spp.), toadflaxes (*Linara* spp.), speedwells (*Veronica* spp.), foxgloves (*Digitalis* spp.), woundworts (*Stachys* spp.), valerians (*Valeriana* spp.), and mulleins (*Verbascum* spp.). The female lays her eggs in clumps on the underside of the leaves, near to the ground. At first, the caterpillars feed communally in a loosely spun shelter, but they separate quite soon, either into smaller groups, or become solitary. The caterpillars hibernate alone, or in small groups, in a spun web. They pupate low down on the foodplant or in the vegetation. The Spotted Fritillary has one to three broods a year, depending on the geographical location and altitude of its breeding ground.

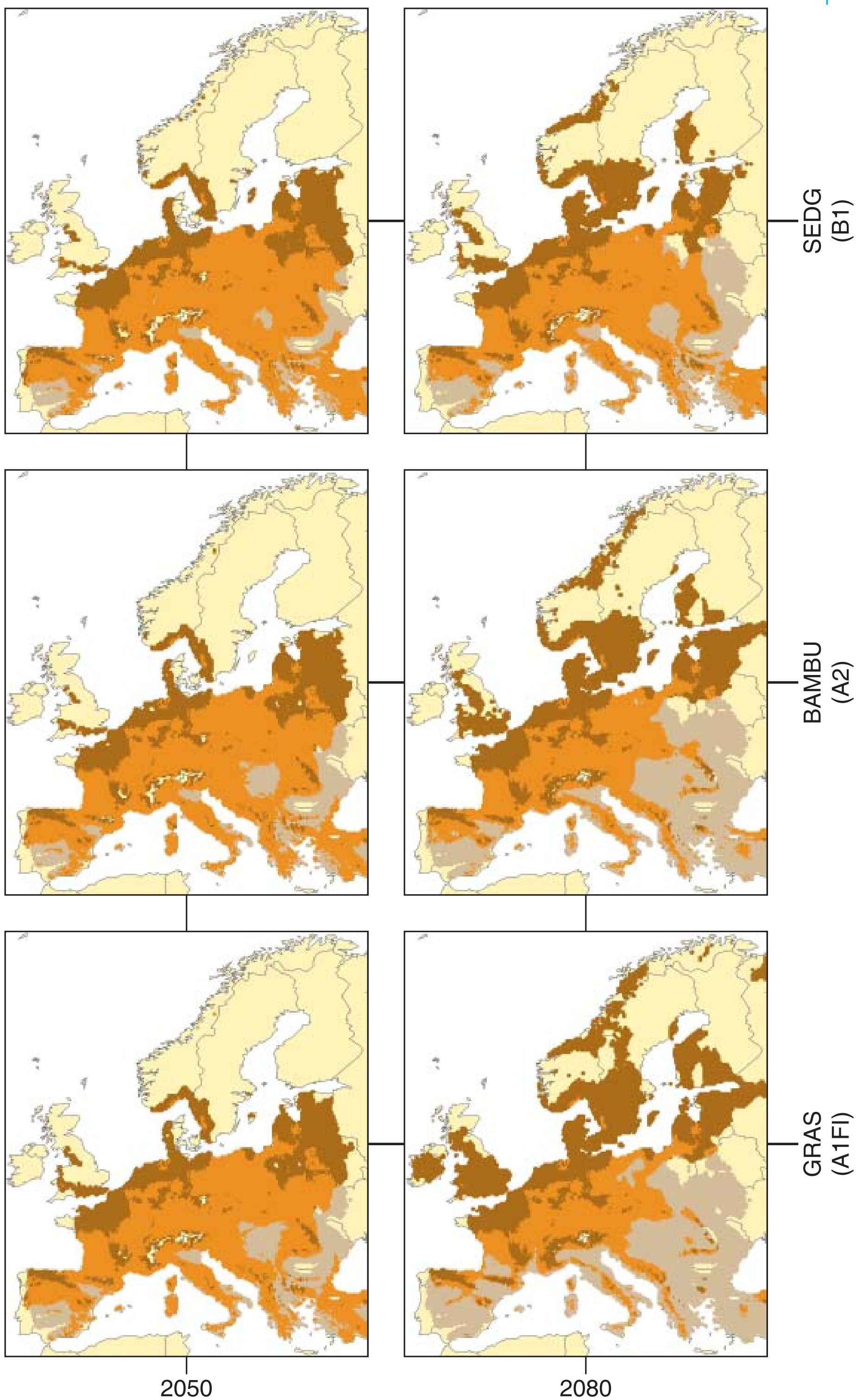
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.77).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melitaea diamina (Lang, 1789) – False Heath Fritillary

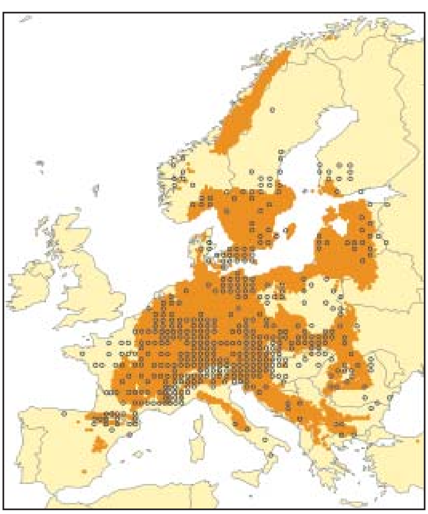
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-1169 (-13.54%)	-2382 (-27.59%)
	BAMBU	171 (1.98%)	-1648 (-19.09%)
	GRAS	-1511 (-17.5%)	-2780 (-32.2%)
2080	SEDG	-2257 (-26.14%)	-4026 (-46.64%)
	BAMBU	-1780 (-20.62%)	-4472 (-51.8%)
	GRAS	-3377 (-39.12%)	-6073 (-70.35%)

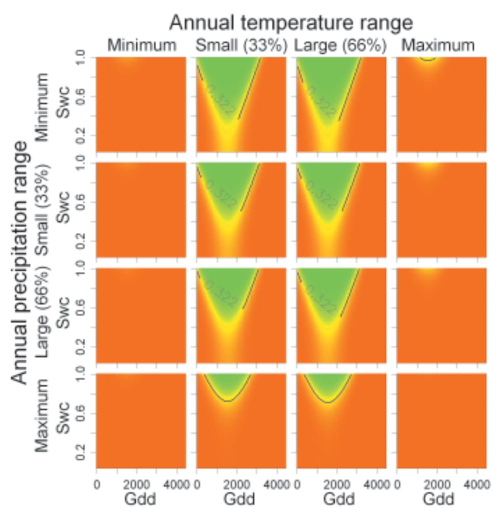
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 8633)

The False Heath Fritillary is found in sheltered, marshy habitats and damp woodland clearings. At higher altitudes, it is also found on rough, calcareous grasslands. Different sorts of valerian (*Valeriana* spp.) are used as foodplants, the female depositing her eggs in large clusters on the underside of the leaves. The small caterpillars only feed for a short time before hibernating communally in a silken shelter. After hibernation, they separate, later pupating low down on the foodplant. The False Heath Fritillary usually has one brood a year, but at low altitudes it sometimes has two.

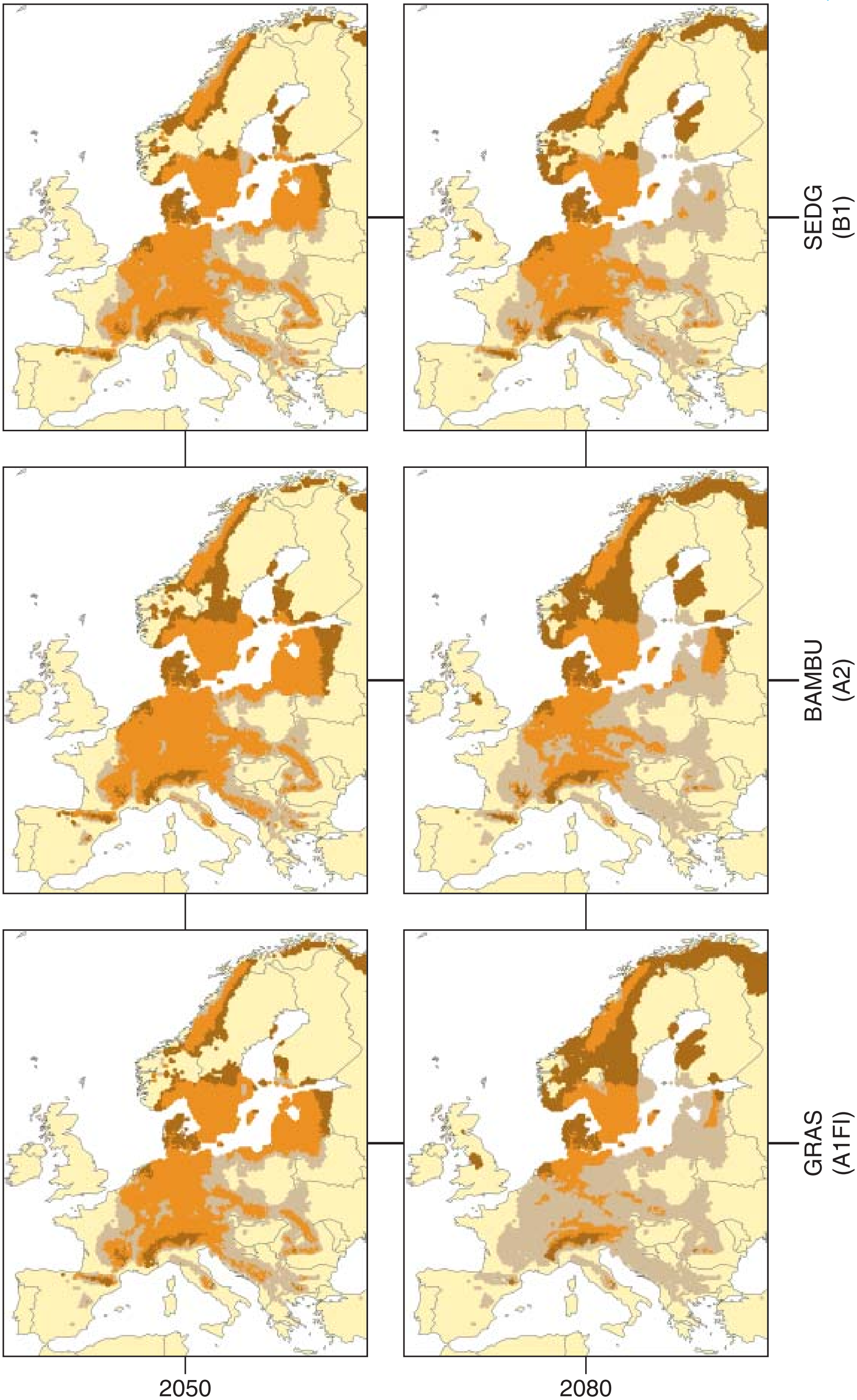
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.84).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melitaea deione (Geyer, 1832) – Provençal Fritillary

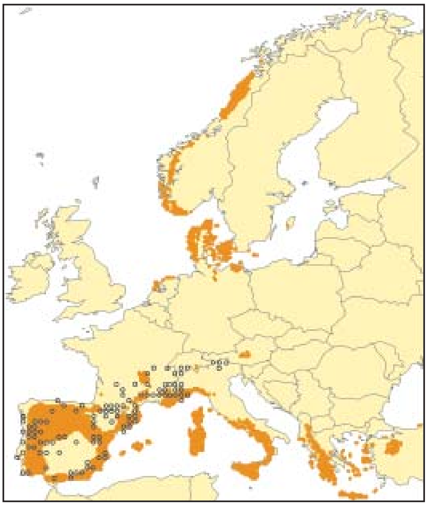
© Martin Wiemers

		Full dispersal	No dispersal
2050	SEDG	-832 (-34.3%)	-1587 (-65.42%)
	BAMBU	-1517 (-62.53%)	-1792 (-73.87%)
	GRAS	-1220 (-50.29%)	-1824 (-75.19%)
2080	SEDG	-1099 (-45.3%)	-2005 (-82.65%)
	BAMBU	-1236 (-50.95%)	-2071 (-85.37%)
	GRAS	-1062 (-43.78%)	-2213 (-91.22%)

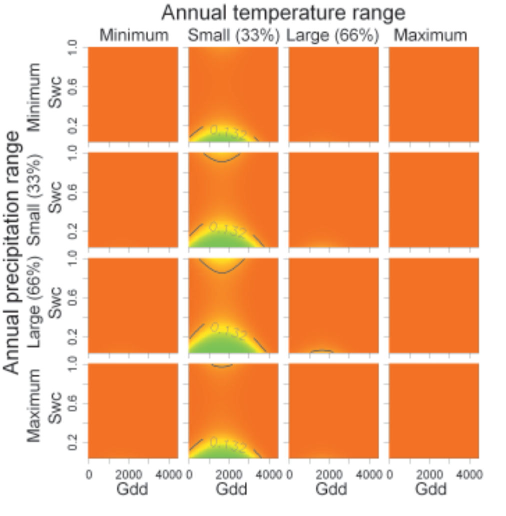
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2426)

The Provençal Fritillary occurs in all sorts of flower-rich, grassy places; on flower-rich grasslands, both in damp and dry places, and on calcareous as well as acid soil, on flower-rich, grassy vegetation on the banks of rivers and streams, in scrub and at woodland edges. In Switzerland, at the extreme north of its distribution range, it is only found in dry, warm, bushy places. Its foodplants are toadflax (*Linaria* spp.), snapdragons (*Antirrhinum* spp.), and sometimes also foxgloves (*Digitalis* spp.). The female lays her eggs in small batches on the underside of the leaves. The caterpillars hibernate in a spun shelter. In most locations, this species has two broods a year, however in cooler places only one.

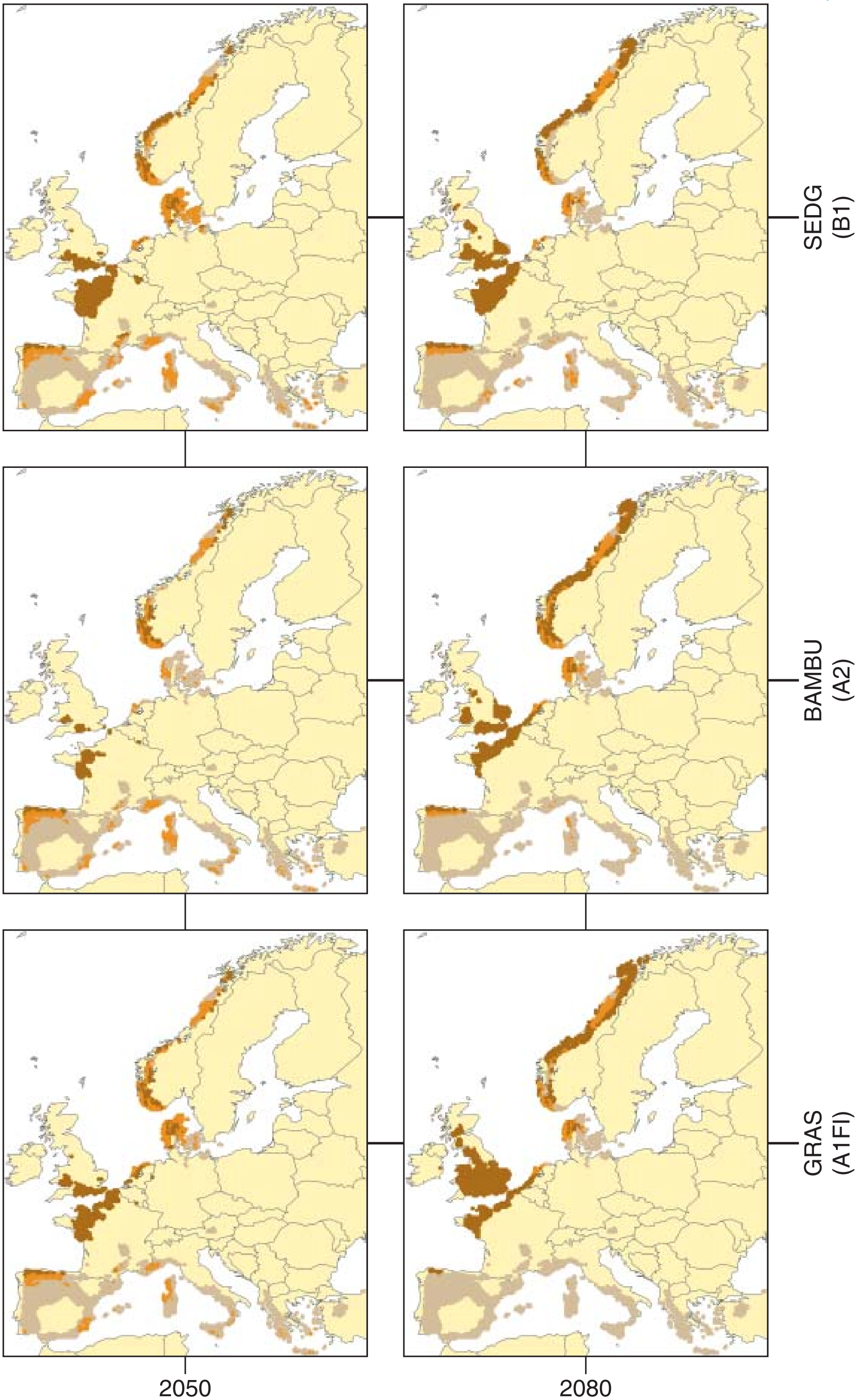
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.76). Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melitaea varia (Meyer-Dür, 1851) – Grisons Fritillary

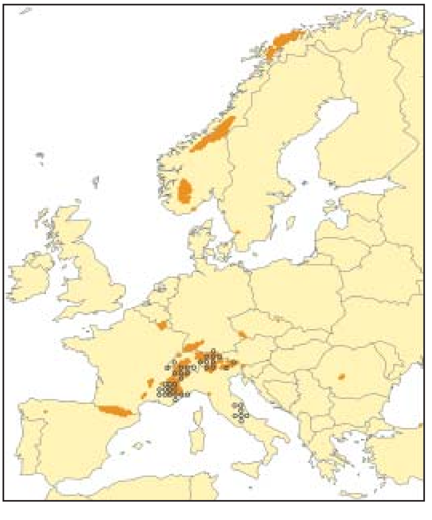
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-19 (-3.75%)	-281 (-55.53%)
	BAMBU	85 (16.8%)	-232 (-45.85%)
	GRAS	-66 (-13.04%)	-298 (-58.89%)
2080	SEDG	-232 (-45.85%)	-438 (-86.56%)
	BAMBU	-123 (-24.31%)	-355 (-70.16%)
	GRAS	-249 (-49.21%)	-434 (-85.77%)

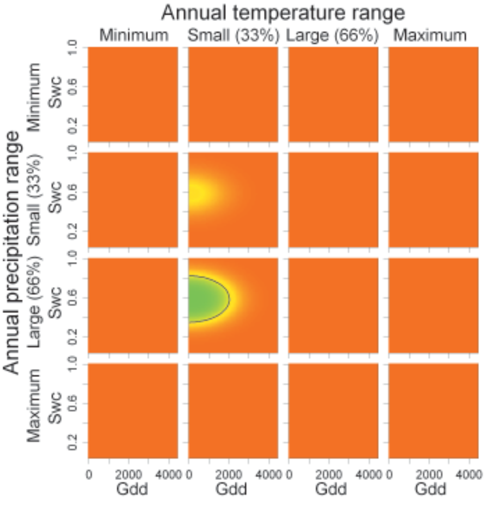
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 506)

The Grisons Fritillary is a small fritillary that breeds on flower-rich sub-alpine and alpine grasslands and on sunny, grassy slopes. The adult butterflies visit mostly low plants for nectar, and the males are also seen on damp patches, excrement, and dead animals. The female lays her eggs in clusters on the foodplant. The caterpillars have been found on Alpine Plantain (*Plantago alpina*) and *Achillea* species, but Spring Gentian (*Gentiana verna*) and Stemless Trumpet Gentian (*G. acaulis*) are also named as foodplants. The caterpillars hibernate, pupating in June or July of the following year, the pupa usually hanging from a stone. However, at higher altitudes, development is slower, taking nearly two years, and they hibernate twice.

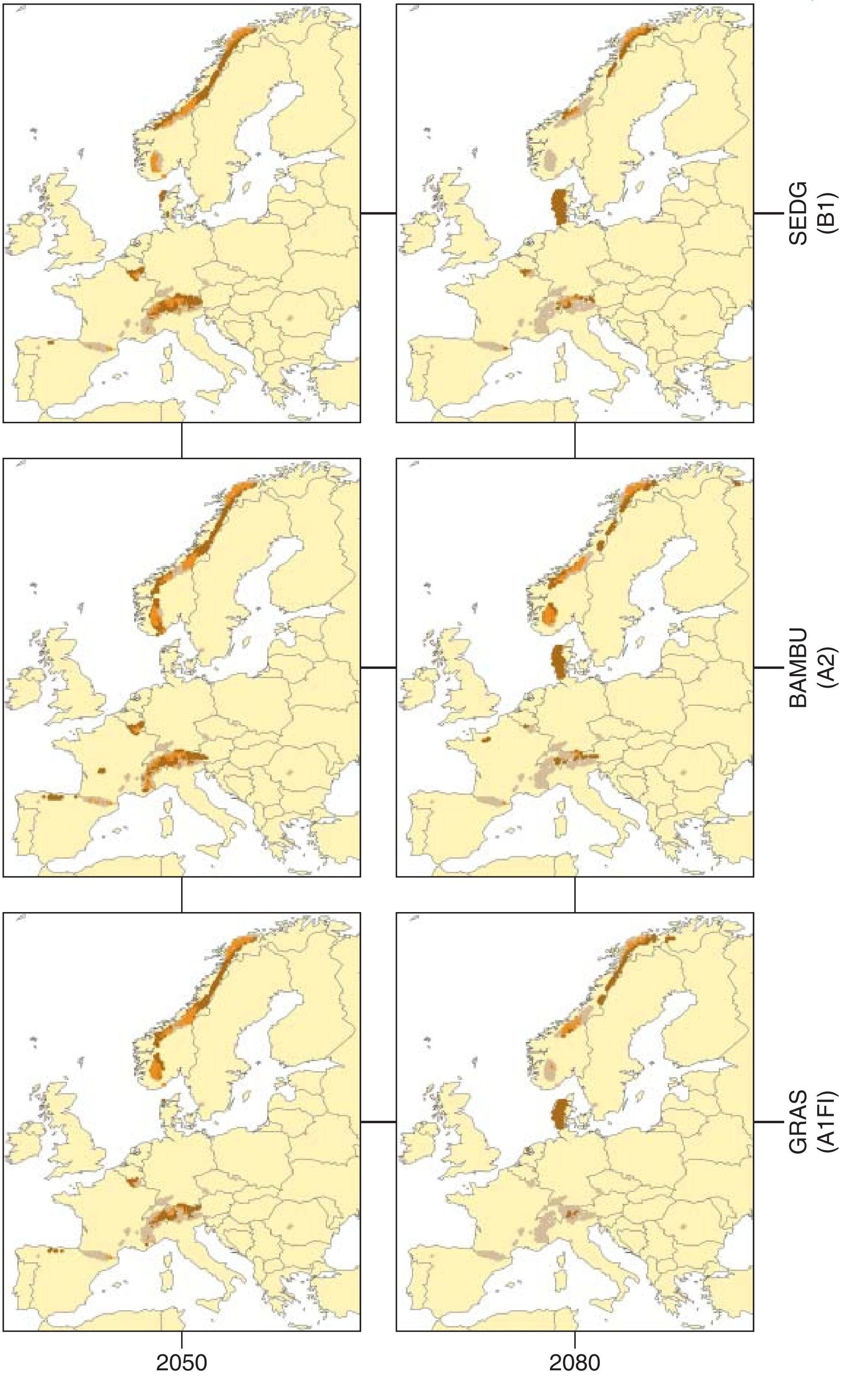
Present distribution can be very well explained by climatic variables (AUC = 0.96).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


2050
2080
SEDG (B1)
BAMBU (A2)
GRAS (A1FI)

Melitaea parthenoides (Keferstein, 1851) – Meadow Fritillary

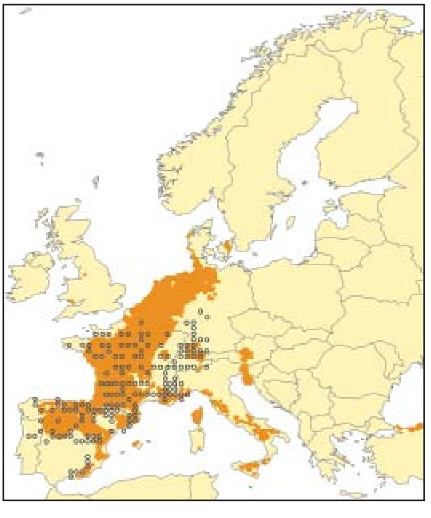
© Henk Bosma

		Full dispersal	No dispersal
2050	SEDG	-263 (-8.26%)	-1251 (-39.3%)
	BAMBU	-467 (-14.67%)	-1326 (-41.66%)
	GRAS	-805 (-25.29%)	-1756 (-55.17%)
2080	SEDG	-1137 (-35.72%)	-2098 (-65.91%)
	BAMBU	-1391 (-43.7%)	-2457 (-77.19%)
	GRAS	-1842 (-57.87%)	-2969 (-93.28%)

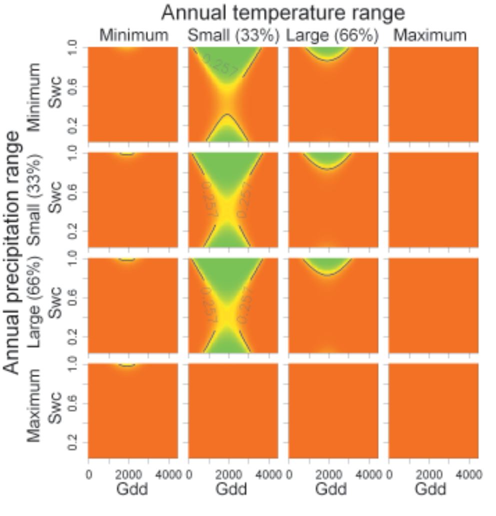
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 3183)

The Meadow Fritillary occurs in both dry and moderately damp habitats in many sorts of open, grassy, flower-rich places near woodland. Plantains (*Plantago* spp.) are the main foodplants, especially Ribwort Plantain (*P. lanceolata*). The eggs are laid in clusters on the underside of the leaves. The caterpillars feed and hibernate communally in a silken shelter, only separating in the last larval instar. They then look for a safe place to pupate, low down on the foodplant. The Meadow Fritillary usually has two generations a year, but only one in cool breeding grounds.

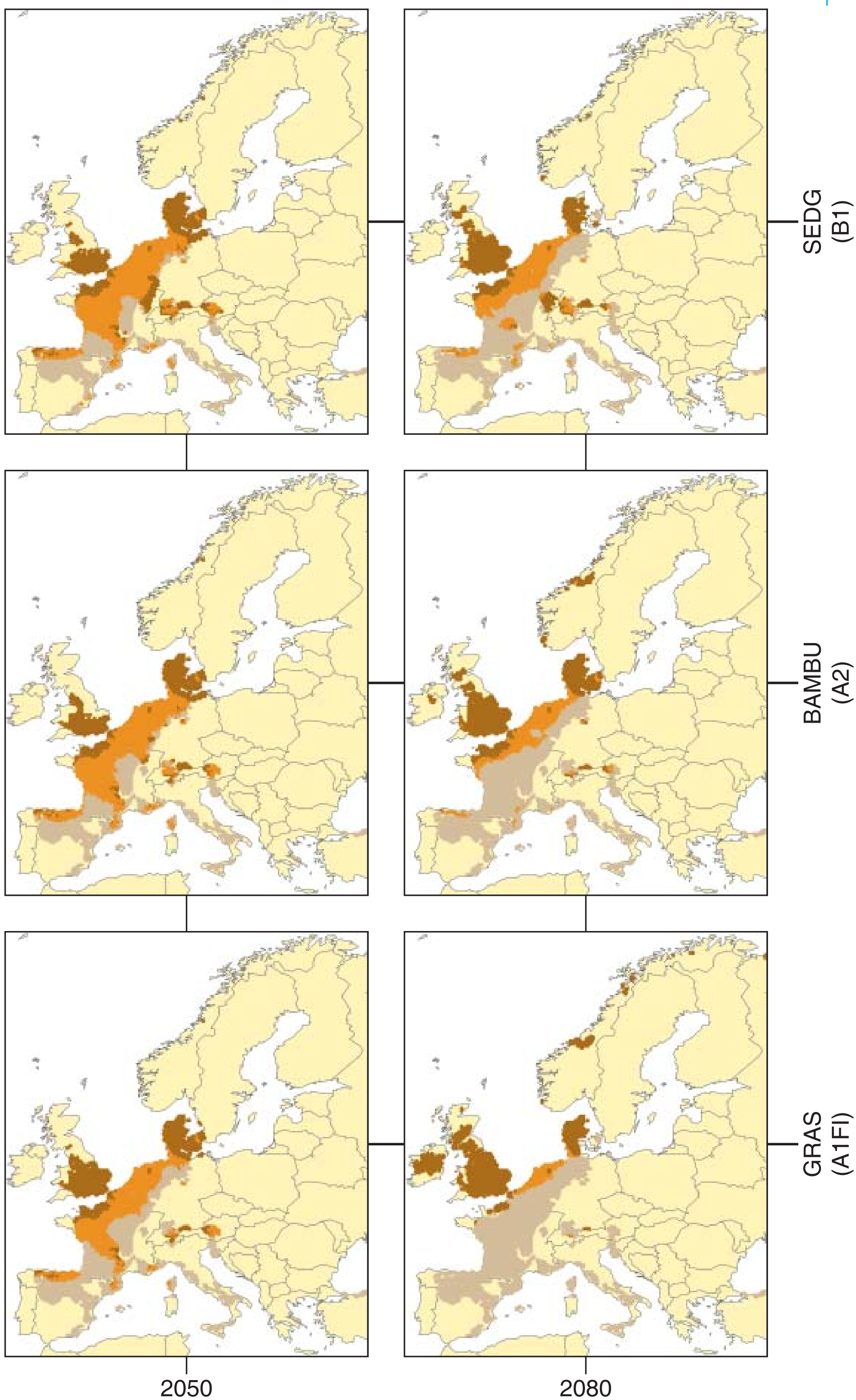
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.84). Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melitaea aurelia (Nickerl, 1850) – Nickerl's Fritillary

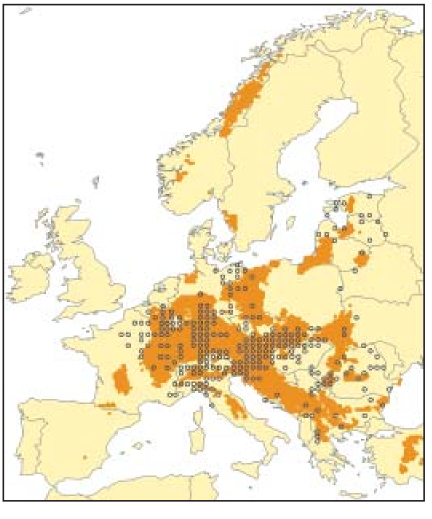
© Martin Wiemers

		Full dispersal	No dispersal
2050	SEDG	335 (7.57%)	-1527 (-34.52%)
	BAMBU	2241 (50.67%)	-1117 (-25.25%)
	GRAS	801 (18.11%)	-1641 (-37.1%)
2080	SEDG	625 (14.13%)	-2076 (-46.94%)
	BAMBU	1372 (31.02%)	-2361 (-53.38%)
	GRAS	490 (11.08%)	-3288 (-74.34%)

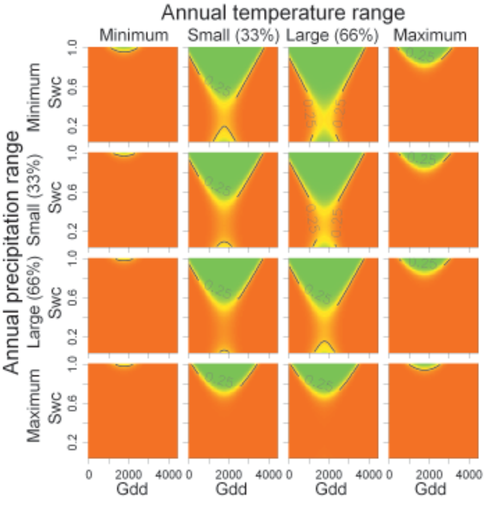
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 4423)

Nickerl's Fritillary occurs on open, dry grasslands and heaths on calcareous slopes and is very heat-tolerant. The female deposits her eggs in clusters on the underside of the leaves of its foodplant Ribwort Plantain (*Plantago lanceolata*). The caterpillars feed and also hibernate in communal silken nests. They pupate low down in the vegetation. Nickerl's Fritillary has one generation a year.

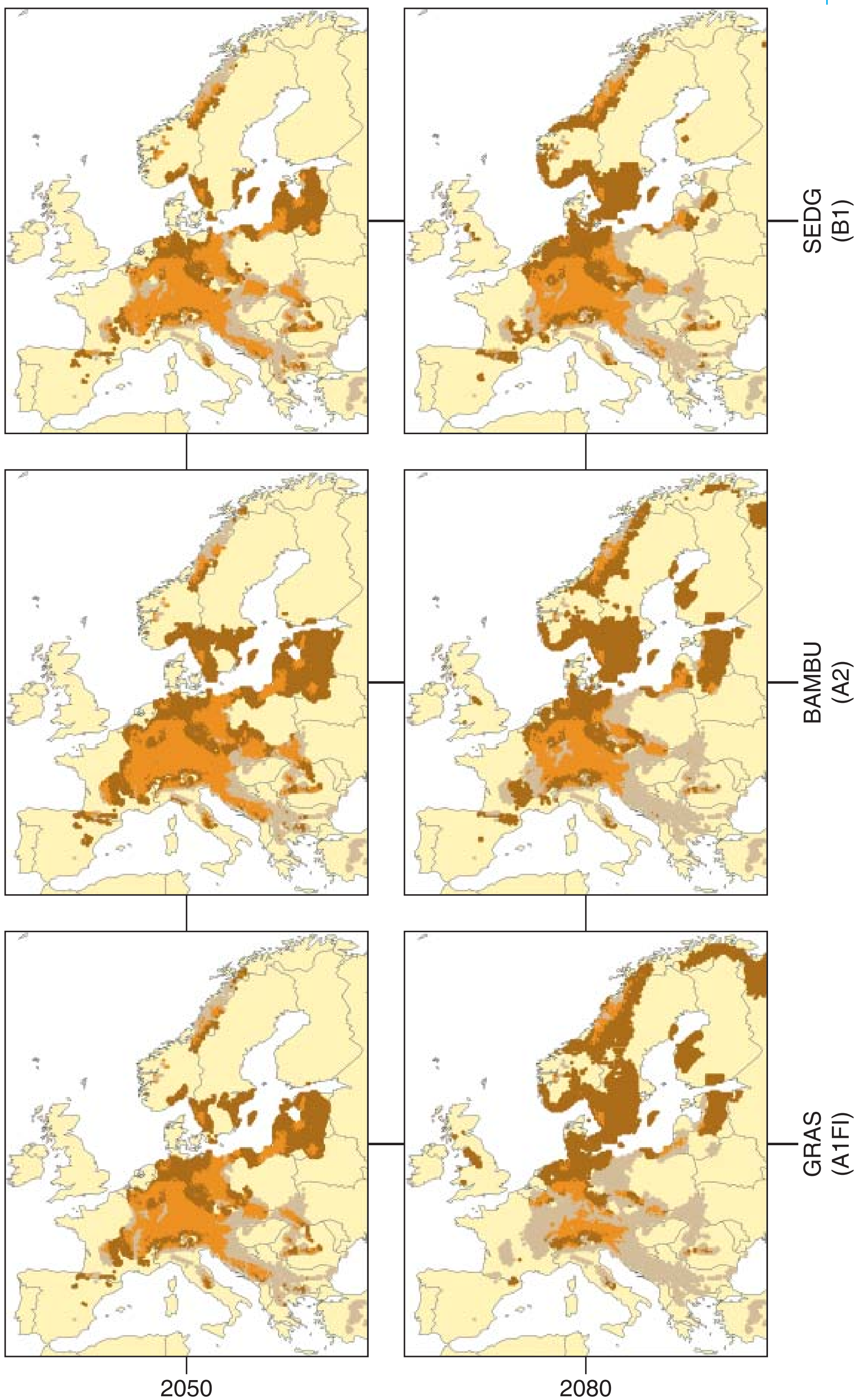
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.82).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melitaea britomartis (Assmann, 1847) – Assmann's Fritillary

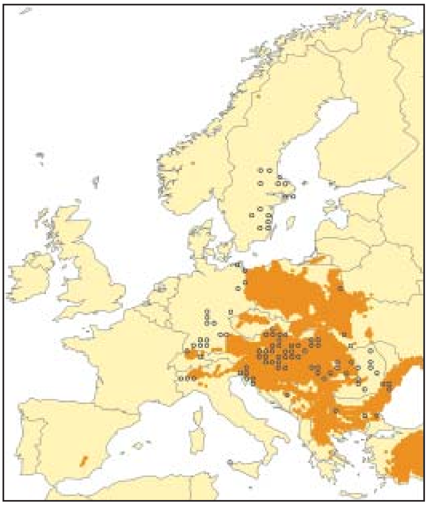
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	1268 (29.63%)	-1324 (-30.93%)
	BAMBU	31 (0.72%)	-2095 (-48.95%)
	GRAS	793 (18.53%)	-1987 (-46.43%)
2080	SEDG	-1646 (-38.46%)	-3144 (-73.46%)
	BAMBU	-1961 (-45.82%)	-3747 (-87.55%)
	GRAS	-2251 (-52.59%)	-4035 (-94.28%)

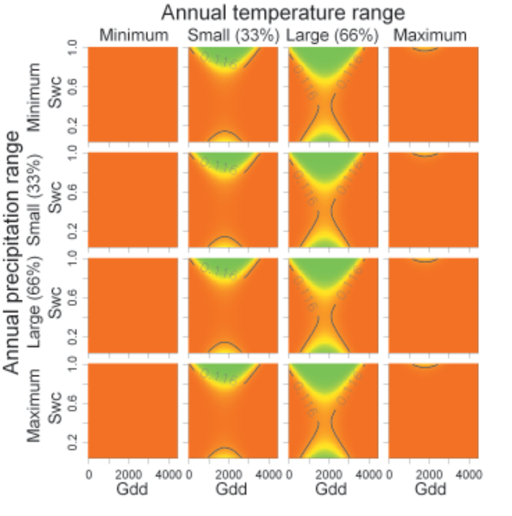
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 4280)

Assmann's Fritillary occurs on warm grasslands and heath that are often situated at the edges of woodland, or near groups of shrubs. Its foodplants are Ribwort Plantain (*Plantago lanceolata*), Yellow Rattle (*Rhinanthus minor*), and the Speedwell (*Veronica austriaca*). The female lays her eggs in batches on the underside of the leaves. The caterpillars feed communally in a silken nest, where they also hibernate. They then separate, later pupating low-down in the vegetation. This fritillary is single-brooded.

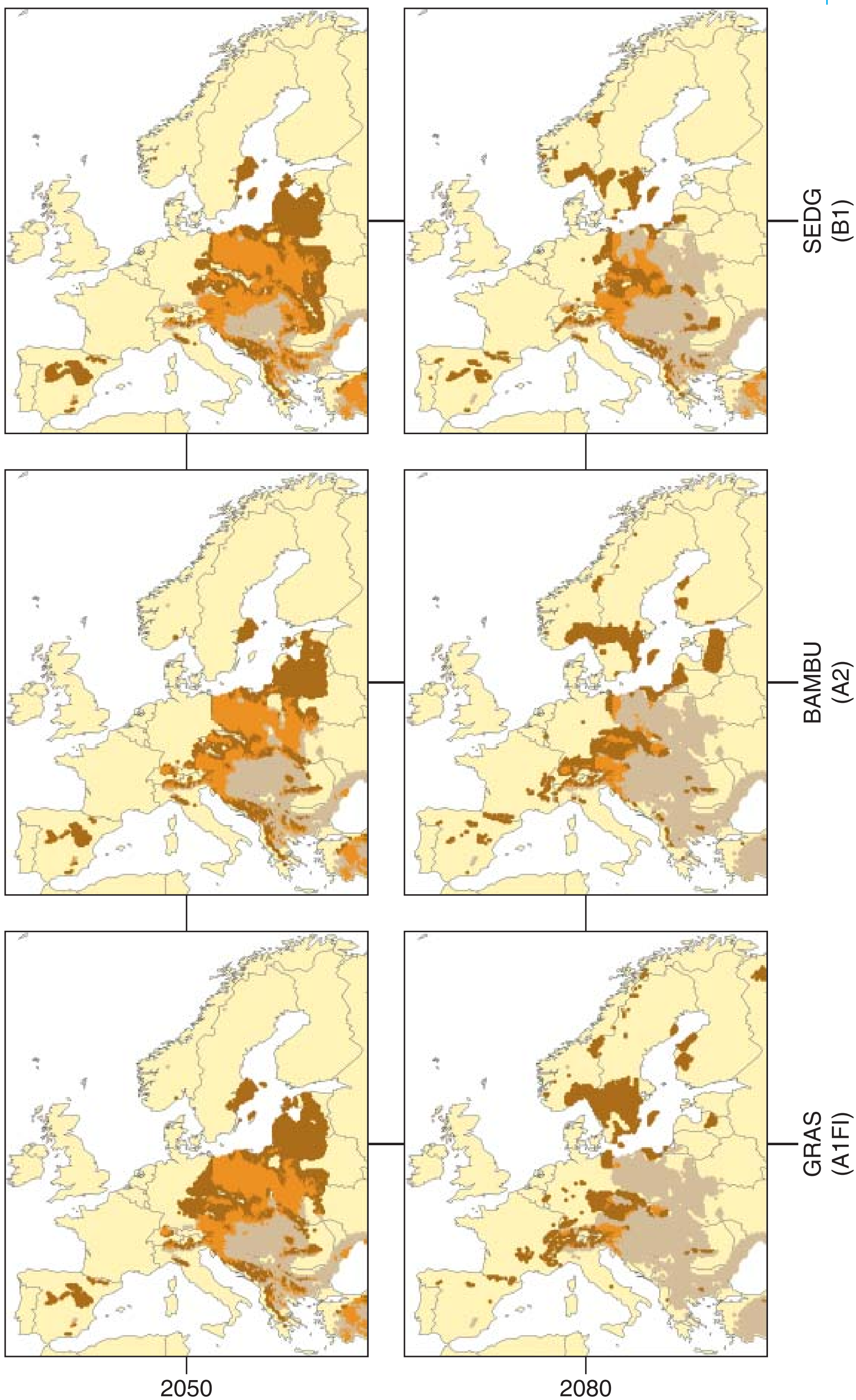
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.83).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melitaea athalia (Rottemburg, 1775) – Heath Fritillary

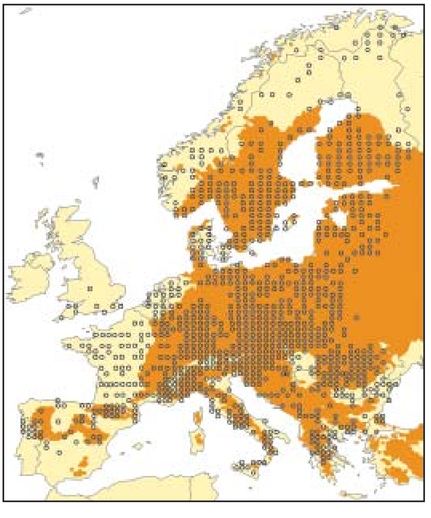
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	109 (0.7%)	-2510 (-16.21%)
	BAMBU	-610 (-3.94%)	-2730 (-17.63%)
	GRAS	-1391 (-8.98%)	-3658 (-23.63%)
2080	SEDG	560 (3.62%)	-3902 (-25.2%)
	BAMBU	-1542 (-9.96%)	-5975 (-38.59%)
	GRAS	-2980 (-19.25%)	-7785 (-50.28%)

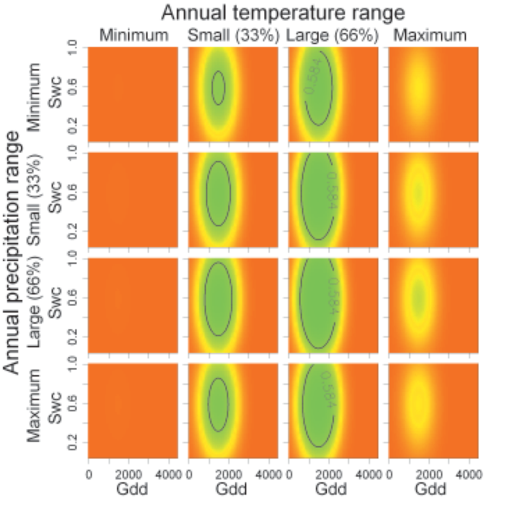
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 15482)

The Heath Fritillary is found in many different sorts of biotope, ranging from dry to damp, grassy, flower-rich places, often situated near bushes or in woodland, or in clearings and along the edges of paths in woods. Its foodplants are plantains (*Plantago* spp.), cow-wheats (*Melampyrum* spp.), speedwells (*Veronica* spp.), foxgloves (*Digitalis* spp.), and toadflaxes (*Linara* spp.). The female lays her eggs in clusters on the underside of the leaves. The caterpillars feed communally in silken nests, also hibernating together when half-grown. They then disperse over the plant, either into small groups, or, mostly, become solitary. They pupate on the foodplant, and usually have one brood a year, except in the south, where they have two.

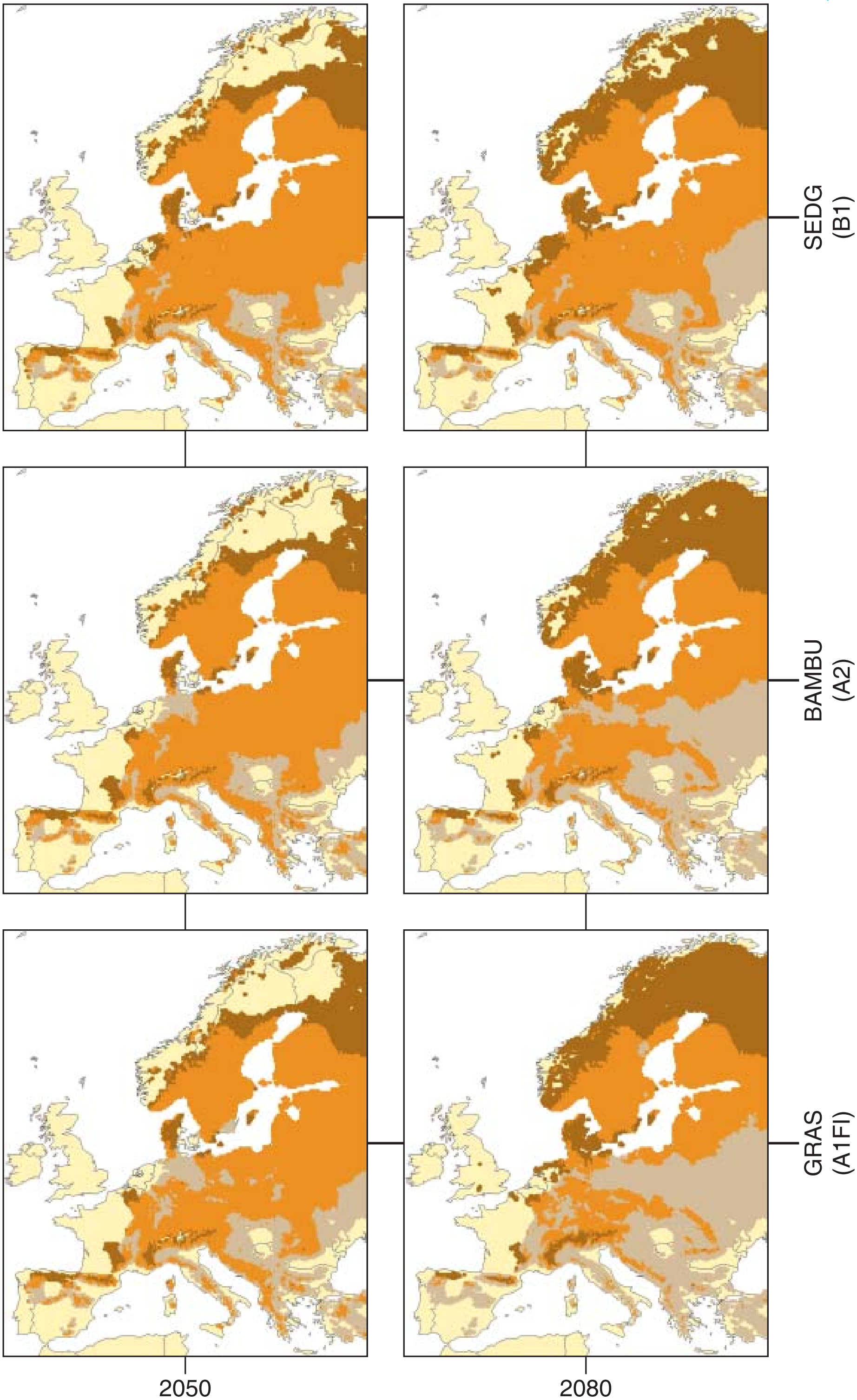
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.79).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Limenitis populi (Linnaeus, 1758) – Poplar Admiral

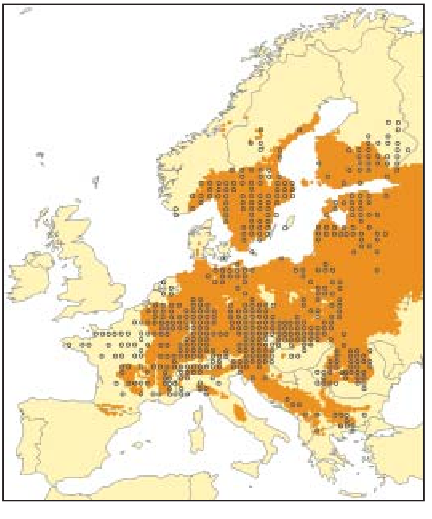
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	-2247 (-19.83%)	-4349 (-38.38%)
	BAMBU	-937 (-8.27%)	-3448 (-30.43%)
	GRAS	-2695 (-23.78%)	-4819 (-42.53%)
2080	SEDG	-1234 (-10.89%)	-5291 (-46.69%)
	BAMBU	-1580 (-13.94%)	-6352 (-56.05%)
	GRAS	-3162 (-27.9%)	-8315 (-73.38%)

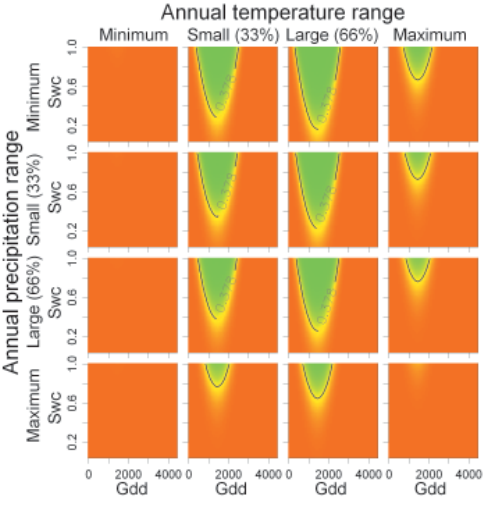
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 11332)

An encounter with the Poplar Admiral is one of those things that one never forgets. It is an impressive butterfly, and the woods it inhabits are areas of natural beauty. They are found in mixed woodlands with damp clearings, where its foodplants Aspen (*Populus tremula*) and Black Poplar (*Populus nigra*) grow. The female deposits her eggs one by one on leaves that are preferably situated in the sun, with more branches above them. The caterpillar feeds on the leaves and usually builds a hibernaculum, which is fastened tightly onto a twig with spun thread. It hibernates in the second larval instar, and in the spring eats large numbers of leaves before finally pupating, suspended from a leaf. The Poplar Admiral has one generation a year.

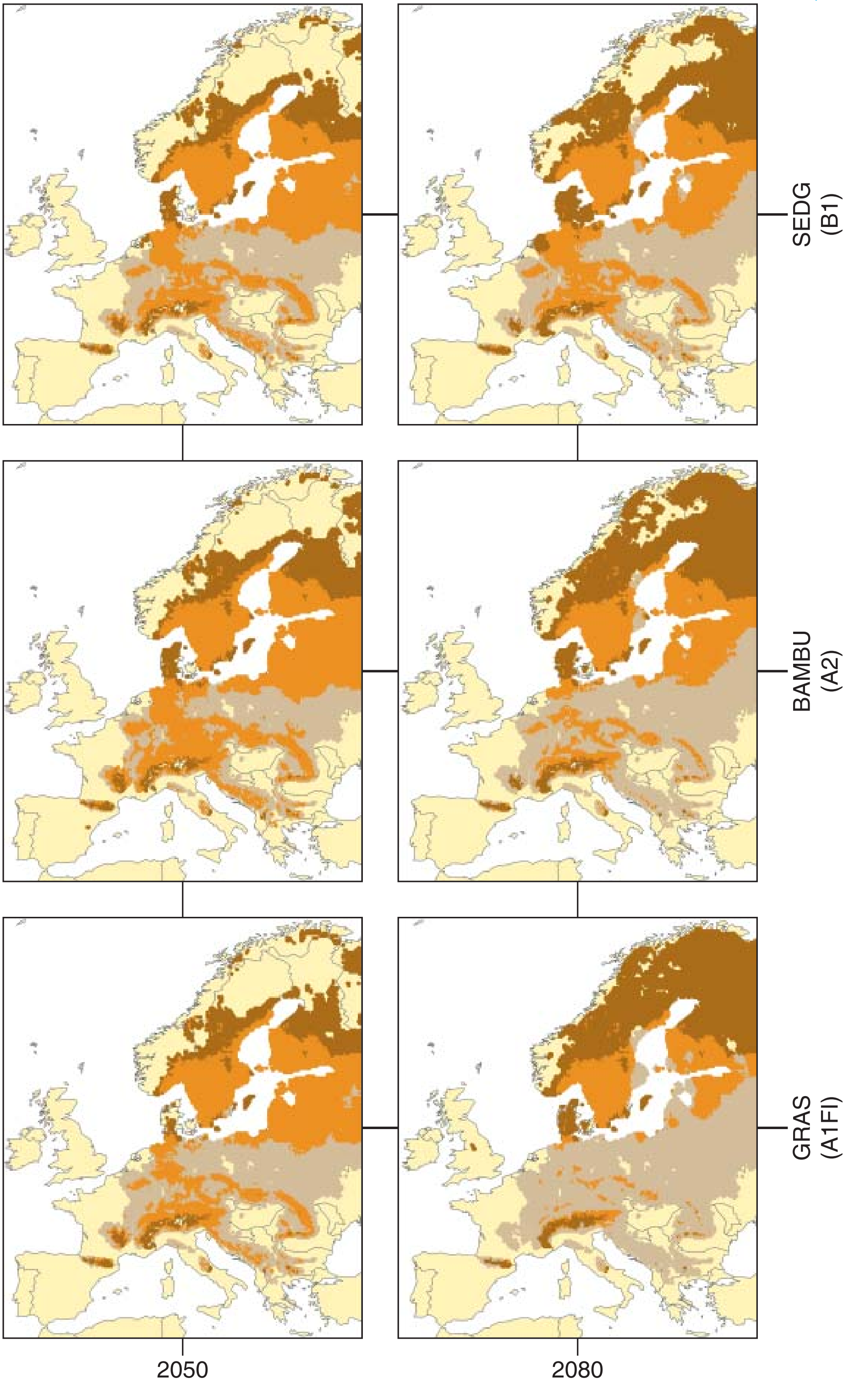
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.84).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Limenitis camilla (Linnaeus, 1764) – White Admiral

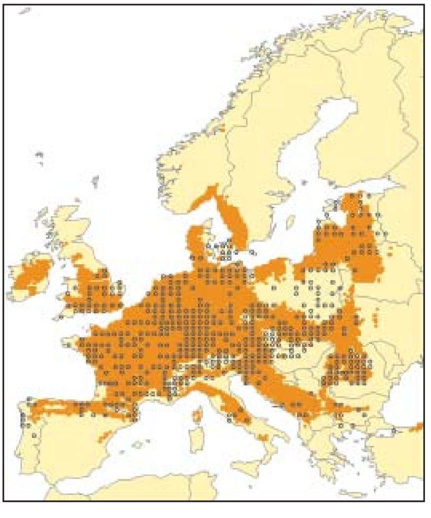
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-1009 (-11.42%)	-2600 (-29.44%)
	BAMBU	890 (10.08%)	-1716 (-19.43%)
	GRAS	-1369 (-15.5%)	-3179 (-35.99%)
2080	SEDG	-979 (-11.08%)	-3580 (-40.53%)
	BAMBU	-161 (-1.82%)	-4232 (-47.91%)
	GRAS	-1447 (-16.38%)	-6253 (-70.79%)

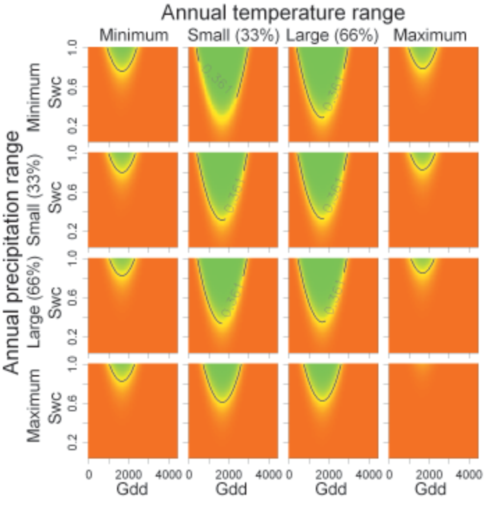
Changes in climatic niche distribution (in 10’×10’ grid cells; present niche space: 8833)

The White Admiral is a true woodland butterfly and is found in clearings and woodland rides. The female lays her eggs on young honeysuckle (*Lonicera* spp.) leaves, preferring those which are half in the shade. The caterpillars feed on the leaves in a characteristic way. Starting at the tip and working towards the stalk, they leave the main nerve intact, and use it to rest upon. The hibernation is in the second larval instar. To make the hibernaculum the remaining part of the leaf is spun into a little tube, and the leaf stalk is spun tightly onto a twig. After hibernating, the caterpillar feeds on the newly-emerged leaves. It pupates upside down on a twig, and has one brood a year.

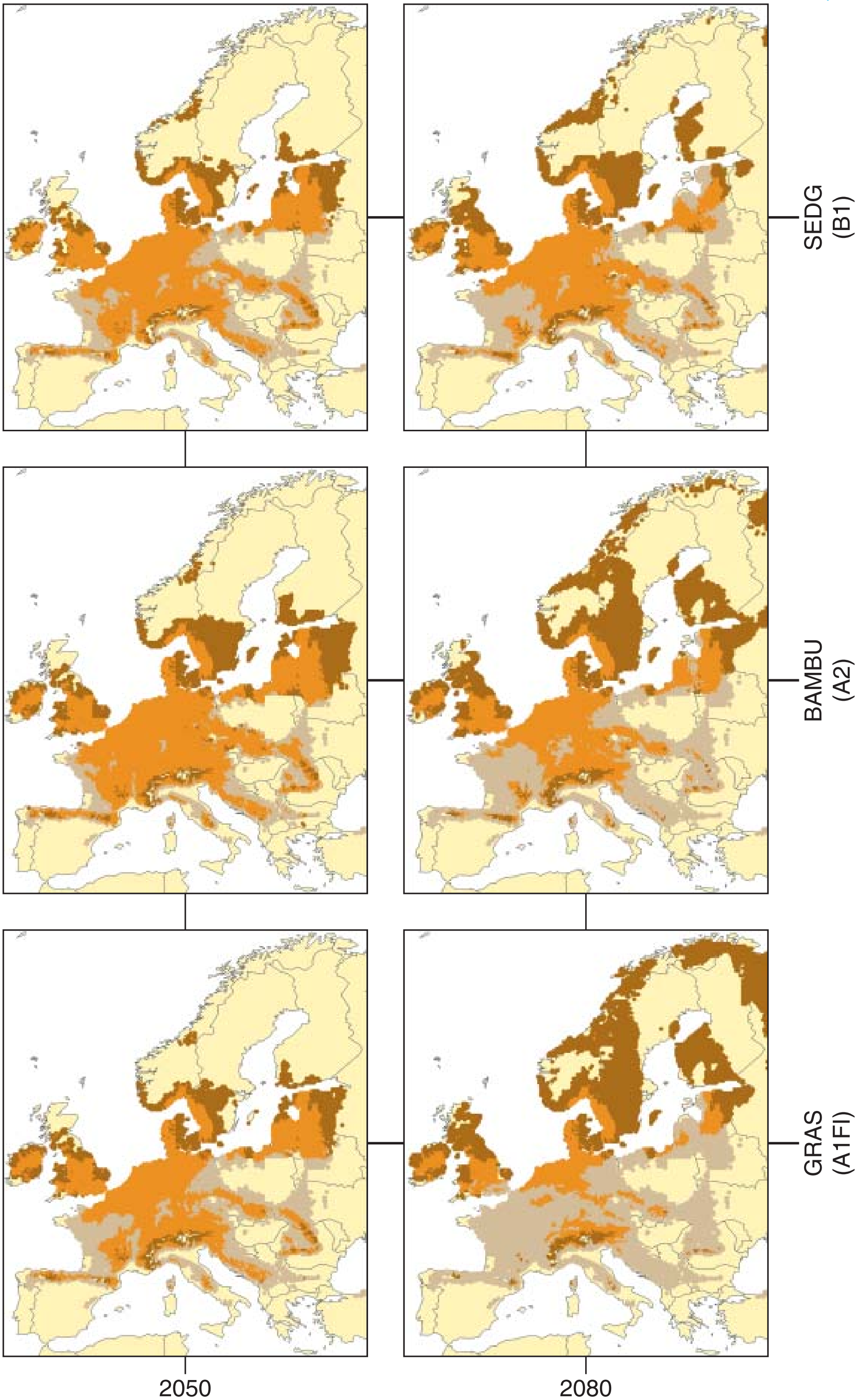
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.81). Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Limenitis reducta (Staudinger, 1901) – Southern White Admiral

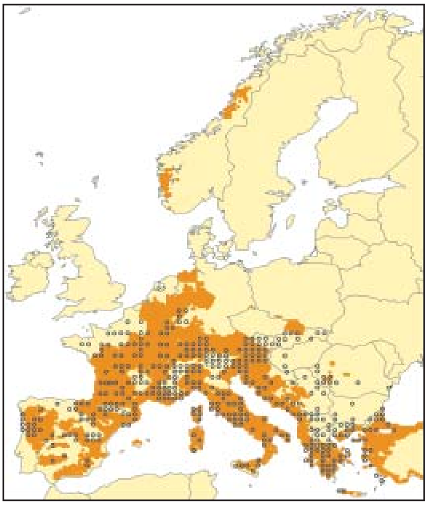
© Peter Ginzinger

		Full dispersal	No dispersal
2050	SEDG	347 (6.07%)	-1259 (-22.03%)
	BAMBU	735 (12.86%)	-1332 (-23.3%)
	GRAS	161 (2.82%)	-1546 (-27.05%)
2080	SEDG	1180 (20.64%)	-1764 (-30.86%)
	BAMBU	897 (15.69%)	-2390 (-41.81%)
	GRAS	254 (4.44%)	-3262 (-57.07%)

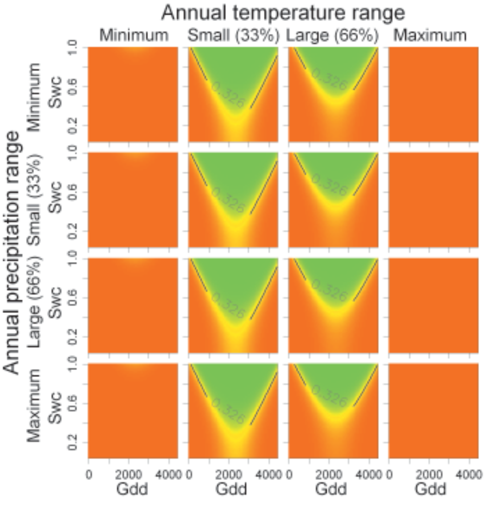
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 5716)

The Southern White Admiral occurs in warm to very warm places in woodland and scrub, often situated near streams, springs or other damp places. The eggs are laid on nearly all species of honeysuckle (*Lonicera* spp.). The caterpillars feed on the leaves in the manner characteristic of this genus, nibbling at the soft tissues while leaving the main nerve free. For hibernation, a small cradle is made from the remains of the leaf, which is secured to a twig with silk. When they come out of hibernation, they begin feeding on the young honeysuckle leaves. The caterpillar pupates suspended from a twig of the foodplant. This species has one brood a year North of the Alps but two in the Mediterranean region.

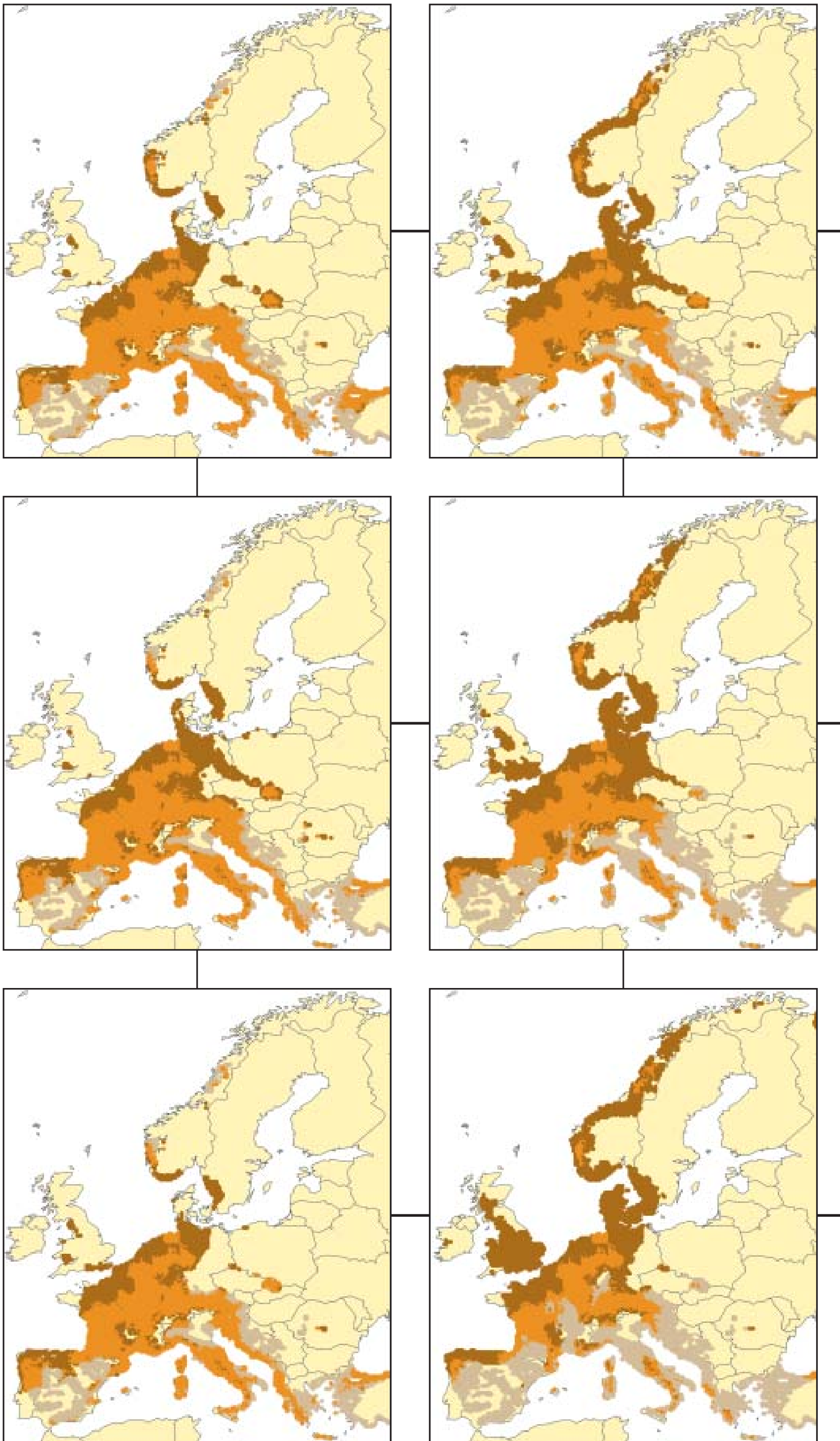
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.82).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold



SEDG (B1)

BAMBU (A2)

GRAS (A1FI)

2050 2080

Neptis sappho (Pallas, 1771) – Common Glider

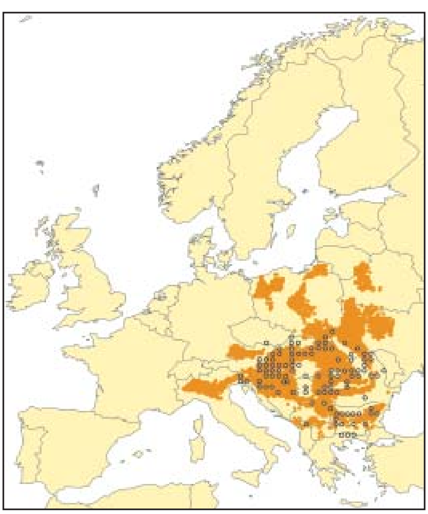
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	1384 (53.09%)	-1028 (-39.43%)
	BAMBU	2187 (83.89%)	-1038 (-39.82%)
	GRAS	1157 (44.38%)	-1389 (-53.28%)
2080	SEDG	876 (33.6%)	-1769 (-67.86%)
	BAMBU	1506 (57.77%)	-2254 (-86.46%)
	GRAS	1649 (63.25%)	-2435 (-93.4%)

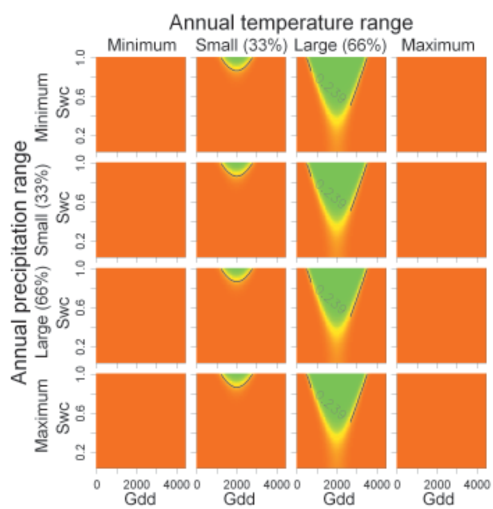
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 2607)

The Common Glider inhabits damp, deciduous woodland, especially in river valleys. The butterflies often settle in the top of the trees to rest or bask in the sun, with their wings wide open, just like the Hungarian Glider (*N. rivularis*). This butterfly has a characteristic flight, elegantly gliding from perch to perch. The caterpillars feed on Spring Pea (*Lathyrus vernus*) and Black Pea (*L. niger*). The Common Glider has two broods a year and hibernates as a small caterpillar.

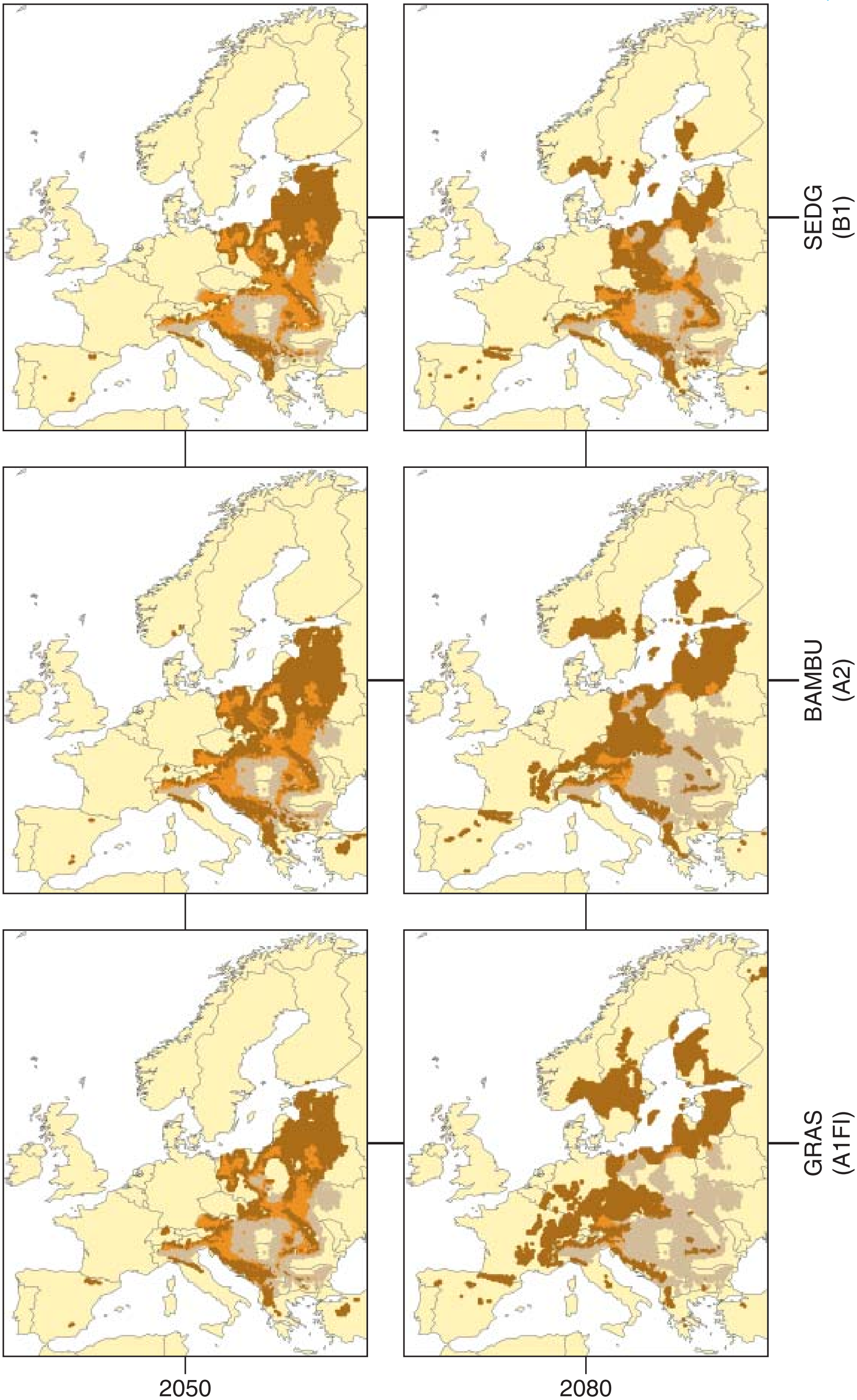
Present distribution can be well explained by climatic variables (AUC = 0.92).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold



2050
2080
SEDG (B1)
BAMBU (A2)
GRAS (A1FI)

Neptis rivularis (Scopoli, 1763) – Hungarian Glider

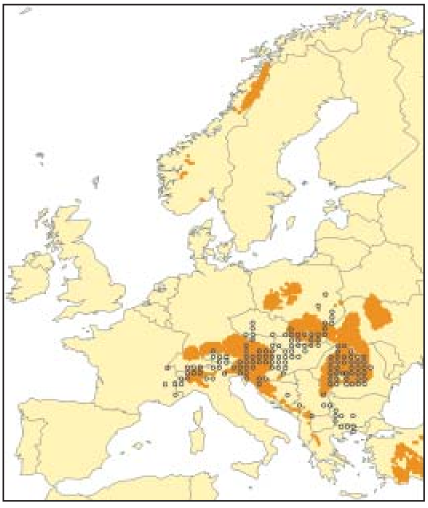
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-655 (-30.68%)	-1086 (-50.87%)
	BAMBU	-739 (-34.61%)	-1113 (-52.13%)
	GRAS	-1082 (-50.68%)	-1391 (-65.15%)
2080	SEDG	74 (3.47%)	-1285 (-60.19%)
	BAMBU	-458 (-21.45%)	-1520 (-71.19%)
	GRAS	-121 (-5.67%)	-1763 (-82.58%)

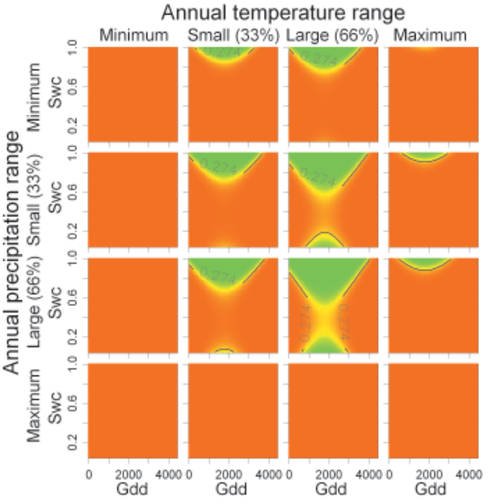
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2135)

The Hungarian Glider is a butterfly of light, damp woodland, occurring in deciduous, as well as in mixed woods. It is similar to the White Admiral (*Limenitis camilla*), which is also a woodland butterfly. The butterflies are rarely seen drinking nectar from flowers. It glides from perch to perch with only an occasional flap of the wings. Goat's-beard (*Aruncus dioicus*), Meadowsweet (*Filipendula ulmaria*), Bridewort (*Spiraea salicifolia*), and *S. chamaedryfolia* are used as foodplants. The female deposits the eggs singly on the upperside of the leaves. After hatching, the tiny caterpillar first eats up the eggshell and then makes itself a shelter in the tip of the leaf. It only leaves the shelter to feed. In the autumn, it makes another shelter in which to hibernate. It has one brood a year.

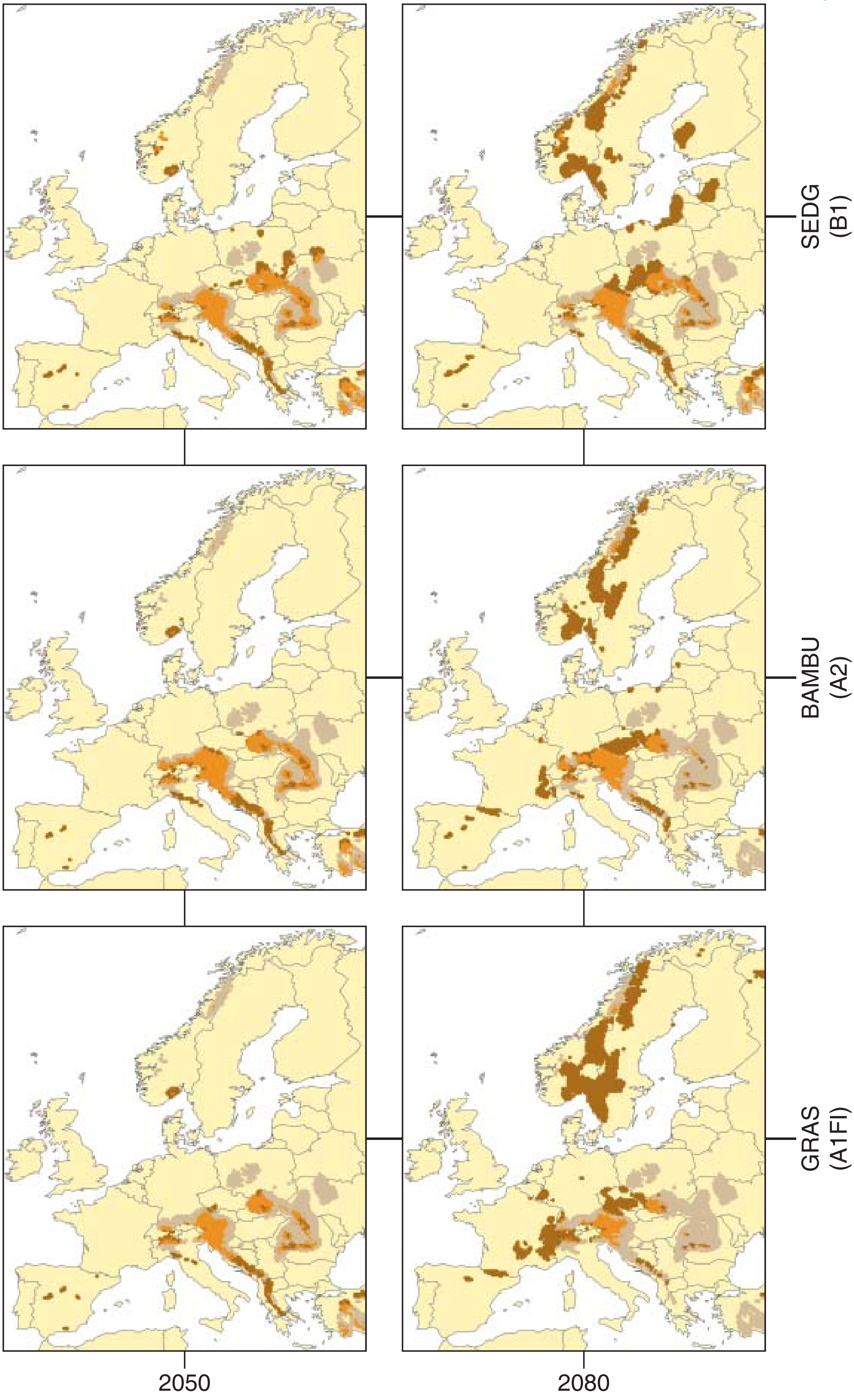
Present distribution can be well explained by climatic variables (AUC = 0.87).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Charaxes jasius (LINNAEUS, 1767) – Two-tailed Pasha

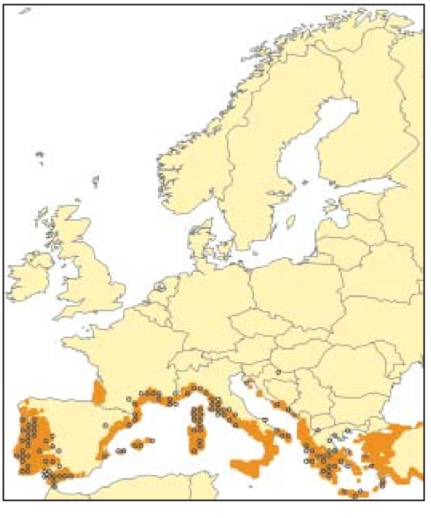
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-760 (-38.4%)	-1174 (-59.32%)
	BAMBU	-879 (-44.42%)	-1198 (-60.54%)
	GRAS	-840 (-42.45%)	-1367 (-69.08%)
2080	SEDG	-795 (-40.17%)	-1504 (-76%)
	BAMBU	-1121 (-56.64%)	-1737 (-87.77%)
	GRAS	-1012 (-51.14%)	-1918 (-96.92%)

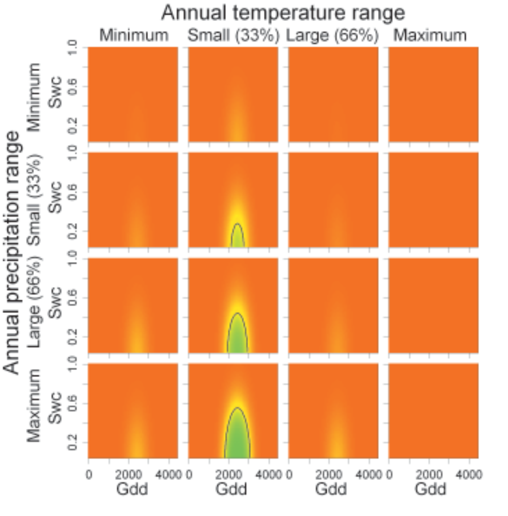
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1979)

With the whimsical patterning on the undersides of its wings and elegant little tails, the Two-tailed Pasha is one of the most beautiful European butterflies. It breeds in warm, dry places with many shrubs and trees where its foodplant, the Strawberry Tree (*Arbutus unedo*), is mostly abundant. The males defend their territory, attacking other insects. The butterflies can often be seen feeding on the juices of rotting fruit, such as figs, and are also attracted to alcoholic drinks. They are strong flyers, often roaming into areas where their foodplant is absent. The Two-tailed Pasha has mostly two broods a year. It hibernates as a caterpillar and pupates suspended from the foodplants. On Gibraltar, Samos and Cyprus, it also uses other foodplants.

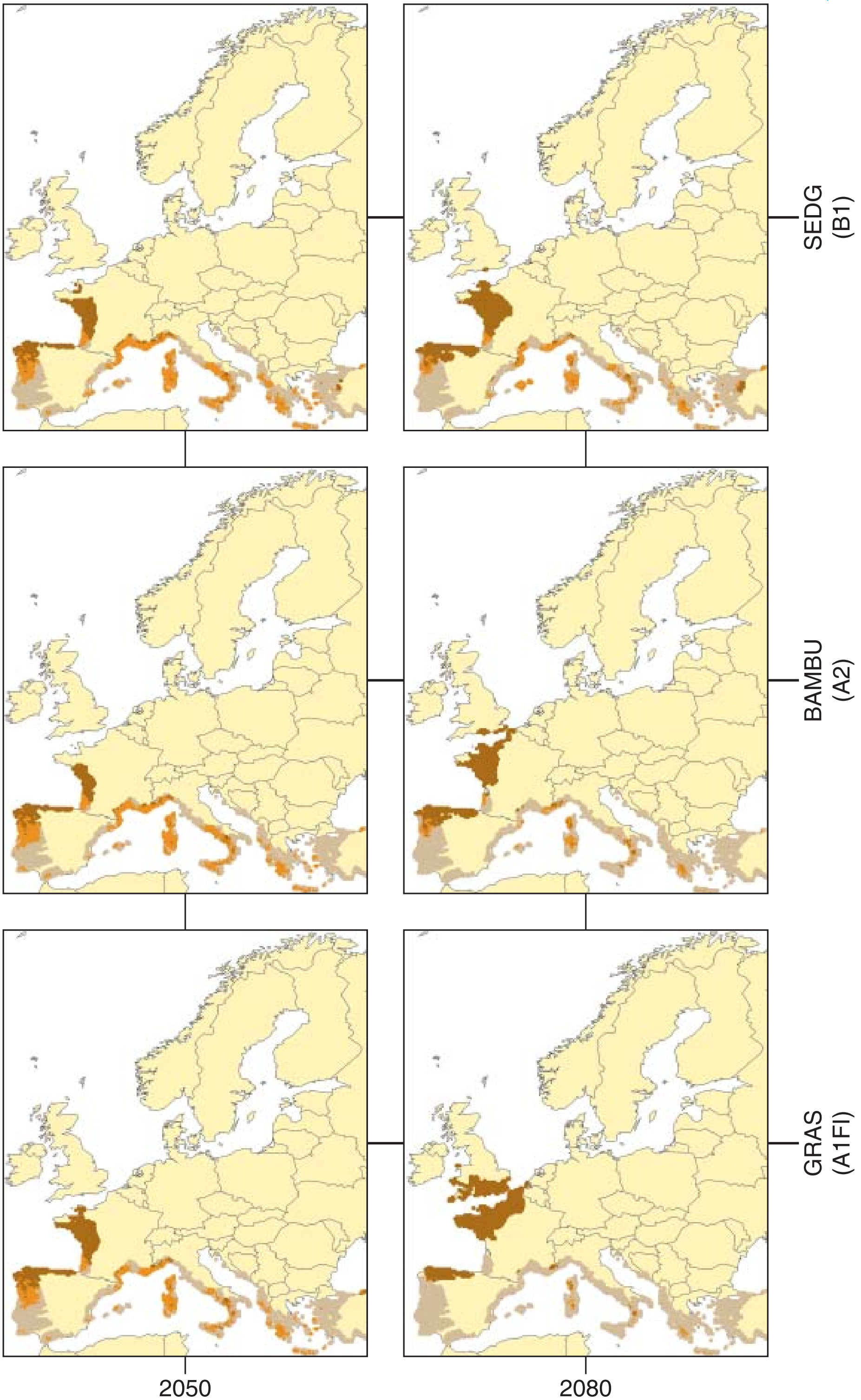
Present distribution can be well explained by climatic variables (AUC = 0.94).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

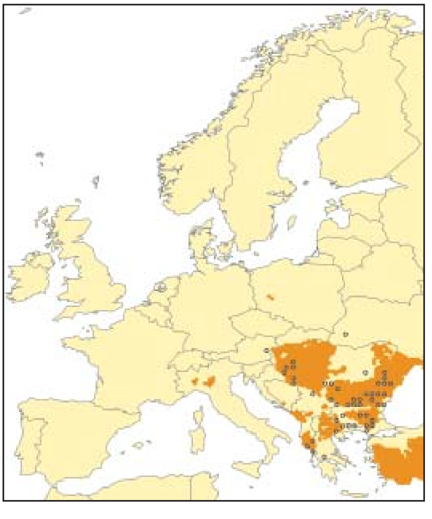
Apatura metis (Freyer, 1829) – Freyer's Purple Emperor

		Full dispersal	No dispersal
2050	SEDG	3014 (144.14%)	-141 (-6.74%)
	BAMBU	1346 (64.37%)	-589 (-28.17%)
	GRAS	2759 (131.95%)	-488 (-23.34%)
2080	SEDG	1951 (93.3%)	-880 (-42.09%)
	BAMBU	212 (10.14%)	-1703 (-81.44%)
	GRAS	787 (37.64%)	-1885 (-90.15%)

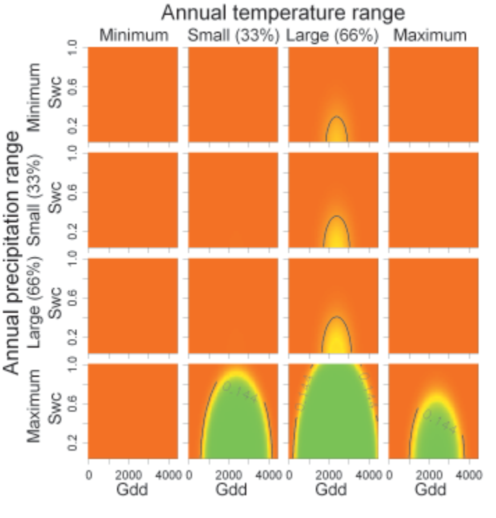
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2091)

Freyer's Purple Emperor is a butterfly of very warm, damp places. The butterflies can be found along wooded riverbanks, where its foodplant, White Willow (*Salix alba*) grows. The males and females meet each other at the tops of tall trees, and the females lay their eggs in small batches at the top of the tree, on leaves in the crown. The caterpillars grow quickly, and pupate suspended under a leaf or on a twig. The caterpillars from the brood that follows, hibernate. The butterflies have a varied diet. The females visit flowers for nectar, aphids for honeydew, and ripe fruit for the sugars. The males are often found on damp ground, on dung and on carrion. The butterflies are also attracted to sap oozing from wounded trees. This species has two generations a year.
This species is listed in Annex IV of the Habitats' Directive.

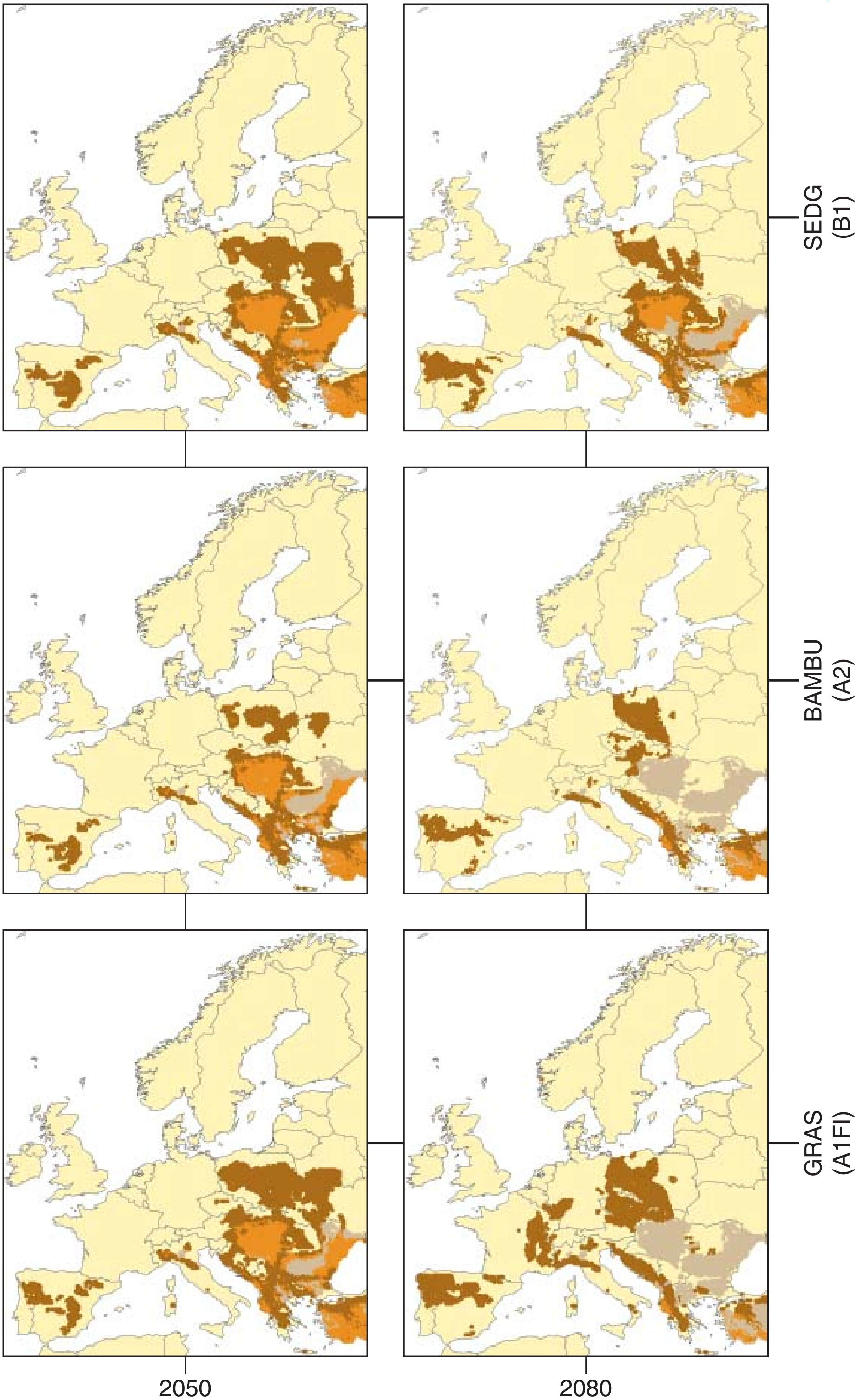
Present distribution can be very well explained by climatic variables (AUC = 0.98).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Apatura ilia ([Schiffermüller], 1775) – Lesser Purple Emperor

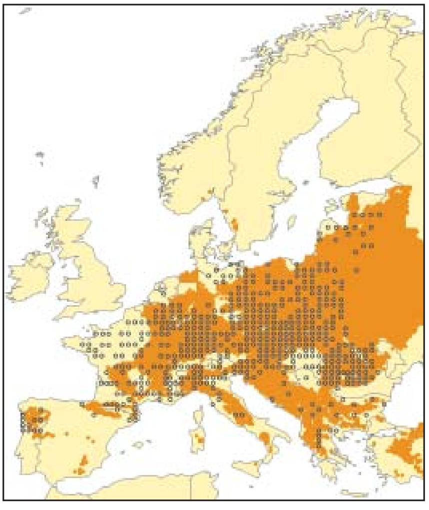
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	322 (3.23%)	-2420 (-24.3%)
	BAMBU	1144 (11.49%)	-2085 (-20.94%)
	GRAS	-633 (-6.36%)	-3412 (-34.26%)
2080	SEDG	1042 (10.46%)	-4137 (-41.54%)
	BAMBU	526 (5.28%)	-5548 (-55.71%)
	GRAS	-37 (-0.37%)	-7270 (-73.01%)

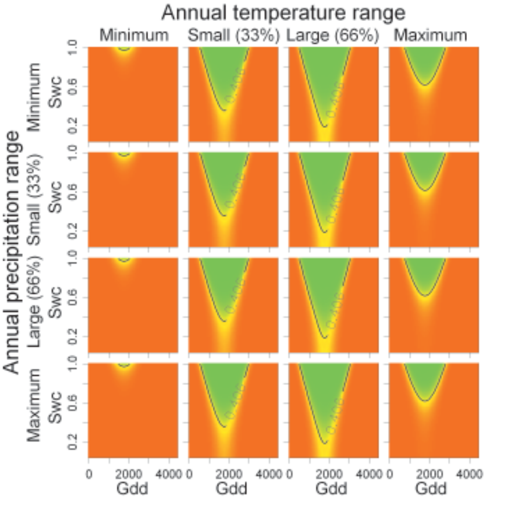
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 9958)

The Lesser Purple Emperor is found in clearings and along paths in damp, deciduous woodland that is often situated in river valleys or on the banks of rivers. The butterflies are often seen near puddles on the road, and on dung from other animals. Especially the males are attracted to strongly smelling cheese. Its foodplants are poplars (*Populus* spp.), and willows (*Salix* spp.). The female, choosing rather small, not so robust trees, deposits her eggs on the upperside of leaves that are half in the shade, or in the sun. The half-grown caterpillar spins itself a little pad in the fork of a twig on which it hibernates. In the spring, it returns to the fresh buds and leaves to feed. It pupates suspended from the underside of a leaf or branch. The Lesser Purple Emperor has one to two broods a year.

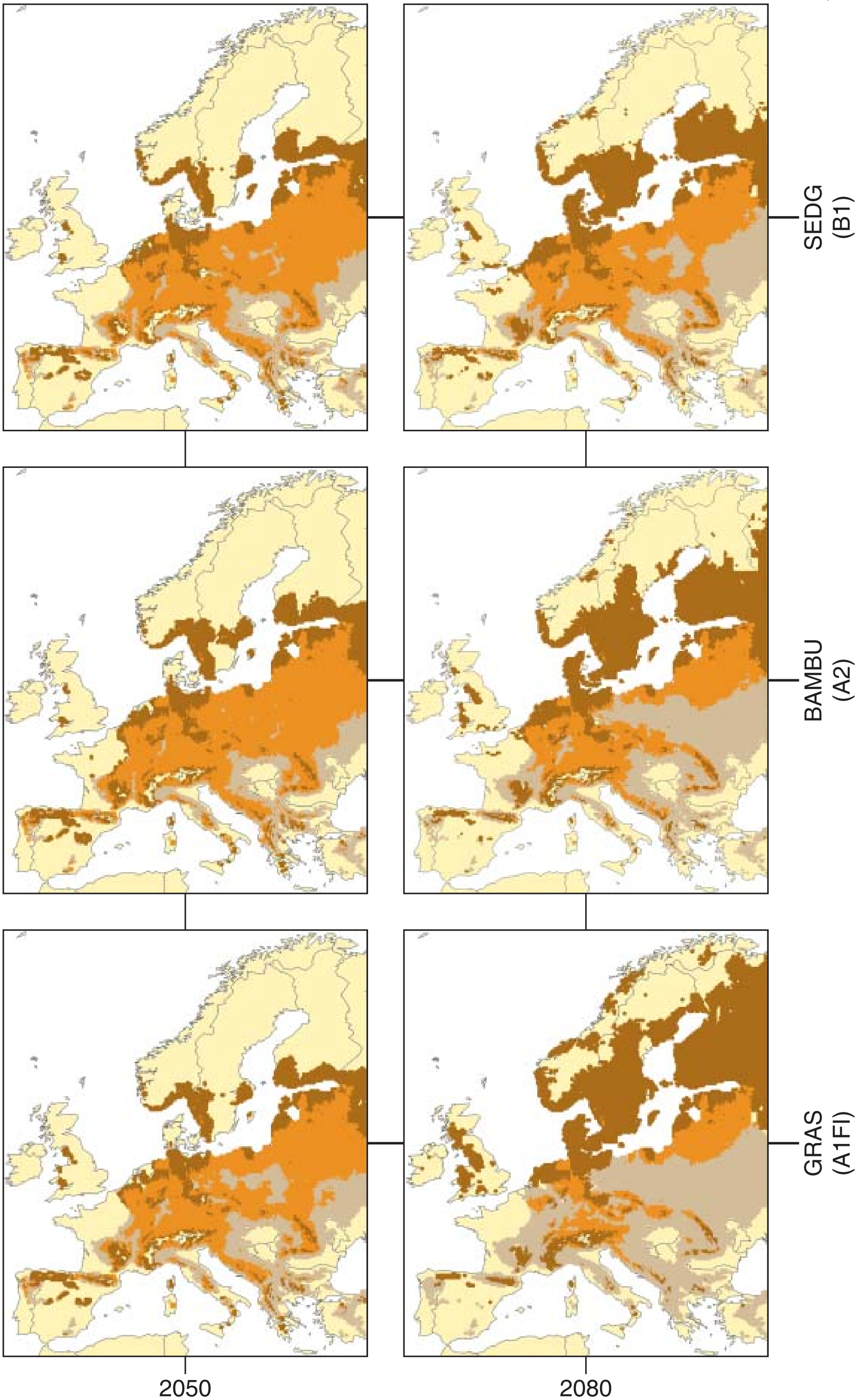
Present distribution can be well explained by climatic variables (AUC = 0.86).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Apatura iris (Linnaeus, 1758) – Purple Emperor

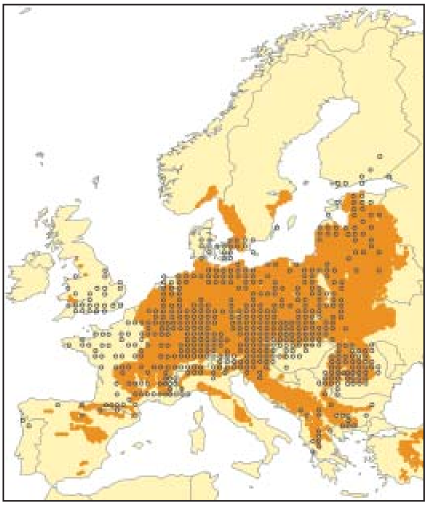
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-1777 (-20.23%)	-3899 (-44.39%)
	BAMBU	-1063 (-12.1%)	-3547 (-40.38%)
	GRAS	-2504 (-28.51%)	-4708 (-53.6%)
2080	SEDG	-2825 (-32.16%)	-5511 (-62.74%)
	BAMBU	-2969 (-33.8%)	-6641 (-75.6%)
	GRAS	-3732 (-42.49%)	-8007 (-91.15%)

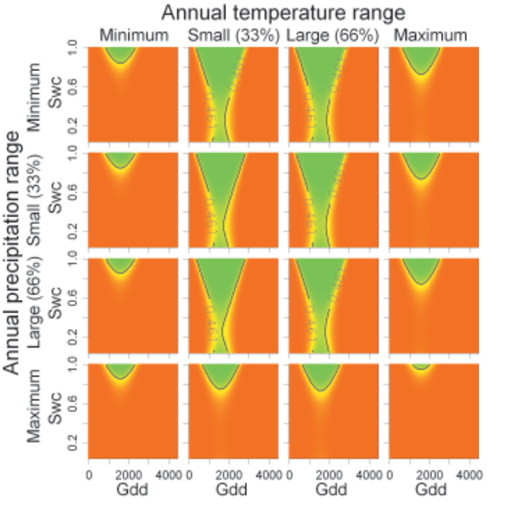
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 8784)

The Purple Emperor inhabits damp, mature, deciduous woods with clearings in them. These woods often have different sorts of trees, stream valleys, and woodland rides. Male butterflies are often seen near puddles on the road and on the dung of other animals. They are also attracted to strongly smelling cheese. Various willows (*Salix* spp.) are used as foodplants, the female depositing her eggs preferably at the top of the tree, on the upperside of leaves that do not get the sun. The half-grown caterpillar spins itself a small cushion in the fork of a twig on which it hibernates. In the spring, it resumes feeding on the buds and fresh young leaves. It pupates, suspended from the underside of a leaf, and has one generation a year.

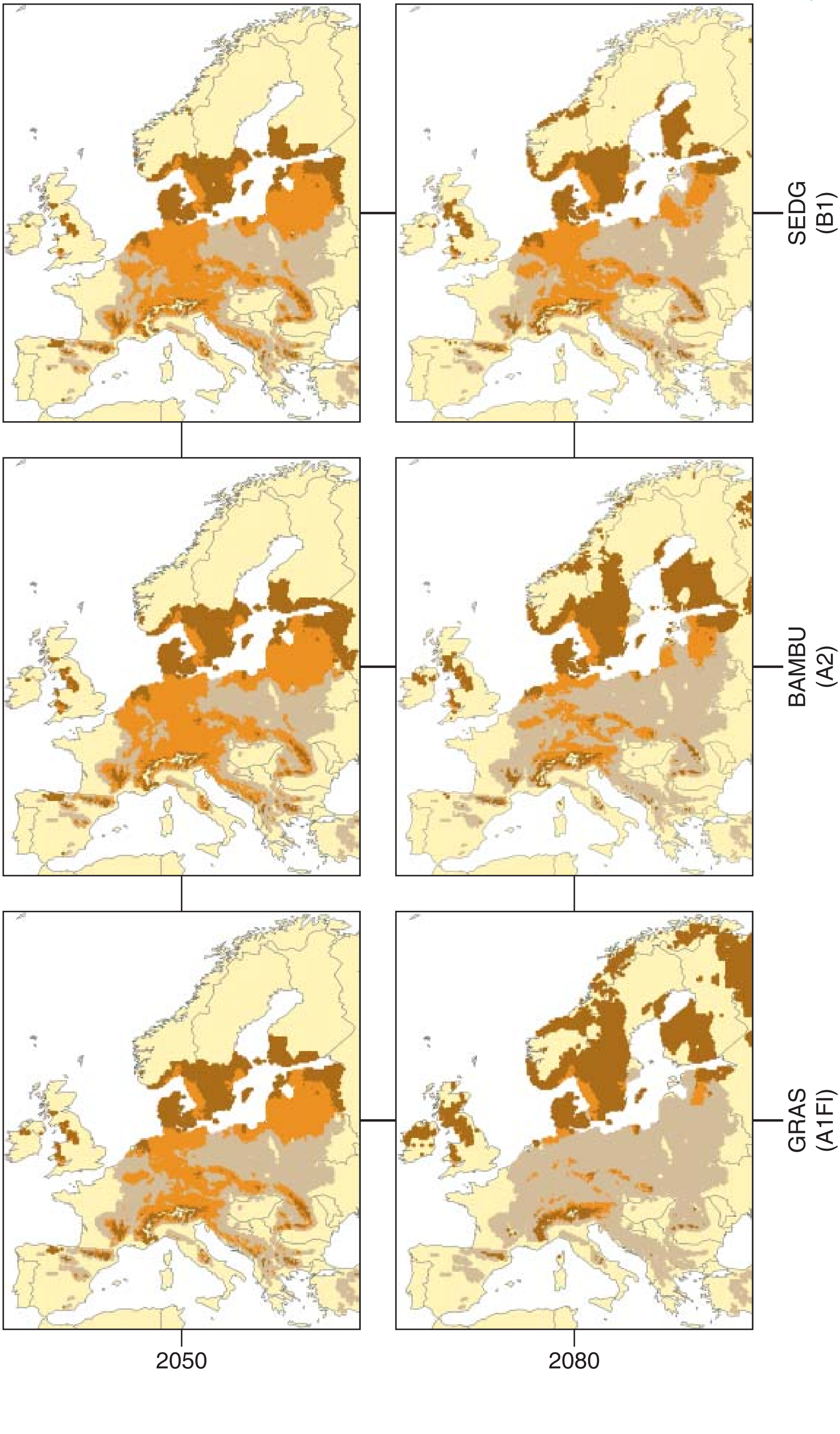
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.85).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Kirinia roxelana (Cramer, 1777) – Lattice Brown

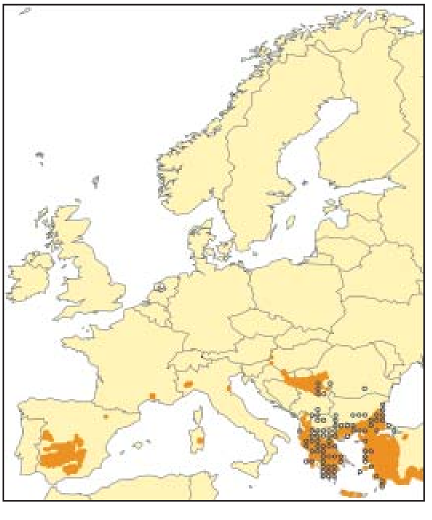
© Peter Ginzinger

		Full dispersal	No dispersal
2050	SEDG	257 (21.45%)	-459 (-38.31%)
	BAMBU	177 (14.77%)	-438 (-36.56%)
	GRAS	207 (17.28%)	-523 (-43.66%)
2080	SEDG	644 (53.76%)	-587 (-49%)
	BAMBU	62 (5.18%)	-726 (-60.6%)
	GRAS	491 (40.98%)	-882 (-73.62%)

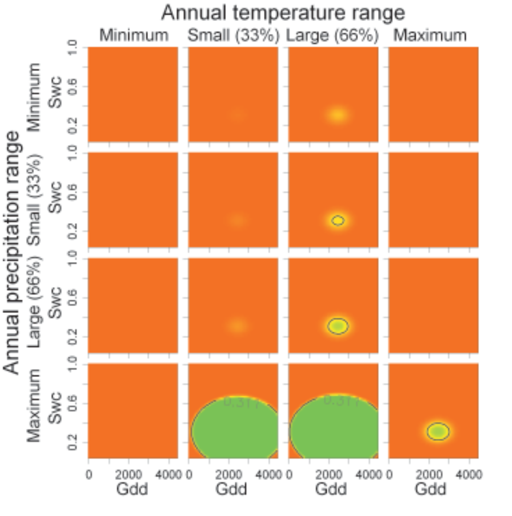
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1198)

The Lattice Brown inhabits open, dry woodland and dry scrub. In the hottest part of the day, the butterflies settle on tree trunks, hiding themselves away in the deep shade of bushes and thickets. They are also sometimes seen on dry riverbeds. The female deposits her eggs in crevices in the bark of trees and bushes. The caterpillars feed on grasses, such as meadow-grass (*Poa* spp.), quaking grass (*Briza* spp.), brome (*Bromus* spp.), and foxtail (*Alopecurus* spp.). The Lattice Brown has one brood a year. It hibernates as a caterpillar.

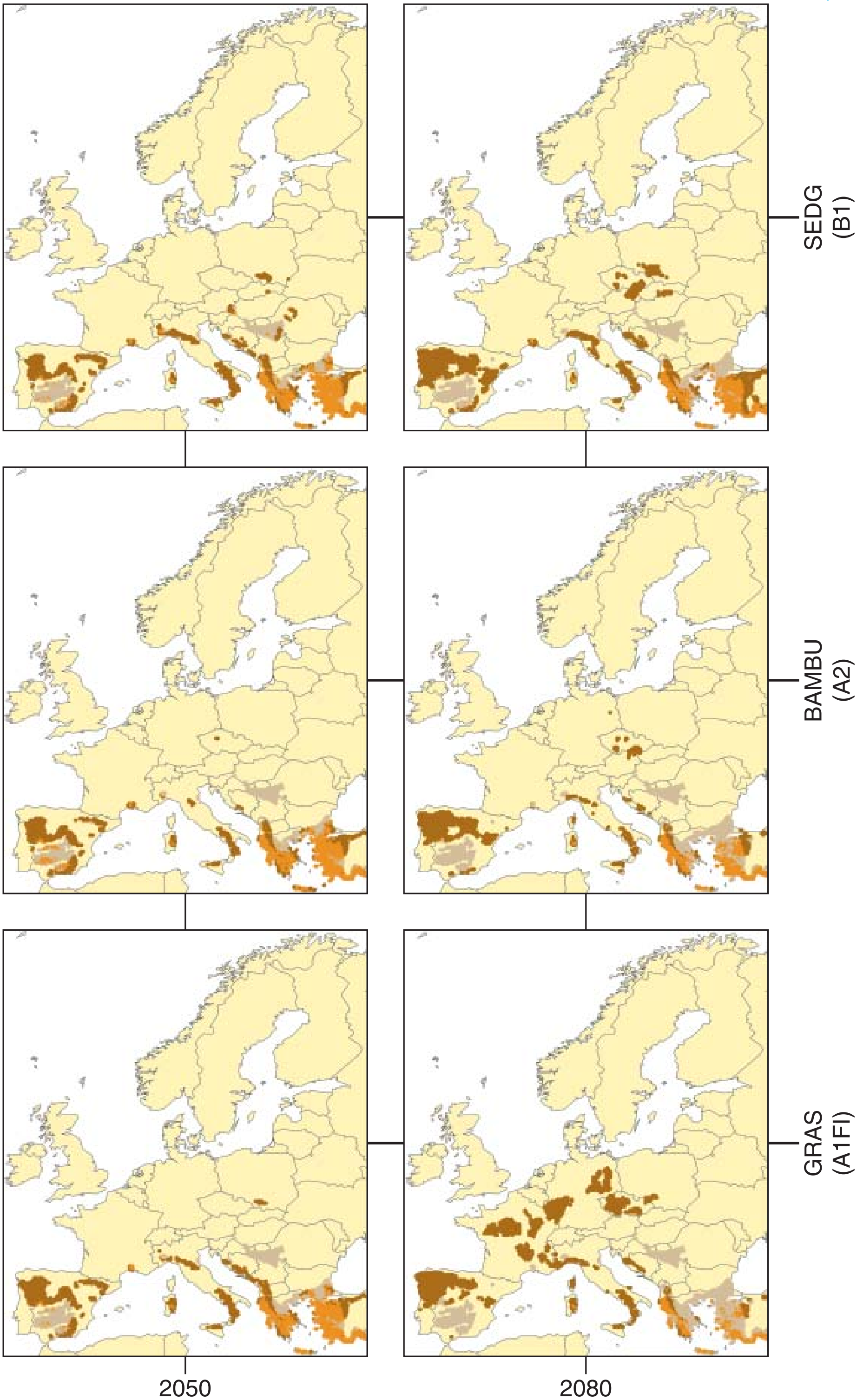
Present distribution can be explained by climatic variables to quite some extent (AUC = 0.91).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pararge aegeria (Linnaeus, 1758) – Speckled Wood

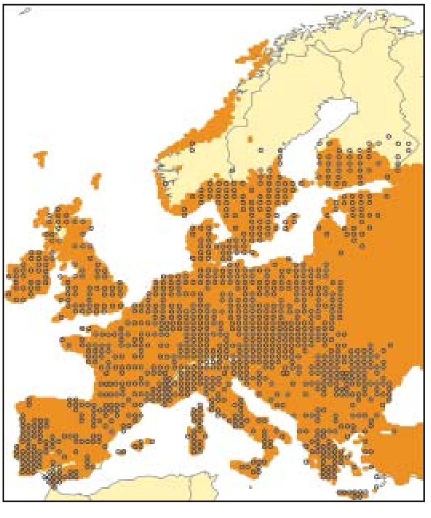
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	111 (0.49%)	-1693 (-7.4%)
	BAMBU	-359 (-1.57%)	-2025 (-8.85%)
	GRAS	-845 (-3.69%)	-2662 (-11.63%)
2080	SEDG	-686 (-3%)	-3718 (-16.25%)
	BAMBU	-2115 (-9.24%)	-5993 (-26.19%)
	GRAS	-3117 (-13.62%)	-8080 (-35.31%)

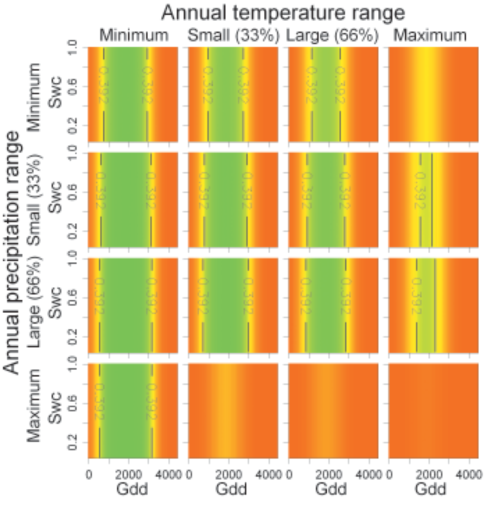
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 22882)

The Speckled Wood is a typical woodland butterfly. The woods may be deciduous, coniferous or mixed, and the butterfly occurs along woodland rides, in clearings and at wood edges. In the north, it occurs mostly in quite extensive areas of woodland, but in the south a line of trees can be sufficient to support a population. Each male claims his territory on a branch that gets the sun, projecting out of the crown of the tree, and waits there for a female to fly along. The foodplants are grasses that grow in woodland and damp grassland, such as fescues (*Festuca* spp.), false-bromes (*Brachypodium* spp.), meadow-grasses (*Poa* spp.), cock's-foot (*Dactylus* spp.), Purple Moor-grass (*Molinea caerulea*) and *Holcus* spp. The female deposits her eggs singly on the blades of grass. Hibernation takes place as a caterpillar or pupa, deep down in a tussock of grass. The Speckled Wood has two to three generations a year.

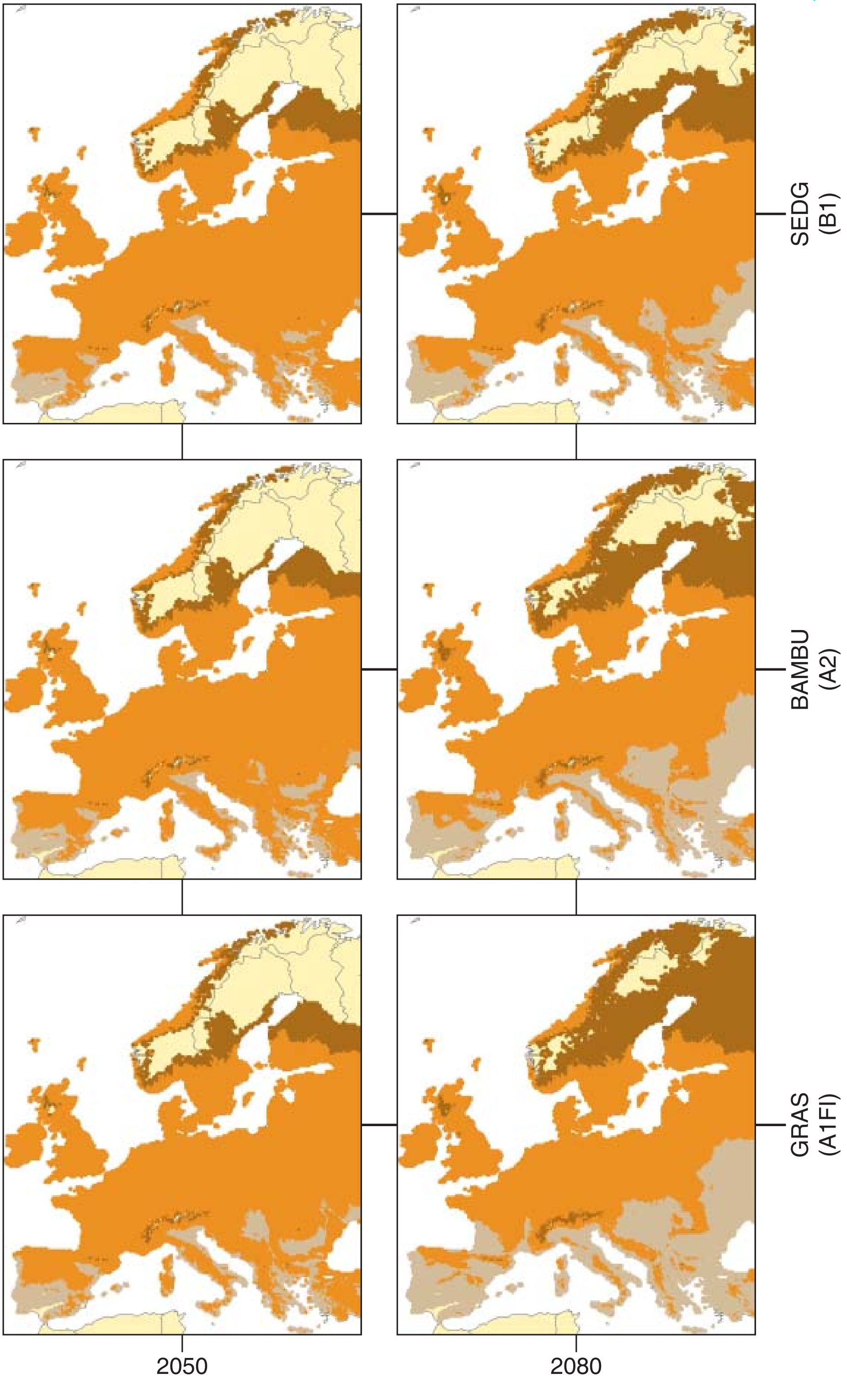
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.65). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Lasiommata megera (Linnaeus, 1767) – Wall Brown

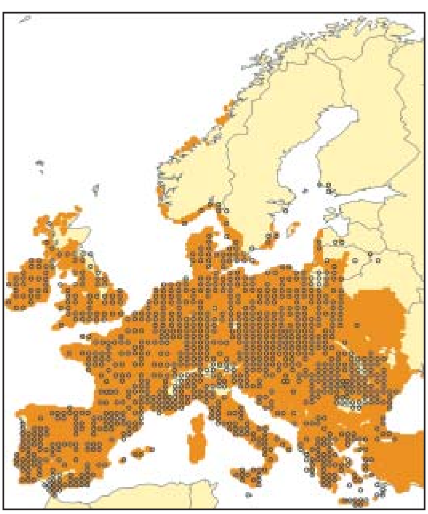
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-590 (-3.57%)	-3165 (-19.15%)
	BAMBU	-2401 (-14.53%)	-4201 (-25.42%)
	GRAS	-2133 (-12.9%)	-4415 (-26.71%)
2080	SEDG	-3806 (-23.03%)	-5677 (-34.35%)
	BAMBU	-6087 (-36.83%)	-8167 (-49.41%)
	GRAS	-7558 (-45.73%)	-9777 (-59.15%)

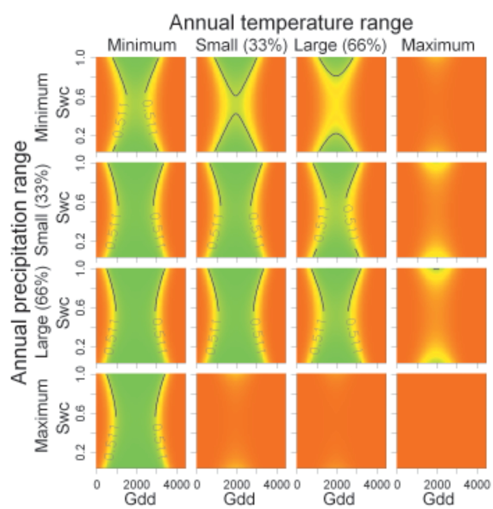
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 16529)

The Wall Brown inhabits many different sorts of grassland, natural grasslands, as well as not all too intensively farmed land. The butterflies are mostly very active, the males very alert. They fly up when disturbed from rocks or walls on which they often bask in the sun, and are therefore conspicuous. The males have a broad scent-brand on their forewings. The female deposits her eggs on the blades of many different grasses, including fescues (*Festuca* spp.), false-bromes (*Brachypodium* spp.), cock's-foot (*Dactylus* spp.), bromes (*Bromus* spp.), and Crested Dog's-tail (*Cynosurus aristatus*). When half-grown, the caterpillar hibernates in the litter layer, where it later, deep down, pupates. The Wall Brown has two to three broods a year.

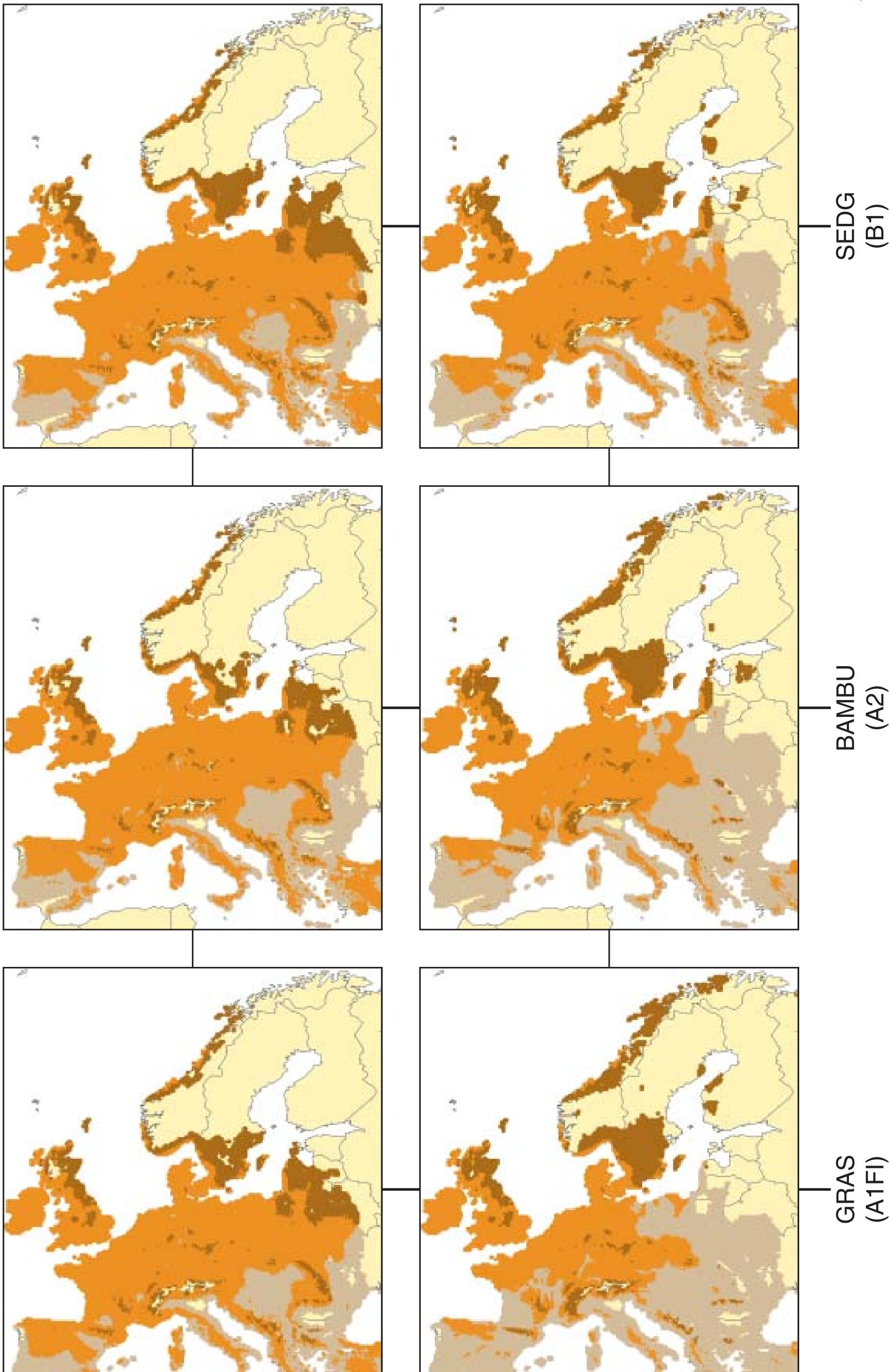
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.75).
Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Lasiommata petropolitana (Fabricius, 1787) – Northern Wall Brown

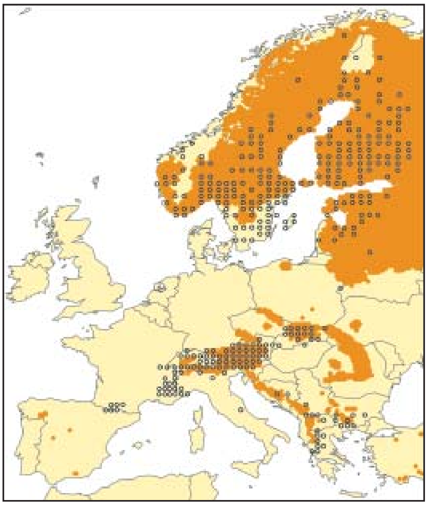
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-2647 (-28.91%)	-3215 (-35.11%)
	BAMBU	-3026 (-33.05%)	-3477 (-37.98%)
	GRAS	-3135 (-34.24%)	-3656 (-39.93%)
2080	SEDG	-2440 (-26.65%)	-3621 (-39.55%)
	BAMBU	-3879 (-42.37%)	-4711 (-51.45%)
	GRAS	-4594 (-50.17%)	-5721 (-62.48%)

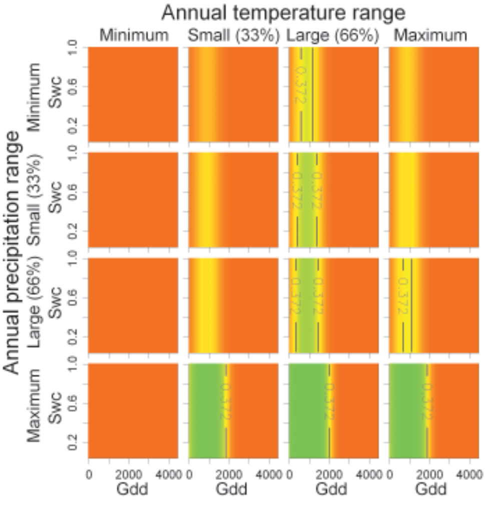
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 9156)

The Northern Wall Brown is found in woodland clearings and meadows in woodland, usually in relatively warm places with large rockmasses. The butterflies are fond of basking in the sun on warm rocks or on the ground. The eggs are laid on a number of grasses, including fescues (*Festuca* spp.), small-reeds (*Calamagrostis* spp.), and cock's-foot (*Dactylus* spp.). The Northern Wall Brown hibernates either in the last larval instar, or as a pupa, and has one brood a year.

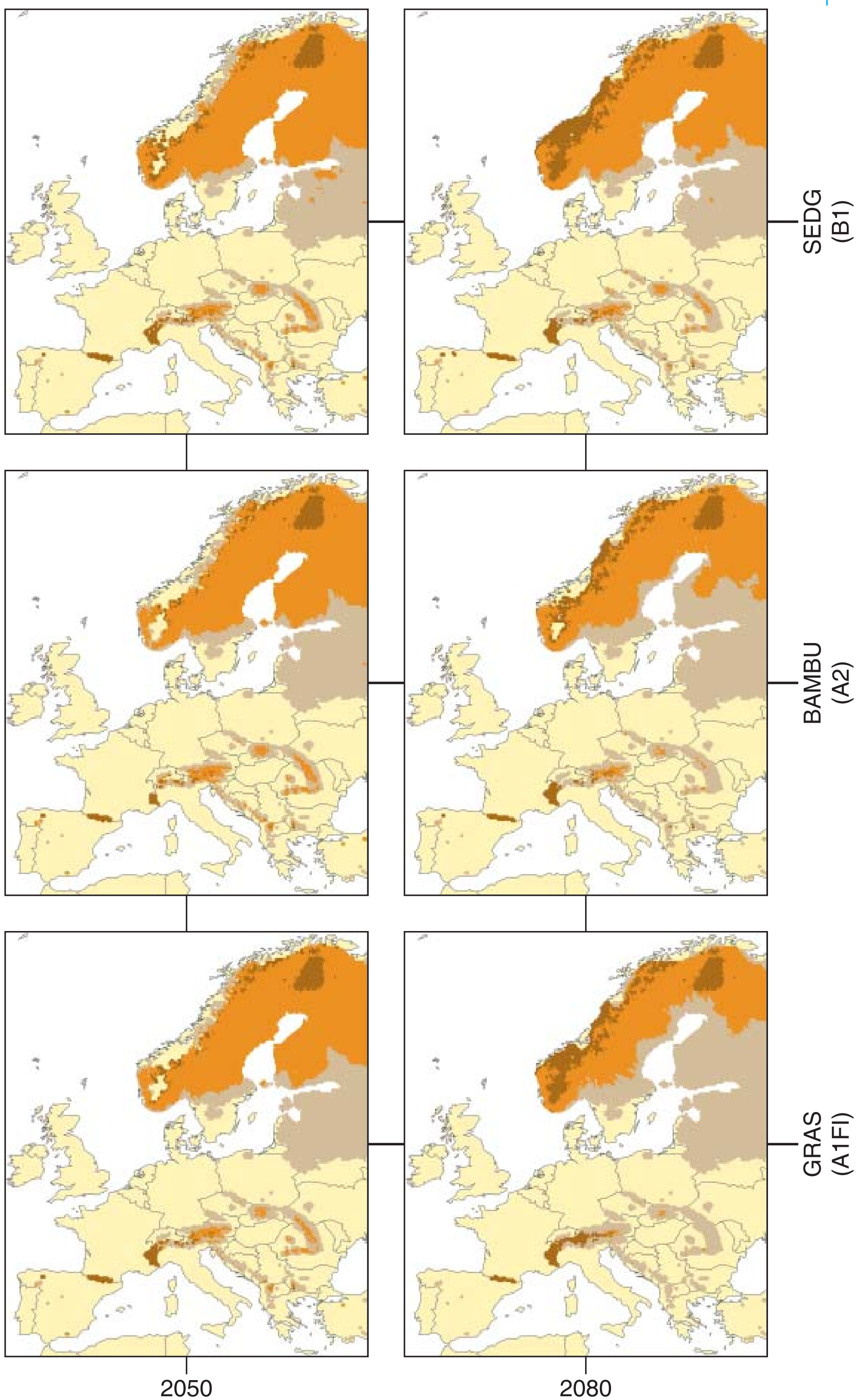
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.84).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Lasiommata maera (Linnaeus, 1758) – Large Wall Brown

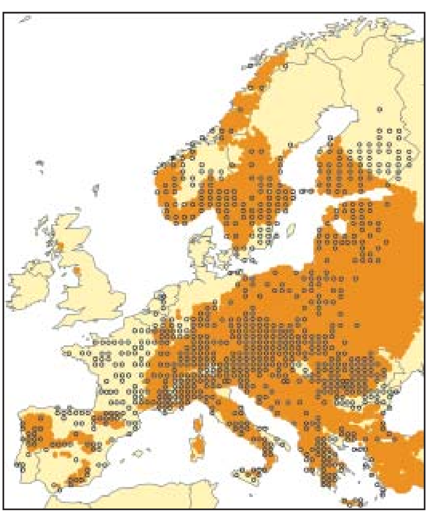
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	-126 (-0.86%)	-2562 (-17.45%)
	BAMBU	-485 (-3.3%)	-2663 (-18.14%)
	GRAS	-1564 (-10.65%)	-3521 (-23.98%)
2080	SEDG	780 (5.31%)	-4420 (-30.1%)
	BAMBU	-1019 (-6.94%)	-6194 (-42.18%)
	GRAS	-1106 (-7.53%)	-7698 (-52.42%)

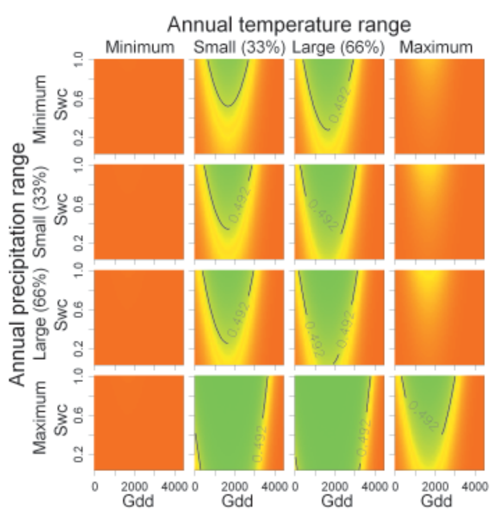
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 14684)

The Large Wall Brown occurs in quite different habitats. It is mainly found in warm, dry places near rocks, and poor grassland, or on rough vegetation near woodland edges. However, it can also occur on damp grassland and rough vegetation near wood margins. The butterflies need a lot of nectar, often visiting purple or pink flowers of thistles and other nectar-rich plants. The female lays her eggs on the blades of grasses that include *Holcus* spp., bents (*Agrostis* spp.), and small-reeds (*Calamagrostis* spp.). The caterpillars hibernate when half-grown in a grass tussock, and pupate later deep down in the vegetation. The Large Wall Brown has one brood a year in the north of its distribution range, and two a year in the south.

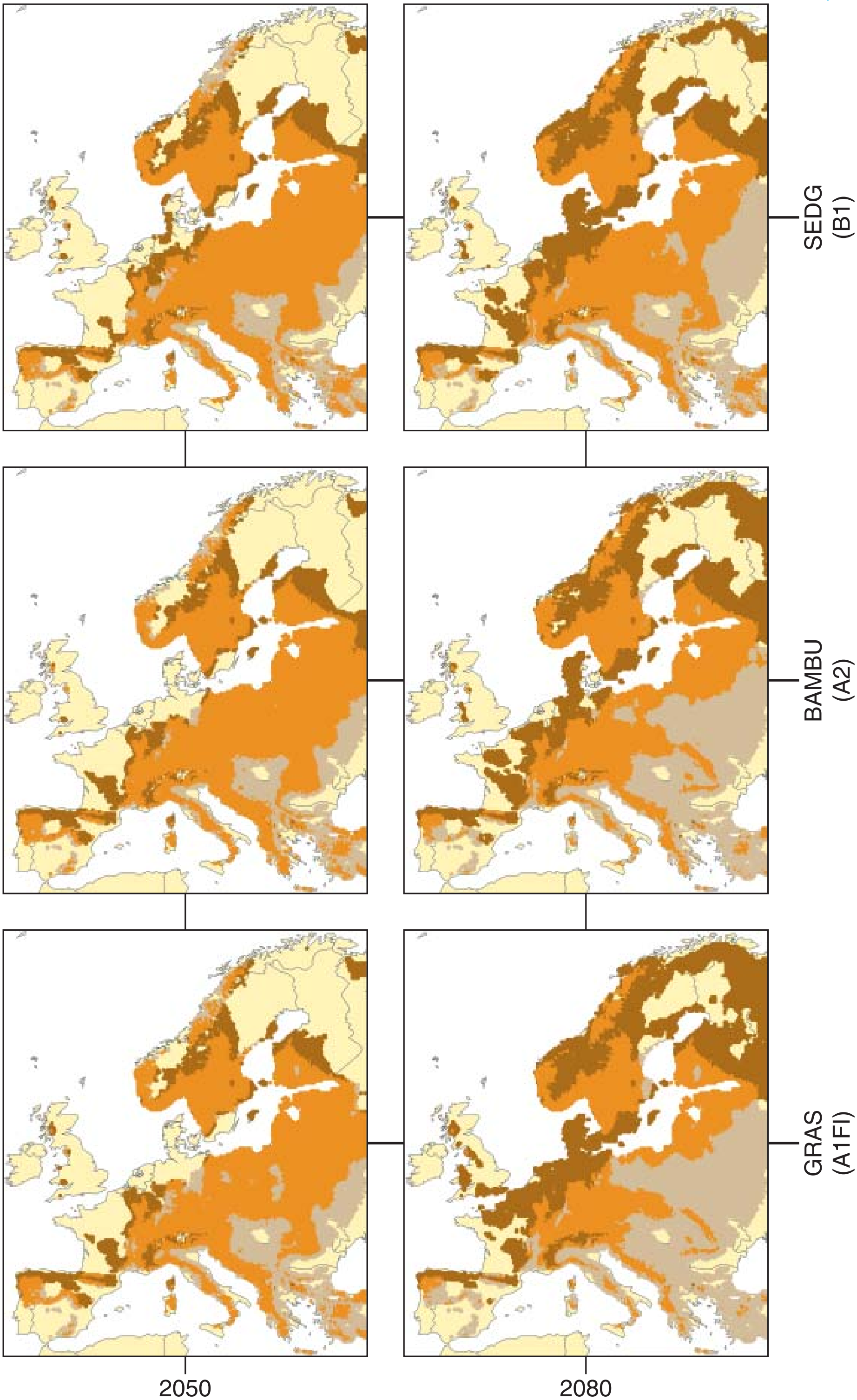
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.75).
Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Lopinga achine (Linnaeus, 1763) – Woodland Brown

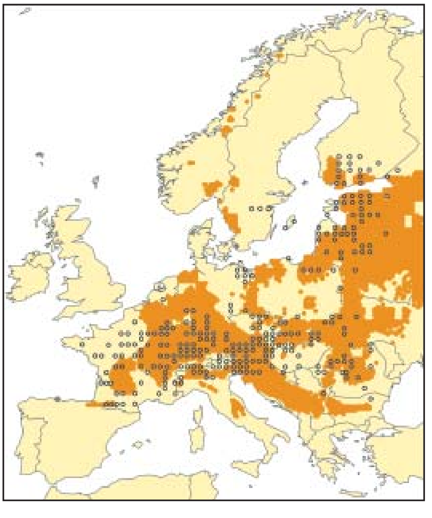
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	-645 (-9.66%)	-2182 (-32.66%)
	BAMBU	2968 (44.43%)	-893 (-13.37%)
	GRAS	-282 (-4.22%)	-2207 (-33.04%)
2080	SEDG	3110 (46.56%)	-2392 (-35.81%)
	BAMBU	4790 (71.71%)	-2501 (-37.44%)
	GRAS	3726 (55.78%)	-3777 (-56.54%)

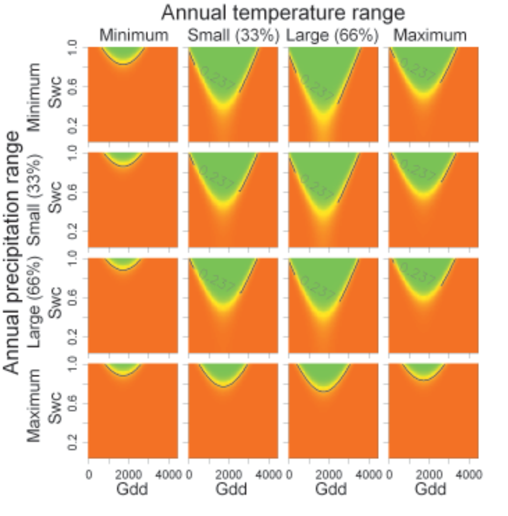
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 6680)

The Woodland Brown is fond of warm, open places in damp, deciduous or mixed woods with well-developed shrub and herbaceous layers. The butterflies rarely visit flowers, preferring to feed on honeydew, moisture on buds, and sap oozing from wounded trees. The males often settle on puddles on the ground, while the females tend to stay in the very top of the trees. Eggs are laid on all sorts of grasses, including fescues (*Festuca* spp.), meadow-grasses (*Poa* spp.), small-reeds (*Calamagrostis* spp.), and false-bromes (*Brachypodium* spp.), and also on sedges (*Carex* spp.). The half-grown caterpillar hibernates in a grass tussock, where later in the year it also pupates. The Woodland Brown has one brood a year.
This species is listed in Annex IV of the Habitats’ Directive.

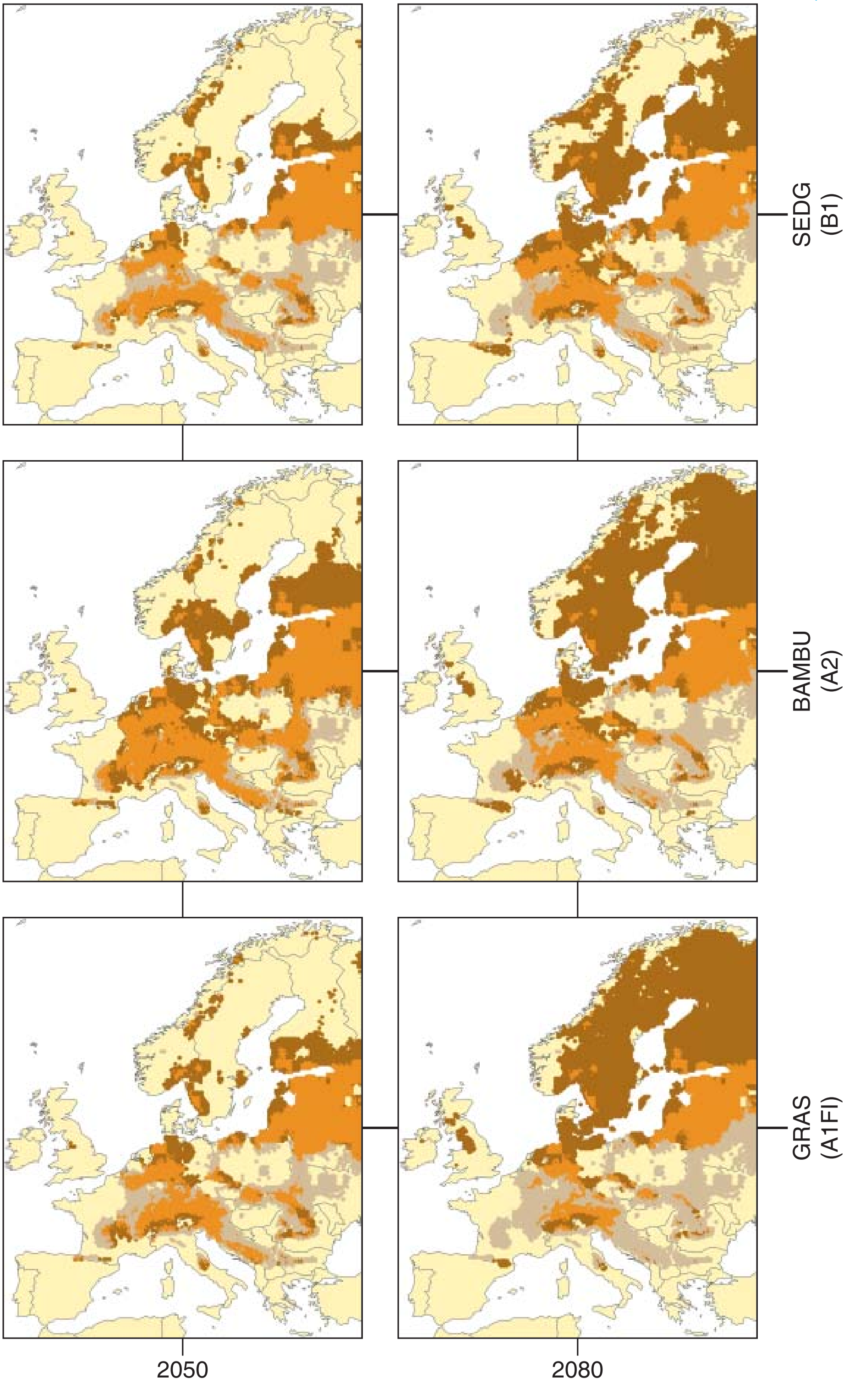
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.81).
Climate risk category: R



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Coenonympha tullia (Müller, 1764) – Large Heath

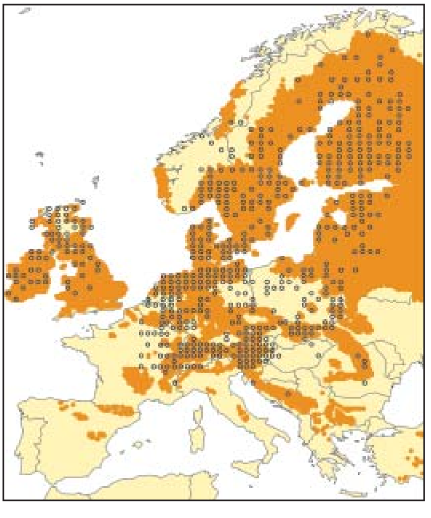
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-3534 (-27.06%)	-4743 (-36.31%)
	BAMBU	-3047 (-23.33%)	-4287 (-32.82%)
	GRAS	-3802 (-29.11%)	-5109 (-39.11%)
2080	SEDG	-4213 (-32.25%)	-6226 (-47.66%)
	BAMBU	-4915 (-37.63%)	-7441 (-56.97%)
	GRAS	-6014 (-46.04%)	-8747 (-66.97%)

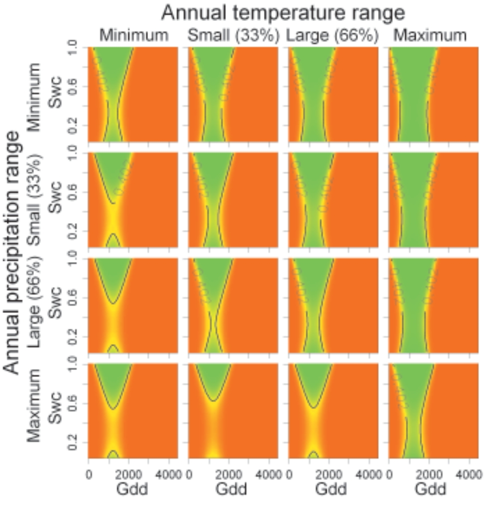
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 13062)

The Large Heath inhabits raised bogs, wet heaths, swampy habitat and wet grasslands, often occurring on quite rough vegetation. As a consequence of land drainage remaining habitat patches are often small, and populations they contain very small indeed, making them difficult to detect. Main foodplants are Cotton-grass (*Eriophorum vaginatum*), as well as other *Eriophorum* species. The female deposits her eggs singly on, or in the neighbourhood of, the foodplant. The caterpillars hibernate in the third or fourth larval instar, hidden in tussocks of grass. They also pupate in the tussocks of the foodplant. The Large Heath has one generation a year. The species already seems to have been affected by climate change and has declined severely at the southern edge of its range.

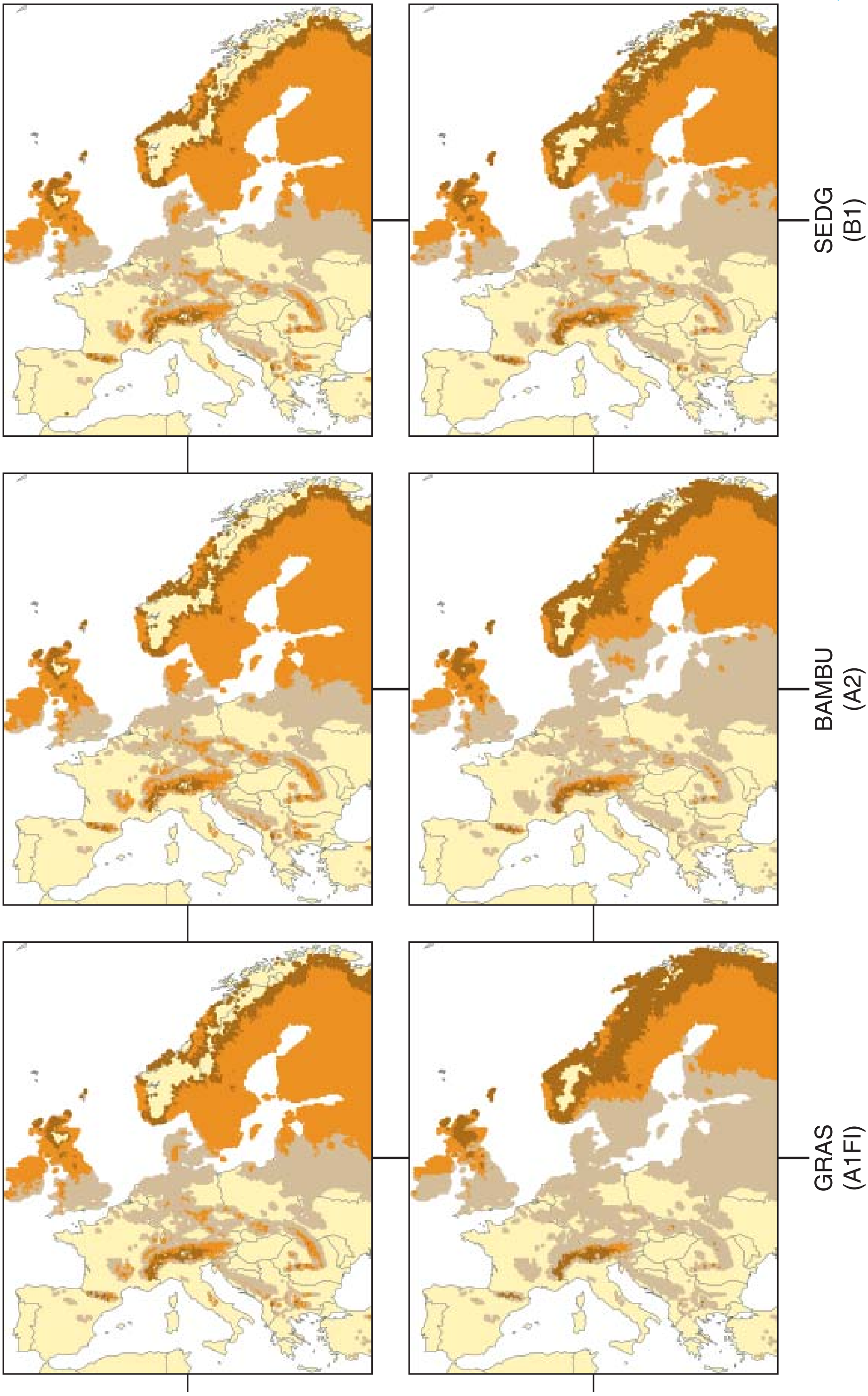
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.83).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Coenonympha oedippus (Fabricius, 1787) – False Ringlet

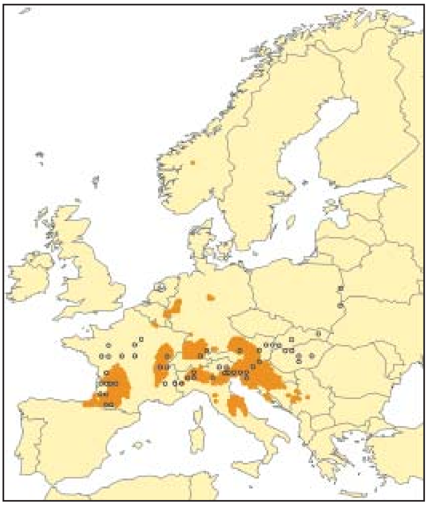
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-5 (-0.47%)	-269 (-25.5%)
	BAMBU	1170 (110.9%)	-109 (-10.33%)
	GRAS	168 (15.92%)	-331 (-31.37%)
2080	SEDG	732 (69.38%)	-387 (-36.68%)
	BAMBU	2128 (201.71%)	-481 (-45.59%)
	GRAS	2236 (211.94%)	-713 (-67.58%)

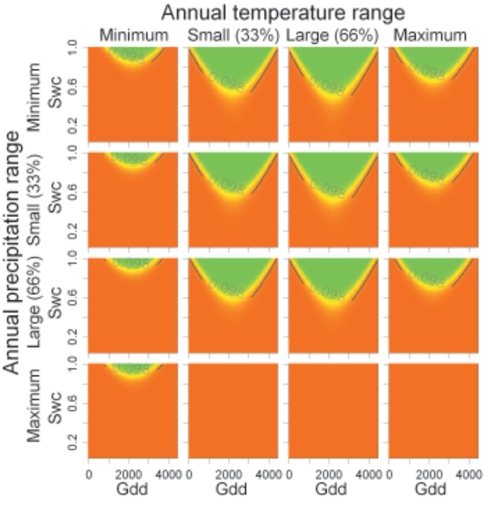
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1055)

The False Ringlet is one of the rarest butterflies of Europe and is declining at an alarming rate. Seeing one is therefore a very special event. The False Ringlet inhabits low-lying, grassy marshes and reed-beds that are usually situated in the shelter of woodland, creating a warm and humid environment. The butterflies fly very slowly and hardly ever migrate to nearby habitats. The eggs are deposited one by one on the blades of grasses, like meadow-grasses (*Poa* spp.), rye-grasses (*Lolium* spp.), hair-grasses (*Deschampsia* spp.) and Purple Moor-grass (*Molinea caerulea*). The caterpillars hibernate half-grown in the tussock, where they pupate as well. The False Ringlet has one generation a year.
This species is listed in Annexes II and IV of the Habitats' Directive.

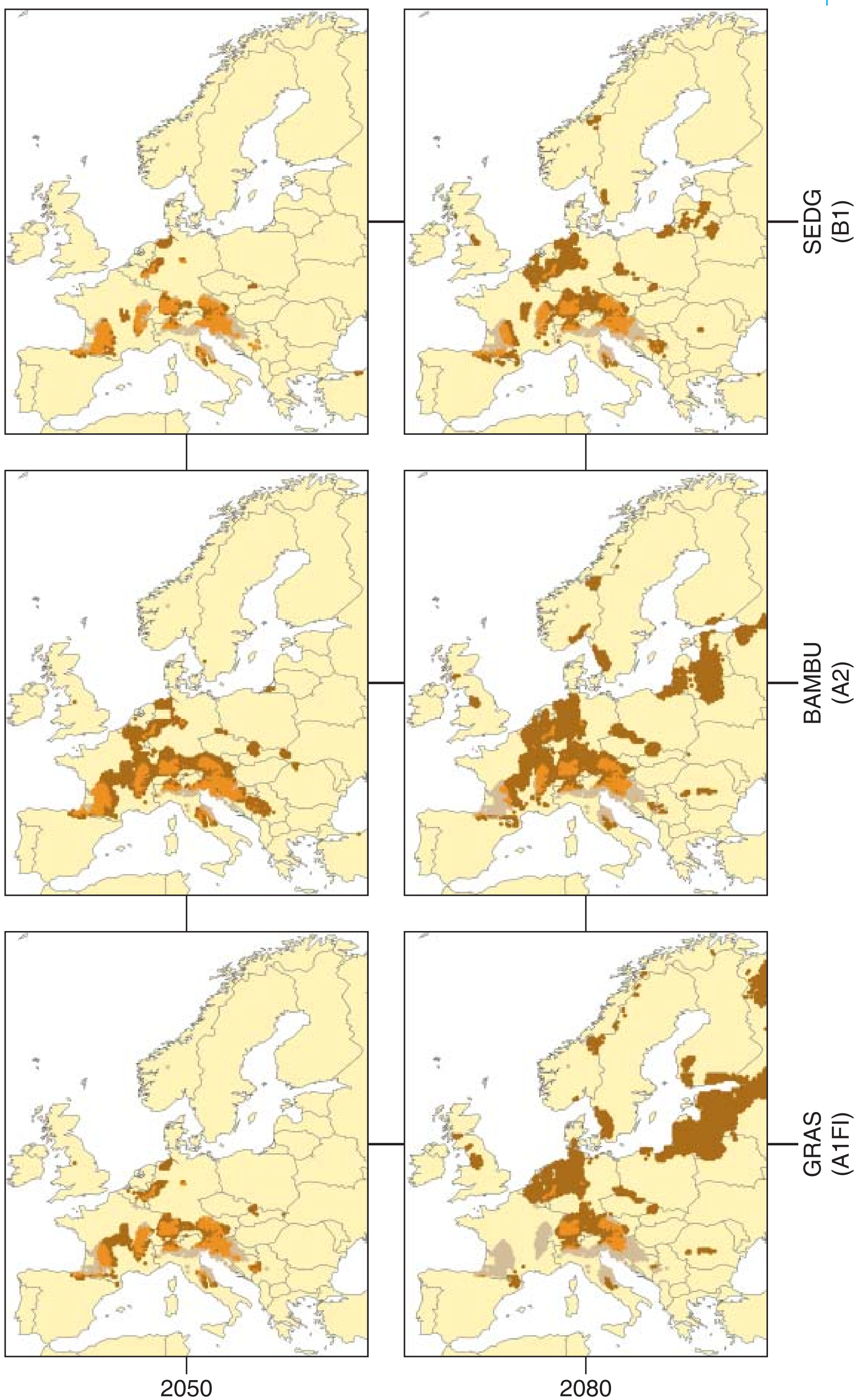
Present distribution can be well explained by climatic variables (AUC = 0.95).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Coenonympha rhodopensis Elwes, 1900 – Eastern Large Heath

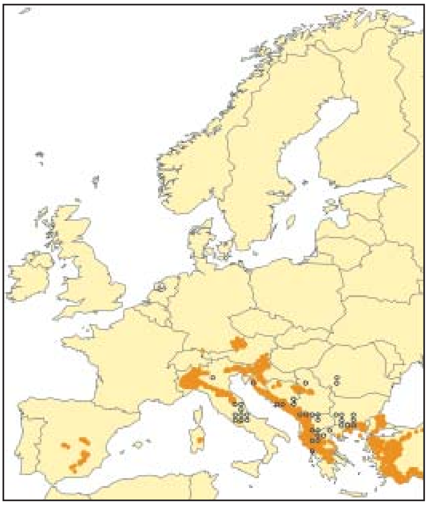
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	332 (43.74%)	-514 (-67.72%)
	BAMBU	125 (16.47%)	-592 (-78%)
	GRAS	197 (25.96%)	-603 (-79.45%)
2080	SEDG	351 (46.25%)	-606 (-79.84%)
	BAMBU	432 (56.92%)	-705 (-92.89%)
	GRAS	322 (42.42%)	-737 (-97.1%)

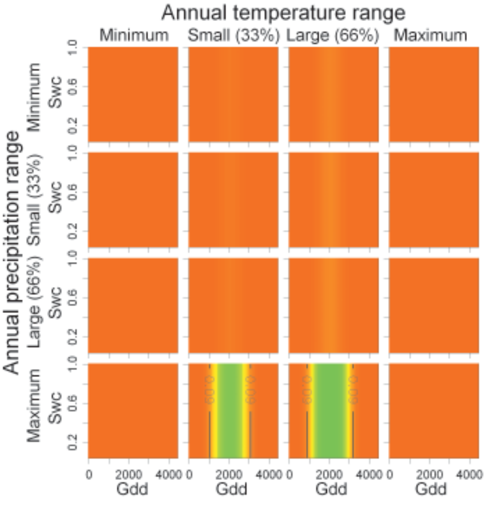
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 759)

The Eastern Large Heath occurs mainly on grasslands above the tree-line. It is also sometimes found in clearings in damp woodland. The caterpillars feed on fescues (*Festuca* spp.), Blue Moor-grass (*Sesleria albicans*), cotton-grasses (*Eriophorum* spp.), White Beak-sedge (*Rhynchospora alba*), and Beaked Sedge (*Carex rostrata*). This species has one generation a year and passes the winter as a caterpillar.

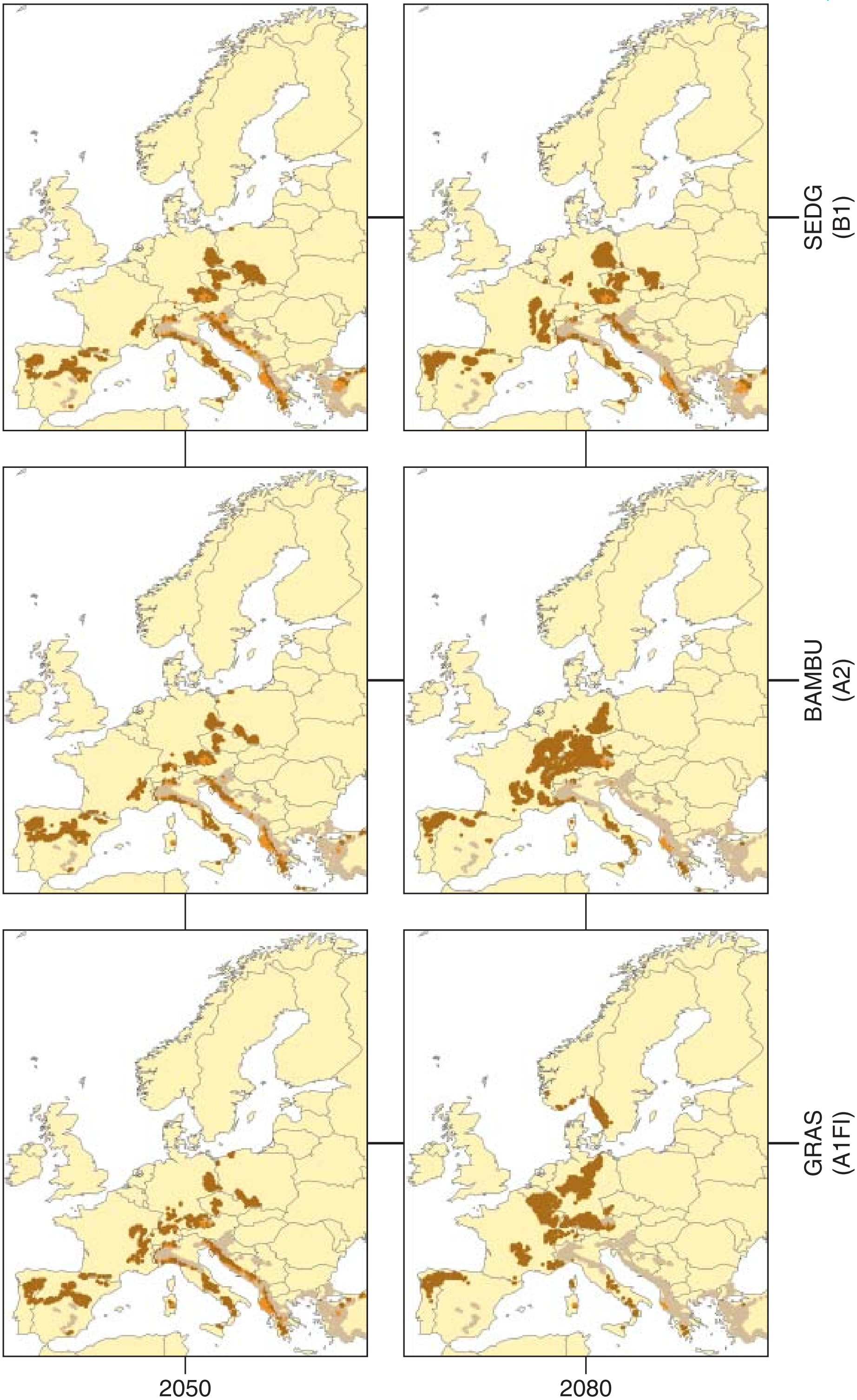
Present distribution can be well explained by climatic variables (AUC = 0.95).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Coenonympha arcania (Linnaeus, 1761) – Pearly Heath

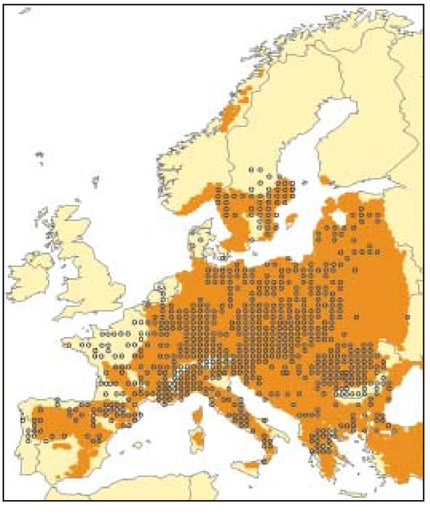
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-389 (-2.87%)	-2771 (-20.46%)
	BAMBU	-1104 (-8.15%)	-3319 (-24.51%)
	GRAS	-1501 (-11.08%)	-3774 (-27.86%)
2080	SEDG	-2377 (-17.55%)	-5692 (-42.03%)
	BAMBU	-3556 (-26.26%)	-7474 (-55.18%)
	GRAS	-4819 (-35.58%)	-9350 (-69.03%)

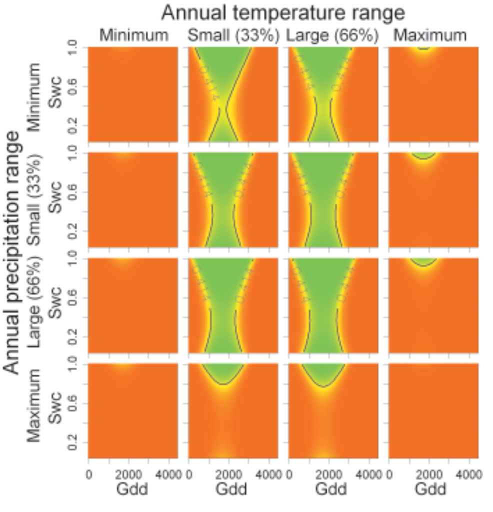
Changes in climatic niche distribution (in 10'×10' grid cells; present niche space: 13544)

The Pearly Heath is found on dry, to moderately damp, grasslands and grassy places at the edges of woodland or scrub. The Pearly Heath is common in some areas. The males can often be found, perched in scrub, basking in the sun, from where they chase females that pass by. In the evening, the butterflies gather together to roost communally in scrub or at wood margins. Meadow-grasses (*Poa* spp.), bents (*Agrostis* spp.), melicks (*Melica* spp.), fescues (*Festuca* spp.), and many other grasses are used as foodplants, the preferred species differing between regions. The female lays her eggs one by one or in short rows, on blades of grass. When half-grown, the caterpillar hibernates in a tussock of grass, also pupating there later, deep down in the tussock. This species has one brood a year.

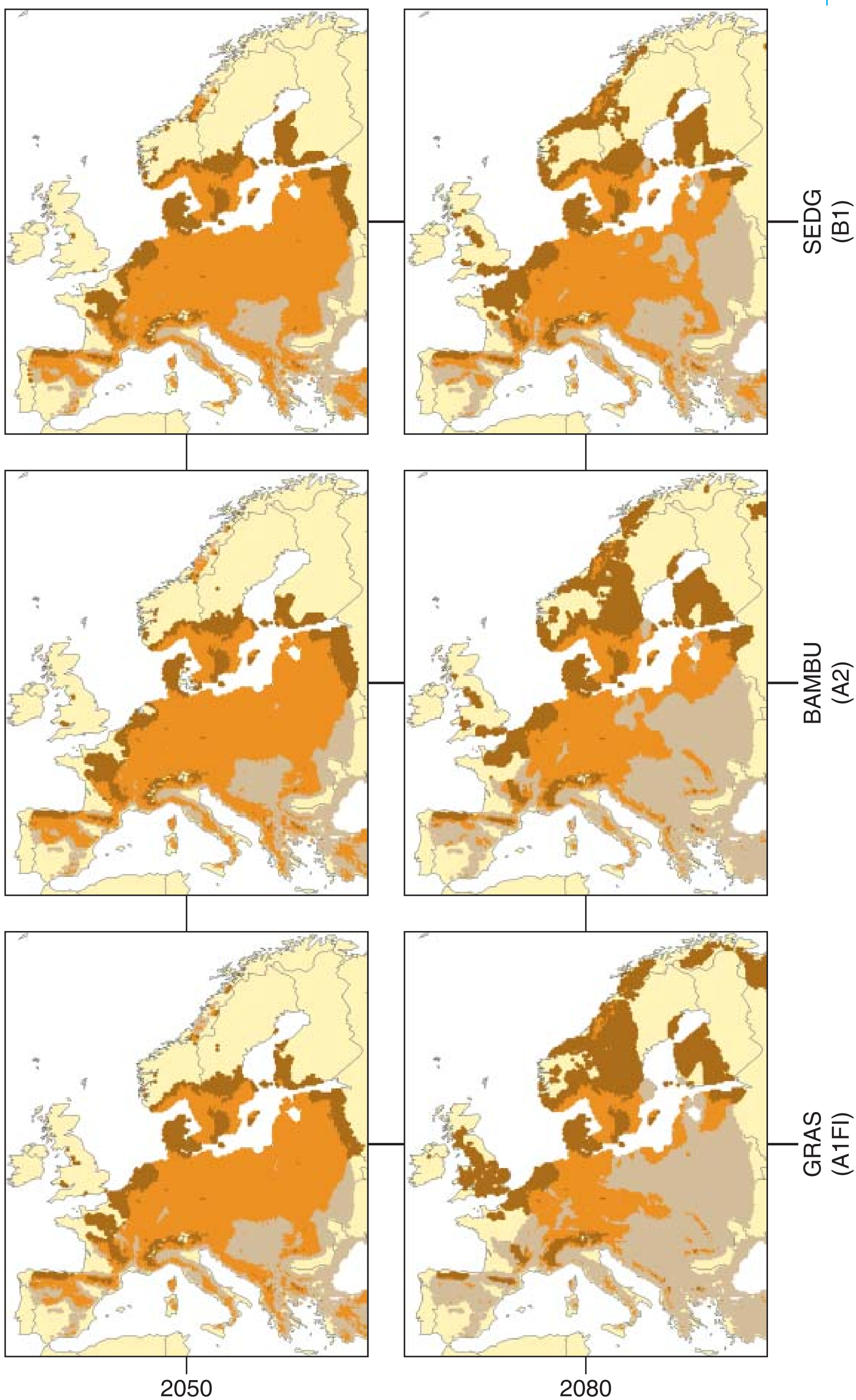
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.83). Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Coenonympha glycerion (BORKHAUSEN, 1788) – Chestnut Heath

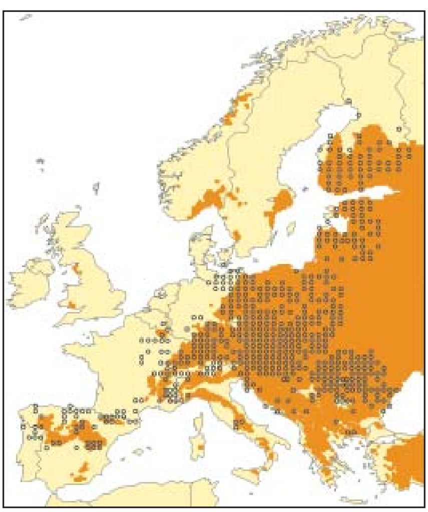
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	735 (5.73%)	-2415 (-18.82%)
	BAMBU	-174 (-1.36%)	-2688 (-20.94%)
	GRAS	90 (0.7%)	-2849 (-22.2%)
2080	SEDG	2334 (18.18%)	-3666 (-28.56%)
	BAMBU	609 (4.74%)	-5395 (-42.03%)
	GRAS	-1143 (-8.91%)	-7723 (-60.17%)

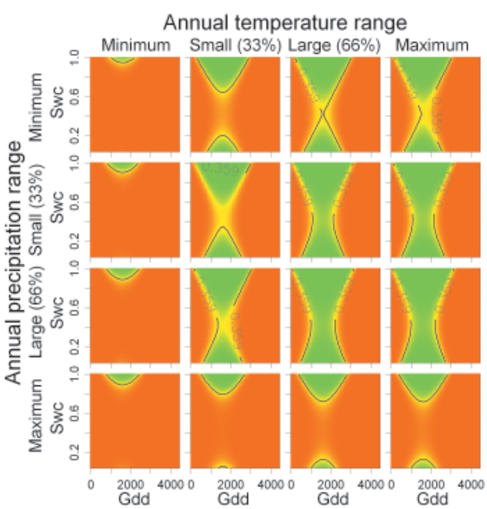
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 12835)

The Chestnut Heath inhabits dry to damp grasslands in woods, meadows, poor grassland, calcareous grasslands, and open marshy habitats. These grasslands are sometimes quite intensively grazed, as can happen on calcareous grassland. However, if grazing is absent, for a few years, change in the grassland does not seem to affect the butterflies. The butterflies do not fly very much, and only cover limited distances. The eggs are laid one by one in short rows on the blades of grasses, such as fescues (*Festuca* spp.), Tor-grass (*Brachypodium pinnatum*), Purple Moor-grass (*Molinea caerulea*), Upright Brome (*Bromus erectus*), and Crested Dog's-tail (*Cynosurus cristatus*). Pupation takes place deep down in the vegetation. The Chestnut Heath mostly has one or two generations a year, depending on altitude and latitude.

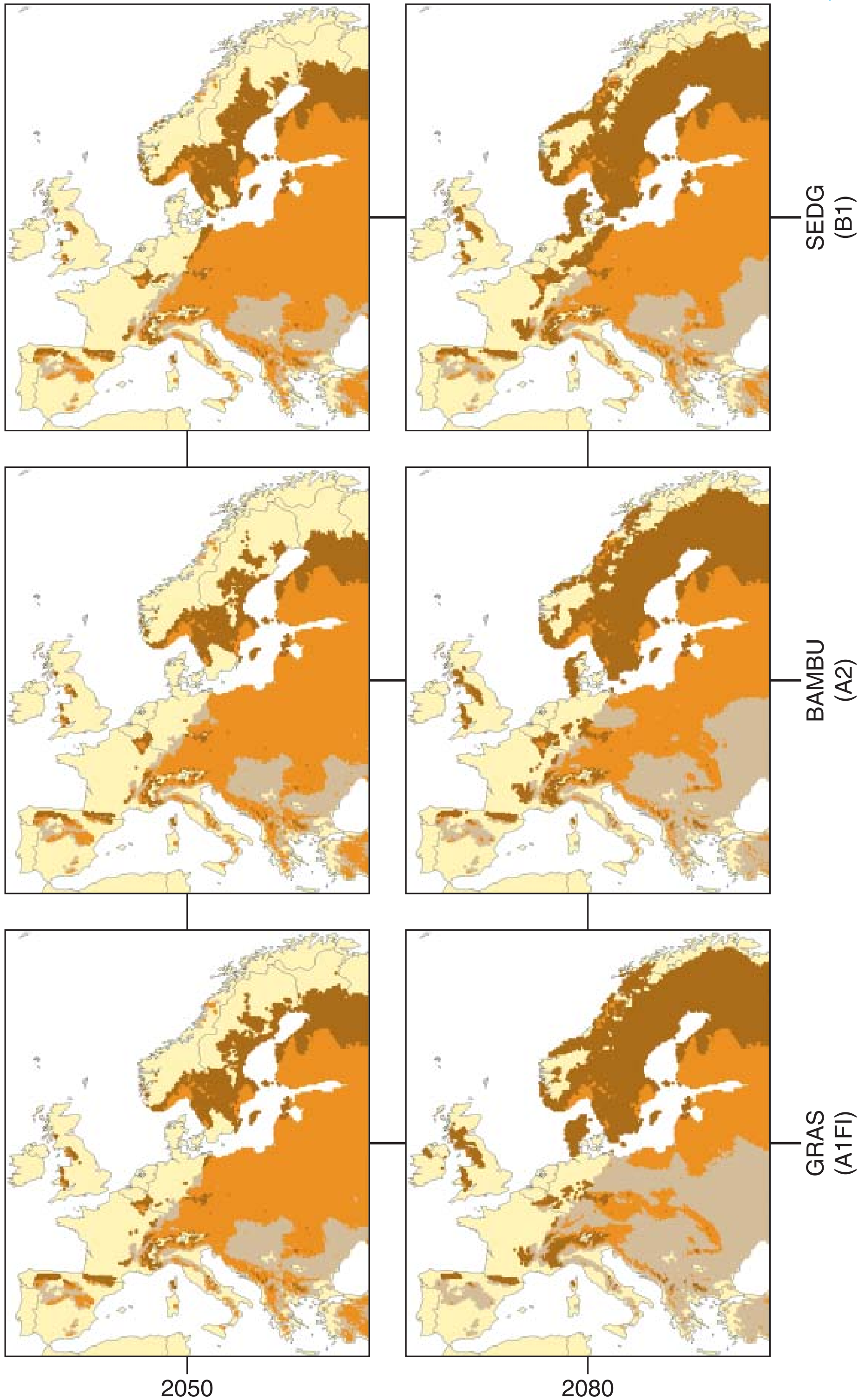
Present distribution can be well explained by climatic variables (AUC = 0.86).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Coenonympha gardetta (Prunner, 1798) – Alpine Heath

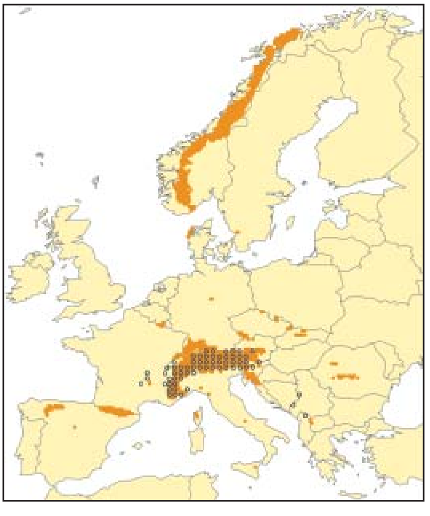
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-167 (-17.75%)	-312 (-33.16%)
	BAMBU	-97 (-10.31%)	-279 (-29.65%)
	GRAS	-207 (-22%)	-354 (-37.62%)
2080	SEDG	-405 (-43.04%)	-570 (-60.57%)
	BAMBU	-213 (-22.64%)	-475 (-50.48%)
	GRAS	-466 (-49.52%)	-662 (-70.35%)

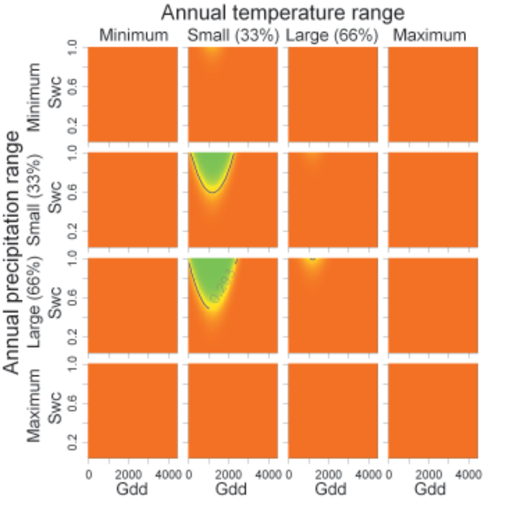
Changes in climatic niche distribution (in 10’×10’ grid cells; present niche space: 941)

The Alpine Heath is mostly found on open, sub-alpine and alpine grasslands, and on grasslands with scattered bushes and trees. It can occur in high numbers in some places. The female lays her eggs, mostly one by one, on grass stalks. The caterpillars hibernate, and pupate at the beginning of the summer, the pupa hanging from a plant, usually close to the ground. It is single-brooded.

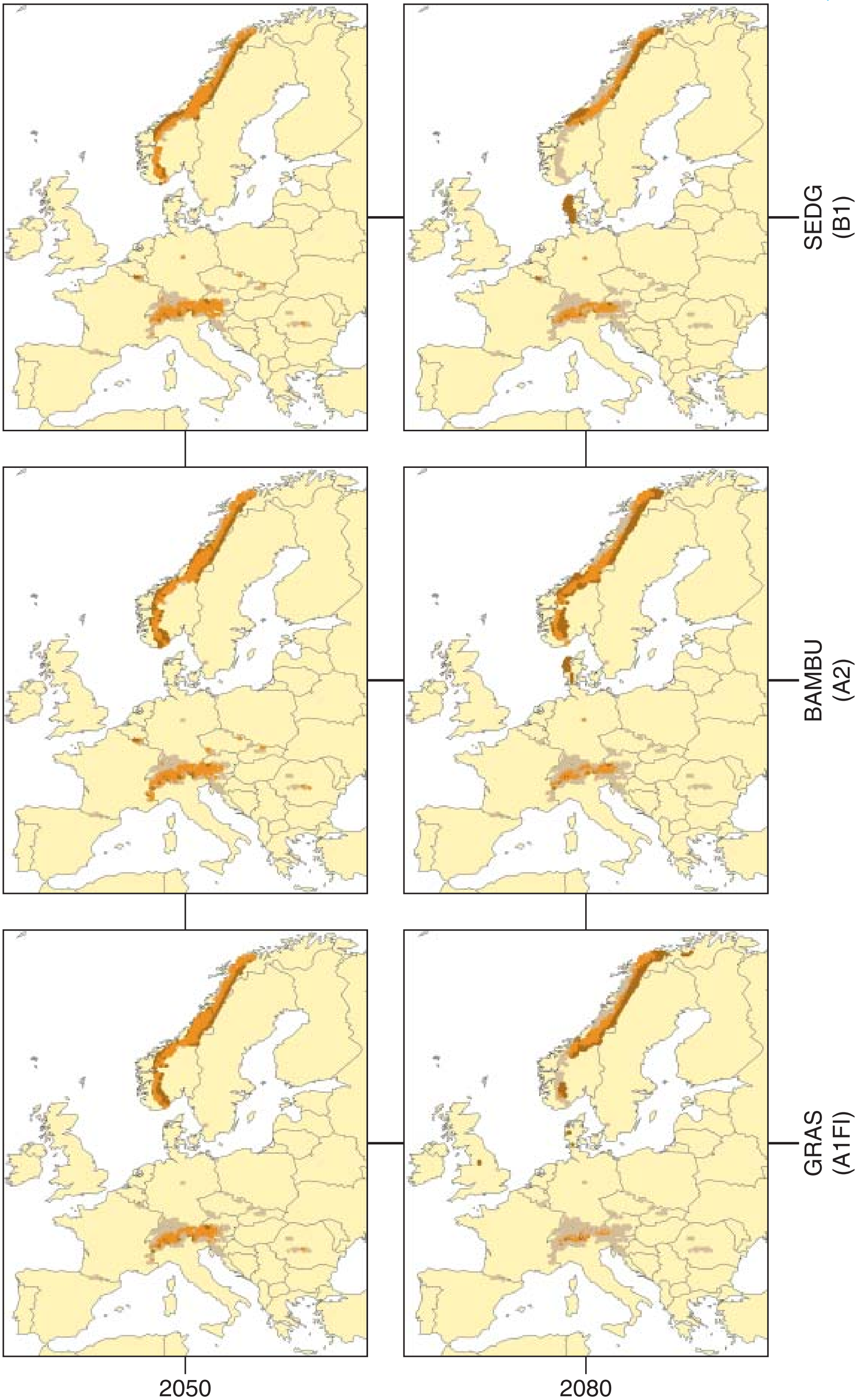
Present distribution can be very well explained by climatic variables (AUC = 0.97).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Coenonympha dorus (Esper, 1782) – Dusky Heath

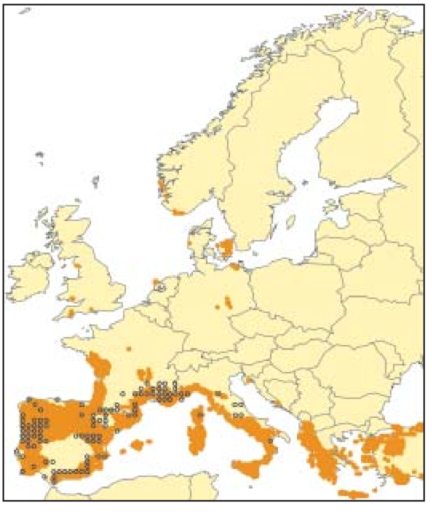
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-508 (-18.27%)	-1864 (-67.03%)
	BAMBU	-1152 (-41.42%)	-1907 (-68.57%)
	GRAS	-856 (-30.78%)	-2128 (-76.52%)
2080	SEDG	-927 (-33.33%)	-2297 (-82.6%)
	BAMBU	-1232 (-44.3%)	-2501 (-89.93%)
	GRAS	-877 (-31.54%)	-2689 (-96.69%)

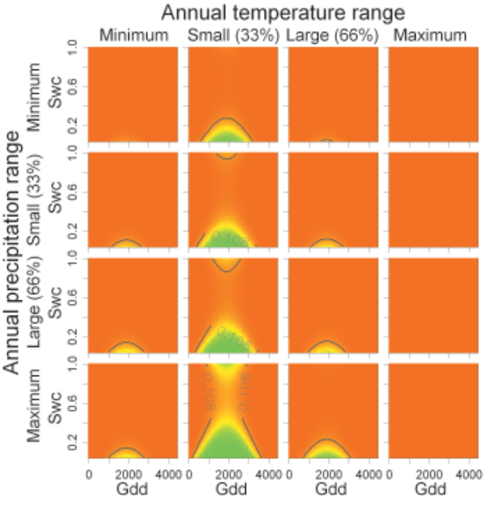
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 2781)

The Dusky Heath is a butterfly of dry, grassy vegetation, such as found on rocky slopes in low scrub, thickets and in woodland clearings. Different grasses are used as foodplant, including bent (*Agrostis* spp.), and Sheep’s-fescue (*Festuca ovina*). It has one generation a year and hibernates as a caterpillar.

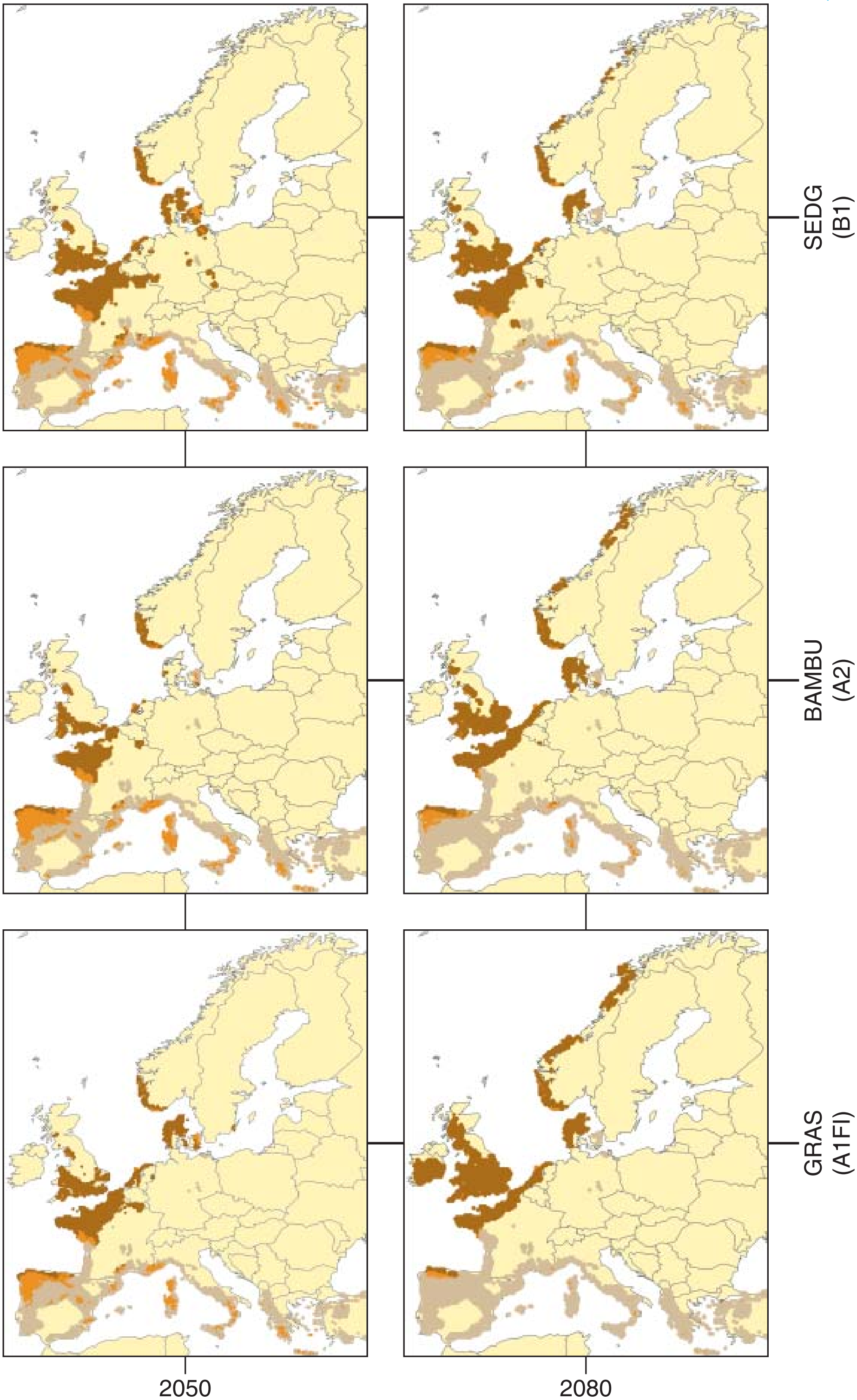
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.83). Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Coenonympha hero (Linnaeus, 1761) – Scarce Heath

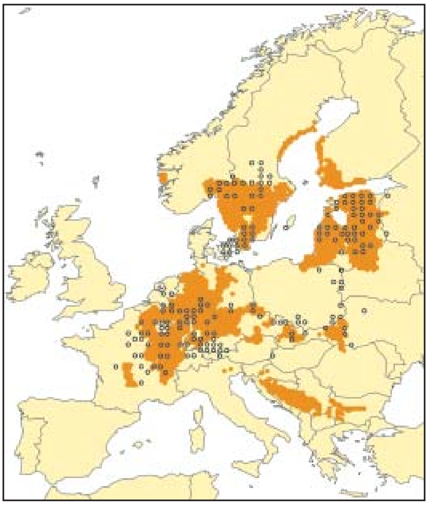
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-1416 (-39.97%)	-1929 (-54.45%)
	BAMBU	941 (26.56%)	-845 (-23.85%)
	GRAS	-517 (-14.59%)	-1545 (-43.61%)
2080	SEDG	-1761 (-49.7%)	-2493 (-70.36%)
	BAMBU	-882 (-24.89%)	-2331 (-65.79%)
	GRAS	-2024 (-57.13%)	-3301 (-93.17%)

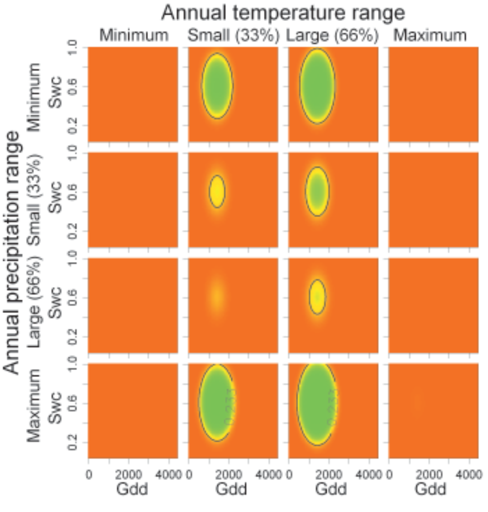
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 3543)

The Scarce Heath occurs in damp to wet grassy meadows in or at the edges of woods. Sometimes, they occur away from woods in drier places or in flower-rich grassland. The butterflies are fond of settling in grass, and do not fly far, nor very often. Among the grasses they use as food are Tufted Hair-grass (*Deschampsia cespitosa*), and Bearded Couch (*Elymus caninus*). When half-grown, the caterpillar hibernates in a grass tussock, where it later also pupates. This species has one generation a year. It should be noted that this species is severely declining. (Many dots on the map actually represent already extinct populations.)
This species is listed in Annex IV of the Habitats' Directive.

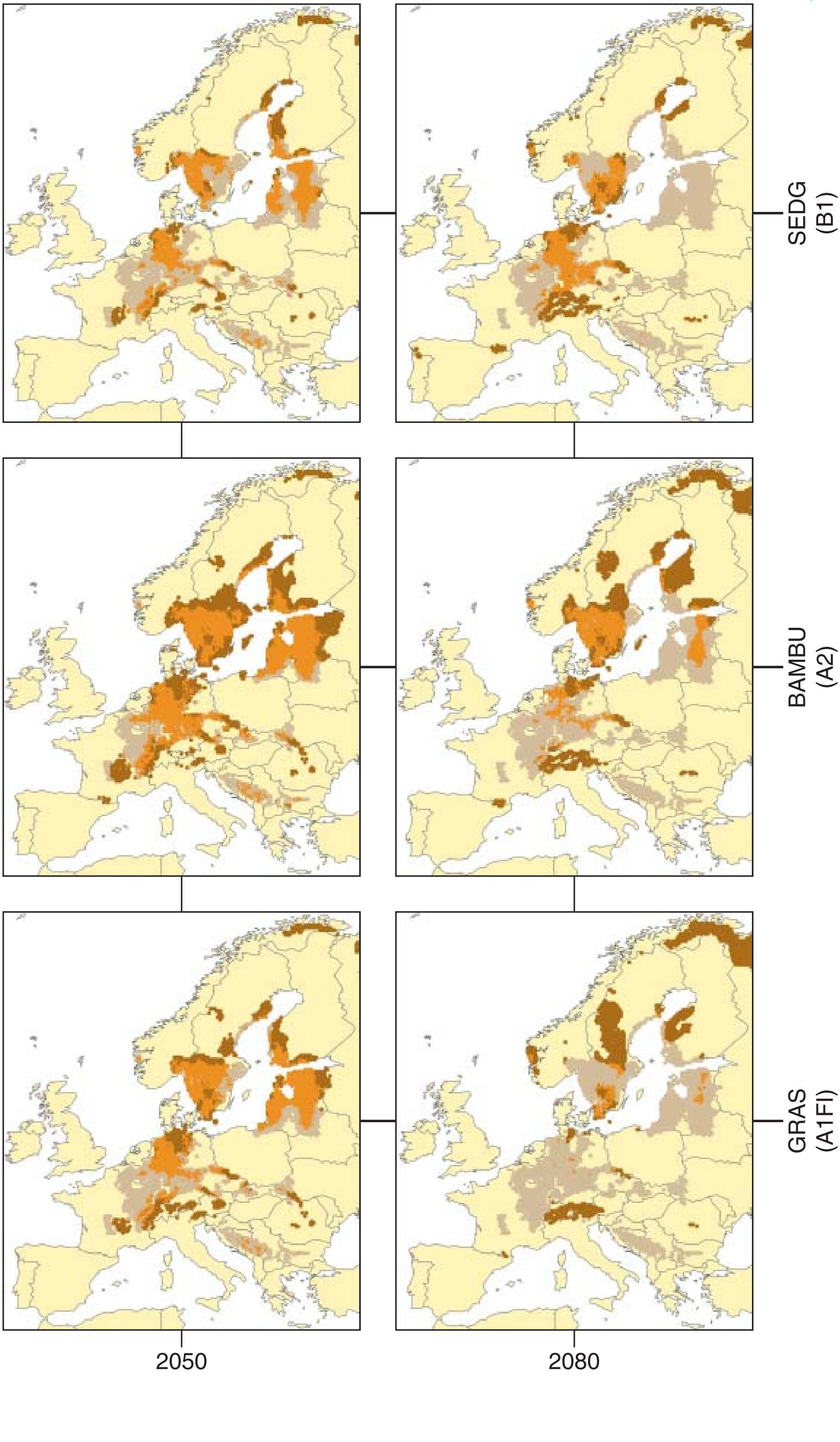
Present distribution can be well explained by climatic variables (AUC = 0.88).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Coenonympha leander (ESPER, 1784) – Russian Heath

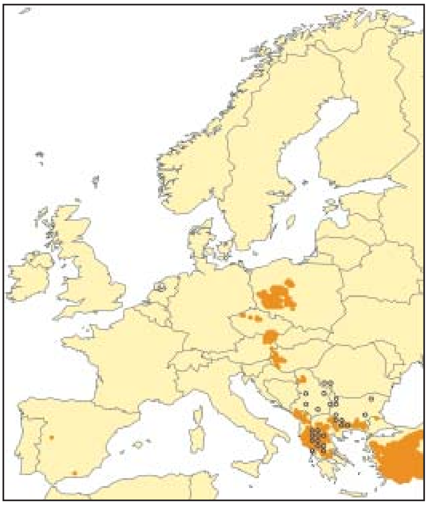
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	225 (27.21%)	-425 (-51.39%)
	BAMBU	-399 (-48.25%)	-597 (-72.19%)
	GRAS	-46 (-5.56%)	-571 (-69.04%)
2080	SEDG	-168 (-20.31%)	-546 (-66.02%)
	BAMBU	-574 (-69.41%)	-746 (-90.21%)
	GRAS	-571 (-69.04%)	-798 (-96.49%)

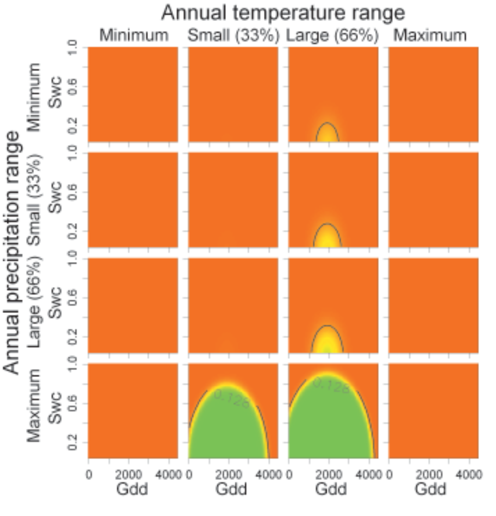
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 827)

The Russian Heath is found both on dry, as well as somewhat damp, grassy vegetation, at wood margins and in woodland clearings and on grasslands. The butterflies have a rather low flight. At rest, just like other heaths, the Russian Heath keeps its wings closed. Sheep's-fescue (*Festuca ovina*) and Slender False-brome (*Brachypodium sylvaticum*) are among the grasses used as foodplants. This species has one brood a year and hibernates as a caterpillar.

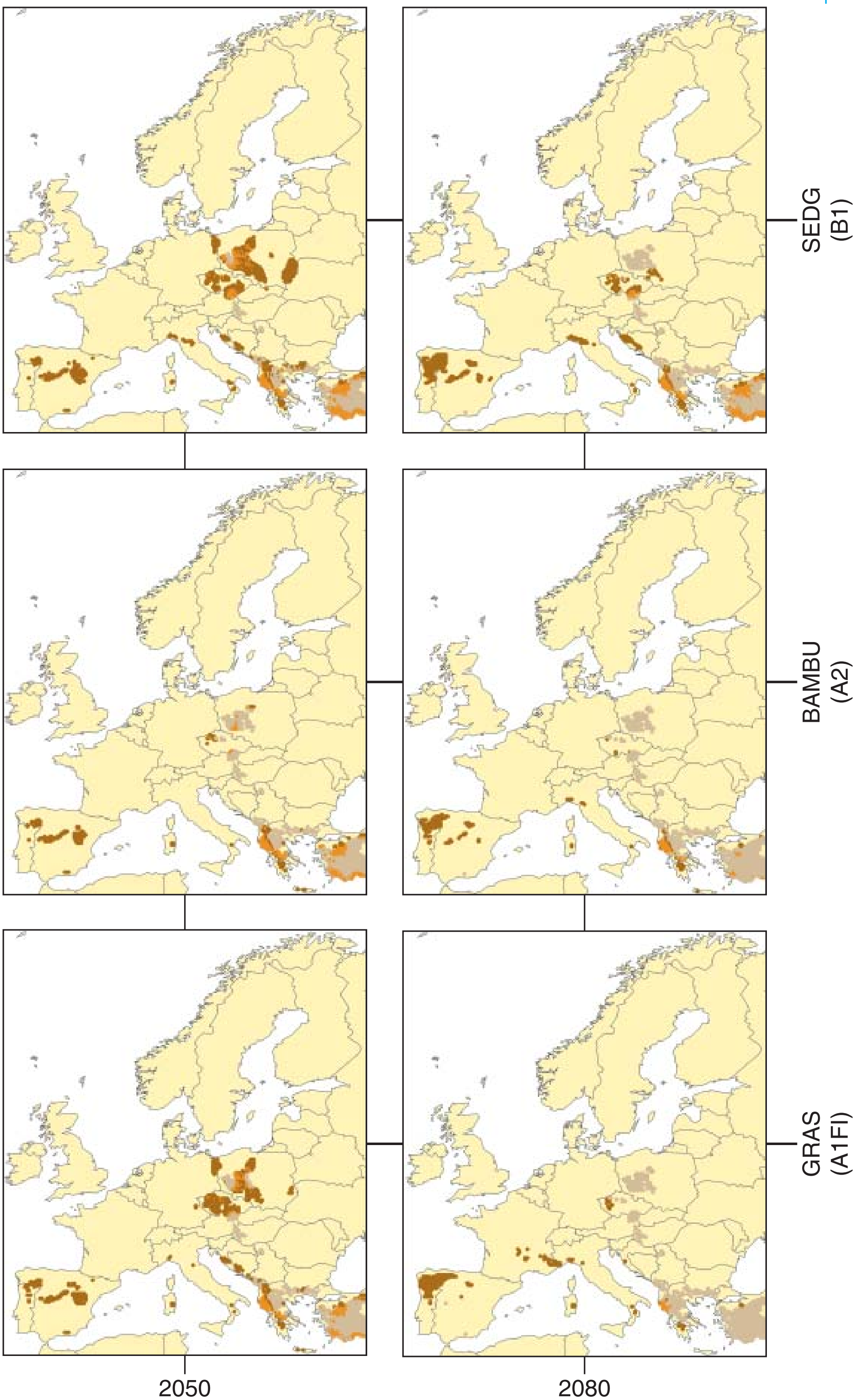
Present distribution can be well explained by climatic variables (AUC = 0.89).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Coenonympha pamphilus (Linnaeus, 1758) – Small Heath

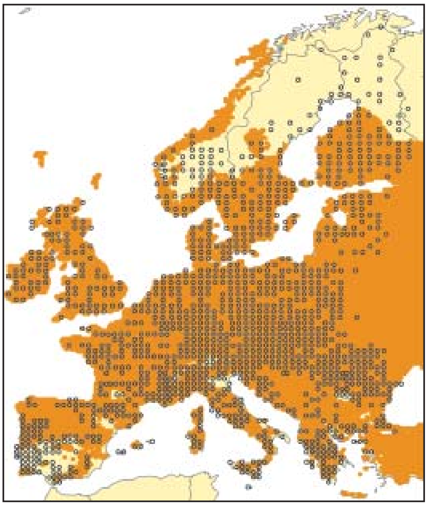
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-1709 (-7.66%)	-3476 (-15.58%)
	BAMBU	-2727 (-12.22%)	-3878 (-17.38%)
	GRAS	-2920 (-13.09%)	-4439 (-19.9%)
2080	SEDG	-1994 (-8.94%)	-5095 (-22.84%)
	BAMBU	-4197 (-18.81%)	-7614 (-34.13%)
	GRAS	-6105 (-27.36%)	-10438 (-46.79%)

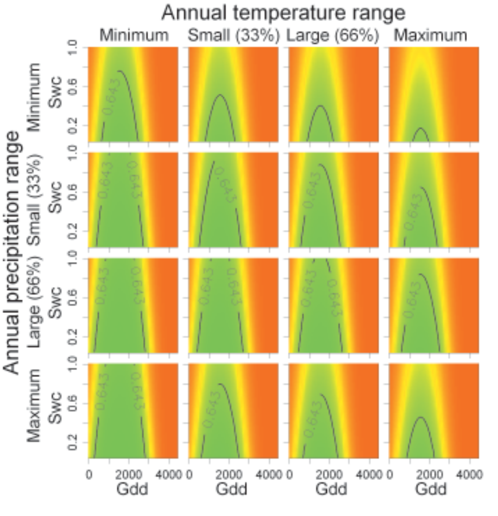
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 22310)

The Small Heath is a common species of nearly all types of grassland. It is mostly found on fairly open, poor meadows and pastures. The female deposits her eggs one by one, or in rows, on the blades of most grasses, including meadow-grasses (*Poa* spp.), Sweet Vernal-grass (*Anthoxanthum odoratum*), fescues (*Festuca* spp.), and bents (*Agrostis* spp.). The caterpillar grows very quickly on nutritious grasses, but can also use poor grasses, growing then more slowly. In the third or fourth larval instar, the caterpillar hibernates deep down in a tussock of grass, where it also later pupates. The number of broods a year is between one and three and depends on the geographical position of the habitat.

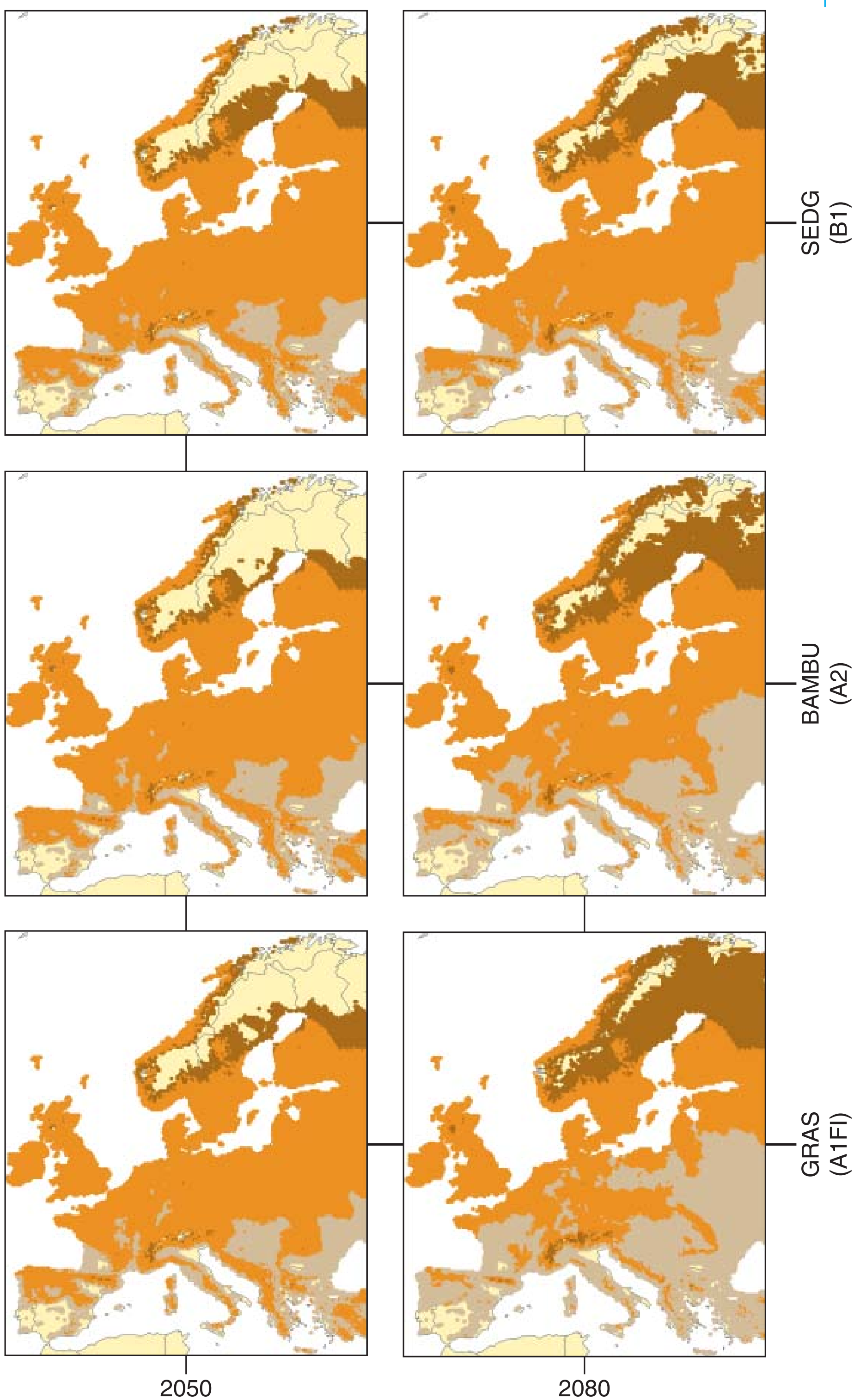
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.66).
Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pyronia tithonus (Linnaeus, 1771) – Gatekeeper

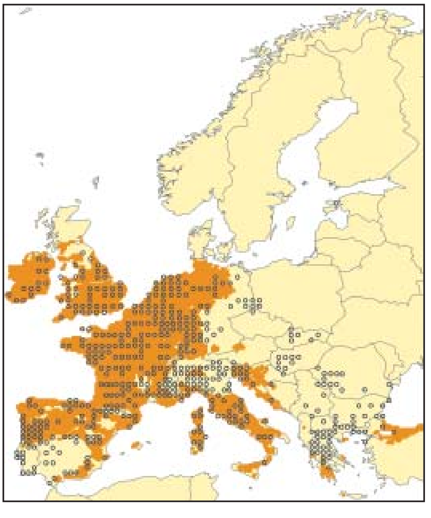
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-385 (-6.01%)	-1451 (-22.63%)
	BAMBU	-48 (-0.75%)	-1437 (-22.41%)
	GRAS	-511 (-7.97%)	-1691 (-26.38%)
2080	SEDG	-898 (-14.01%)	-2029 (-31.65%)
	BAMBU	-1165 (-18.17%)	-2649 (-41.32%)
	GRAS	-2622 (-40.9%)	-3899 (-60.82%)

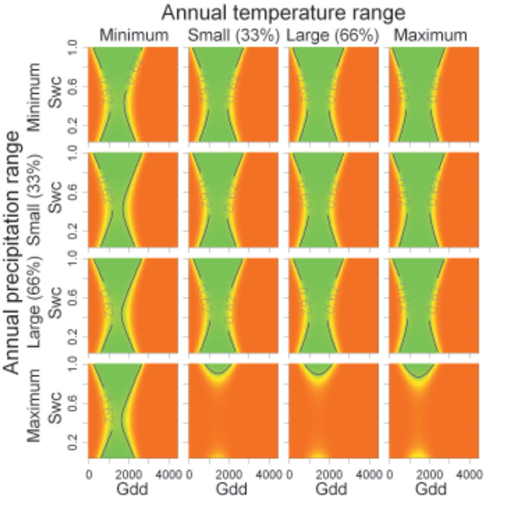
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 6411)

The Gatekeeper occurs on many different types of grassland. Mostly, it chooses rather rough, dry to damp vegetation, situated beside woodland or scrub, or not far from them. The butterflies are fond of basking in the sun on scrub, and are often seen visiting flowers. The female lays her eggs singly on the leaf-blades of nearly all soft grasses, such as Cock's-foot (*Dactylus* spp.), fescues (*Festuca* spp.), bents (*Agrostis* spp.), and Rye-Grass (*Lolium* spp.). The caterpillar avoids bright sunlight, and feeds mostly on grasses growing in the shade. When half-grown, it hibernates in a tussock of grass. It completes its growth the following year, and pupates low down in the vegetation. The Gatekeeper is single-brooded.

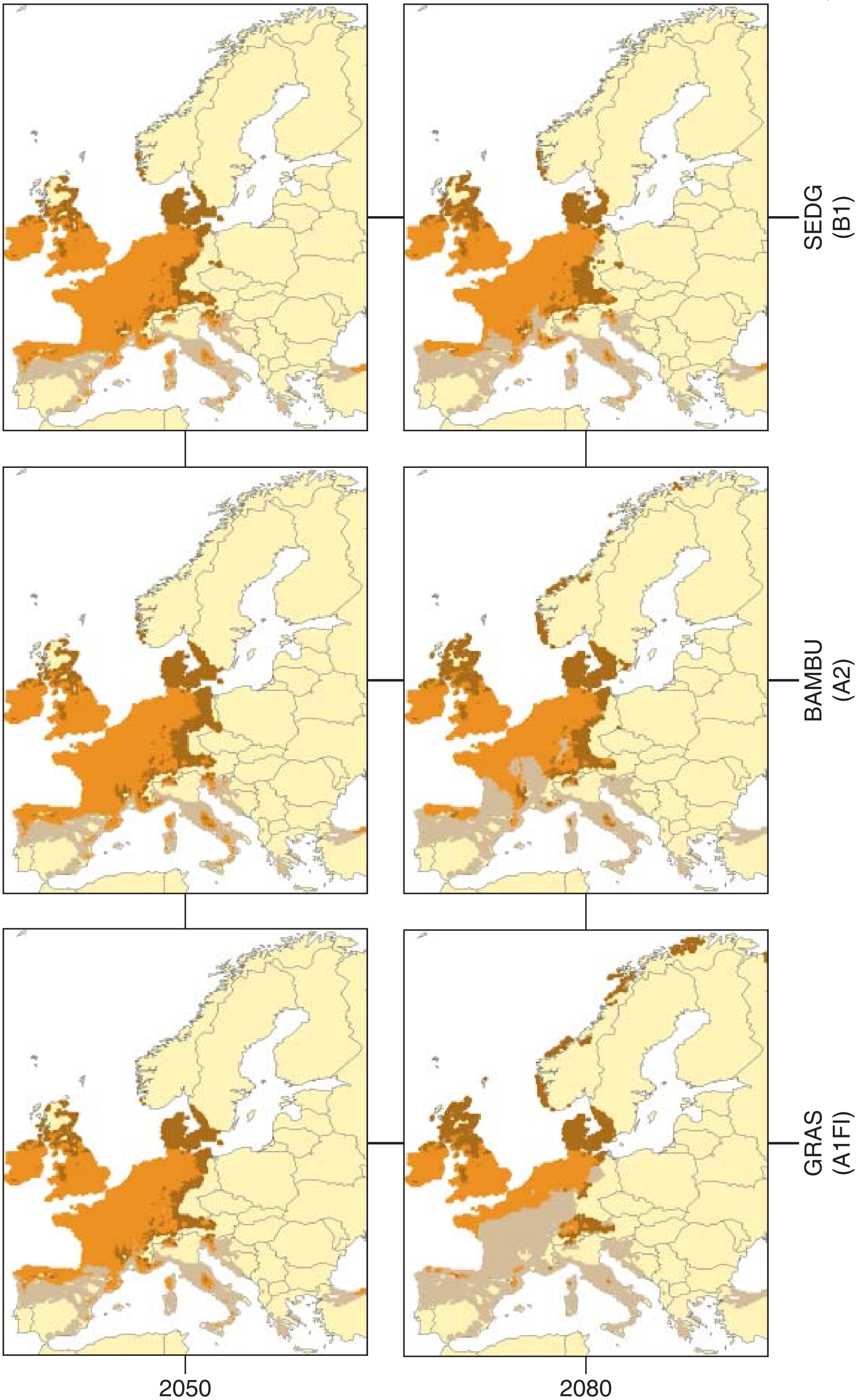
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.82).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pyronia cecilia (Vallantin, 1894) – Southern Gatekeeper

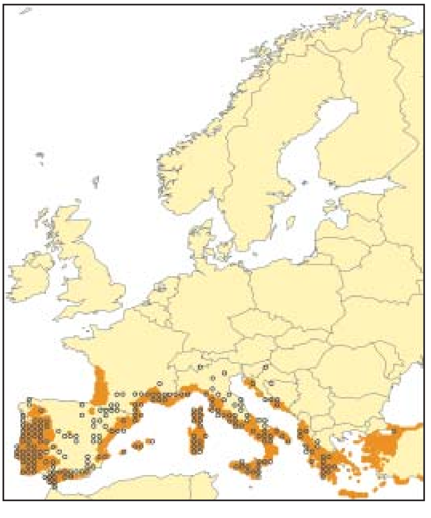
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-794 (-33.79%)	-1382 (-58.81%)
	BAMBU	-925 (-39.36%)	-1406 (-59.83%)
	GRAS	-939 (-39.96%)	-1613 (-68.64%)
2080	SEDG	-891 (-37.91%)	-1781 (-75.79%)
	BAMBU	-1206 (-51.32%)	-2042 (-86.89%)
	GRAS	-1037 (-44.13%)	-2280 (-97.02%)

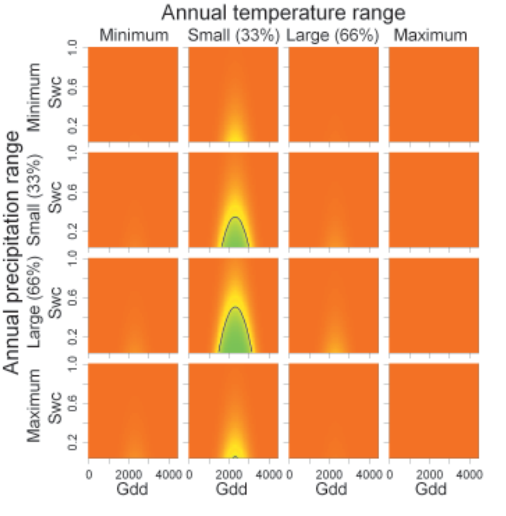
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2350)

The Southern Gatekeeper can be found on dry grasslands, rocky slopes with grassy vegetation, in open scrub, and now and then in woodland clearings. The foodplants are grasses, probably Tufted Hair-grass (*Deschampsia cespitosa*), although this is still uncertain. This butterfly species has one or two broods a year, and passes the winter as a caterpillar.

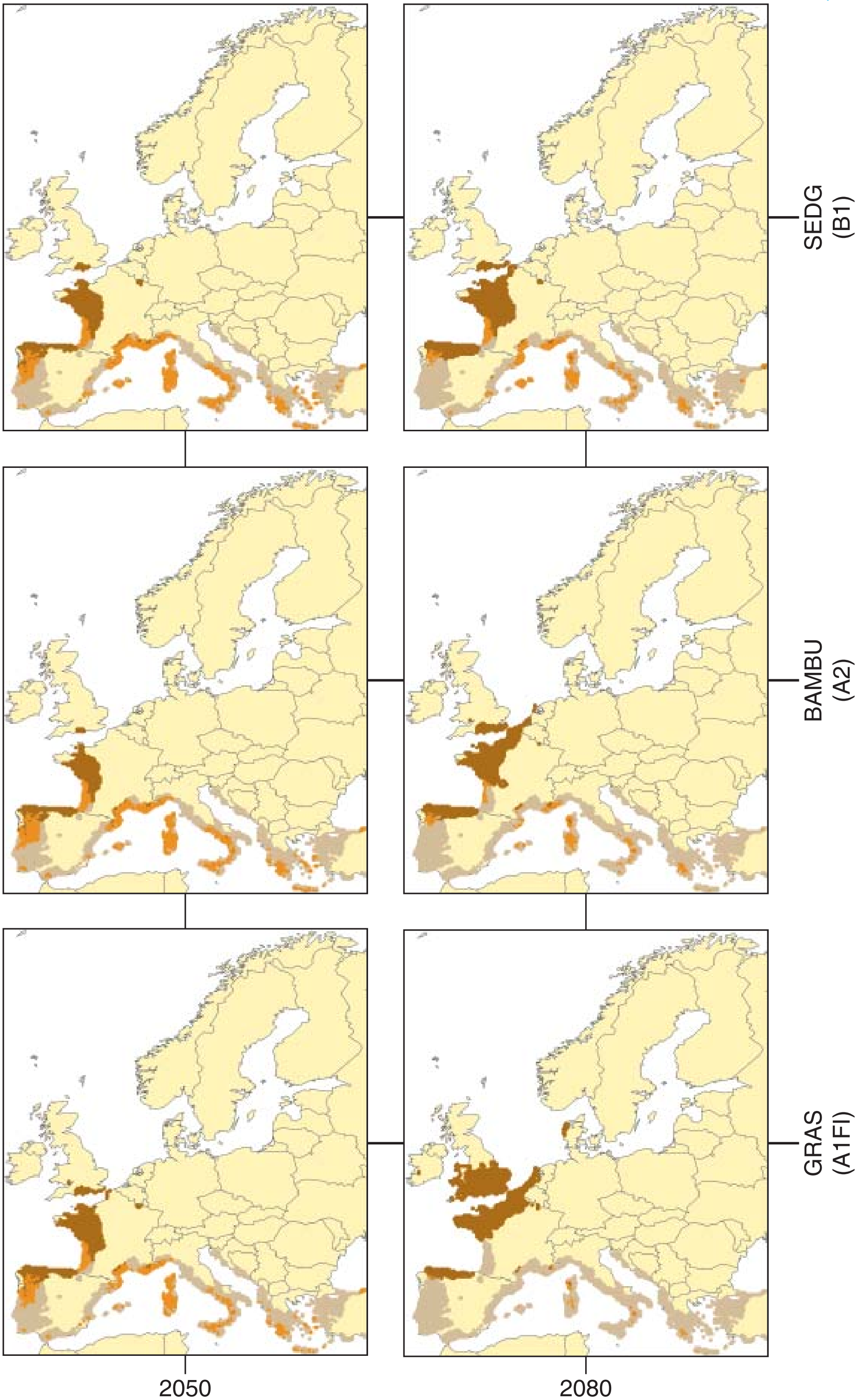
Present distribution can be well explained by climatic variables (AUC = 0.91).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pyronia bathseba (Fabricius, 1793) – Spanish Gatekeeper

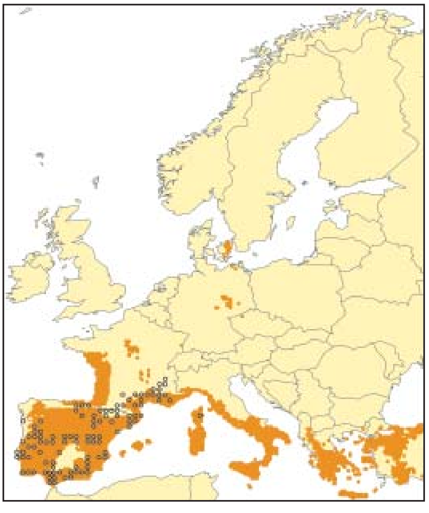
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-696 (-20.11%)	-1954 (-56.46%)
	BAMBU	-1440 (-41.61%)	-2070 (-59.81%)
	GRAS	-1151 (-33.26%)	-2282 (-65.93%)
2080	SEDG	-1610 (-46.52%)	-2673 (-77.23%)
	BAMBU	-2178 (-62.93%)	-3150 (-91.01%)
	GRAS	-2079 (-60.07%)	-3404 (-98.35%)

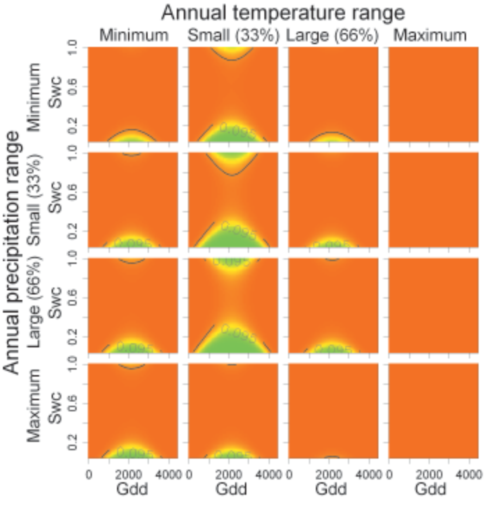
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 3461)

The markings on the Spanish Gatekeeper are brighter than those of the other gatekeepers. The butterflies are mostly found on dry, rather rough, grassy vegetation with trees or bushes in the neighbourhood. The caterpillars feed on grasses, especially false-bromes (*Brachypodium* spp.), but also probably bromes (*Bromus* spp), and meadow-grasses (*Poa* spp.). The Spanish Gatekeeper is single-brooded, and passes the winter in the caterpillar stage.

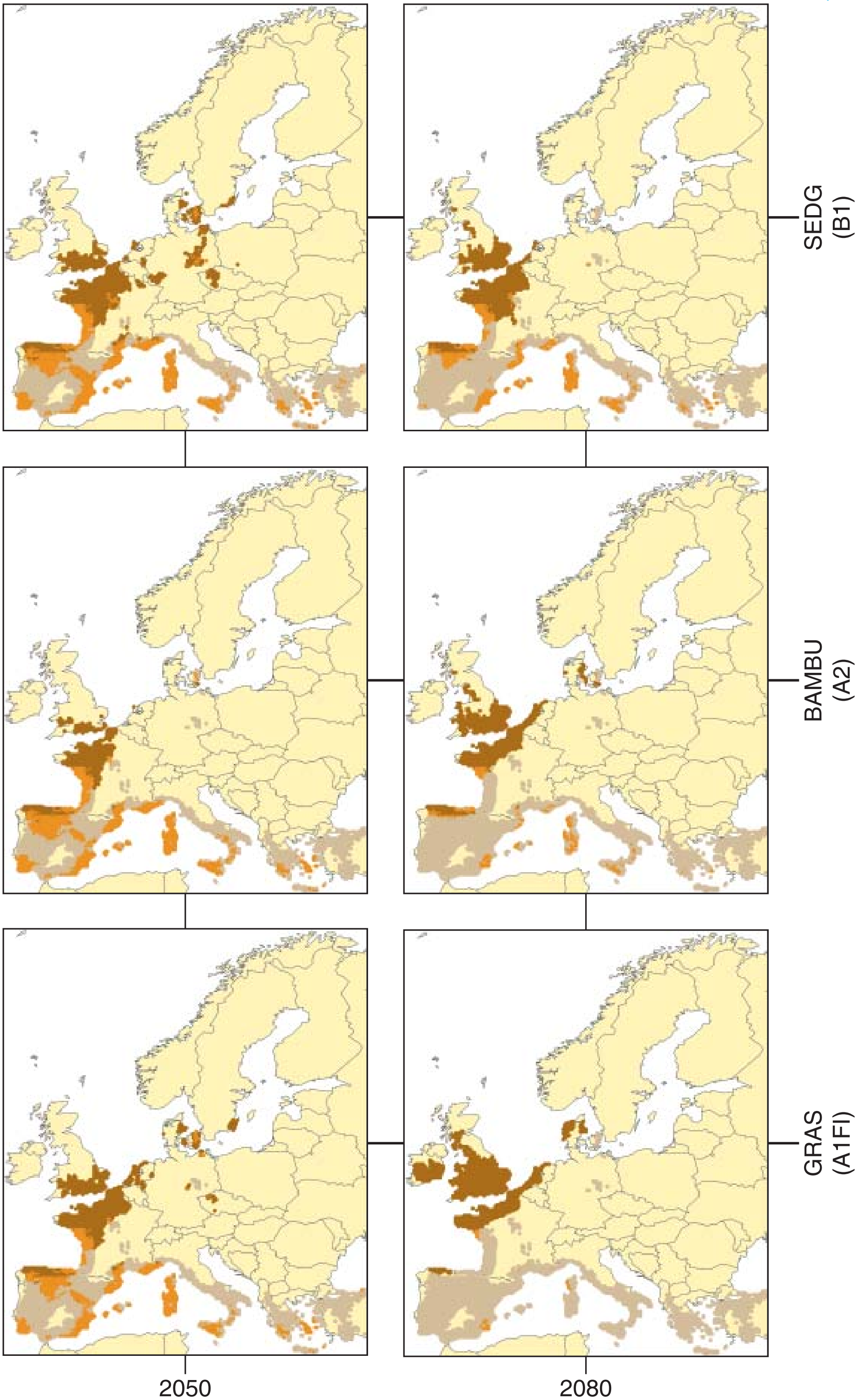
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.83).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Aphantopus hyperantus (Linnaeus, 1758) – Ringlet

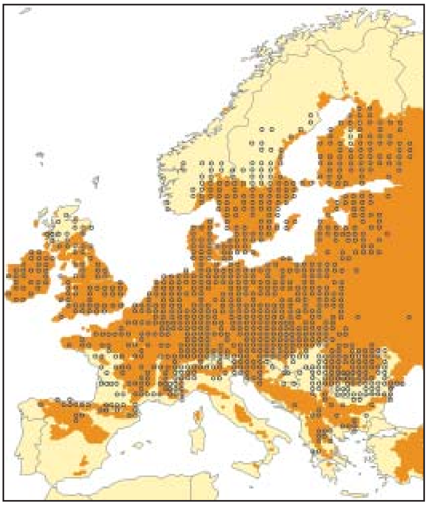
© Peter Ginzinger

		Full dispersal	No dispersal
2050	SEDG	-1583 (-9.49%)	-3790 (-22.73%)
	BAMBU	-1875 (-11.25%)	-4274 (-25.64%)
	GRAS	-2340 (-14.04%)	-4840 (-29.03%)
2080	SEDG	-3828 (-22.96%)	-7230 (-43.37%)
	BAMBU	-5021 (-30.12%)	-9337 (-56%)
	GRAS	-7118 (-42.69%)	-12005 (-72.01%)

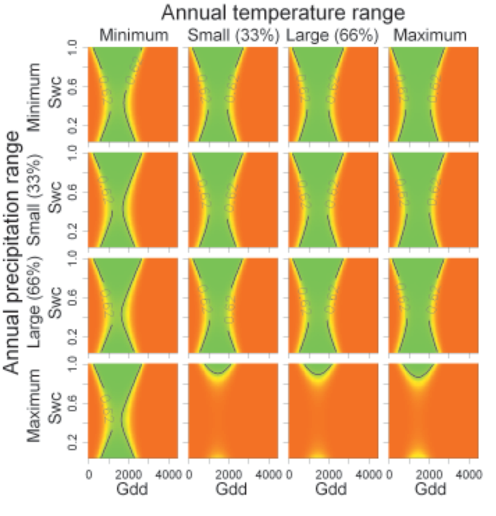
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 17662)

The Ringlet can be found in grassy places with bushes, woodland clearings, and on grasslands bordering woods. The habitats vary from dry to rather wet, such as at the edge of a raised bog. The butterflies are avid visitors of such flowers as thistles, knapweed, and other plants rich in nectar. The caterpillars feed on nutrient-rich grasses, such as cock's-foot (*Dactylus* spp.), false-bromes (*Brachypodium* spp.), fescues (*Festuca* spp.), and cat's-tails (*Phleum* spp.). The female usually just releases her eggs, letting them fall into the vegetation, either while perched or in flight. The caterpillars hibernate, hidden in a grass tussock, and when they resume feeding, only do so at night. They also pupate deep down in the vegetation. The Ringlet has one brood a year.

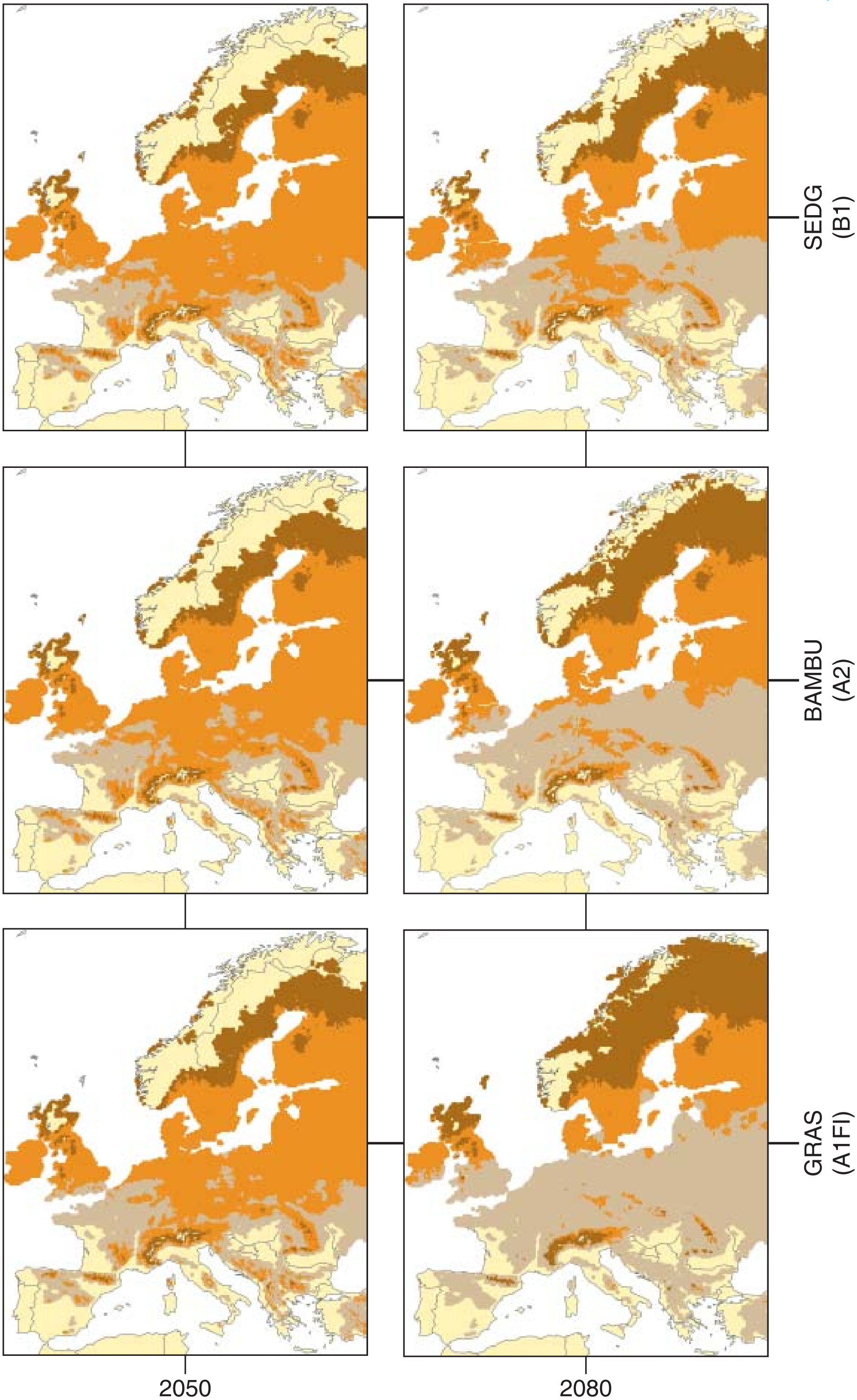
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.84).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Maniola jurtina (Linnaeus, 1758) – Meadow Brown

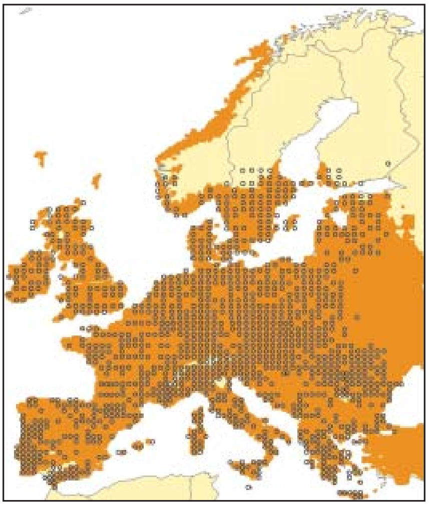
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-1330 (-6.1%)	-3022 (-13.85%)
	BAMBU	-2884 (-13.22%)	-4188 (-19.19%)
	GRAS	-2986 (-13.68%)	-4489 (-20.57%)
2080	SEDG	-4349 (-19.93%)	-6262 (-28.7%)
	BAMBU	-6627 (-30.37%)	-9090 (-41.66%)
	GRAS	-9317 (-42.7%)	-11852 (-54.32%)

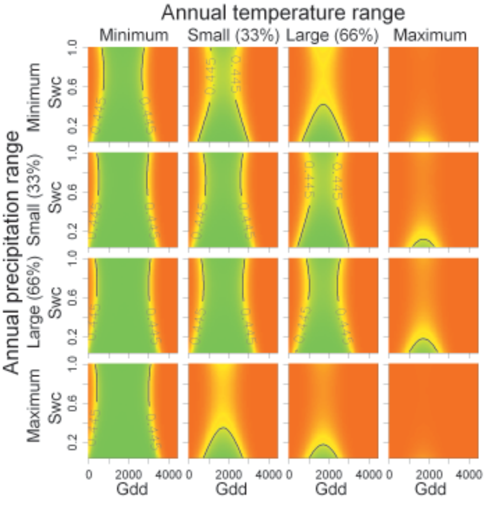
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 21820)

The Meadow Brown is a common butterfly of many different sorts of grassland, both natural grasslands and not too intensively used farmland, and semi-natural grassland. The butterflies are noticeable by their lively behaviour. The female deposits her eggs on a large number of grasses, including species of fescue (*Festuca* spp.), false-brome (*Brachypodium* spp.), cock's-foot (*Dactylus* spp.), dog's-tail (*Cynosurus* spp.), and brome (*Bromus* spp.). Sometimes, she also just drops the eggs in flight. The caterpillar goes into hibernation in the litter layer when half-grown. It also pupates deep in the litter layer. The Meadow Brown has one generation a year.

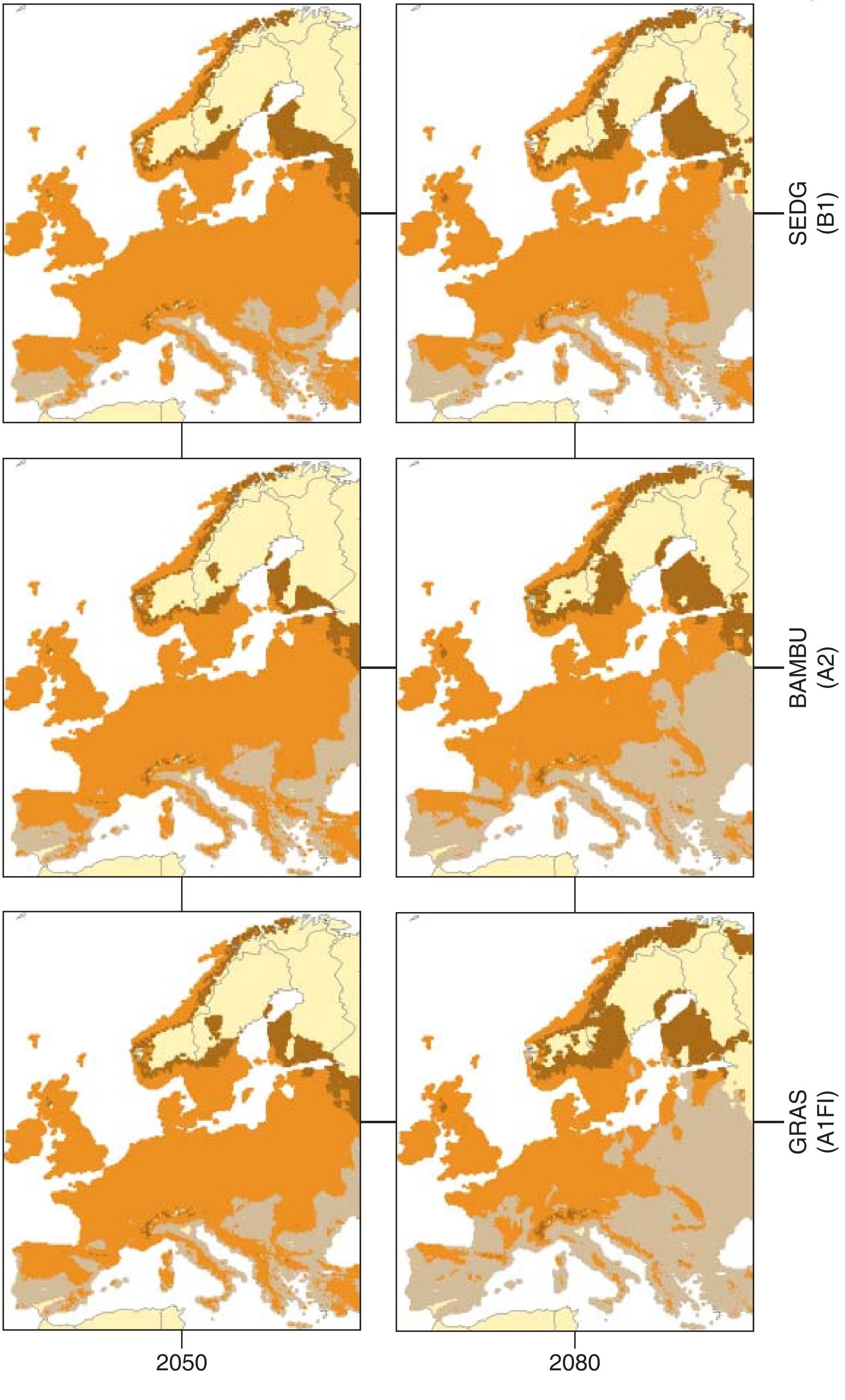
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.7). Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold



SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Hyponephele lycaon (Kühn, 1774) – Dusky Meadow Brown

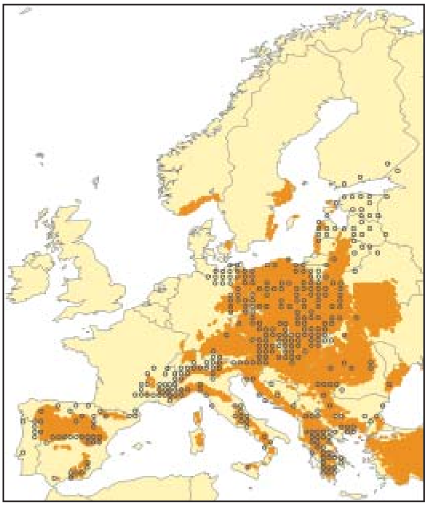
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-805 (-11.69%)	-2069 (-30.06%)
	BAMBU	-3974 (-57.73%)	-4245 (-61.66%)
	GRAS	-2698 (-39.19%)	-3454 (-50.17%)
2080	SEDG	-3582 (-52.03%)	-4792 (-69.61%)
	BAMBU	-5739 (-83.37%)	-6138 (-89.16%)
	GRAS	-5461 (-79.33%)	-6406 (-93.06%)

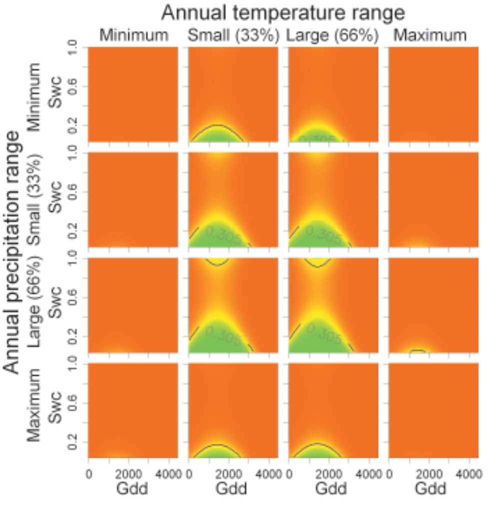
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 6884)

The Dusky Meadow Brown occurs in many different sorts of grassland. It is important that its habitat is dry and warm. In the north of its range, the grassland is steppe-like, and more to the south the butterfly is found on closer vegetation. It uses various grasses as foodplant, including fescues (*Festuca* spp.), false-bromes (*Brachypodium* spp.), and *Stipa* species. When the female is about to lay an egg, she first alights on the ground and walks to a foodplant, then she chooses a low-hanging grass blade on which to deposit an egg. The caterpillar hibernates in the first larval instar and only starts feeding in the spring. At first, it feeds mainly during day, but when the weather gets too warm, it only feeds at night. Pupation takes place deep in the vegetation or litter layer. The Dusky Meadow Brown is single-brooded.

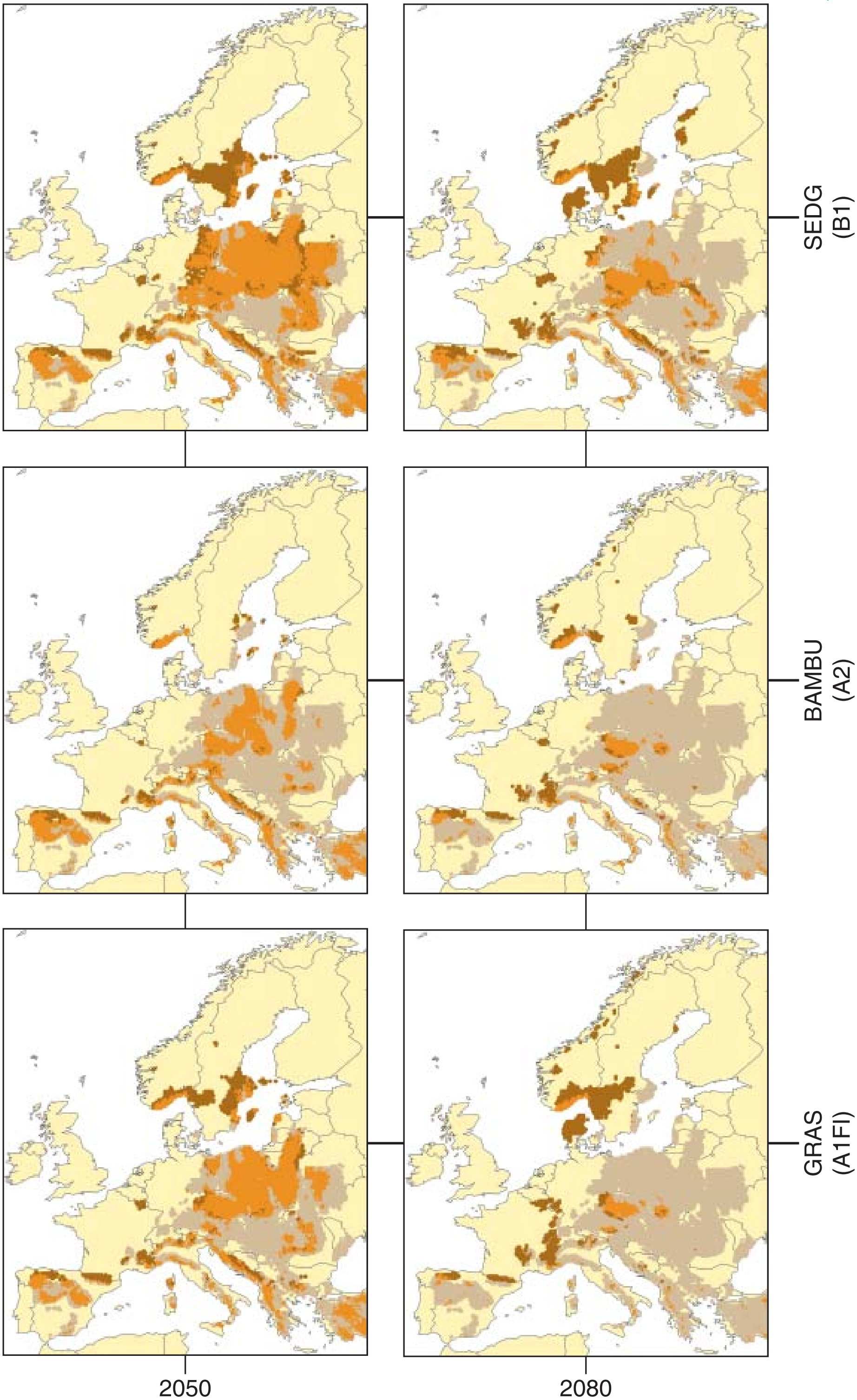
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.78). Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Hyponephele lupina (Costa, 1836) – Oriental Meadow Brown

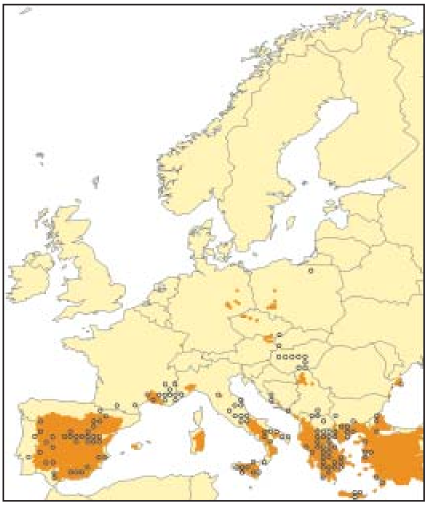
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-389 (-13.75%)	-1308 (-46.24%)
	BAMBU	-1228 (-43.41%)	-1547 (-54.68%)
	GRAS	-981 (-34.68%)	-1690 (-59.74%)
2080	SEDG	-1383 (-48.89%)	-1845 (-65.22%)
	BAMBU	-2198 (-77.7%)	-2482 (-87.73%)
	GRAS	-2354 (-83.21%)	-2720 (-96.15%)

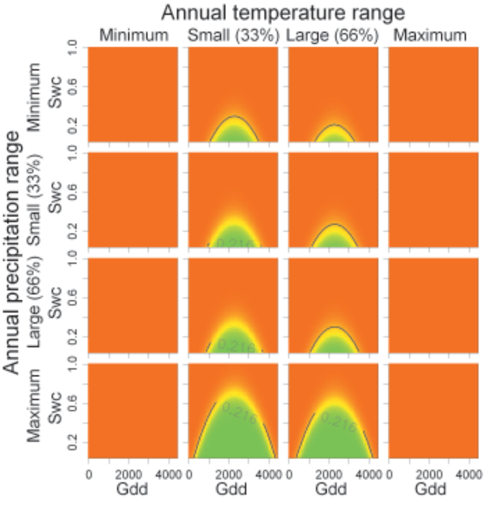
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2829)

The Oriental Meadow Brown is a butterfly of warm, dry places. The butterflies can be found on dry grasslands with scattered bushes, or dry scrub vegetation, and in light woodland. At rest, their wings are almost always closed. They have a rapid flight, often keeping to the shadow cast by trees or bushes. Grasses, such as meadow-grasses (*Poa* spp.) and fescues (*Festuca* spp.) are used as foodplants. The species has one generation a year and hibernates in the larval stage.

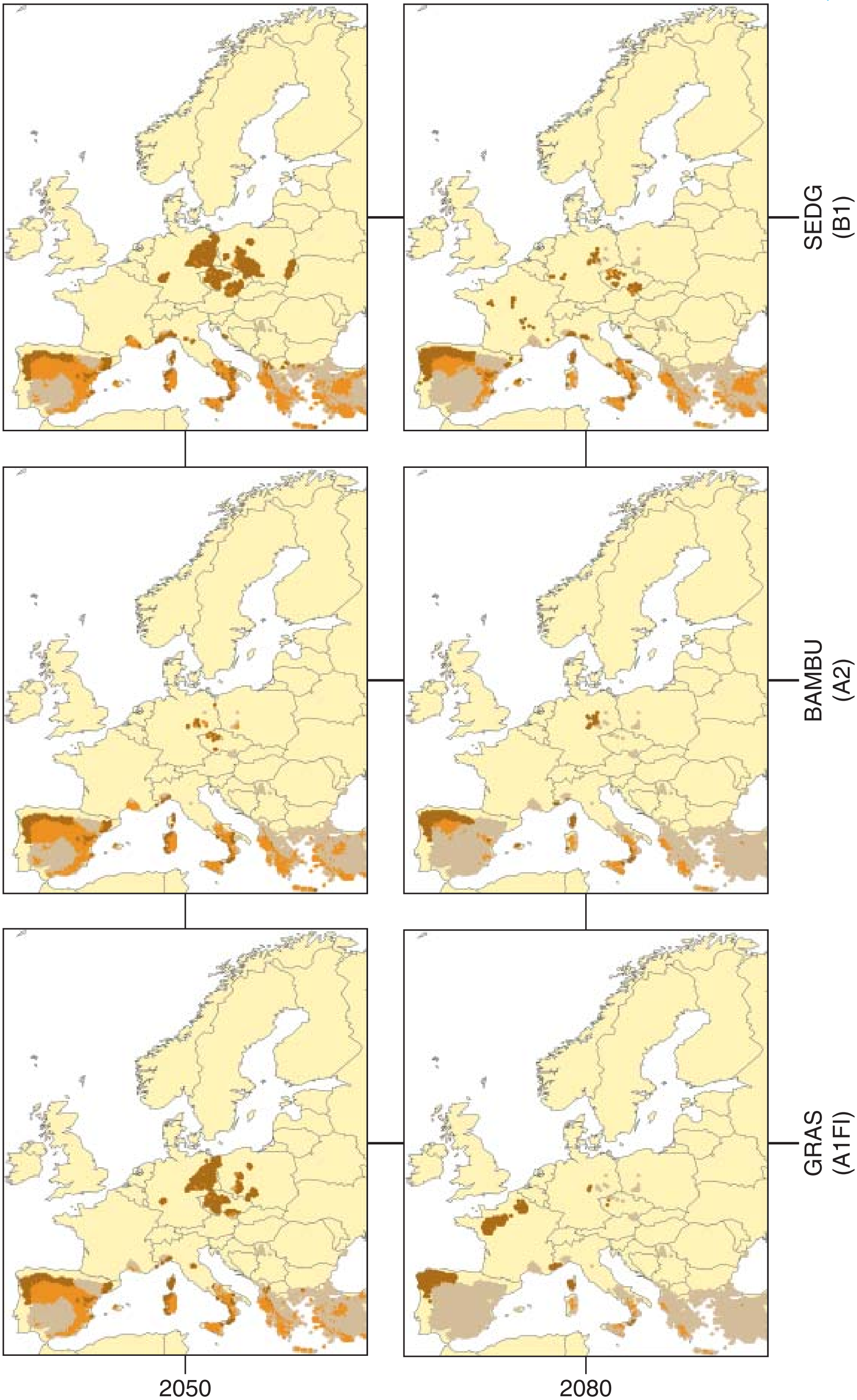
Present distribution can be well explained by climatic variables (AUC = 0.88).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

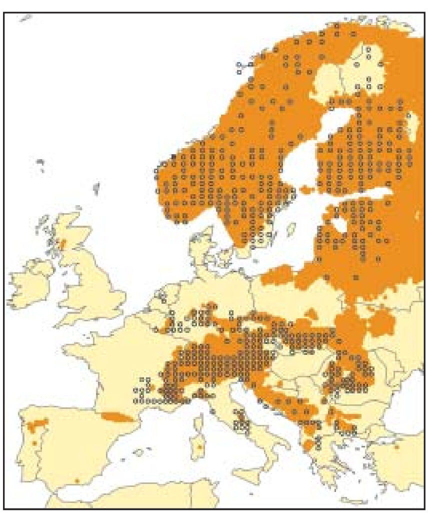
Erebia ligea (Linnaeus, 1758) – Arran Brown

		Full dispersal	No dispersal
2050	SEDG	-2958 (-23.74%)	-3875 (-31.09%)
	BAMBU	-2415 (-19.38%)	-3187 (-25.57%)
	GRAS	-4075 (-32.7%)	-4737 (-38.01%)
2080	SEDG	-2798 (-22.45%)	-3895 (-31.26%)
	BAMBU	-4435 (-35.59%)	-5388 (-43.24%)
	GRAS	-5485 (-44.01%)	-6418 (-51.5%)

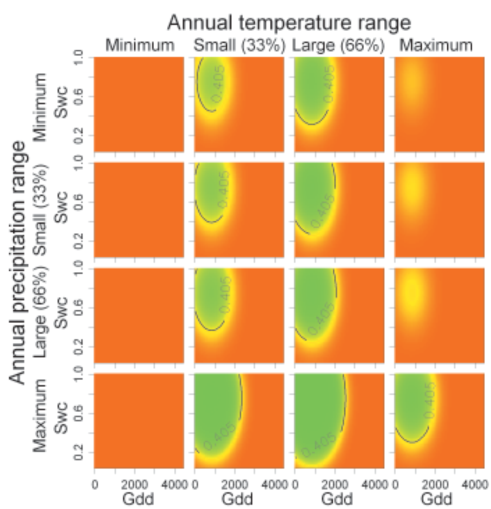
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 12462)

The Arran Brown occurs in sheltered, grassy, flower-rich places in woodland. These places are usually rather damp and in deep shade. The female deposits her eggs on the withered blades of various grasses, including cock’s-foots (*Dactylus* spp.), hair-grasses (*Deschampsia* spp.), fescues (*Festuca* spp.), and Heath-grass (*Danthonia decumbens*). Sedges (*Carex* spp.) are also used. The egg hibernates, and the following year, the caterpillar feeds and grows, and in the last larval instar hibernates again. In the summer, the caterpillar pupates. The Arran Brown is single-brooded, but the life cycle takes two years to complete.

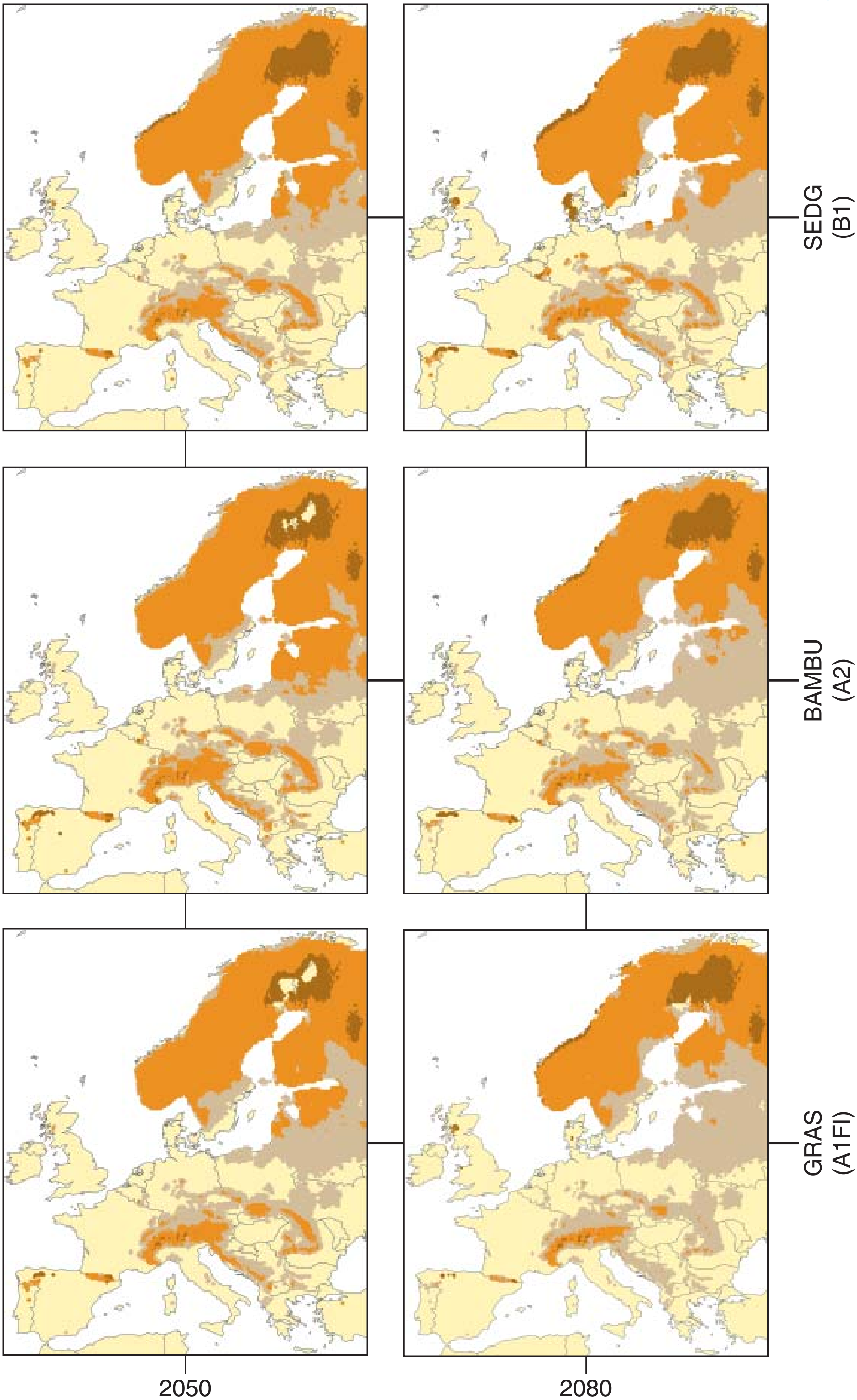
Present distribution can be well explained by climatic variables (AUC = 0.86).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia euryale (Esper, 1805) – Large Ringlet

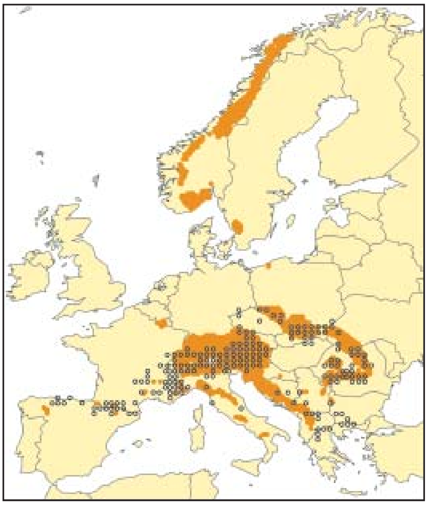
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	-524 (-25.05%)	-825 (-39.44%)
	BAMBU	-435 (-20.79%)	-769 (-36.76%)
	GRAS	-791 (-37.81%)	-1100 (-52.58%)
2080	SEDG	-326 (-15.58%)	-1147 (-54.83%)
	BAMBU	-275 (-13.15%)	-1218 (-58.22%)
	GRAS	-500 (-23.9%)	-1541 (-73.66%)

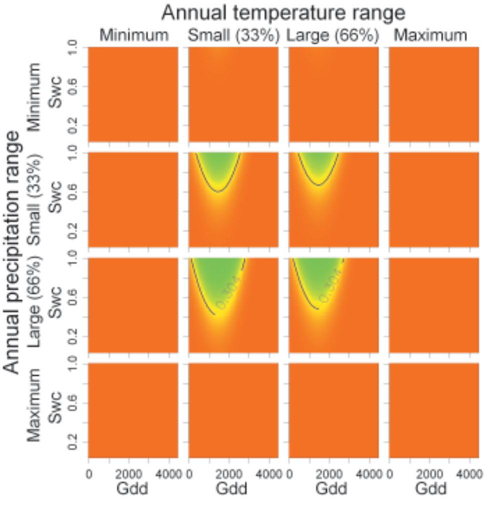
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2092)

The Large Ringlet occurs in light woodland, in grassy clearings in woods, and above the tree-line on grassland with rather tall vegetation. In the Jura Mountains, these butterflies can be found at the edge of raised bogs, and at an altitude of 1000 m, also in light, damp woods. The Greek populations also seem to prefer damp places. Both the males and females visit flowers for their nectar and the males can often be seen drinking on damp ground or on dung. Various grasses are used as foodplant, including Blue Moor-grass (*Sesleria albicans*), Wood Meadow-grass (*Poa nemoralis*), Red Fescue (*Festuca rubra*), Sheep's-fescue (*F. ovina*), *Calamagrostis varia*, and also sedges (*Carex* spp.). It takes two years for the development from egg to butterfly.

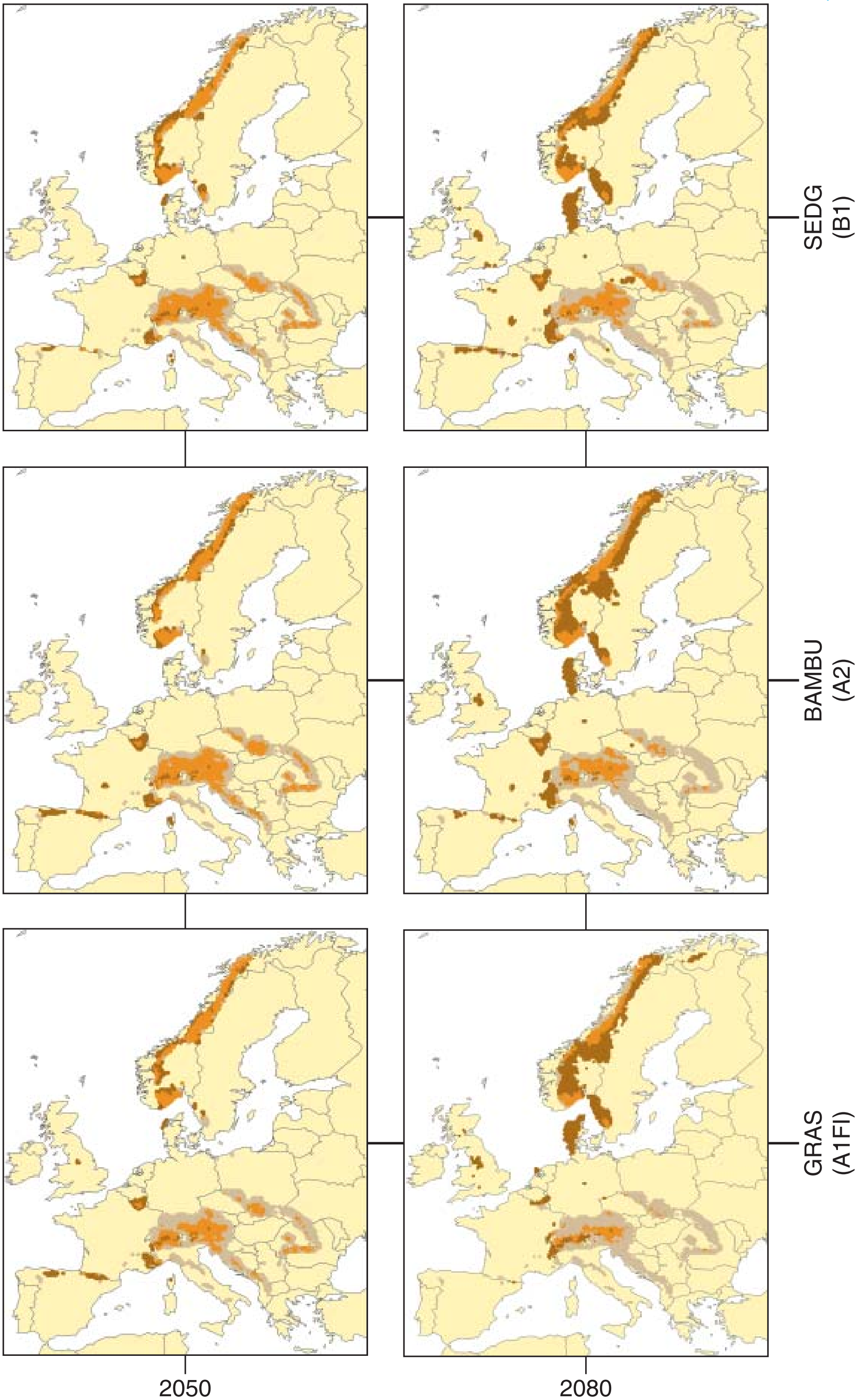
Present distribution can be well explained by climatic variables (AUC = 0.89).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia eriphyle (Freyer, 1836) – Eriphyle Ringlet

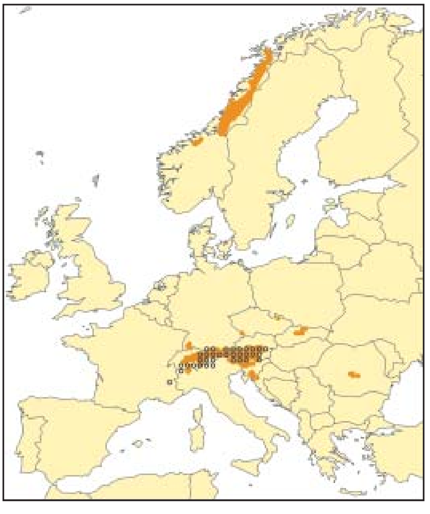
© Josef Pennerstorfer

		Full dispersal	No dispersal
2050	SEDG	-57 (-14.81%)	-144 (-37.4%)
	BAMBU	-33 (-8.57%)	-141 (-36.62%)
	GRAS	-99 (-25.71%)	-172 (-44.68%)
2080	SEDG	-168 (-43.64%)	-250 (-64.94%)
	BAMBU	-76 (-19.74%)	-251 (-65.19%)
	GRAS	-121 (-31.43%)	-304 (-78.96%)

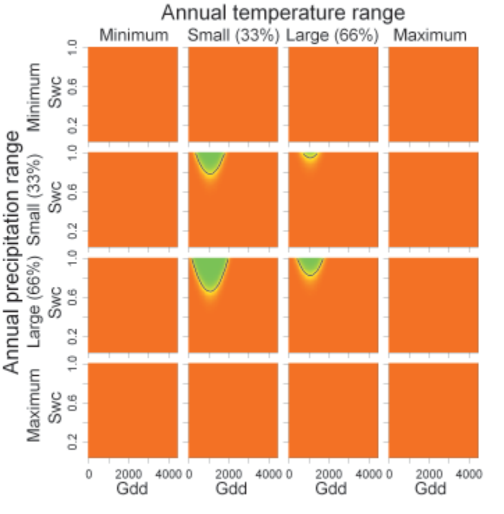
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 385)

The Eriphyle Ringlet occurs locally in the Alps and is one of the smaller ringlets. It is a characteristic species of the north-facing slopes, occurring on rough, herbaceous vegetation in the alpine and sub-alpine zones, where there are plenty of alder (*Alnus* spp.) saplings. They are often found in places where the conspicuous plants *Adenostyles alliariae* and Masterwort (*Peucedanum ostruthium*) are growing. It uses Sweet-Vernal-grass (*Anthoxanthum odoratum*) and Tufted Hair-grass (*Deschampsia cespitosa*) as foodplants. Some of the caterpillars leave the egg before the winter, but the rest hibernate in the egg and emerge in the spring, when they all start feeding on grasses. In the autumn, they hibernate again and moult twice before pupating at the end of May.

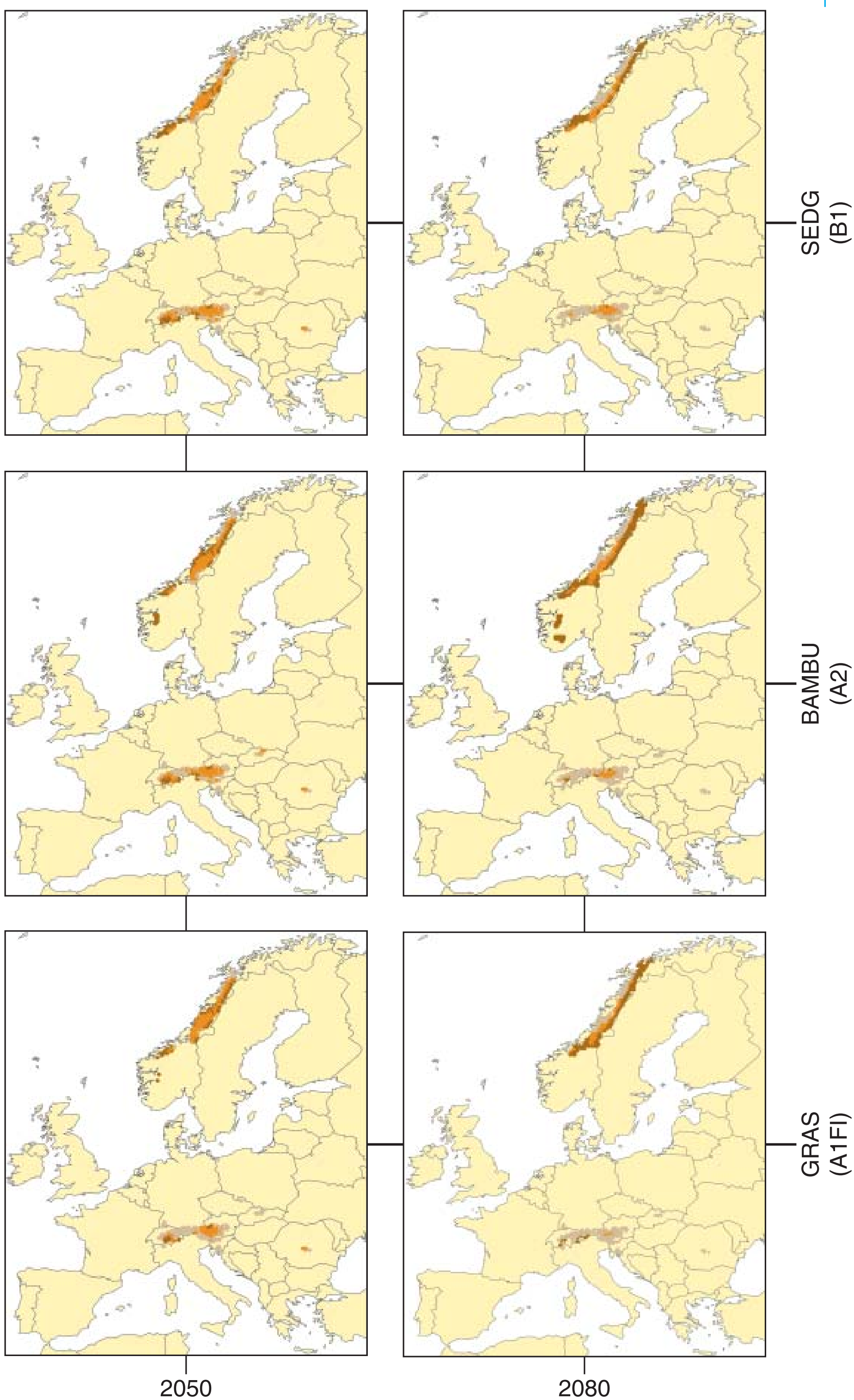
Present distribution can be very well explained by climatic variables (AUC = 0.99).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia manto ([Schiffermüller], 1775) – Yellow-spotted Ringlet

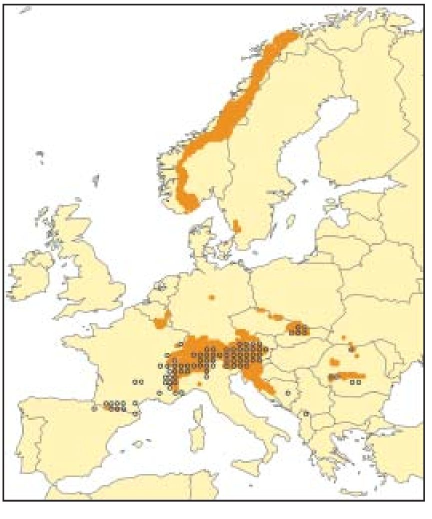
© Josef Pennerstorfer

		Full dispersal	No dispersal
2050	SEDG	-258 (-19.07%)	-466 (-34.44%)
	BAMBU	-165 (-12.2%)	-394 (-29.12%)
	GRAS	-357 (-26.39%)	-548 (-40.5%)
2080	SEDG	-368 (-27.2%)	-668 (-49.37%)
	BAMBU	-228 (-16.85%)	-661 (-48.85%)
	GRAS	-402 (-29.71%)	-850 (-62.82%)

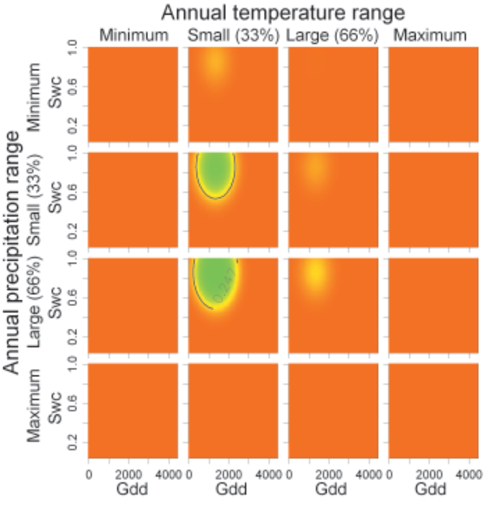
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1353)

The Yellow-spotted Ringlet is a species of cool and cold conditions. Above the tree-line it occurs on open mountain meadows, and below it inhabits damp, flower-rich grasslands and woodland glades. The female deposits her eggs one at a time on the blades of various grasses, such as fescues (*Festuca* spp.) and cat's-tails (*Phleum* spp.). It hibernates twice, the first time as an egg or a tiny caterpillar, without having fed at all. During the next summer, the caterpillar develops as far as the penultimate stage and then hibernates again. It pupates in the following summer.

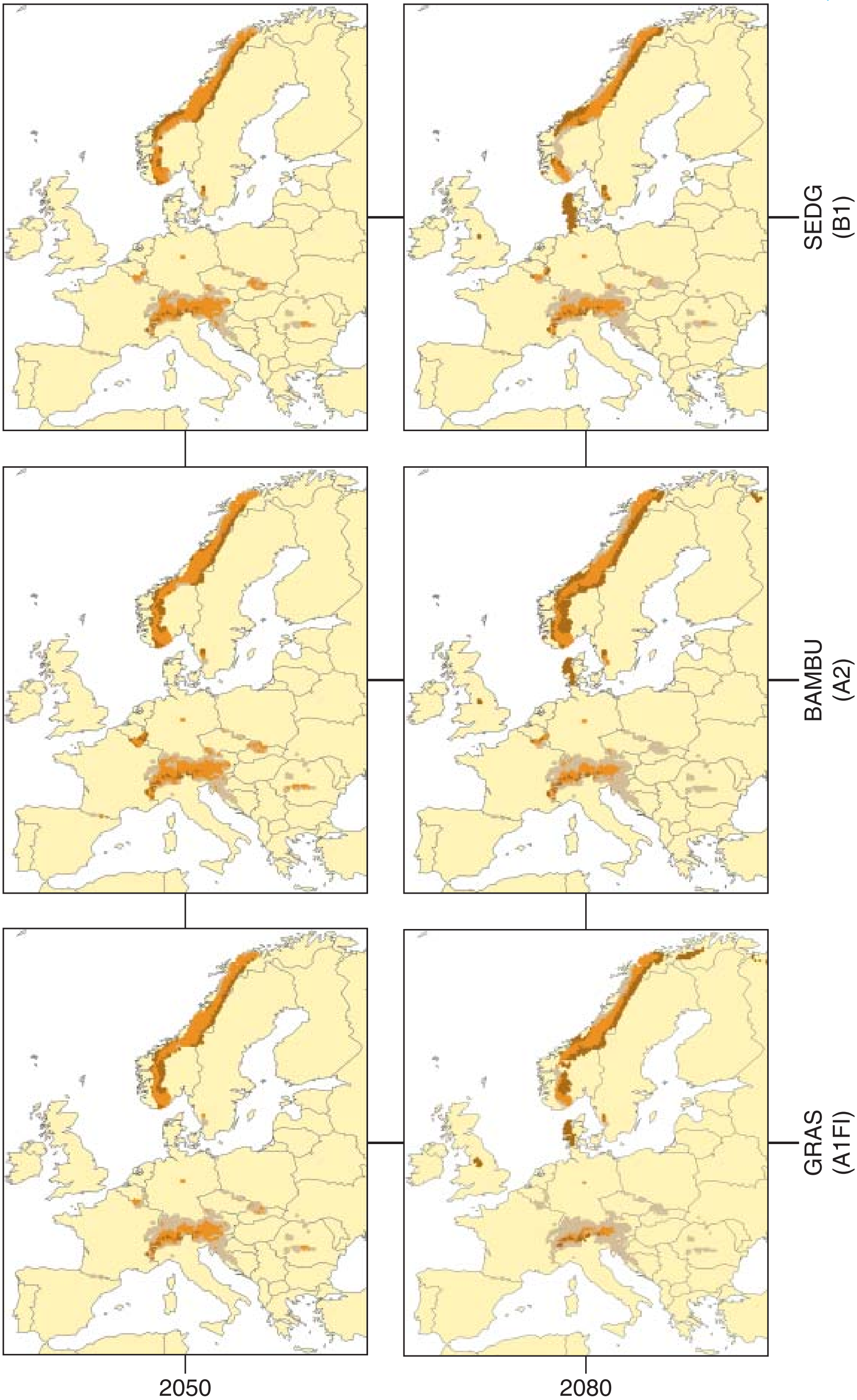
Present distribution can be well explained by climatic variables (AUC = 0.9).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

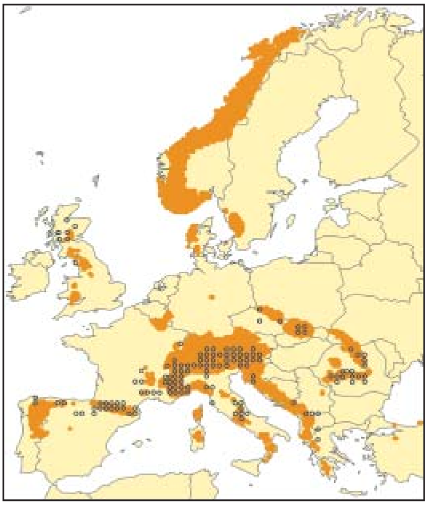
Erebia epiphron (Knoch, 1783) – Mountain Ringlet

		Full dispersal	No dispersal
2050	SEDG	-747 (-23.03%)	-1068 (-32.93%)
	BAMBU	-761 (-23.47%)	-1057 (-32.59%)
	GRAS	-980 (-30.22%)	-1321 (-40.73%)
2080	SEDG	-524 (-16.16%)	-1317 (-40.61%)
	BAMBU	-717 (-22.11%)	-1526 (-47.06%)
	GRAS	-679 (-20.94%)	-1837 (-56.65%)

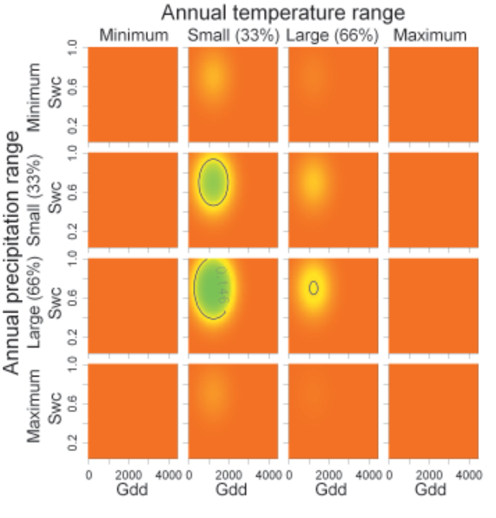
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 3243)

The Mountain Ringlet inhabits mountainous areas that are snow-covered in winter. It is found on damp grasslands and rough vegetation, often in the shelter of a slope or woodland edge. The female lays her eggs on various grasses and sedges, including fescues (*Festuca* spp.), Mat-grass (*Nardus stricta*), and Heath-grass (*Danthonia decumbens*). The caterpillar hibernates twice. It completes the first larval instar before hibernating the first time. By the end of the summer it reaches the last but one stage before hibernating again. The following year, it pupates in the summer, and the butterfly emerges. The Mountain Ringlet is a very variable butterfly with many local and regional subspecies and forms.

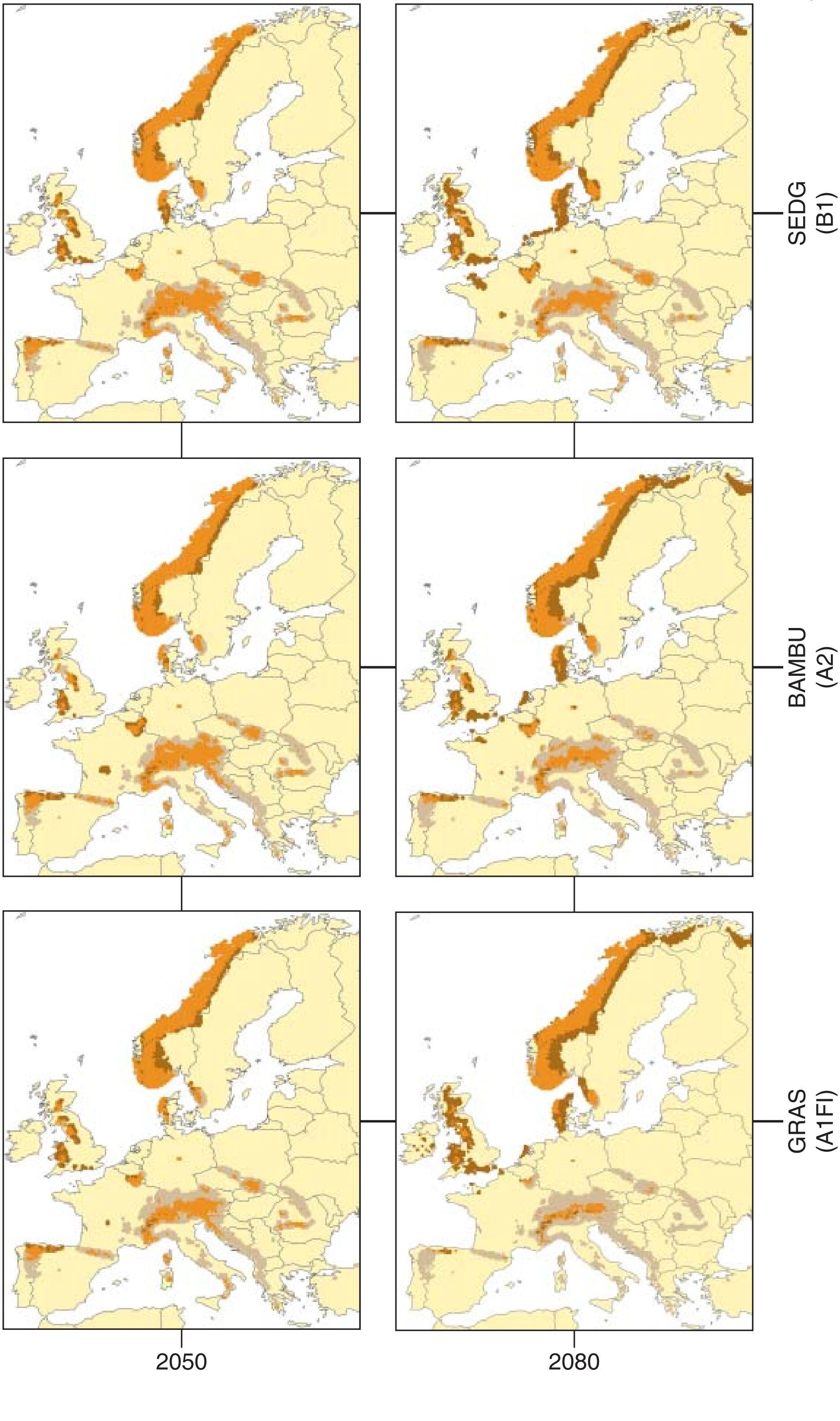
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.84).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia pharte (Hübner, 1804) – Blind Ringlet

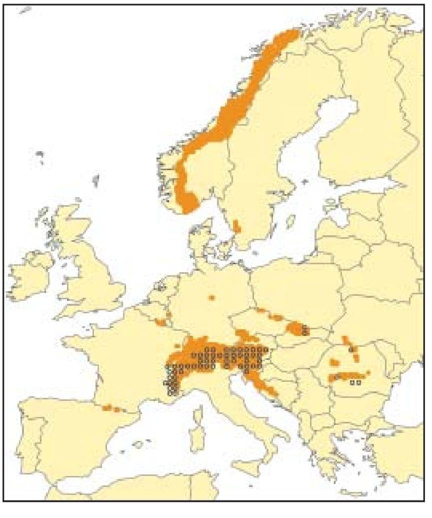
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-284 (-20.94%)	-487 (-35.91%)
	BAMBU	-212 (-15.63%)	-429 (-31.64%)
	GRAS	-337 (-24.85%)	-542 (-39.97%)
2080	SEDG	-428 (-31.56%)	-679 (-50.07%)
	BAMBU	-269 (-19.84%)	-666 (-49.12%)
	GRAS	-426 (-31.42%)	-832 (-61.36%)

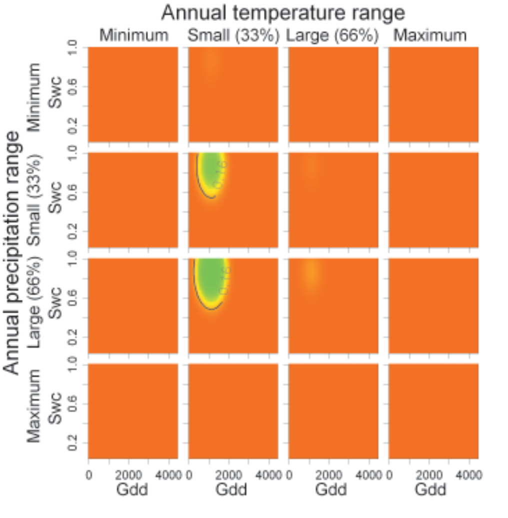
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1356)

This Ringlet owes its rather odd name to the absence of eye-spots on both surfaces of the wings. The Blind Ringlet occurs both on dry and damp grasslands, especially where the vegetation is tall, and in grassy places at the edge of woodland. Above the tree-line, they occur mainly on dry vegetation. They have various foodplants, depending on the habitat. In dry places, the caterpillars can be found on Mat-grass (*Nardus stricta*), *Festuca quadriflora*, and Sheep's Fescue (*F. ovina*), and in damper places in the shade on Red Fescue (*F. rubra*), Glaucous Sedge (*Carex flacca*), and *C. ferruginea*. The caterpillar hibernates twice, pupating at the end of May between spun grass stalks.

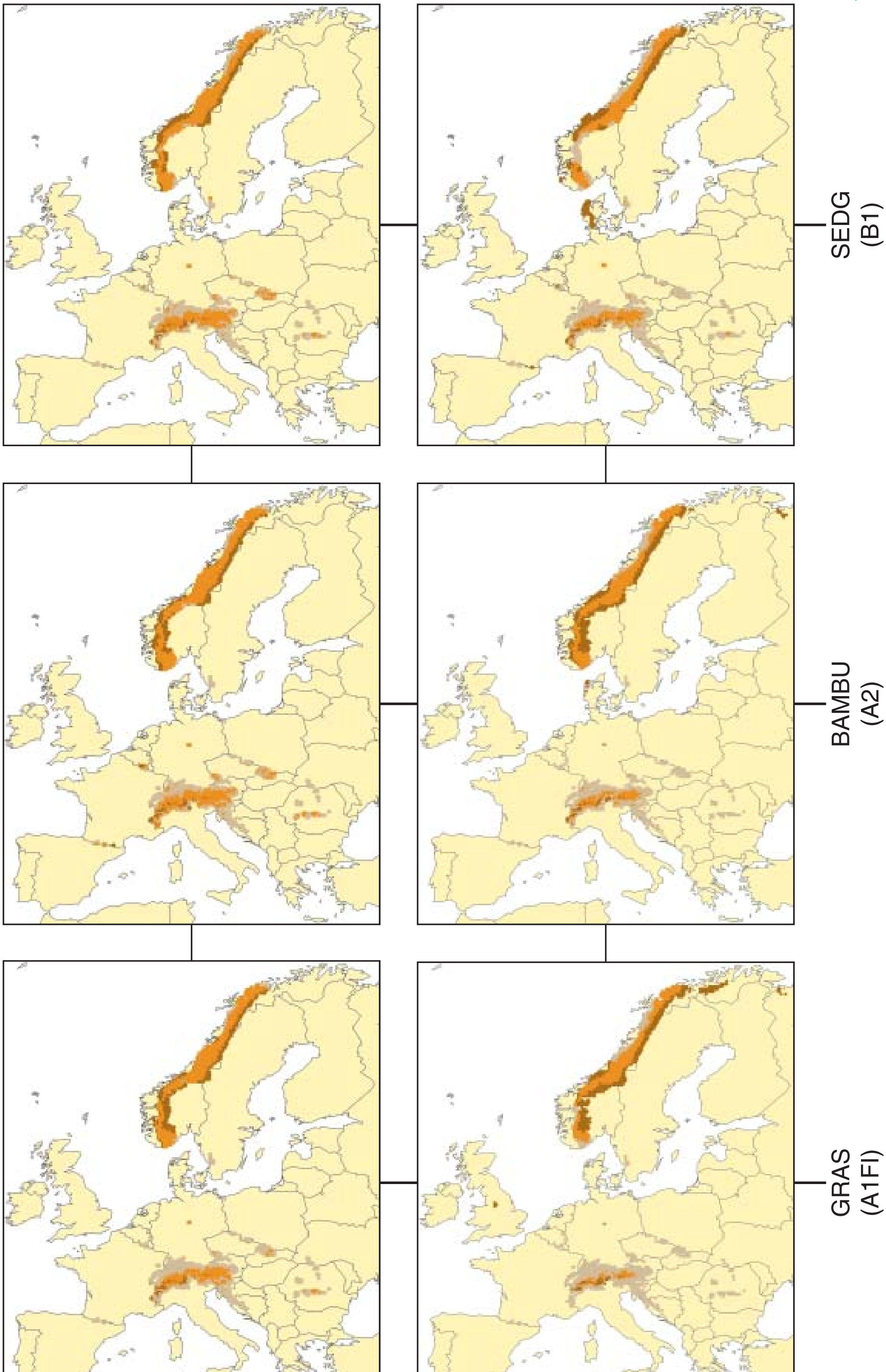
Present distribution can be well explained by climatic variables (AUC = 0.89).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia melampus (Fuessli, 1775) – Lesser Mountain Ringlet

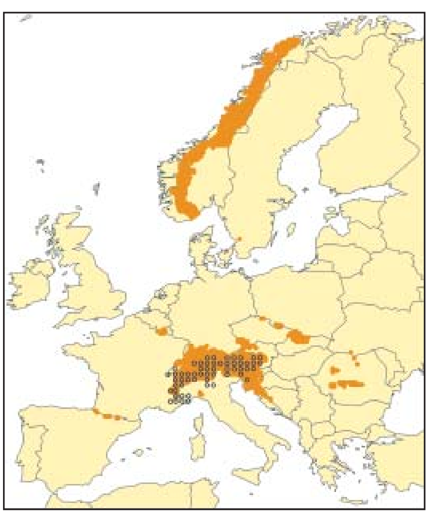
© Martin Wiemers

		Full dispersal	No dispersal
2050	**SEDG**	-333 (-23.43%)	-444 (-31.25%)
	BAMBU	-244 (-17.17%)	-389 (-27.38%)
	GRAS	-413 (-29.06%)	-520 (-36.59%)
2080	**SEDG**	-499 (-35.12%)	-740 (-52.08%)
	BAMBU	-379 (-26.67%)	-686 (-48.28%)
	GRAS	-588 (-41.38%)	-917 (-64.53%)

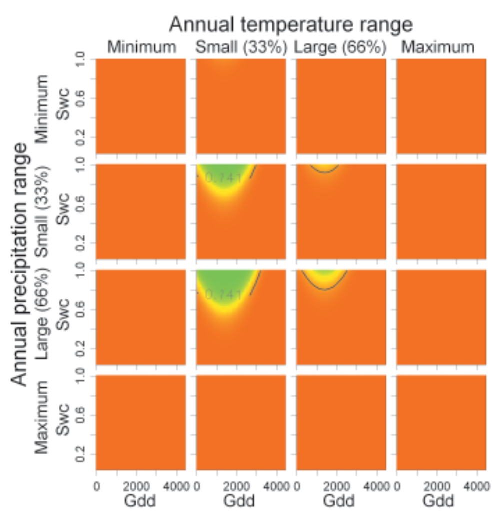
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1421)

The Lesser Mountain Ringlet occurs in many different biotopes. It can be found on wet grasslands, pastures and meadows, on dry, nutrient-poor grasslands in light woodland, on dry grasslands with bracken, and above the tree-line on alpine grasslands. Because of the wide choice in biotope, this butterfly is common throughout the Alps. In the time up to hibernation, the caterpillars feed during the day. After hibernating, they are only active at night. They can be found on Wood Meadow-grass (*Poa nemoralis*), Sweet Vernal-grass (*Anthoxanthum odoratum*), and Sheep's Fescue (*Festuca ovina*). The development from egg to butterfly takes one year.

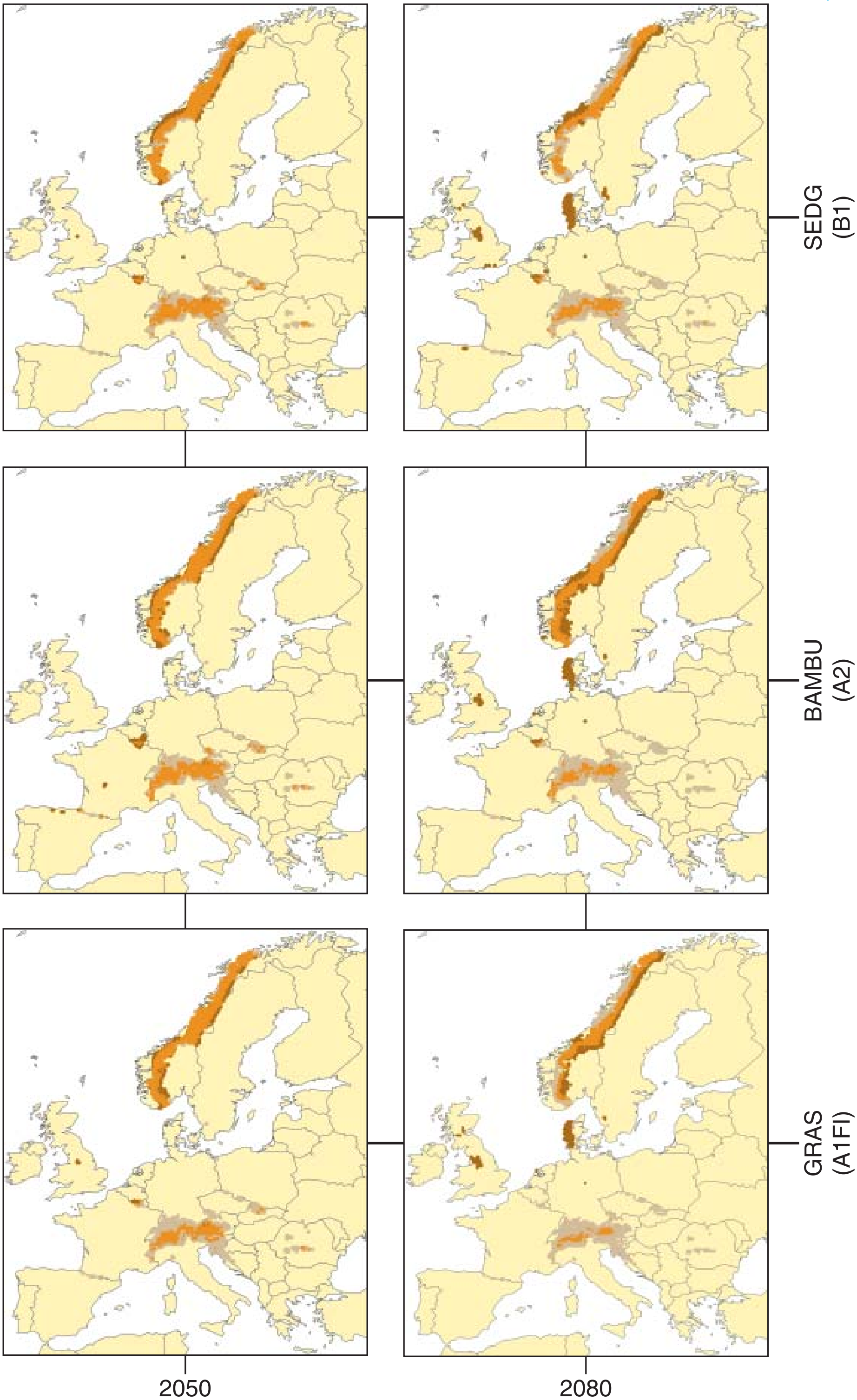
Present distribution can be very well explained by climatic variables (AUC = 0.98).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia aethiops (Esper, 1777) – Scotch Argus

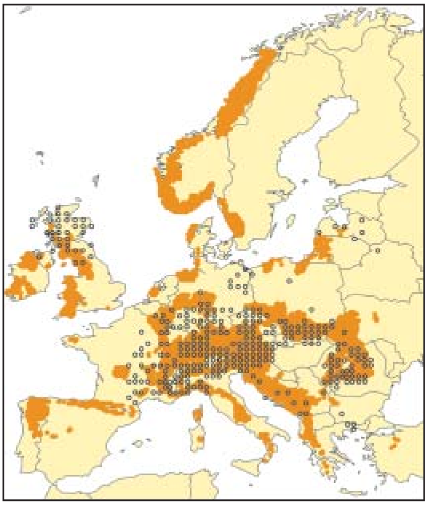
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-968 (-21.4%)	-1883 (-41.63%)
	BAMBU	-519 (-11.47%)	-1542 (-34.09%)
	GRAS	-1395 (-30.84%)	-2226 (-49.22%)
2080	SEDG	491 (10.86%)	-1899 (-41.99%)
	BAMBU	316 (6.99%)	-2318 (-51.25%)
	GRAS	548 (12.12%)	-2876 (-63.59%)

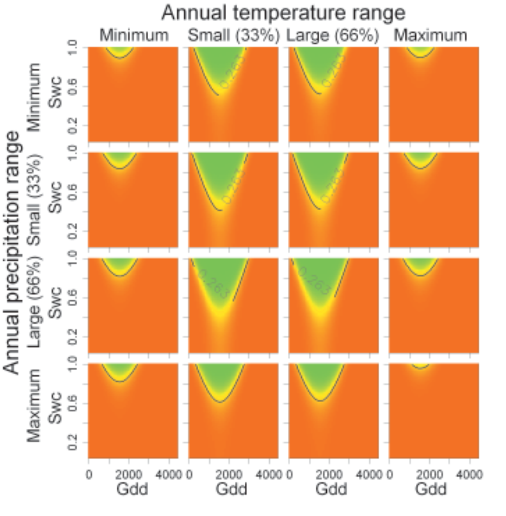
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 4523)

The Scotch Argus can be found in a wide variety of habitats. It inhabits flower-rich grasslands and grassy woodland clearings, and can also be found on heathland, bogs and marshy areas with very open woodland. Many different grasses can be used as a foodplant, such as Purple Moor-grass (*Molinea caerulea*), Blue Moor-grass (*Sesleria albicans*), Tor-grass (*Brachypodium pinnatum*), Cock's-foot (*Dactylus glomerata*), fescues (*Festuca* spp.), cat's-tails (*Phleum* spp.), Sweet Vernal-grass (*Anthoxanthum odoratum*), and Quaking Grass (*Briza media*), and also sedges (*Carex* spp.). The caterpillar hibernates in the second or third larval instar. It pupates in the litter layer, and is single-brooded.

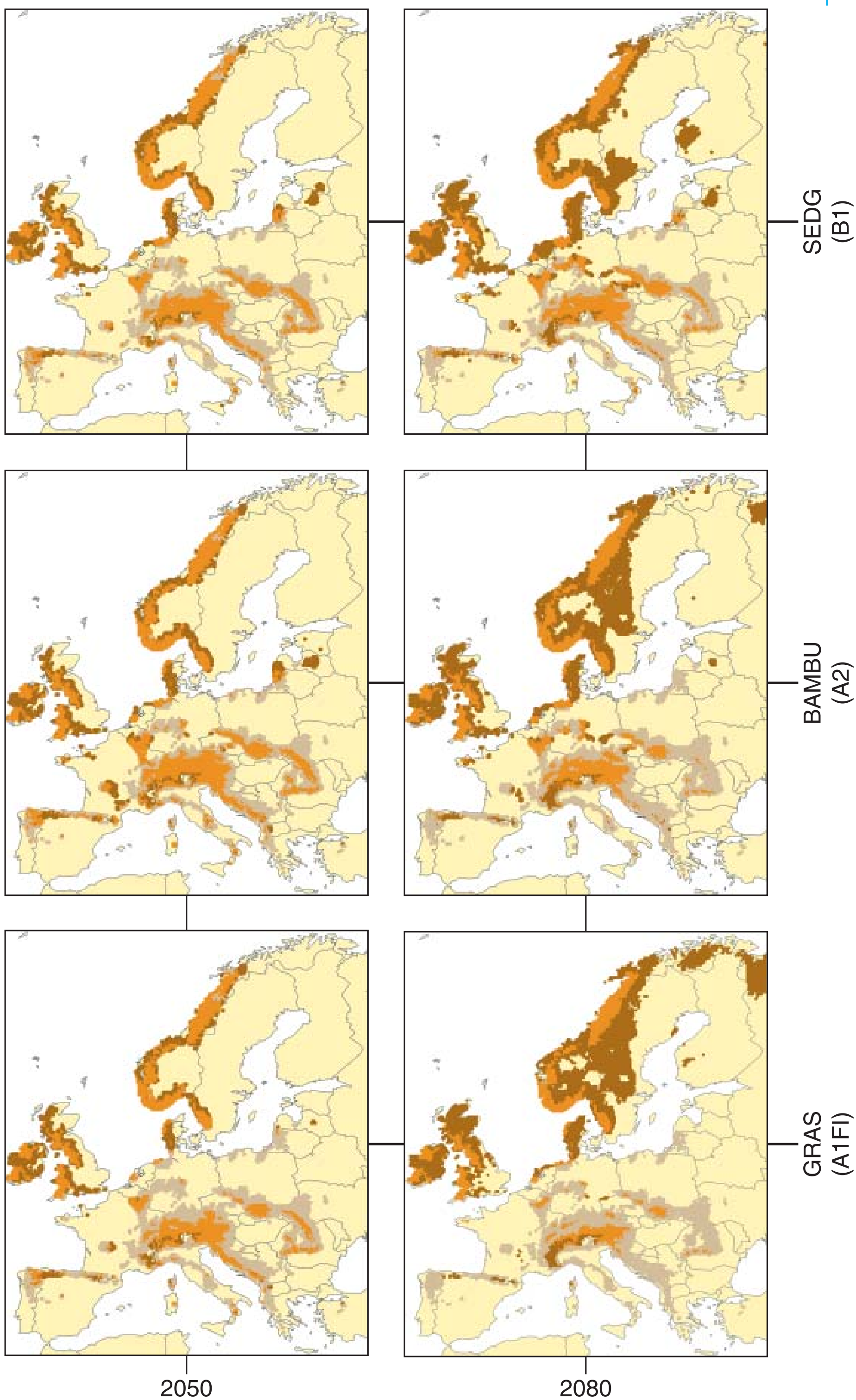
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.82).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia triaria (Prunner, 1798) – de Prunner's Ringlet

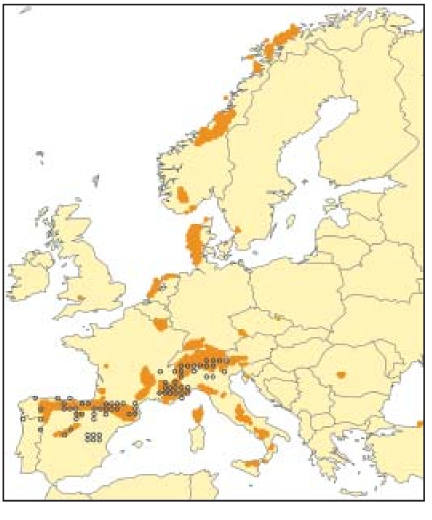
© Bernard Fransen

		Full dispersal	No dispersal
2050	SEDG	70 (5.99%)	-590 (-50.47%)
	BAMBU	7 (0.6%)	-608 (-52.01%)
	GRAS	-66 (-5.65%)	-690 (-59.02%)
2080	SEDG	-255 (-21.81%)	-877 (-75.02%)
	BAMBU	-236 (-20.19%)	-847 (-72.46%)
	GRAS	-285 (-24.38%)	-943 (-80.67%)

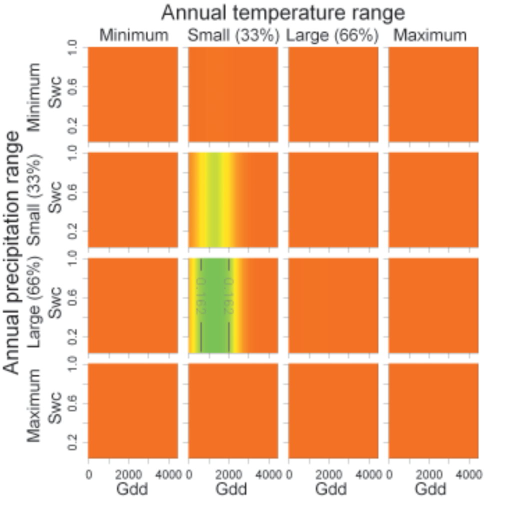
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1169)

In the Alps, de Prunner's Ringlet is found on very dry grasslands with scattered rocks, whereas more to the south it occurs in clearings in woods growing on rocky ground, in Spain in clearings in pine forests on limestone. Its foodplants are Sheep's-fescue (*Festuca ovina*), Smooth Meadow-grass (*Poa pratensis*), Alpine Meadow-grass (*P. alpina*), and Feather-grass (*Stipa pinnata*). It hibernates as a caterpillar and has one brood a year.

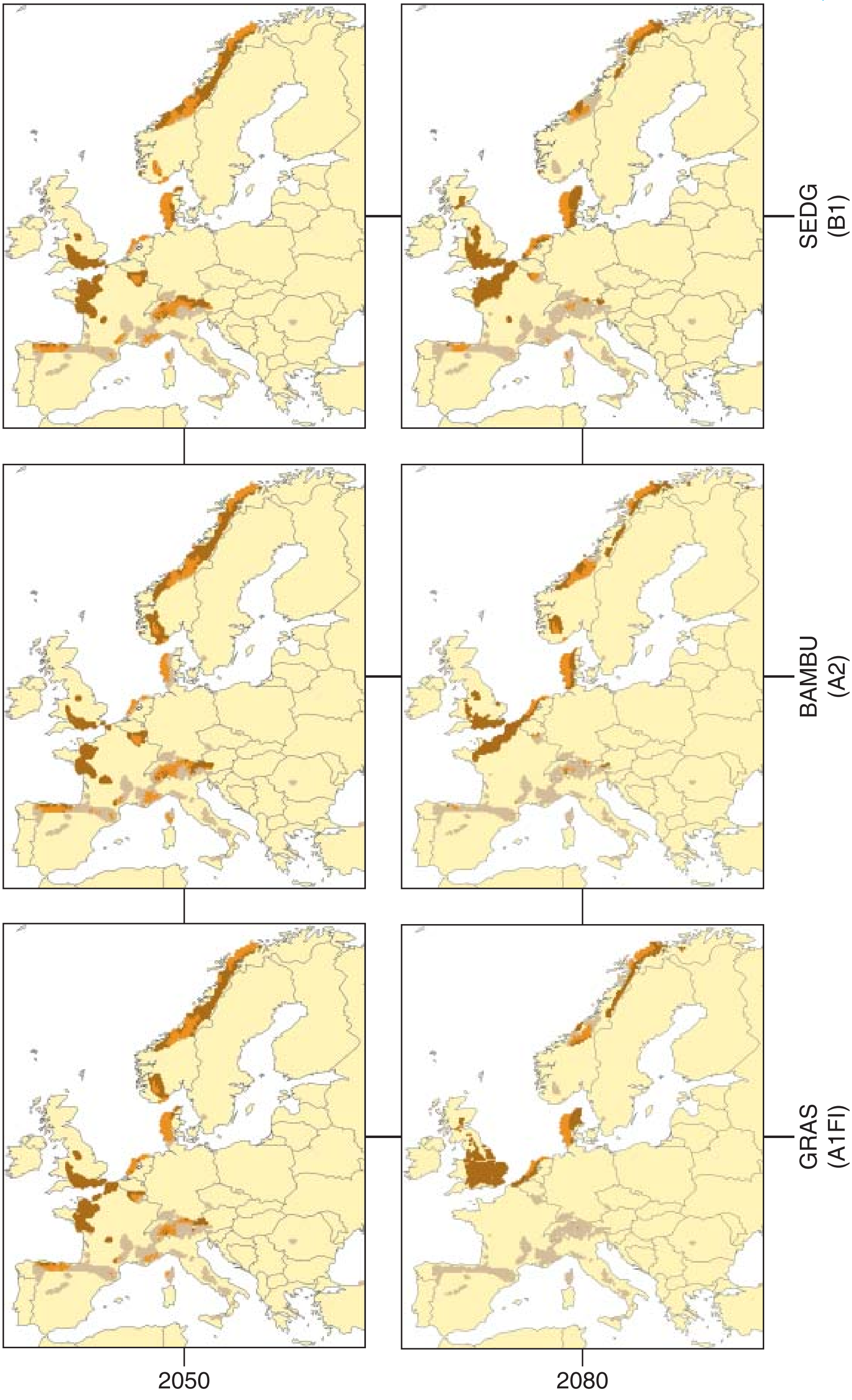
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.81). Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG (B1)
BAMBU (A2)
GRAS (A1FI)
2050
2080

Erebia embla (Becklin, 1791) – Lapland Ringlet

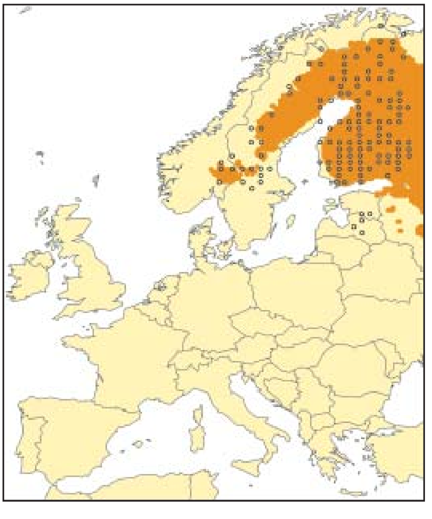
© Jostein Engdal

		Full dispersal	No dispersal
2050	SEDG	-835 (-21.95%)	-1141 (-29.99%)
	BAMBU	-782 (-20.56%)	-1145 (-30.1%)
	GRAS	-806 (-21.19%)	-1207 (-31.73%)
2080	SEDG	-1583 (-41.61%)	-1864 (-49%)
	BAMBU	-1605 (-42.19%)	-2010 (-52.84%)
	GRAS	-2238 (-58.83%)	-2592 (-68.14%)

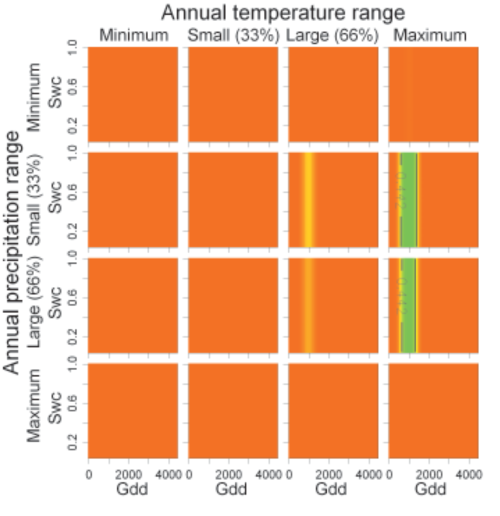
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 3804)

The Lapland Ringlet inhabits bogs and marshes with sedges and grasses, and scattered groups of willows and myrtle. The marshes are often situated in coniferous or birch woods. Its foodplants are probably sedges (*Carex* spp.), Tufted Hair-grass (*Deschampsia cespitosa*), and Bog Hair-grass (*D. setacea*). These butterflies are difficult to find because they are shy and always occur in low numbers. Also, their habitat is very inaccessible. The development of the Lapland Ringlet takes two years.

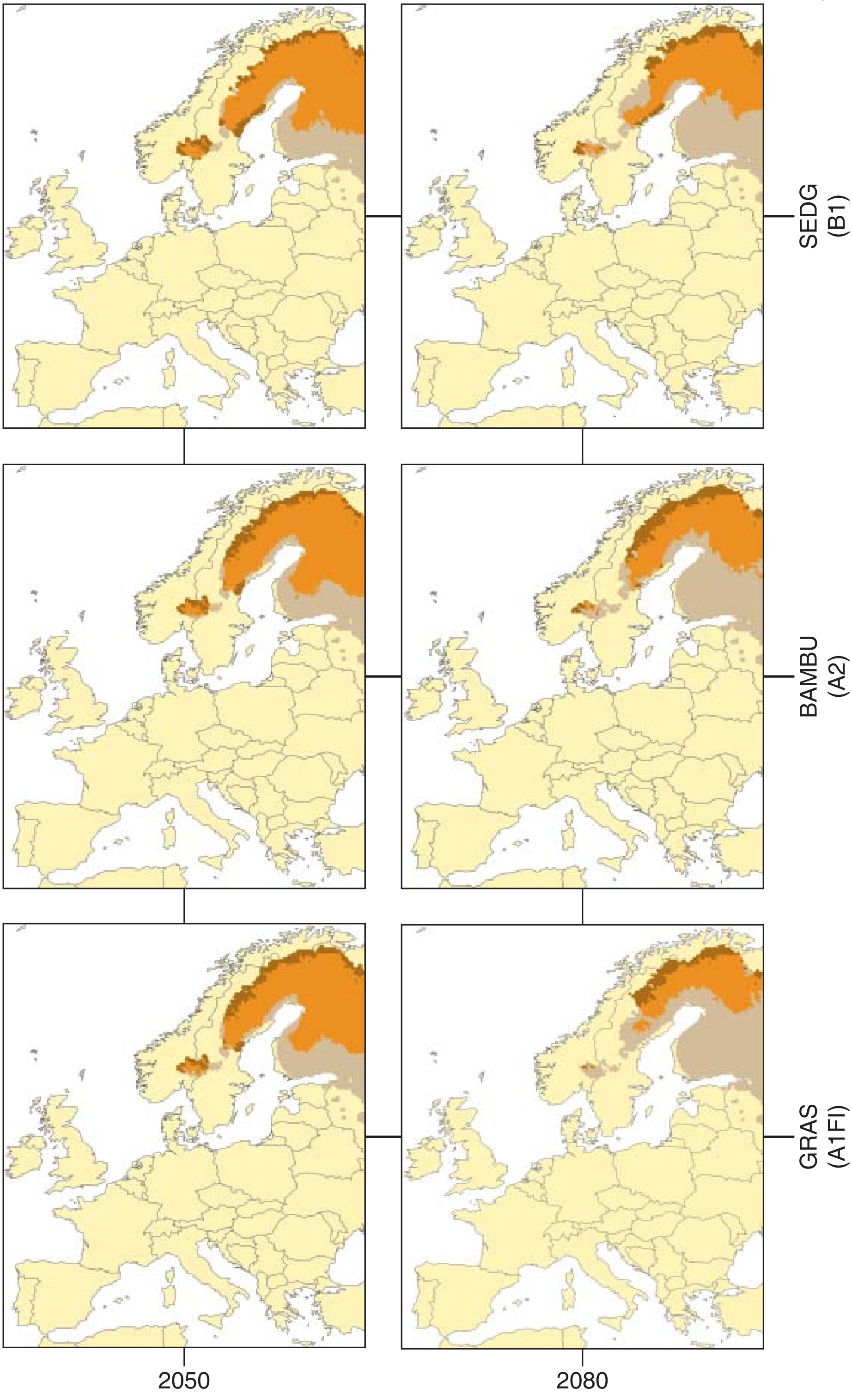
Present distribution can be very well explained by climatic variables (AUC = 0.97).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia disa (Becklin, 1791) – Arctic Ringlet

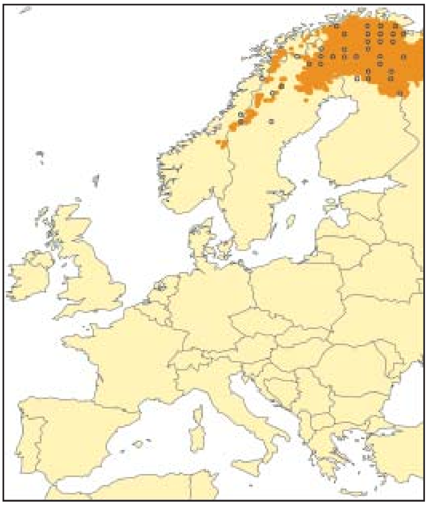
© Jostein Engdal

		Full dispersal	No dispersal
2050	SEDG	-1068 (-72.41%)	-1242 (-84.2%)
	BAMBU	-956 (-64.81%)	-1166 (-79.05%)
	GRAS	-1025 (-69.49%)	-1249 (-84.68%)
2080	SEDG	-1285 (-87.12%)	-1446 (-98.03%)
	BAMBU	-1347 (-91.32%)	-1470 (-99.66%)
	GRAS	-1405 (-95.25%)	-1472 (-99.8%)

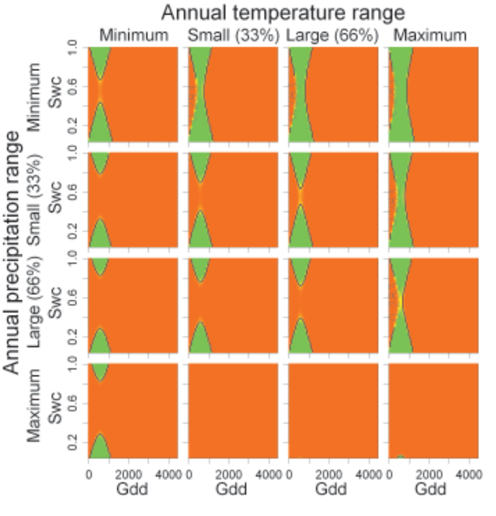
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1475)

Just like the Lapland Ringlet (*E. embla*), the Arctic Ringlet is a marsh butterfly, but the two species do not overlap, the Arctic Ringlet avoiding lowland marshes. It occurs above 350 m altitude, on open marshes in woods, namely marshes with a low cover of grasses and sedges without trees or bushes, although surrounded by birch trees. It also occurs at lakesides and near small streams and is also seen in woodland clearings in its search for nectar. Its foodplants are grasses. It takes two years for the egg to develop into a butterfly.

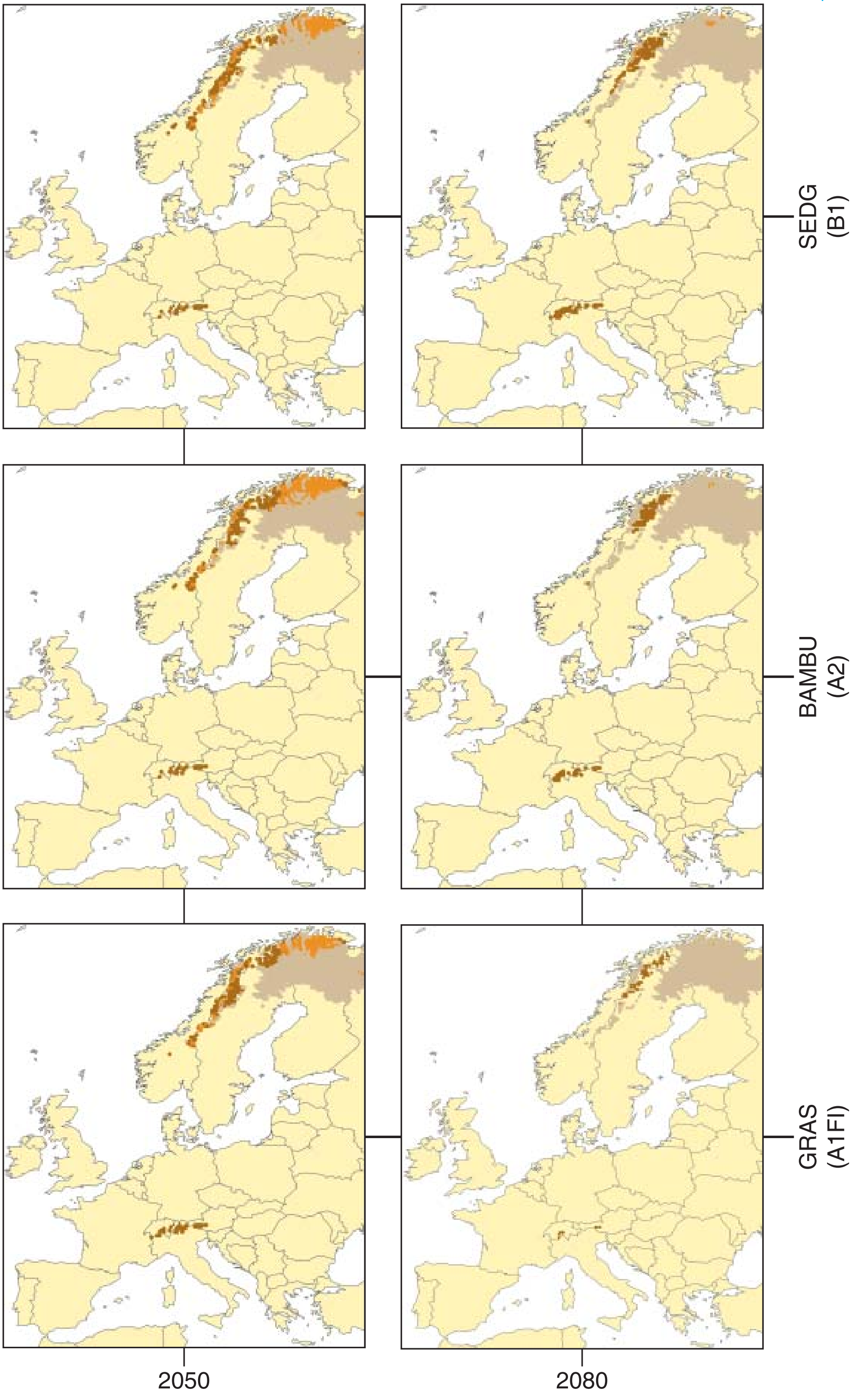
Present distribution can be very well explained by climatic variables (AUC = 0.99).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia medusa (Fabricius, 1787) – Woodland Ringlet

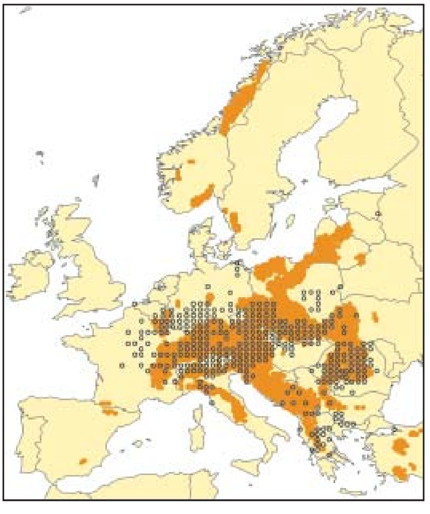
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-943 (-22.87%)	-1907 (-46.24%)
	BAMBU	-151 (-3.66%)	-1635 (-39.65%)
	GRAS	-1416 (-34.34%)	-2279 (-55.26%)
2080	SEDG	304 (7.37%)	-2199 (-53.32%)
	BAMBU	106 (2.57%)	-2660 (-64.5%)
	GRAS	-111 (-2.69%)	-3288 (-79.73%)

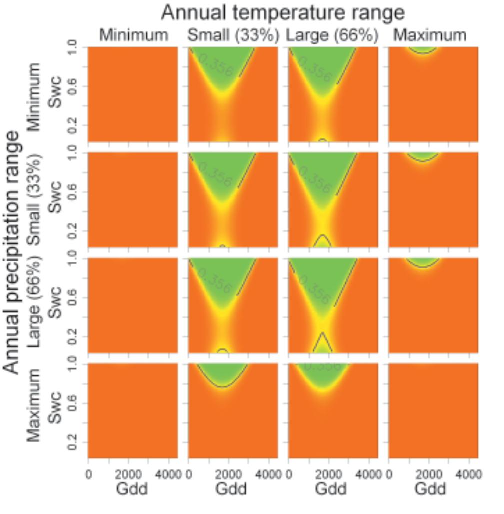
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 4124)

The Woodland Ringlet occurs in many different biotopes. It can be found on damp, flower-rich grasslands and rough vegetation near or in woodland, in marshes, but also on calcareous grasslands. Its foodplants are various grasses, such as Purple Moor-grass (*Molinea caerulea*), fescues (*Festuca* spp.), Tor-grass (*Brachypodium pinnatum*), Upright Brome (*Bromus erectus*), and Wood Millet (*Milium effusum*), and also sedges (*Carex* spp.). The caterpillar is active at night and mostly hibernates when half-grown, but at very high altitudes it may hibernate twice. It pupates in the litter layer. The development takes between one and two years.

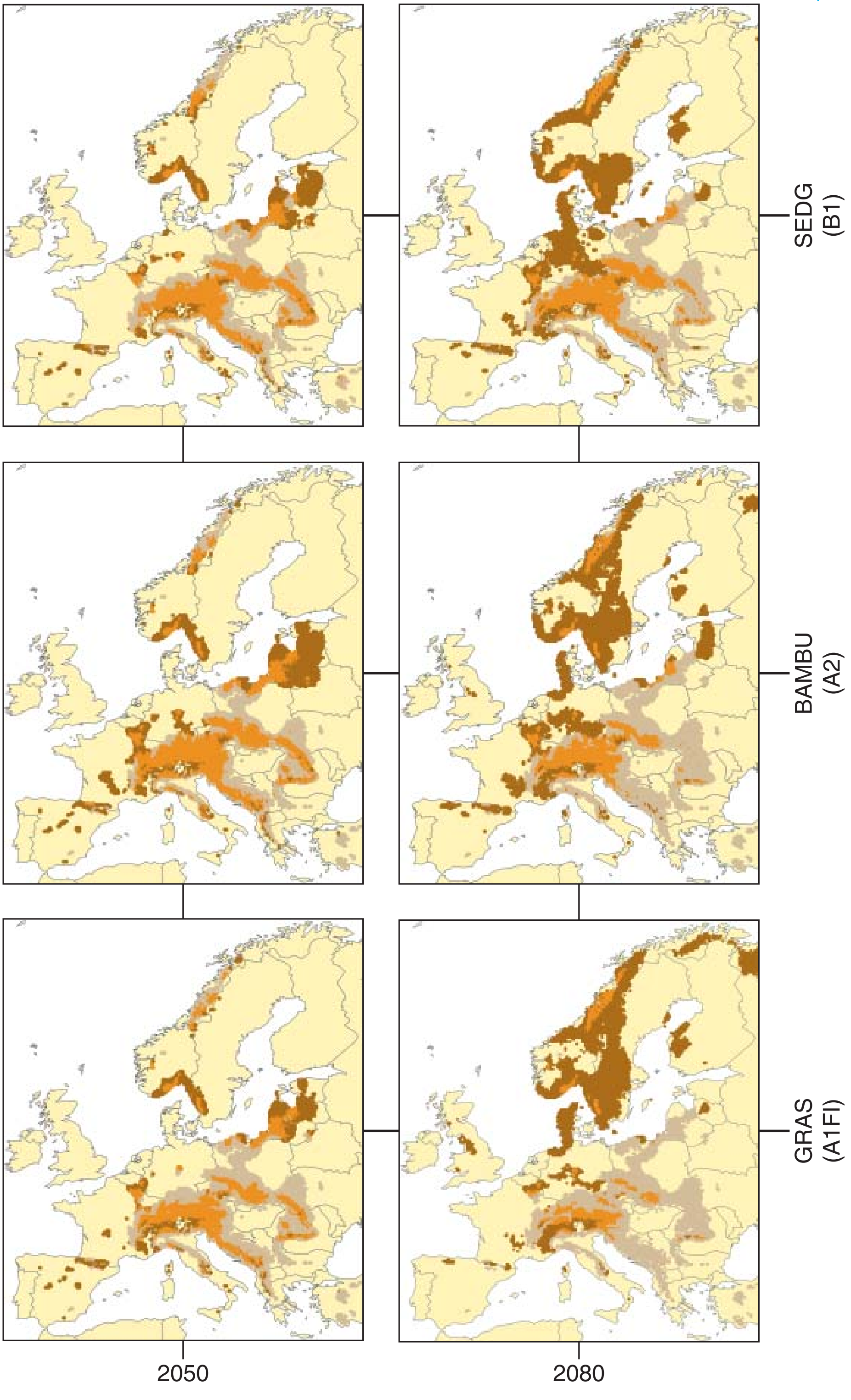
Present distribution can be well explained by climatic variables (AUC = 0.9).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia alberganus (Prunner, 1798) – Almond-eyed Ringlet

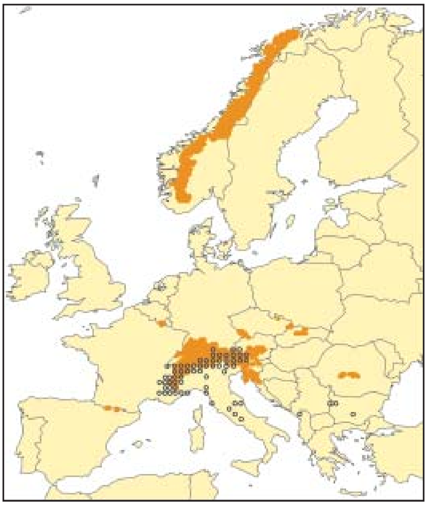
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-208 (-20.29%)	-328 (-32%)
	BAMBU	-95 (-9.27%)	-258 (-25.17%)
	GRAS	-244 (-23.8%)	-352 (-34.34%)
2080	SEDG	-427 (-41.66%)	-585 (-57.07%)
	BAMBU	-276 (-26.93%)	-483 (-47.12%)
	GRAS	-513 (-50.05%)	-685 (-66.83%)

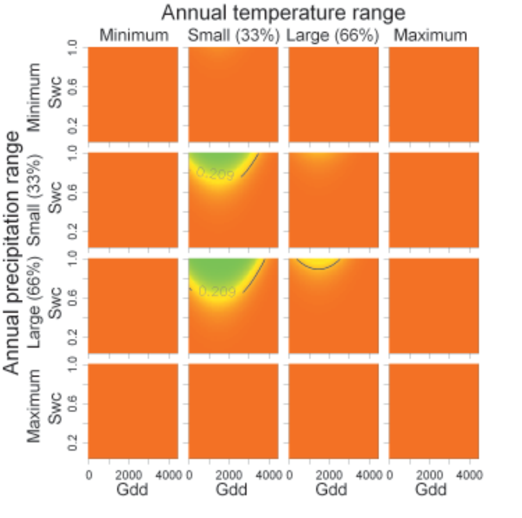
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1025)

The Almond-eyed Ringlet is found on sub-alpine grasslands, and on, sometimes damp, grasslands, in woodland clearings or in the shelter of woods. The butterflies can often be seen on flowers, drinking nectar. On warm days, the males congregate to drink on damp patches. In the Alps, the caterpillars feed on Sheep's Fescue (*Festuca ovina*) and Sweet Vernal-grass (*Anthoxanthum odoratum*). They hibernate when half-grown, and pupate at the end of the following spring.

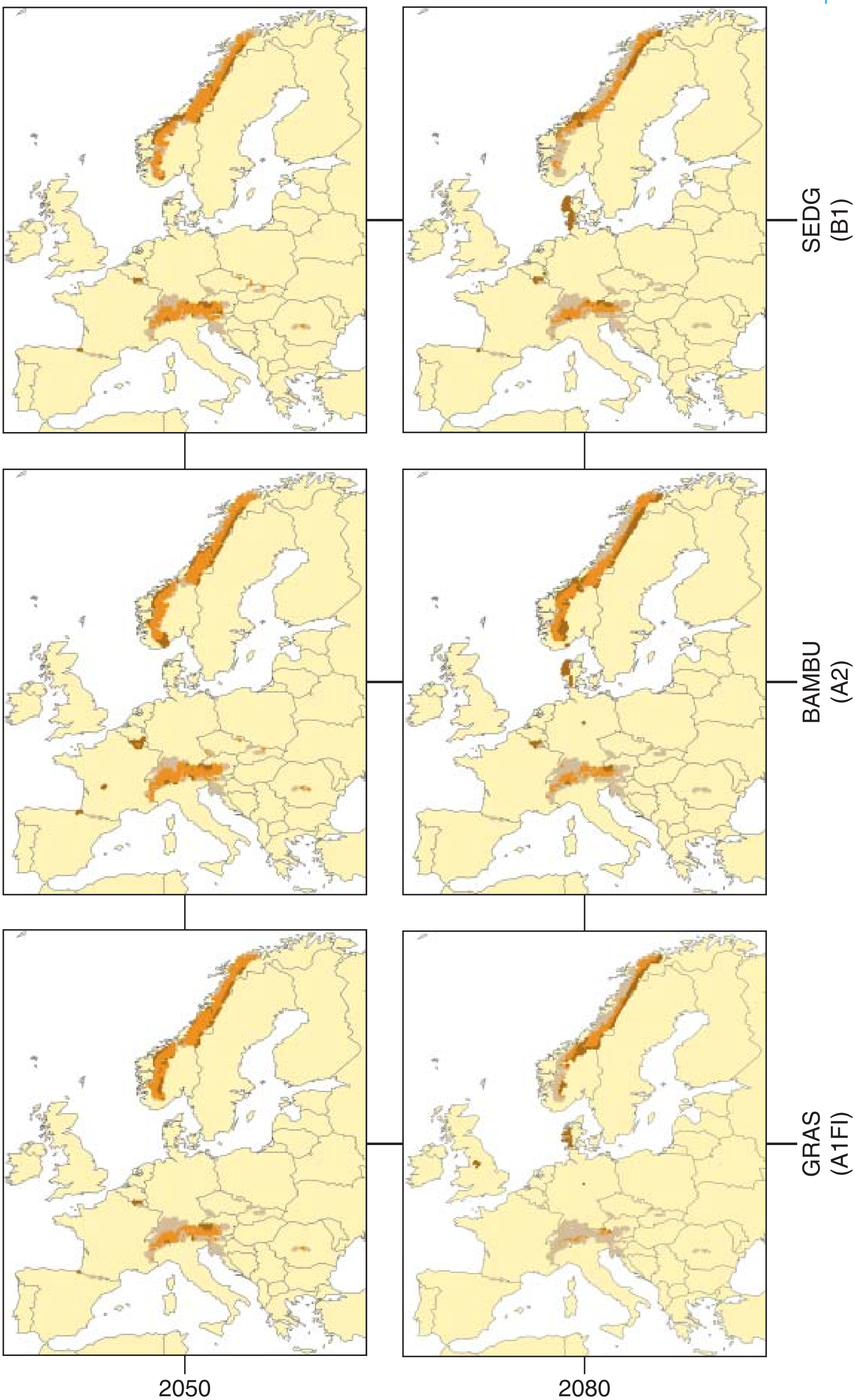
Present distribution can be well explained by climatic variables (AUC = 0.87).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold



SEDG (B1)
BAMBU (A2)
GRAS (A1FI)
2050
2080

Erebia pluto (Prunner, 1798) – Sooty Ringlet

© Kars Veling

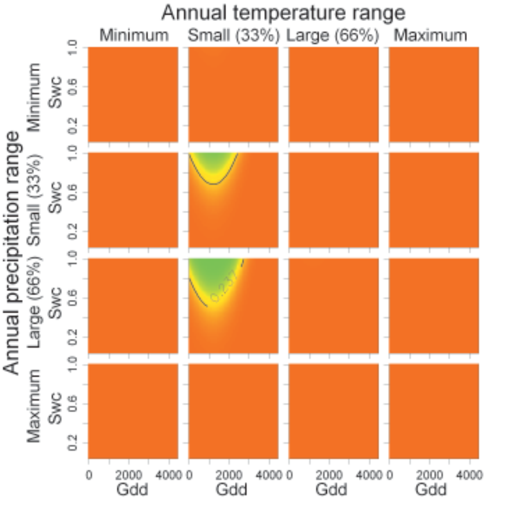
		Full dispersal	No dispersal
2050	SEDG	-189 (-21.4%)	-306 (-34.65%)
	BAMBU	-145 (-16.42%)	-274 (-31.03%)
	GRAS	-239 (-27.07%)	-353 (-39.98%)
2080	SEDG	-437 (-49.49%)	-597 (-67.61%)
	BAMBU	-285 (-32.28%)	-467 (-52.89%)
	GRAS	-468 (-53%)	-648 (-73.39%)

Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 883)

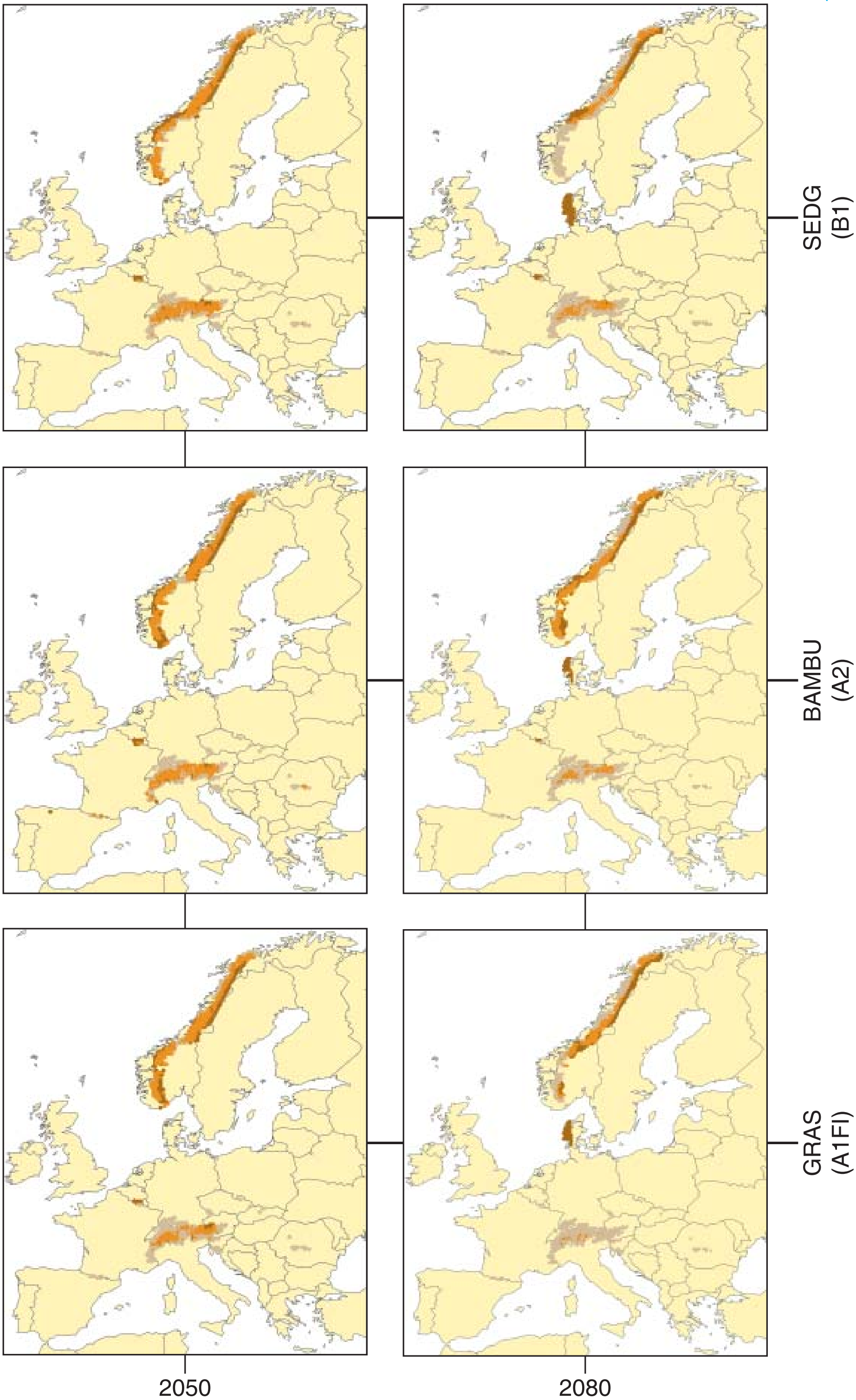
The Sooty Ringlet is a butterfly of mountainous areas with everlasting snows and glaciers. It occurs high up, on steep screes and moraines, breeding on patches with a mosaic of sparse vegetation and small stones. The female deposits the pale-coloured eggs on mostly light-coloured stones. Once the caterpillar has emerged from the egg, it sometimes has to travel some distance before finding one of the grasses it uses as a foodplant. Caterpillars have been found on the fescues *Festuca halleri* and *F. quadriflora*, as well as on Annual Meadow-grass (*Poa annua*). The caterpillars take two or possibly three years to develop.

Present distribution can be very well explained by climatic variables (AUC = 0.98).
Climate risk category: HR.

Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold



SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia gorge (Esper, 1805) – Silky Ringlet

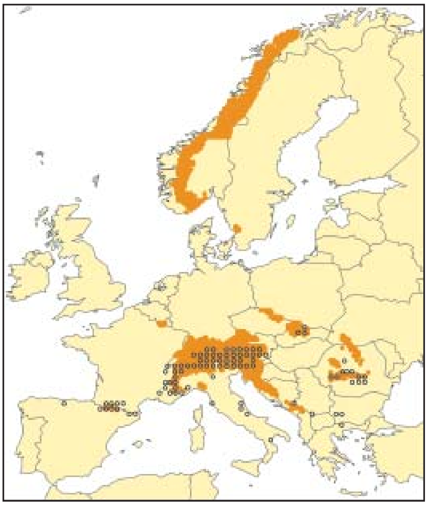
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-452 (-26.49%)	-578 (-33.88%)
	BAMBU	-375 (-21.98%)	-538 (-31.54%)
	GRAS	-602 (-35.29%)	-717 (-42.03%)
2080	SEDG	-587 (-34.41%)	-884 (-51.82%)
	BAMBU	-534 (-31.3%)	-900 (-52.75%)
	GRAS	-721 (-42.26%)	-1128 (-66.12%)

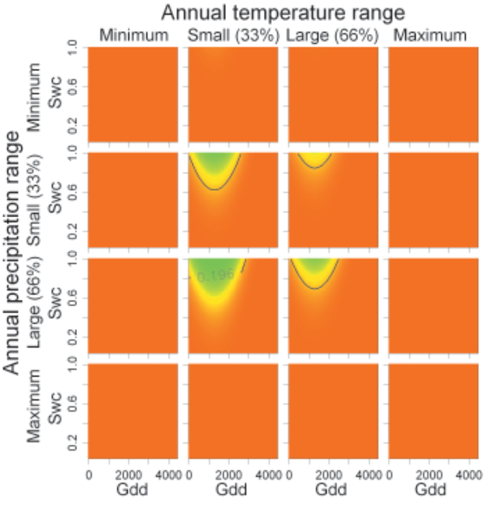
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1706)

The Silky Ringlet can be found on screes, sunny, rocky slopes, and dry grasslands with scattered rocks. The butterflies often bask in the sun on stones, but, their wings closed, they are hardly noticeable. They are rarely seen visiting flowers. The caterpillars are found on fescues (*Festuca* spp.), Alpine Meadow-grass (*Poa alpina*), *P. minor,* and Blue Moor-grass (*Sesleria albicans*). The caterpillars take two years to develop.

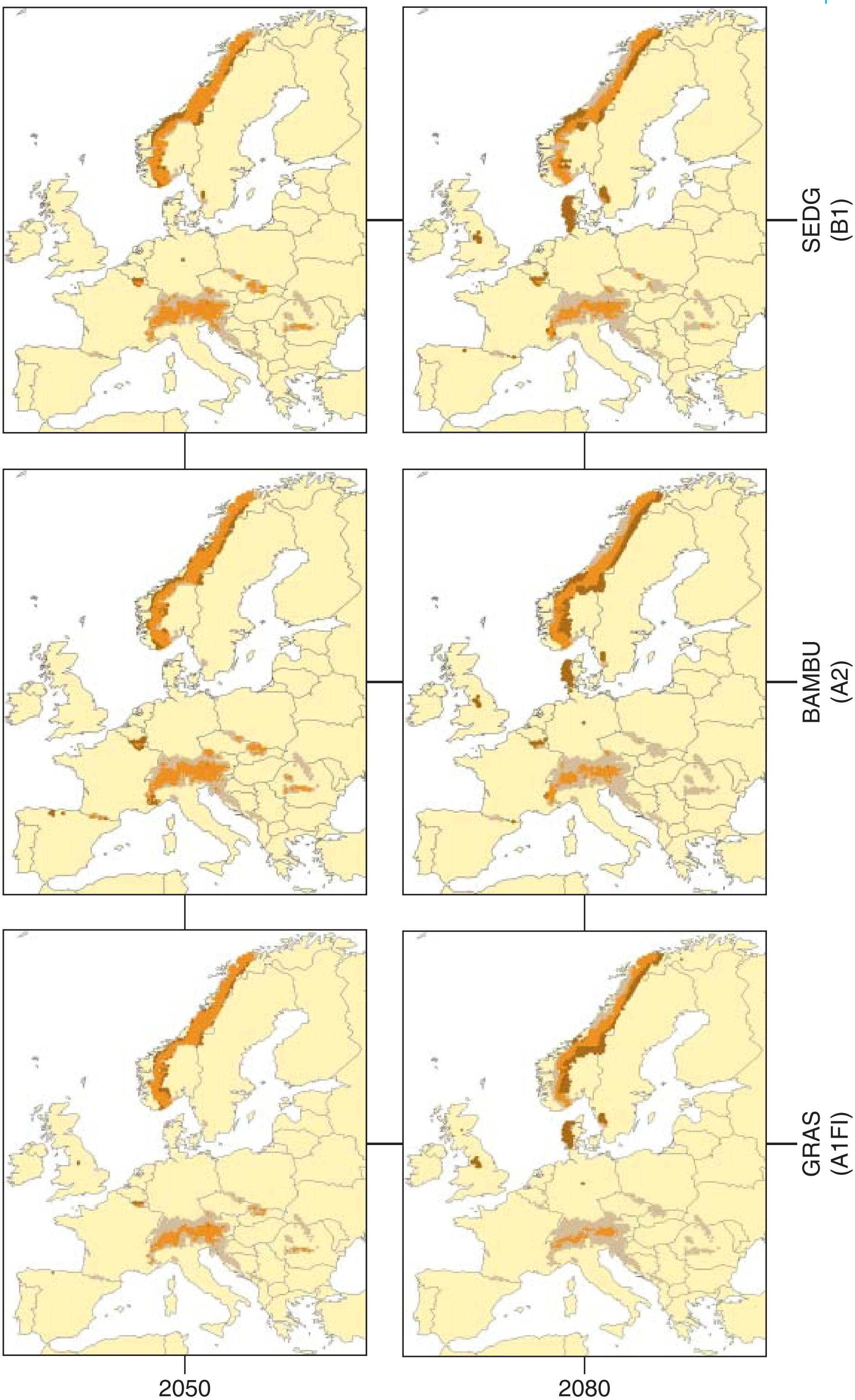
Present distribution can be well explained by climatic variables (AUC = 0.88).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia mnestra (Esper, 1805) – Mnestra's Ringlet

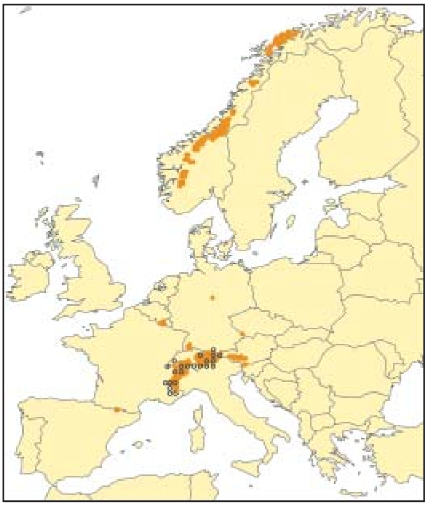
© Martin Wiemers

		Full dispersal	No dispersal
2050	SEDG	72 (25.71%)	-119 (-42.5%)
	BAMBU	160 (57.14%)	-68 (-24.29%)
	GRAS	75 (26.79%)	-108 (-38.57%)
2080	SEDG	-169 (-60.36%)	-216 (-77.14%)
	BAMBU	-69 (-24.64%)	-173 (-61.79%)
	GRAS	-185 (-66.07%)	-241 (-86.07%)

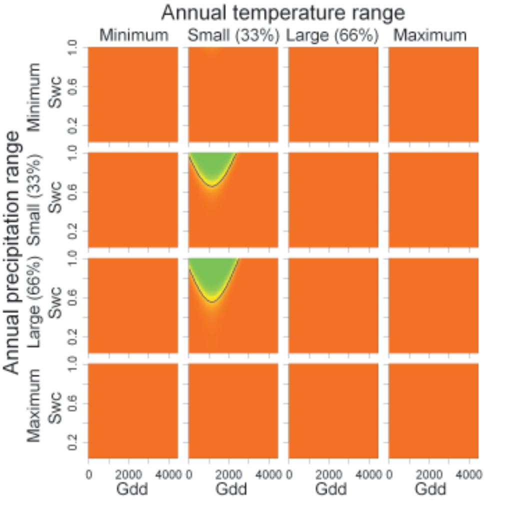
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 280)

Mnestra's Ringlet occurs on sub-alpine and alpine grasslands, especially dry grasslands on steep, sunny slopes. The butterflies are seldom seen on flowers, drinking nectar. The female lays her eggs close to the ground on dry stalks of grass. The plain green caterpillars have been found on fescues (*Festuca* spp.) and also on Blue Moor-grass (*Sesleria albicans*). They hibernate twice.

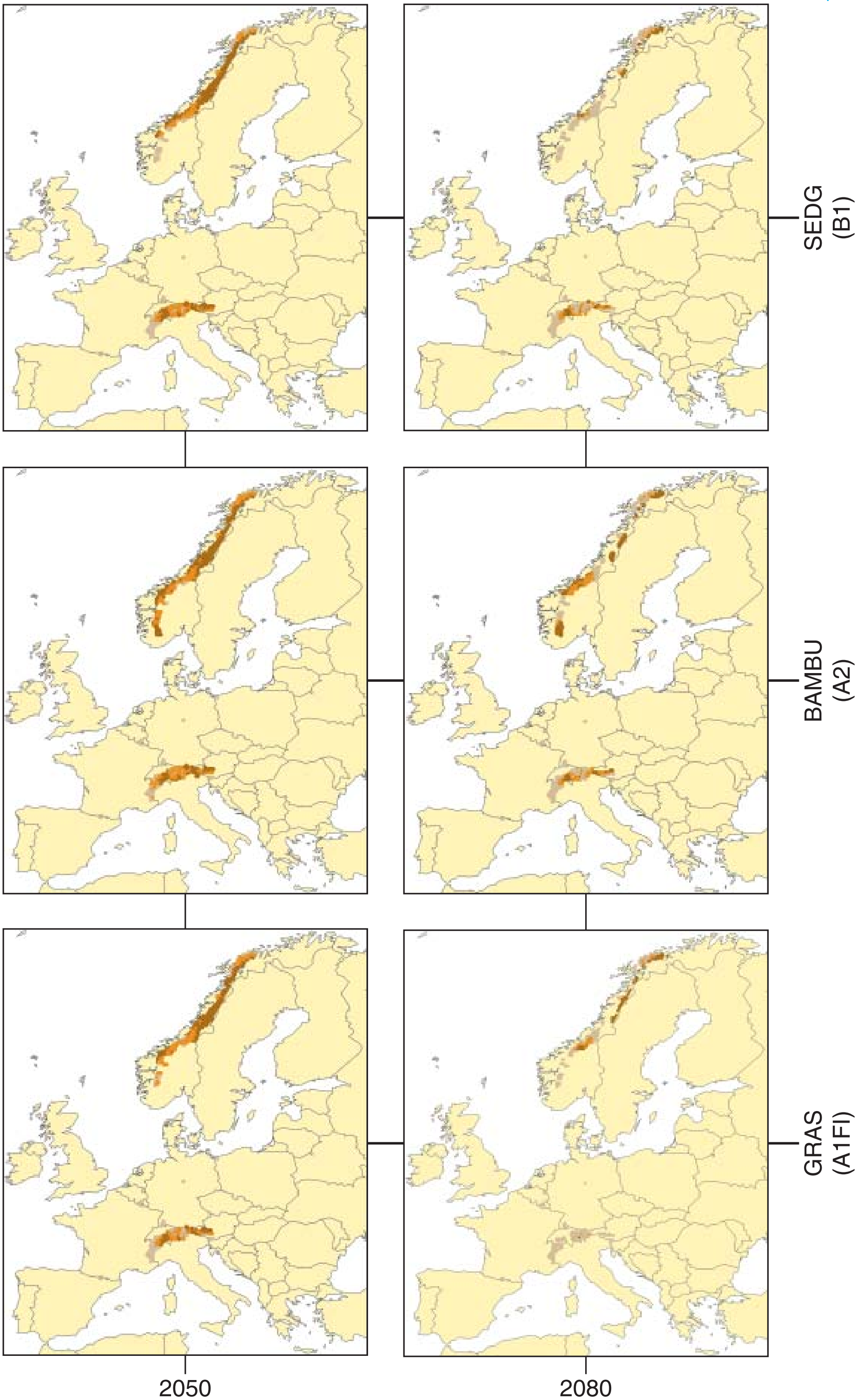
Present distribution can be very well explained by climatic variables (AUC = 0.96).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia epistygne (Hübner, 1819) – Spring Ringlet

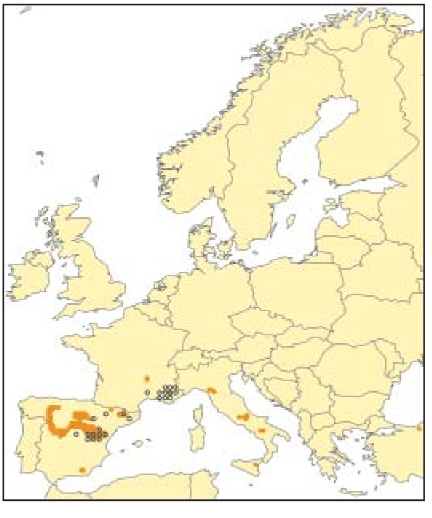
© Bernard Fransen

		Full dispersal	No dispersal
2050	SEDG	-137 (-79.65%)	-162 (-94.19%)
	BAMBU	-165 (-95.93%)	-167 (-97.09%)
	GRAS	-165 (-95.93%)	-170 (-98.84%)
2080	SEDG	-166 (-96.51%)	-172 (-100%)
	BAMBU	-172 (-100%)	-172 (-100%)
	GRAS	-172 (-100%)	-172 (-100%)

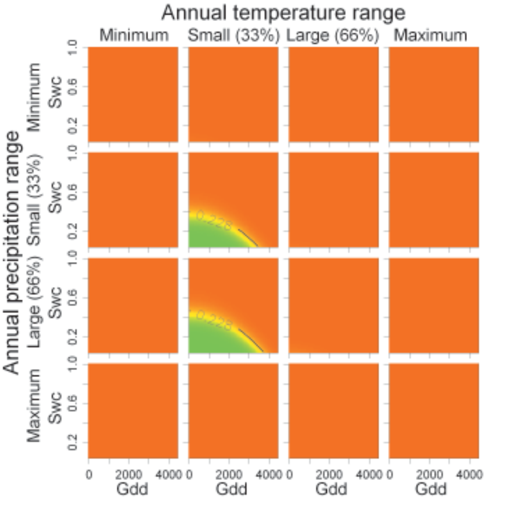
Changes in climatic niche distribution (in 10'×10' grid cells; present niche space: 172)

The Spring Ringlet appears in the early spring in grassy, rocky clearings in light woodland. The Spanish populations in the Montes Universales occur in clearings or on level ground in light pinewoods on calcareous soil, on short, grassy vegetation with low shrubs and scattered rocks. The main foodplant is Sheep's-fescue (*Festuca ovina*), but other fescues and meadow-grasses (*Poa* spp.) have also been named as foodplants. *E. epistygne* has one generation per year.

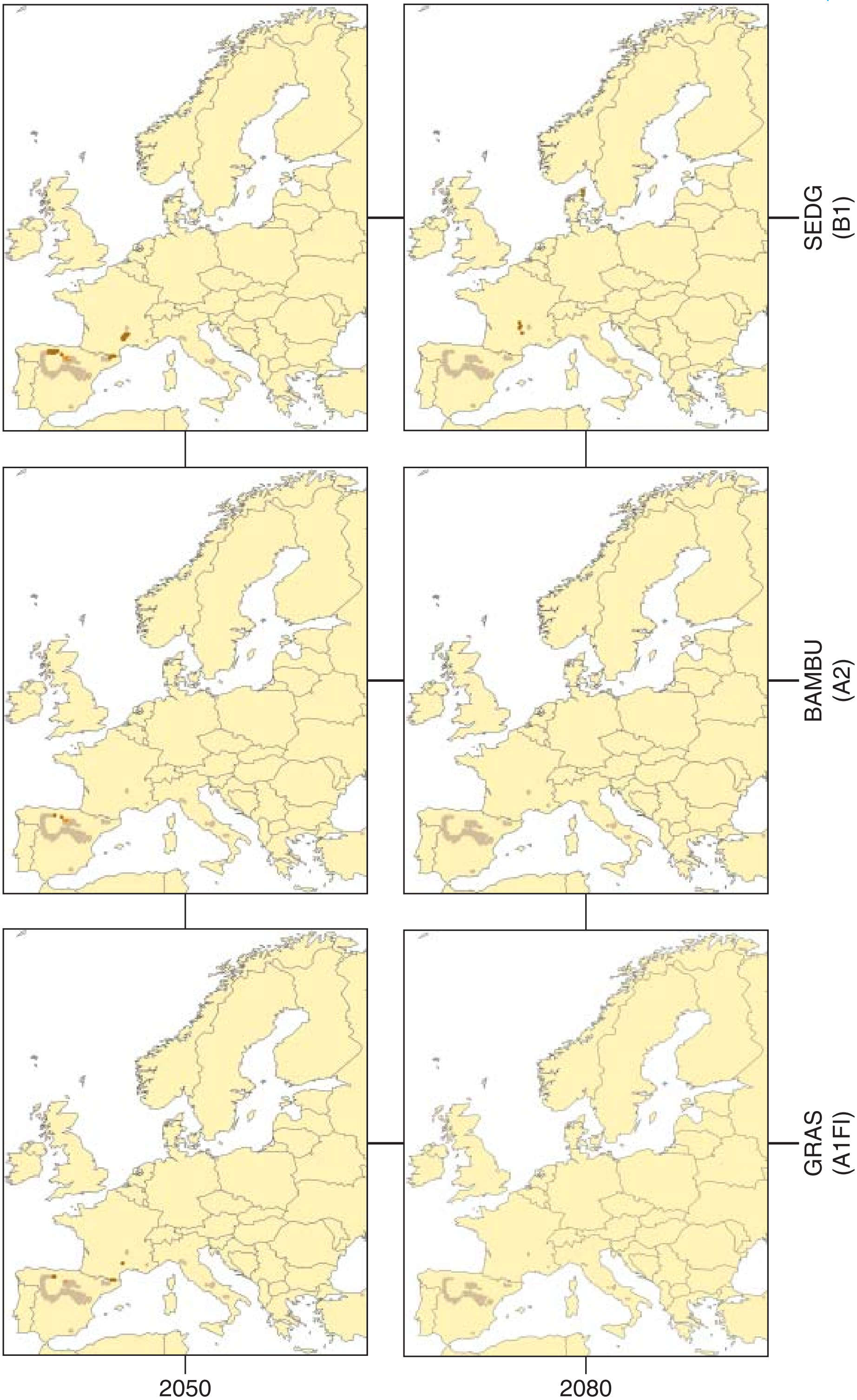
Present distribution can be well explained by climatic variables (AUC = 0.91).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia ottomana (Herrich-Schäffer, 1847) – Ottoman Brassy Ringlet

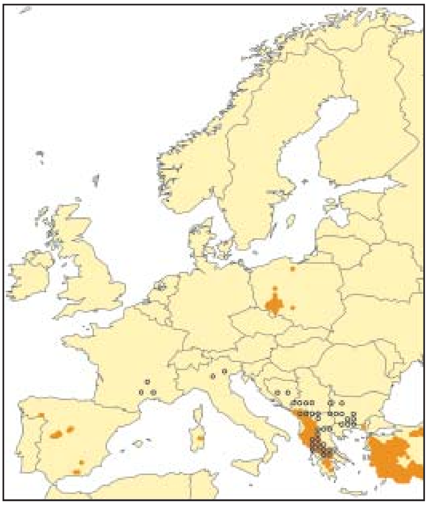
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-69 (-10.94%)	-240 (-38.03%)
	BAMBU	-144 (-22.82%)	-297 (-47.07%)
	GRAS	-95 (-15.06%)	-304 (-48.18%)
2080	SEDG	193 (30.59%)	-212 (-33.6%)
	BAMBU	-158 (-25.04%)	-431 (-68.3%)
	GRAS	-118 (-18.7%)	-476 (-75.44%)

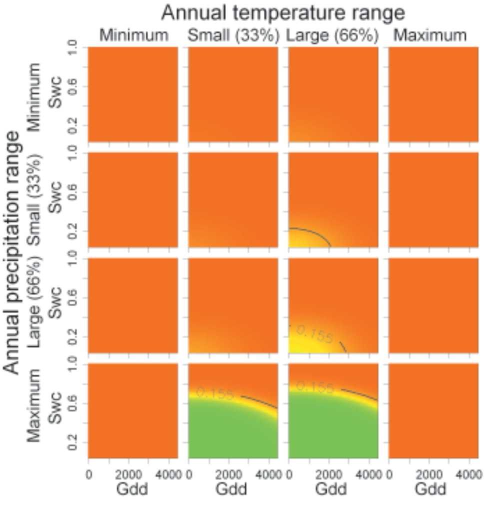
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 631)

In the mountains, the Ottoman Brassy Ringlet occurs on slopes and level ground with grassy vegetation. At lower altitudes, it is found in woodland clearings. The caterpillars feed on Sheep's-fescue (*Festuca ovina*) and other fine-leaved grasses. It is single-brooded.

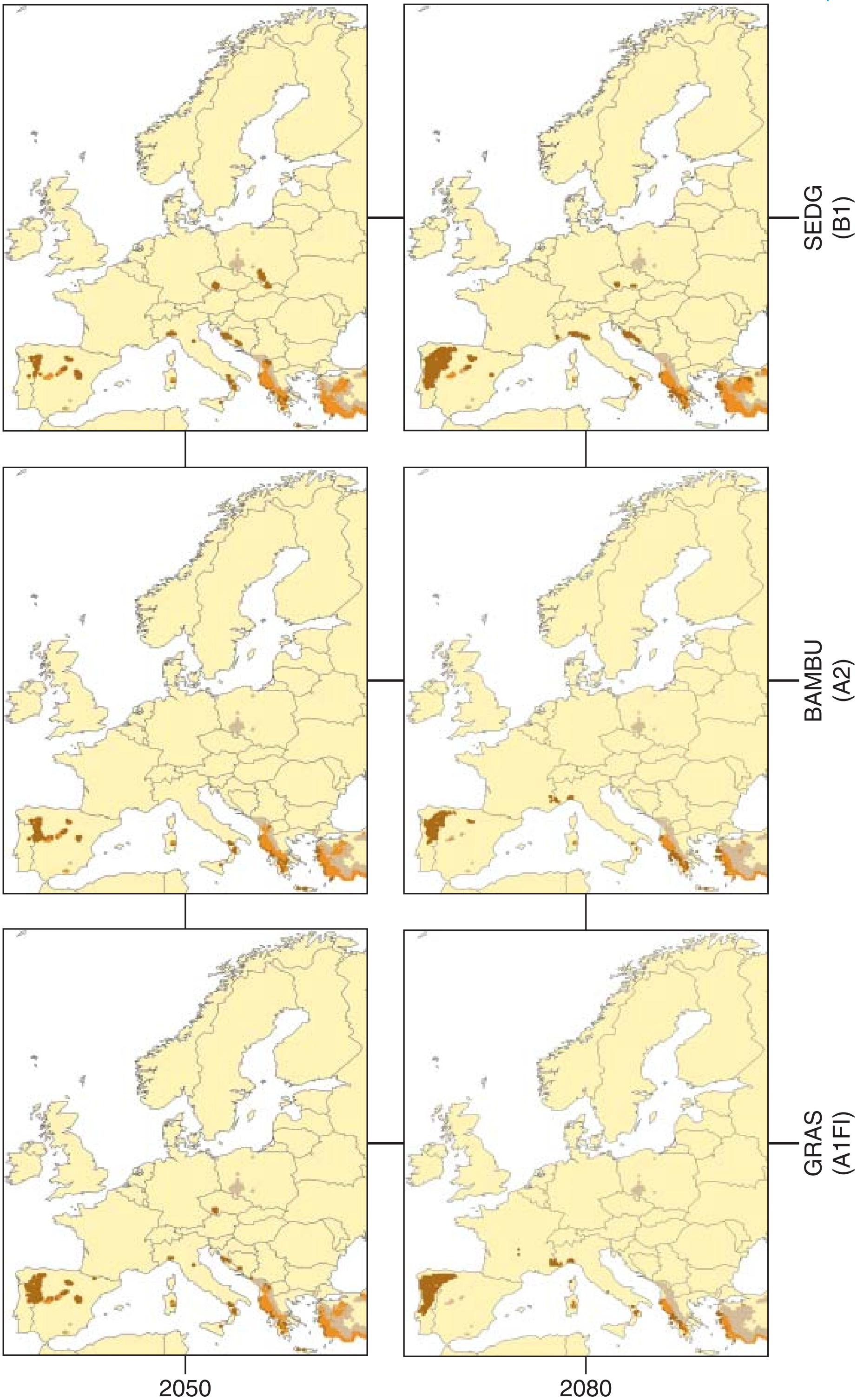
Present distribution can be explained by climatic variables to quite some extent (AUC = 0.81). Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia tyndarus (Esper, 1781) – Swiss Brassy Ringlet

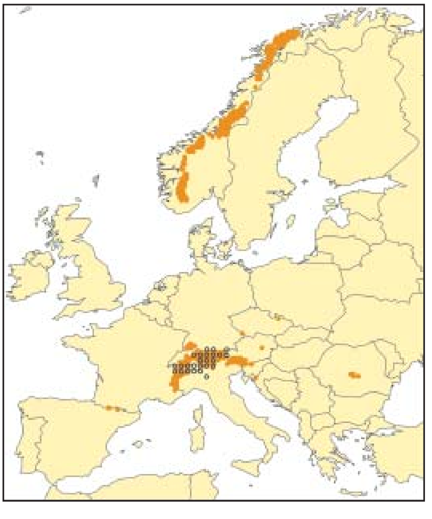
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-24 (-5.52%)	-205 (-47.13%)
	BAMBU	51 (11.72%)	-160 (-36.78%)
	GRAS	-11 (-2.53%)	-204 (-46.9%)
2080	SEDG	-251 (-57.7%)	-357 (-82.07%)
	BAMBU	-80 (-18.39%)	-272 (-62.53%)
	GRAS	-200 (-45.98%)	-339 (-77.93%)

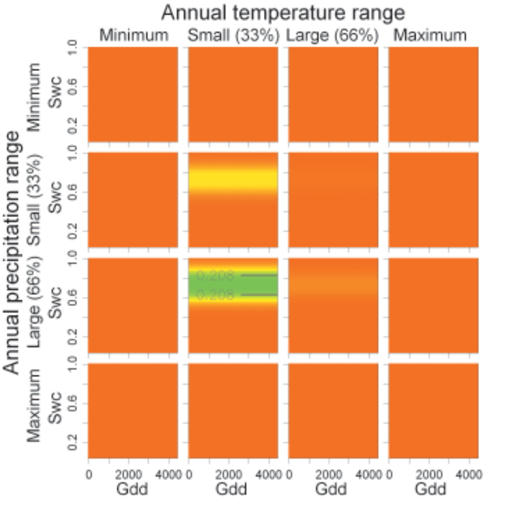
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 435)

The Swiss Brassy Ringlet occurs in woodland clearings on grassy, rocky slopes, and on screes. The caterpillars feed on different fescues (*Festuca* spp.) and on Mat-grass (*Nardus stricta*). The caterpillars hibernate when they are still small. They develop further the following spring, pupating sometime between June and August.

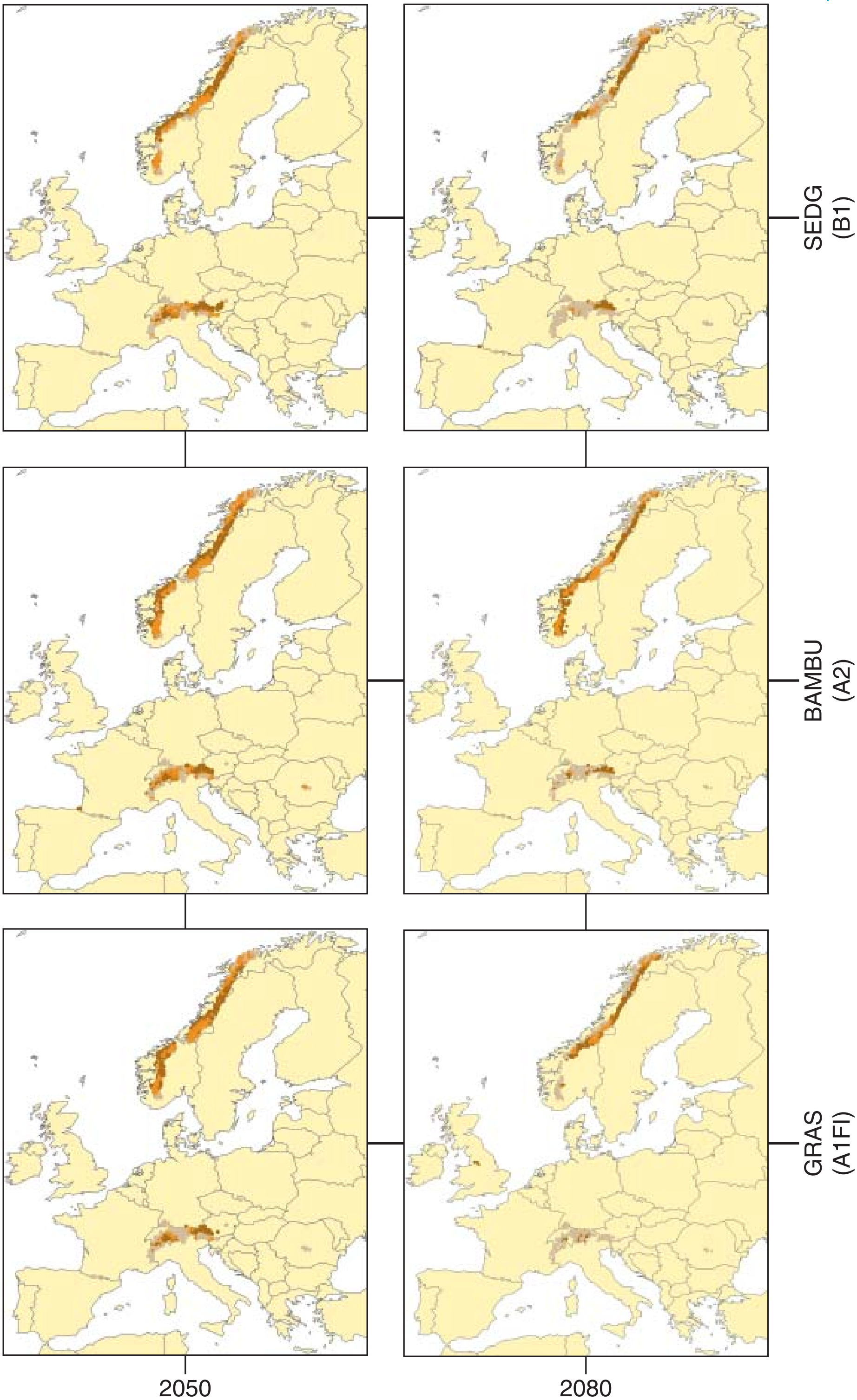
Present distribution can be very well explained by climatic variables (AUC = 0.99).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia cassioides (Reiner & Hohenwarth, 1792) (complex) – Common Brassy Ringlet

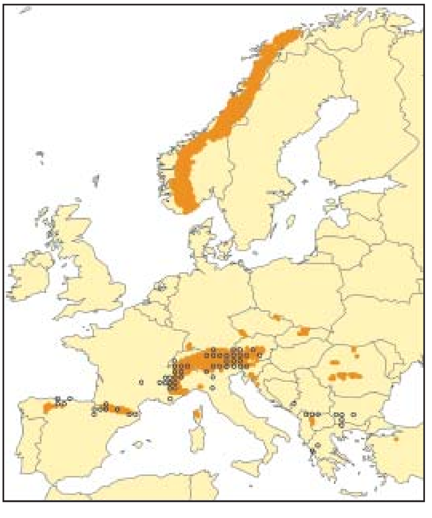
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-337 (-28.66%)	-404 (-34.35%)
	BAMBU	-320 (-27.21%)	-378 (-32.14%)
	GRAS	-398 (-33.84%)	-457 (-38.86%)
2080	SEDG	-656 (-55.78%)	-746 (-63.44%)
	BAMBU	-525 (-44.64%)	-630 (-53.57%)
	GRAS	-647 (-55.02%)	-747 (-63.52%)

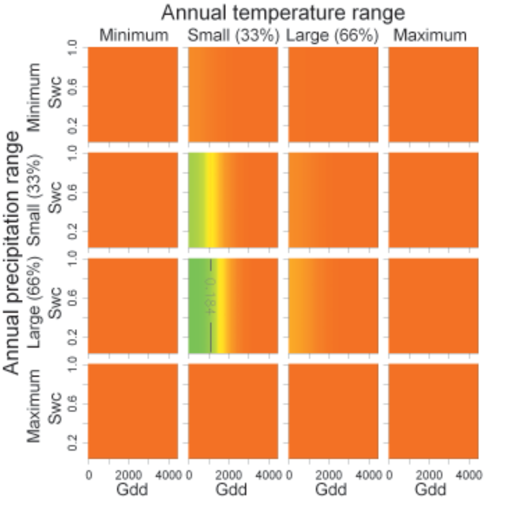
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 1176)

The Common Brassy Ringlet encompasses 4 taxa which are included in this species complex: *arvernensis*, *cassioides*, *macedonica*, *carmenta*. They represent isolates in different glacial refugia. Their separate species status however is still uncertain and requires verification. The butterflies live on dry, grassy slopes, rocky slopes with patches of grassy vegetation, and scree. The females lay their eggs on dry stalks of grass, close to the ground. The species’ foodplants are various fescues (*Festuca* spp.). The caterpillars hibernate in the first or second larval instar and pupate the following year between June and August.

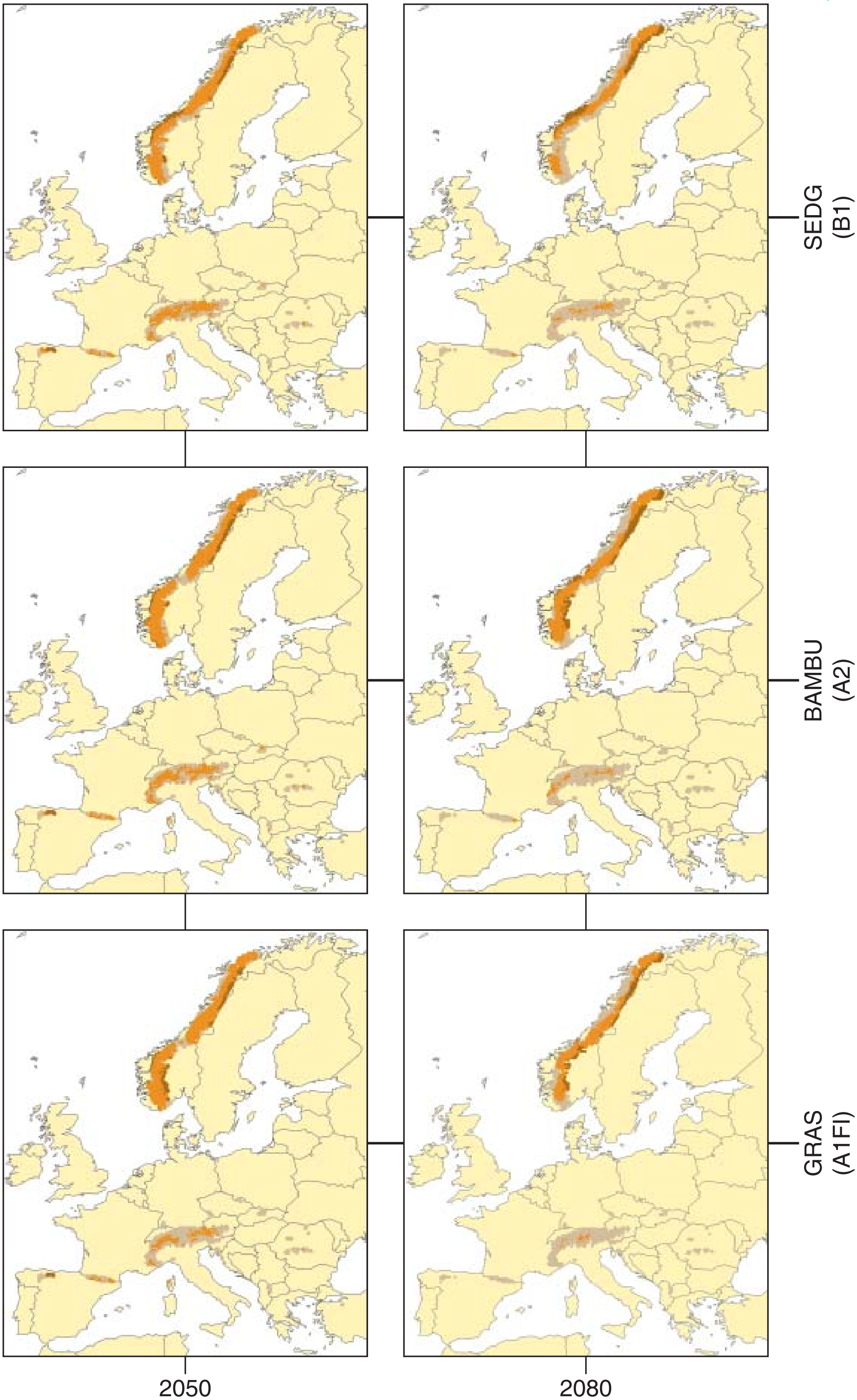
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.8).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia pronoe (Esper, 1780) – Water Ringlet

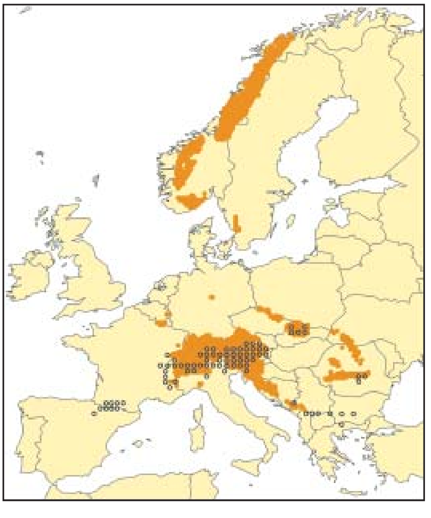
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-407 (-24.23%)	-570 (-33.93%)
	BAMBU	-326 (-19.4%)	-472 (-28.1%)
	GRAS	-586 (-34.88%)	-692 (-41.19%)
2080	SEDG	-315 (-18.75%)	-721 (-42.92%)
	BAMBU	-319 (-18.99%)	-774 (-46.07%)
	GRAS	-466 (-27.74%)	-1011 (-60.18%)

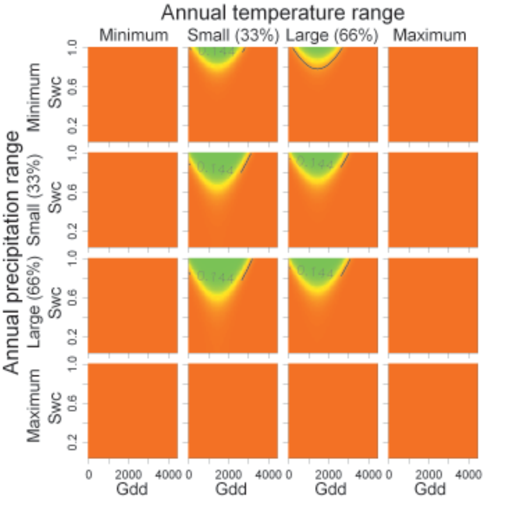
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1680)

The Water Ringlet is found especially on flower-rich grasslands, rocky, grassy slopes, and near woodland. The female usually deposits her eggs close to the ground, on dry stalks of grass. The caterpillars feed on Sheep's Fescue (*Festuca ovina*), *F. quadriflora* and various meadow-grasses (*Poa* spp.). The caterpillars hibernate in the first larval instar and pupate in June or July of the following year.

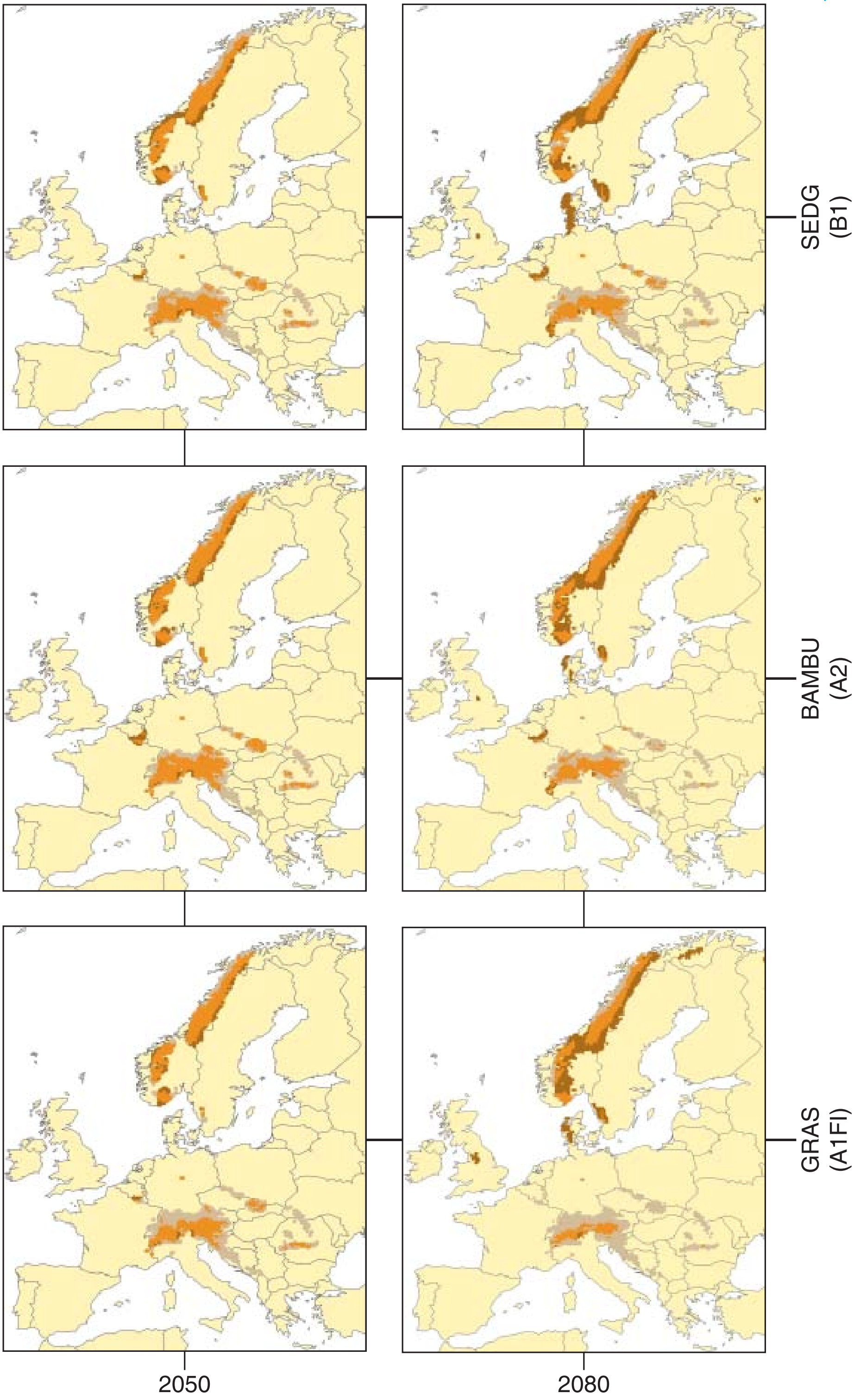
Present distribution can be well explained by climatic variables (AUC = 0.89).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia styx (Freyer, 1834) – Stygian Ringlet

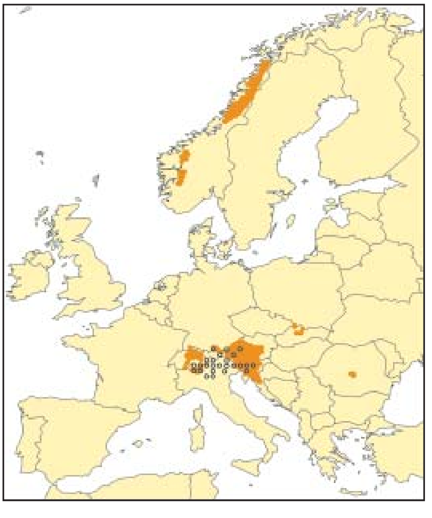
© Martin Wiemers

		Full dispersal	No dispersal
2050	SEDG	-200 (-46.62%)	-227 (-52.91%)
	BAMBU	-186 (-43.36%)	-206 (-48.02%)
	GRAS	-255 (-59.44%)	-264 (-61.54%)
2080	SEDG	-247 (-57.58%)	-282 (-65.73%)
	BAMBU	-242 (-56.41%)	-280 (-65.27%)
	GRAS	-287 (-66.9%)	-361 (-84.15%)

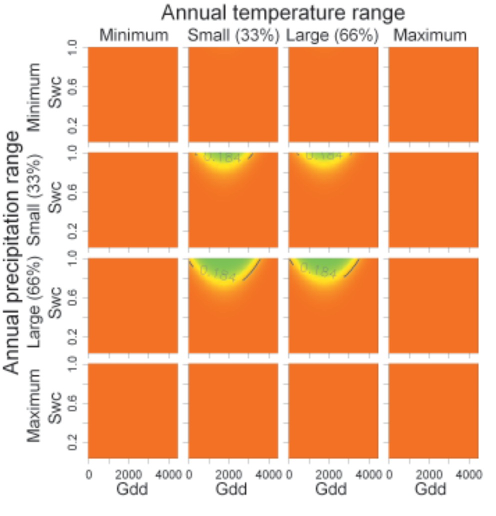
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 429)

The Stygian Ringlet occurs on warm, steep, rocky slopes with grassy vegetation and sometimes scattered bushes, often on limestone. Its foodplant is Blue Moor-grass (*Sesleria albicans*). In Switzerland, it takes two years for the egg to develop into a butterfly. The tiny caterpillar goes into hibernation immediately after leaving the egg, only starting to feed the next spring. In the autumn, they again hibernate, pupating in June or July of the following year. In other areas at lower altitudes, they can complete their life cycle in one year.

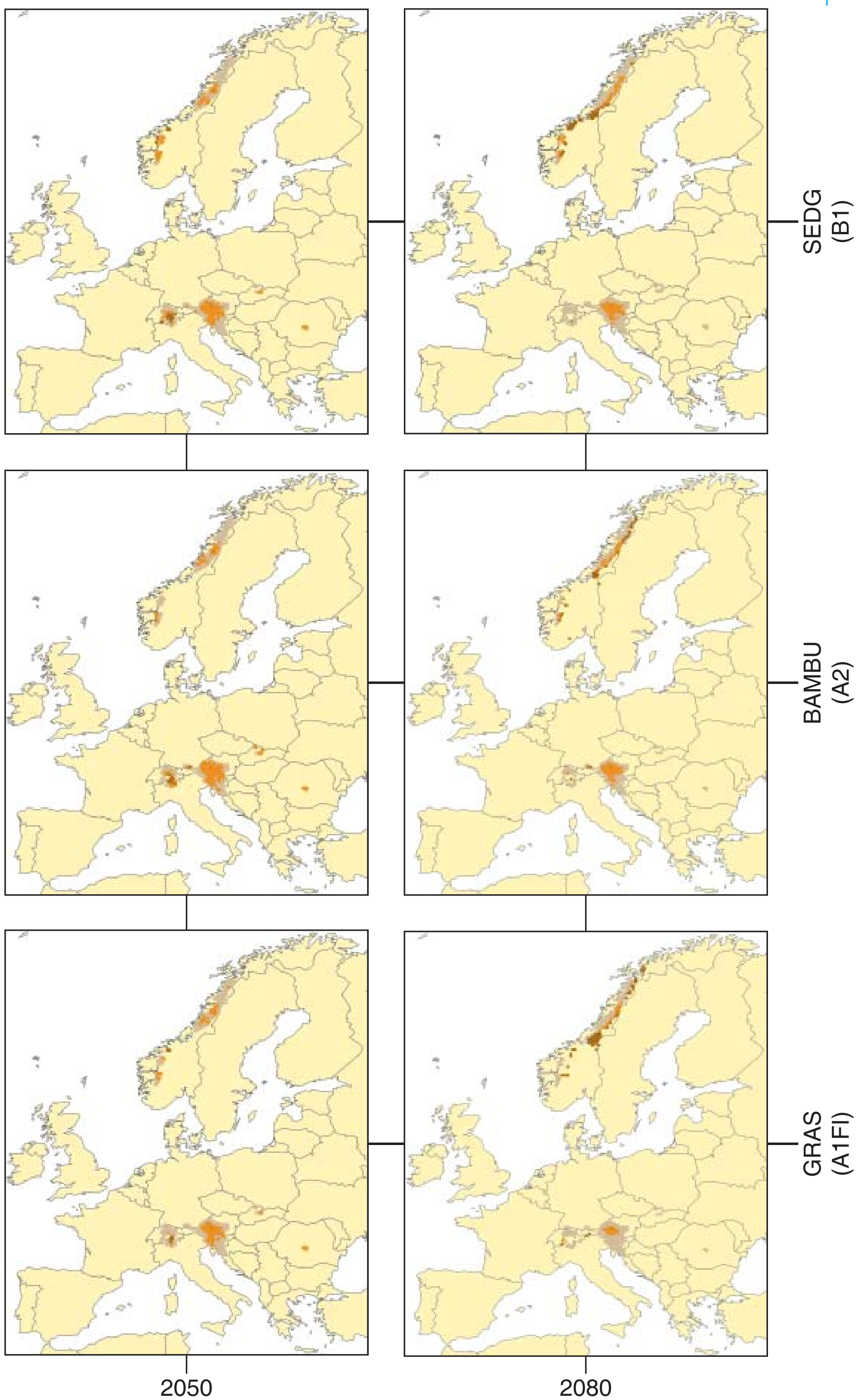
Present distribution can be well explained by climatic variables (AUC = 0.95).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


2050
2080
SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)

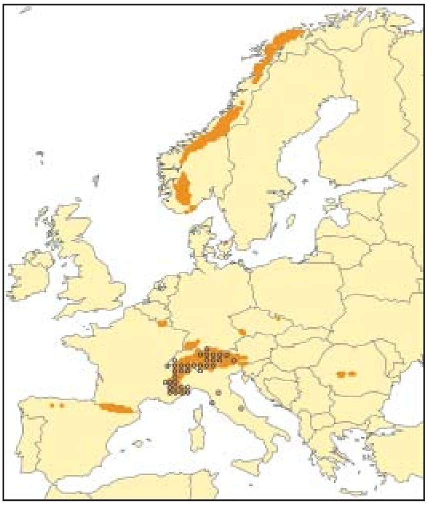
Erebia montana (Prunner, 1798) – Marbled Ringlet

		Full dispersal	No dispersal
2050	SEDG	-77 (-12.13%)	-282 (-44.41%)
	BAMBU	25 (3.94%)	-224 (-35.28%)
	GRAS	-112 (-17.64%)	-303 (-47.72%)
2080	SEDG	-349 (-54.96%)	-530 (-83.46%)
	BAMBU	-186 (-29.29%)	-409 (-64.41%)
	GRAS	-332 (-52.28%)	-512 (-80.63%)

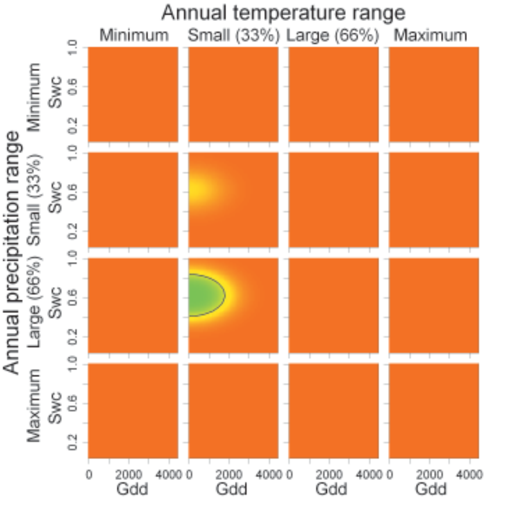
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 635)

The Marbled Ringlet is mainly found on warm, rocky slopes with patches of grassy vegetation in flower-rich grasslands, and occasionally in woods, for the most part on limestone. When the butterflies settle on stones or on the ground with their wings closed, they are hardly noticeable. However, they can be seen visiting flowers, which they do regularly. The caterpillars hibernate in the first larval instar and in the spring begin feeding on fescues (*Festuca* spp.), or on Mat-grass (*Nardus stricta*). The caterpillars have been found on the larger tussocks growing in the shelter of rocks. They pupate in June or July.

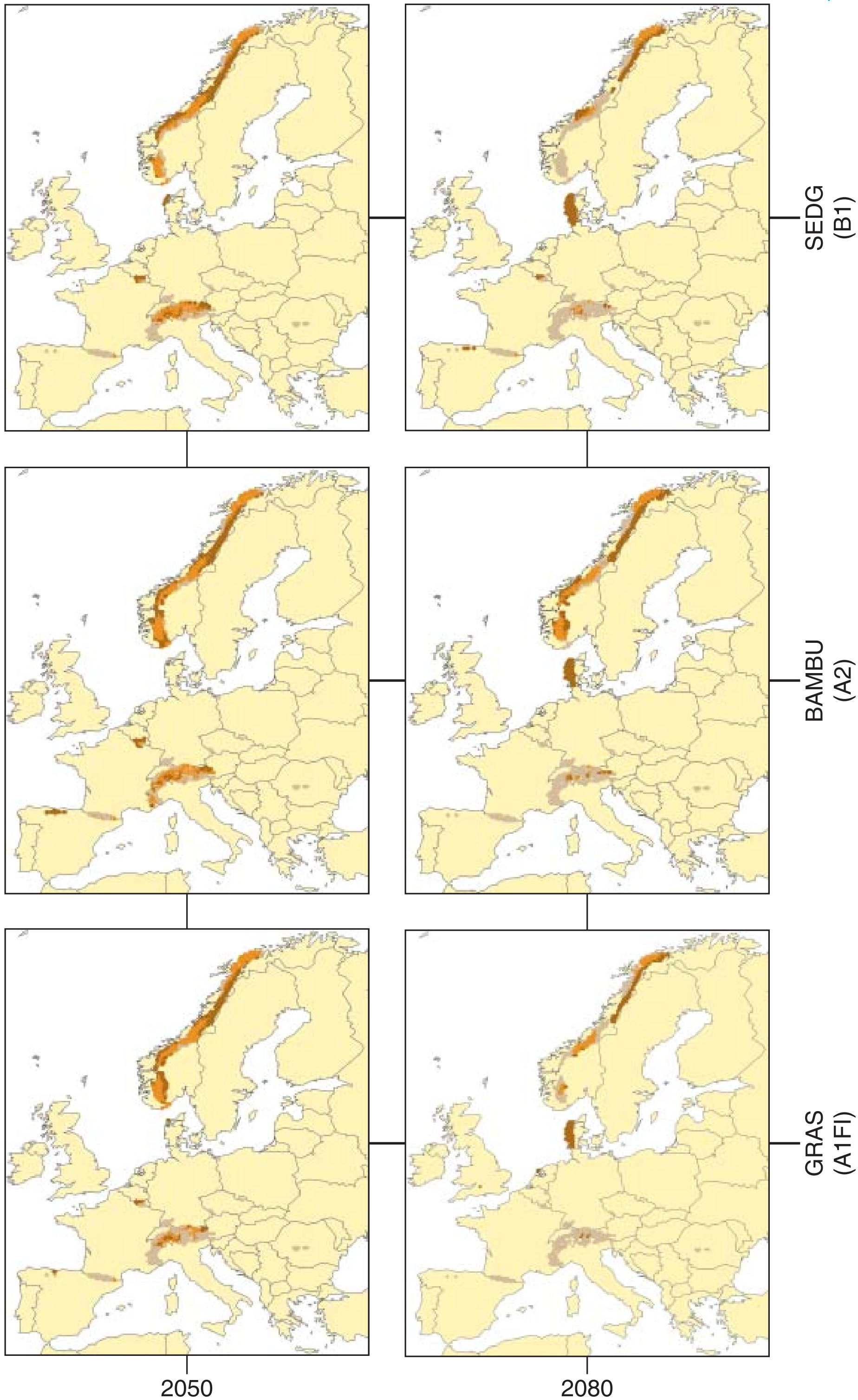
Present distribution can be very well explained by climatic variables (AUC = 0.98).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia neoridas (Boisduval, 1828) – Autumn Ringlet

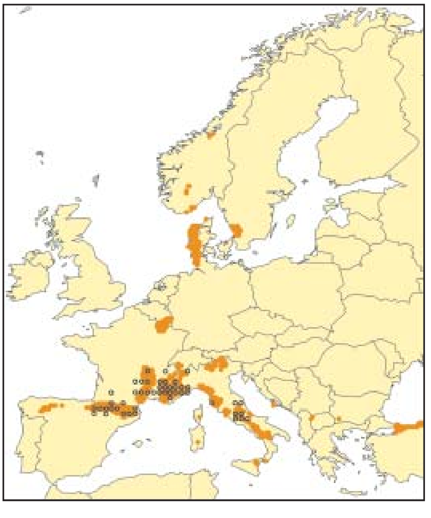
© Matt Rowlings

		Full dispersal	No dispersal
2050	SEDG	-10 (-1.48%)	-473 (-69.87%)
	BAMBU	-1 (-0.15%)	-488 (-72.08%)
	GRAS	18 (2.66%)	-521 (-76.96%)
2080	SEDG	219 (32.35%)	-560 (-82.72%)
	BAMBU	-162 (-23.93%)	-591 (-87.3%)
	GRAS	-265 (-39.14%)	-605 (-89.36%)

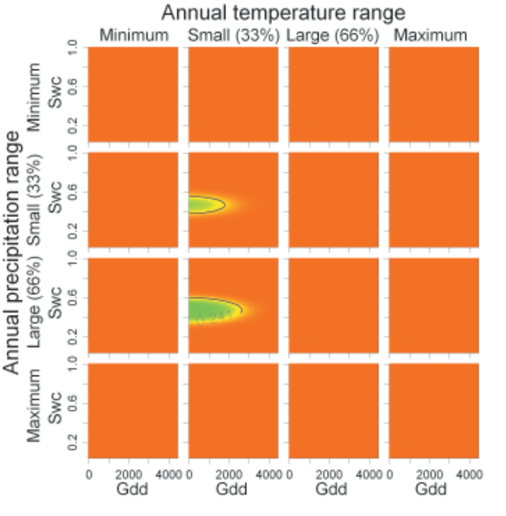
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 677)

The Autumn Ringlet occurs in woodland clearings and on grassy vegetation with scattered bushes. The caterpillars feed on different grasses, such as Crab-grass (*Digitaria sanguinalis*), Alpine Meadow-Grass (*Poa alpina)*, Smooth Meadow-grass (*Poa pratensis*), Annual Meadow-grass (*P. annua*), Sheep's-fescue (*Festuca ovina*), and Meadow Fescue (*F. pratensis*). This species is single-brooded and hibernates as a caterpillar.

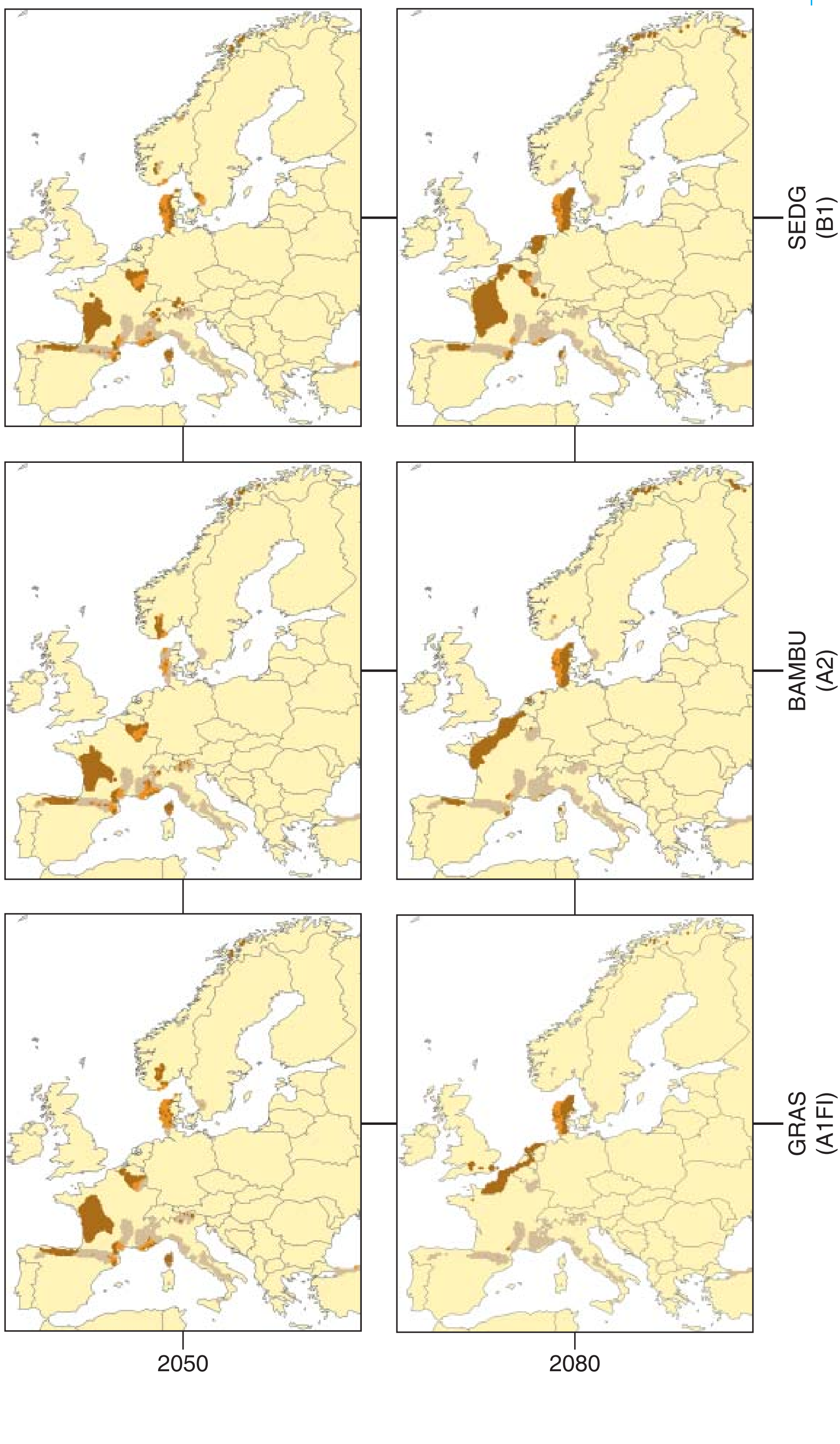
Present distribution can be well explained by climatic variables (AUC = 0.93).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia melas (Herbst, 1796) – Black Ringlet

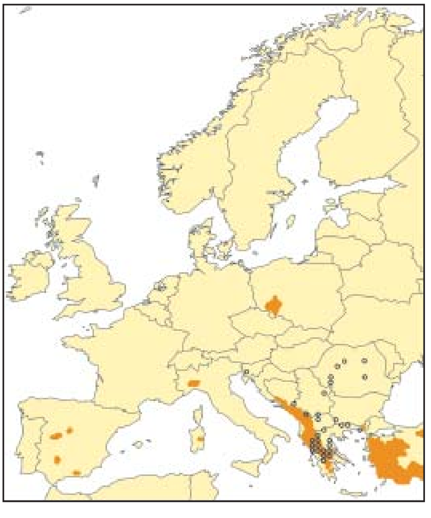
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	179 (27.54%)	-158 (-24.31%)
	BAMBU	40 (6.15%)	-239 (-36.77%)
	GRAS	121 (18.62%)	-231 (-35.54%)
2080	SEDG	416 (64%)	-167 (-25.69%)
	BAMBU	-35 (-5.38%)	-434 (-66.77%)
	GRAS	40 (6.15%)	-496 (-76.31%)

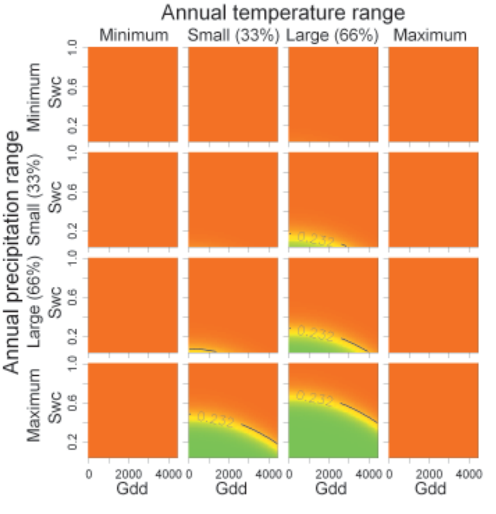
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 650)

The Black Ringlet can be found on rocky slopes with patches of grassy vegetation, in dry and sub-alpine and alpine grasslands, and sometimes in clearings in coniferous woods. The butterflies fly close to the ground, often resting with wings widespread. The caterpillars feed on Sheeps’-fescue (*Festuca ovina*), and possibly other grasses. The Black Ringlet has one generation a year and hibernates in the larval stage.

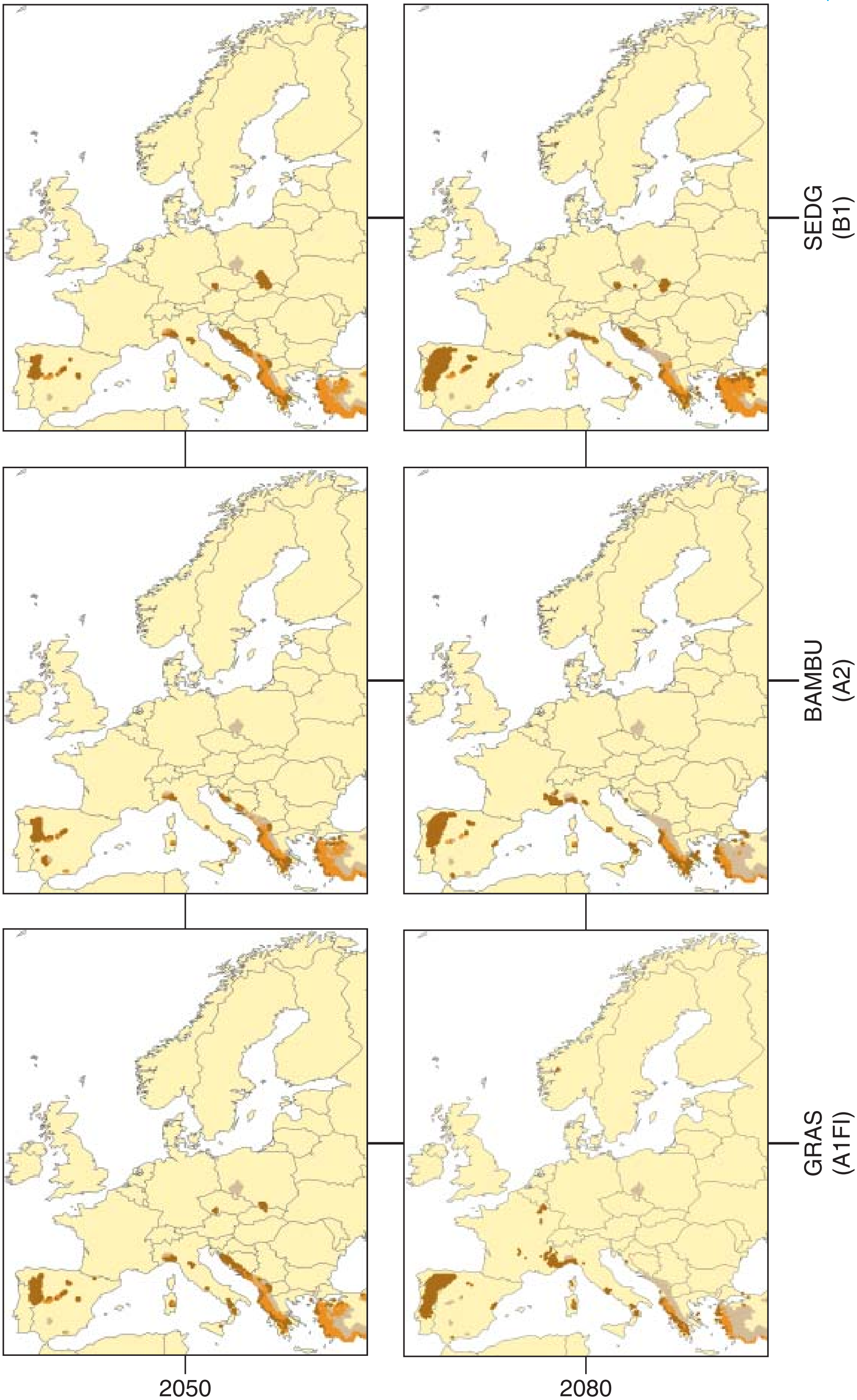
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.84).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia oeme (Esper, 1805) – Bright-eyed Ringlet

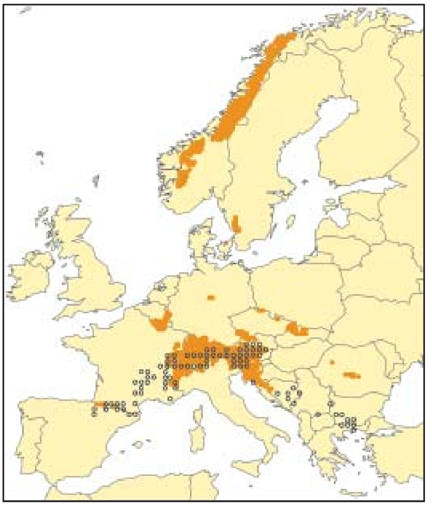
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	-195 (-17.81%)	-357 (-32.6%)
	BAMBU	-32 (-2.92%)	-276 (-25.21%)
	GRAS	-298 (-27.21%)	-427 (-39%)
2080	SEDG	-260 (-23.74%)	-538 (-49.13%)
	BAMBU	-155 (-14.16%)	-523 (-47.76%)
	GRAS	-413 (-37.72%)	-732 (-66.85%)

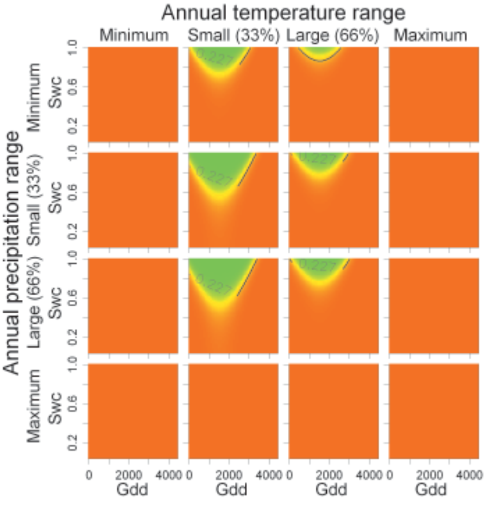
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1095)

The Bright-eyed Ringlet is often found on damp to wet grasslands, sometimes with lots of sedges in the vegetation. However, it also occurs on dry grasslands, rocky slopes and in woodland clearings. The grass in some of these habitats may be quite tall. Several different foodplants are known, including sedges (*Carex* spp.), rushes (*Juncus* spp.), Purple Moor-grass (*Molinea caerulea*), Quaking Grass (*Briza media*), Red Fescue (*Festuca rubra*), and meadow-grasses (*Poa* spp.). The caterpillars take one or two years to develop, depending on the altitude of the breeding ground.

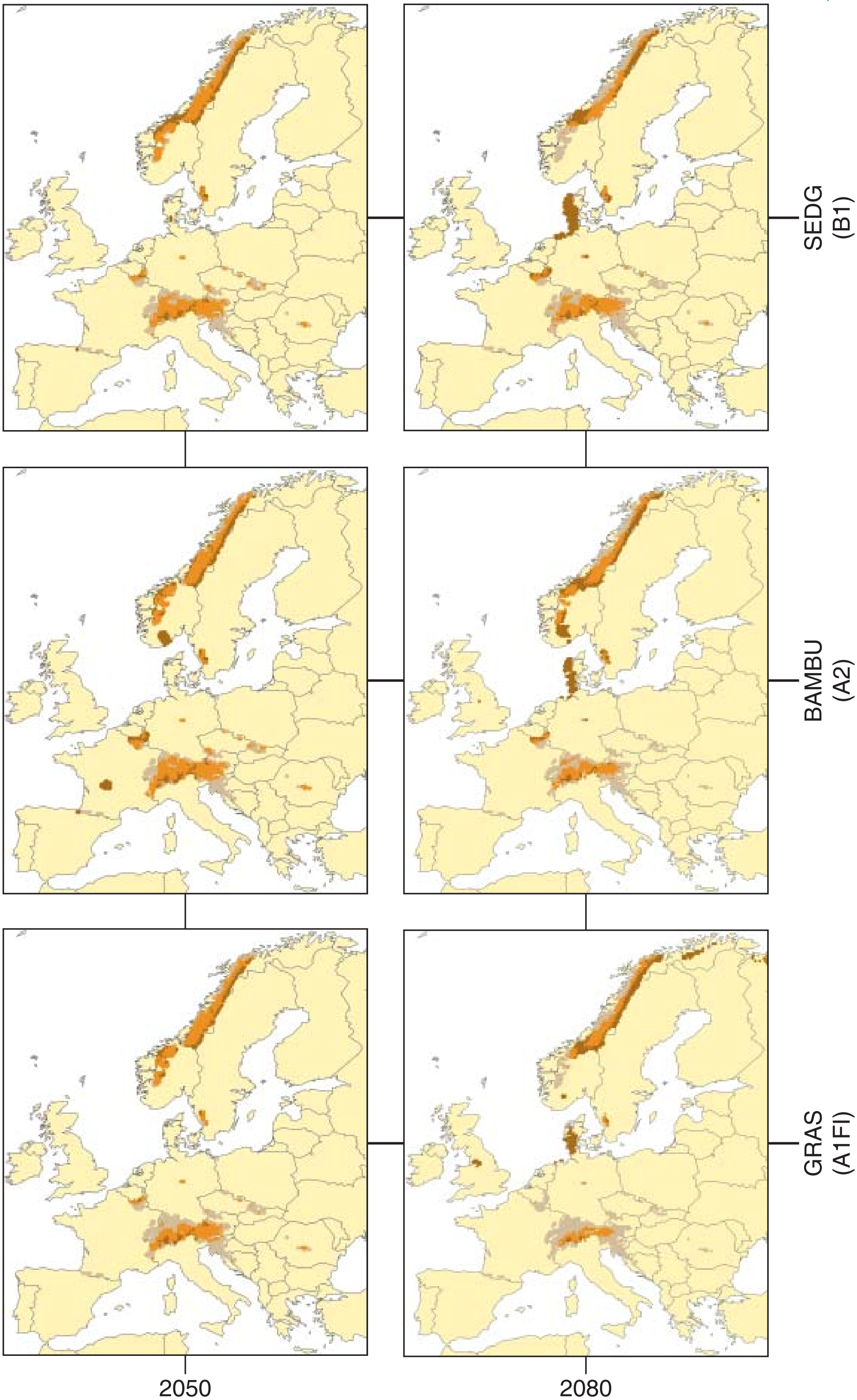
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.89).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Erebia meolans (Prunner, 1798) – Piedmont Ringlet

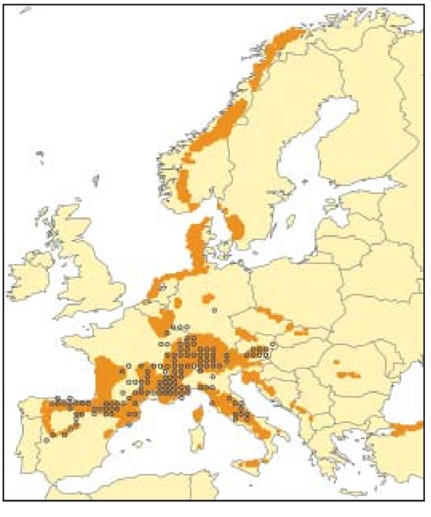
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-89 (-3.23%)	-1130 (-40.97%)
	BAMBU	-153 (-5.55%)	-1103 (-39.99%)
	GRAS	-342 (-12.4%)	-1389 (-50.36%)
2080	SEDG	-360 (-13.05%)	-1687 (-61.17%)
	BAMBU	-644 (-23.35%)	-1813 (-65.74%)
	GRAS	-1145 (-41.52%)	-2198 (-79.7%)

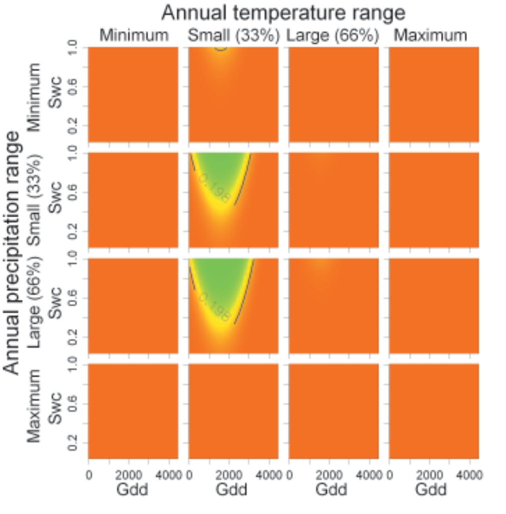
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2758)

The Piedmont Ringlet occurs on a variety of grassy places in and near woods. The female lays her eggs on many different grasses, including fescues (*Festuca* spp.), Wavy Hair-grass (*Deschampsia flexuosa*), Mat-grass (*Nardus stricta*), and several sorts of bent (*Agrostis* spp.). At very high altitudes, when the caterpillars are half-grown, they hibernate in the litter layer. They may hibernate twice before pupating deep down in the vegetation.

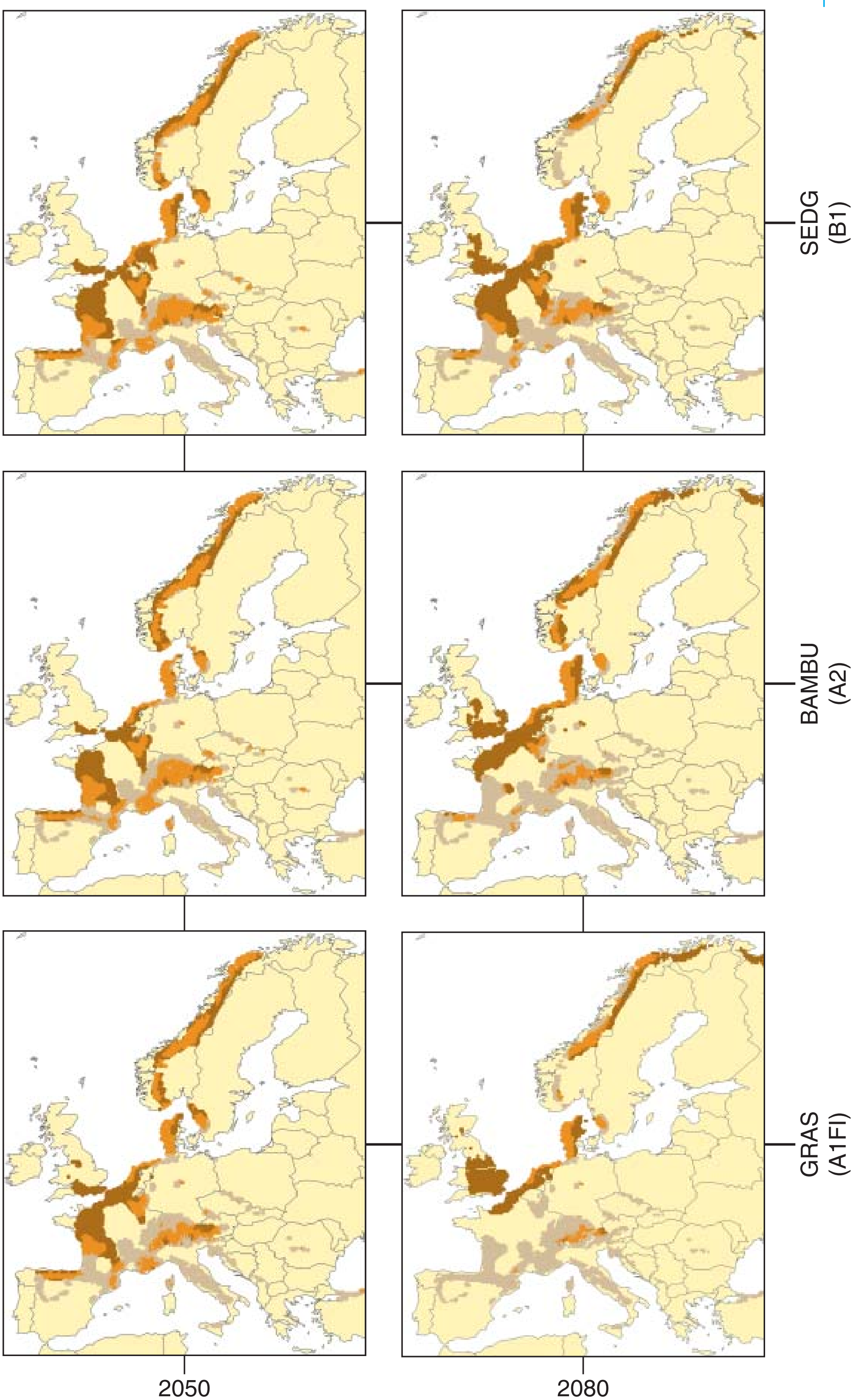
Present distribution can be well explained by climatic variables (AUC = 0.92).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

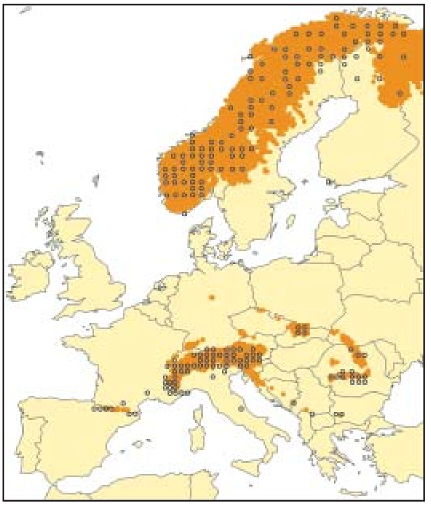
Erebia pandrose (Borkhausen, 1788) – Dewy Ringlet

		Full dispersal	No dispersal
2050	SEDG	-950 (-21.14%)	-1006 (-22.39%)
	BAMBU	-779 (-17.34%)	-830 (-18.47%)
	GRAS	-1212 (-26.98%)	-1215 (-27.04%)
2080	SEDG	-883 (-19.65%)	-1106 (-24.62%)
	BAMBU	-1128 (-25.11%)	-1265 (-28.15%)
	GRAS	-1444 (-32.14%)	-1546 (-34.41%)

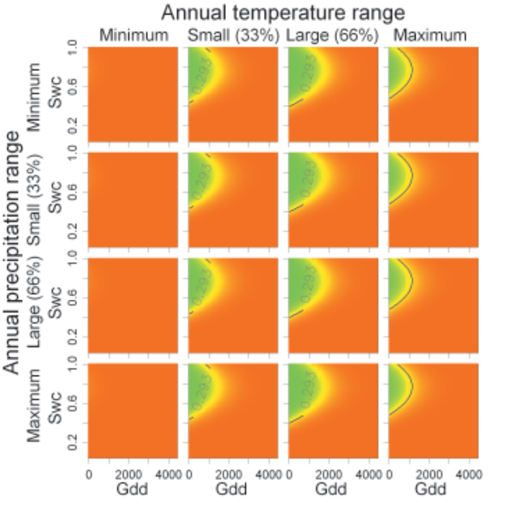
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 4493)

The Dewy Ringlet is a common species. In Scandinavia, it is mostly found in damp places where grass and bushes are growing, often near small streams, and in more mountainous areas on grassy slopes. In Central Europe, the butterflies occur on stony, alpine meadows with a vegetation of short grasses and dwarf shrubs. These butterflies have a characteristic, undulating flight. This gives the impression that they are not using their hindwings, and are just about to fall to the ground. The female lays her eggs on different grasses, such as fescues (*Festuca* spp.), meadow-grasses (*Poa* spp.), Blue Moor-grass (*Sesleria albicans*), or Mat-grass (*Nardus stricta*). In most parts of its range, the caterpillars hibernate twice.

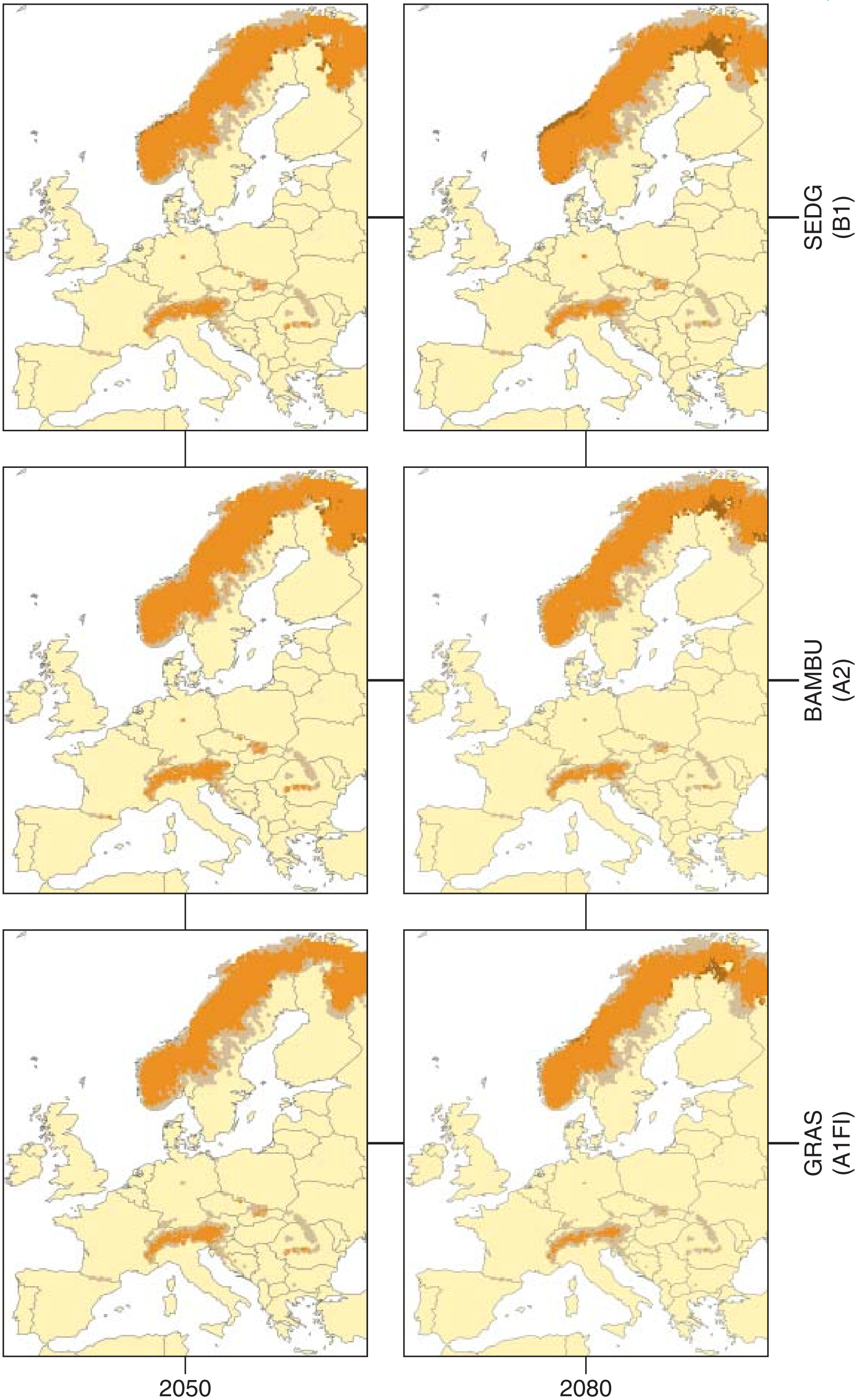
Present distribution can be well explained by climatic variables (AUC = 0.86).
Climate risk category: LR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melanargia russiae (Esper, 1784) – Esper's Marbled White

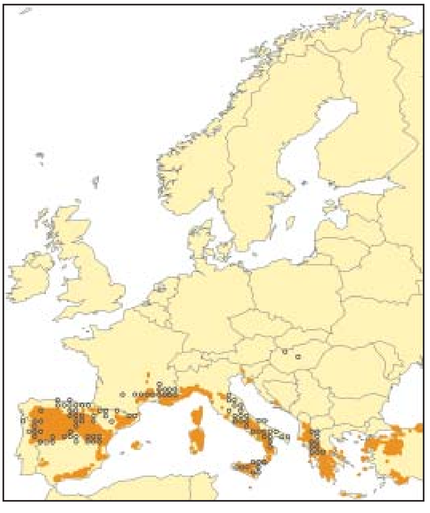
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-781 (-51.55%)	-1158 (-76.44%)
	BAMBU	-988 (-65.21%)	-1169 (-77.16%)
	GRAS	-982 (-64.82%)	-1275 (-84.16%)
2080	SEDG	-752 (-49.64%)	-1352 (-89.24%)
	BAMBU	-1026 (-67.72%)	-1441 (-95.12%)
	GRAS	-752 (-49.64%)	-1504 (-99.27%)

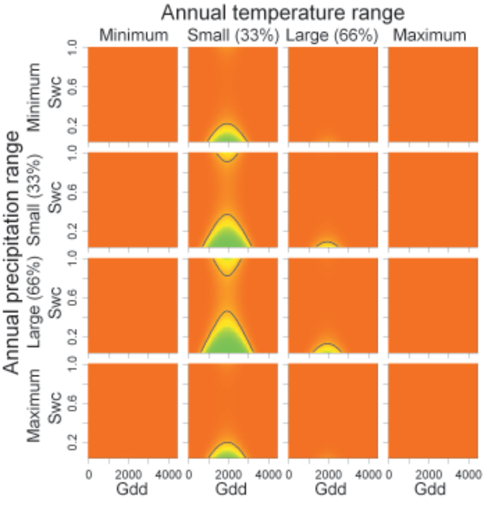
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1515)

Esper's Marbled White is a butterfly of grassy vegetation, occurring both on acid and calcareous soils. The butterflies are often found on dry, rocky slopes but also in grassy glades in woods. They are fond of visiting thistles and like plants for their nectar. Various meadow grasses (*Poa* spp.) and false bromes (*Brachypodium* spp.), Feather Grass (*Stipa pinnata*), and *Aegilops geniculata* are used as foodplants. The caterpillars hibernate and pupate on the ground in the spring. This species is single-brooded.

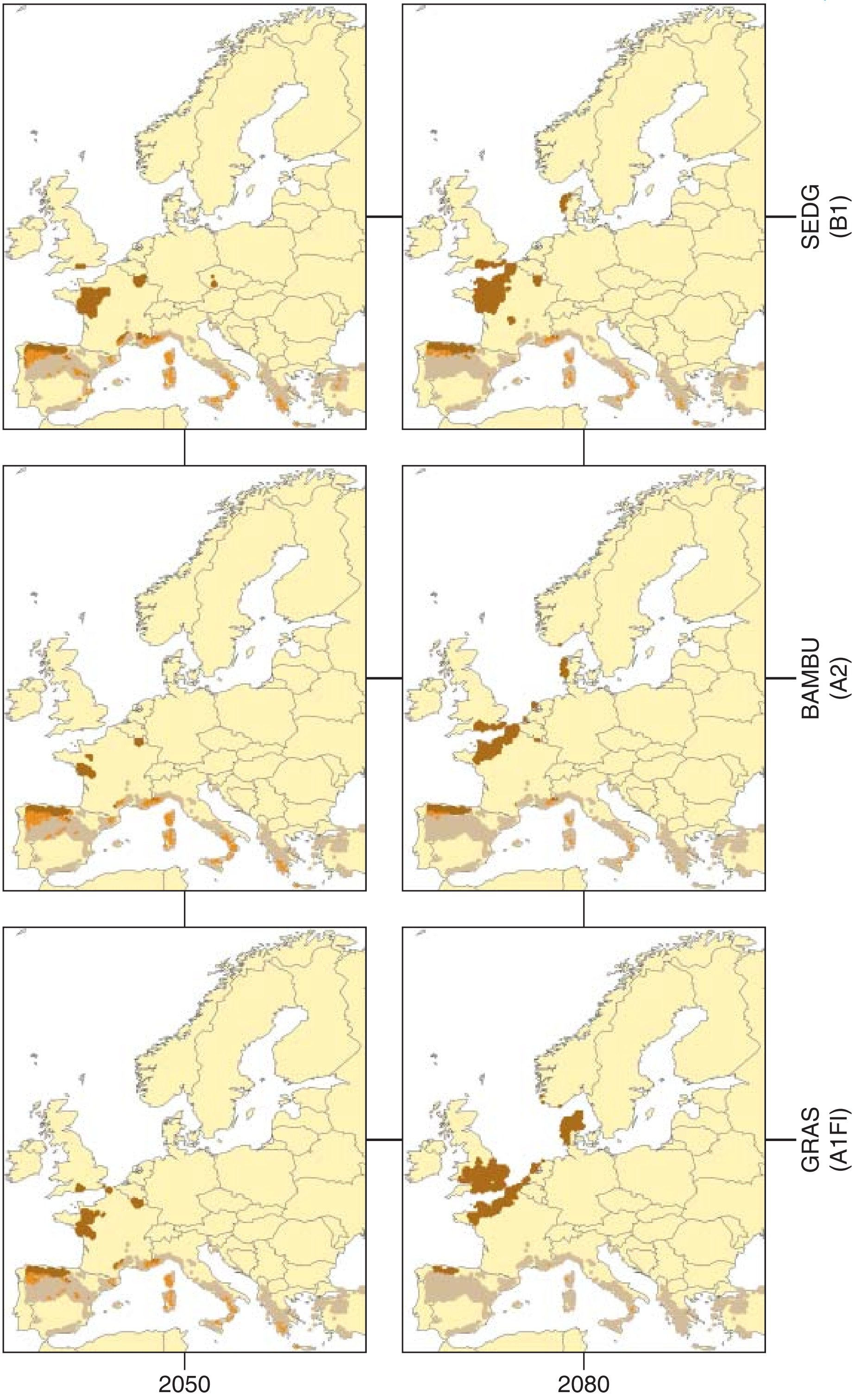
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.85).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

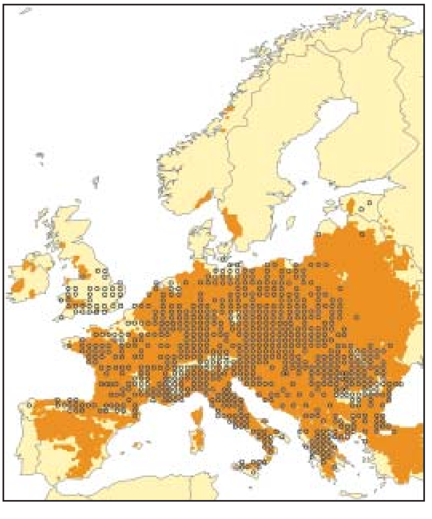
Melanargia galathea (Linnaeus, 1758) – Marbled White

		Full dispersal	No dispersal
2050	SEDG	884 (6.33%)	-2681 (-19.21%)
	BAMBU	912 (6.53%)	-3015 (-21.6%)
	GRAS	-12 (-0.09%)	-3686 (-26.41%)
2080	SEDG	483 (3.46%)	-4811 (-34.47%)
	BAMBU	-22 (-0.16%)	-6633 (-47.52%)
	GRAS	-609 (-4.36%)	-8654 (-62%)

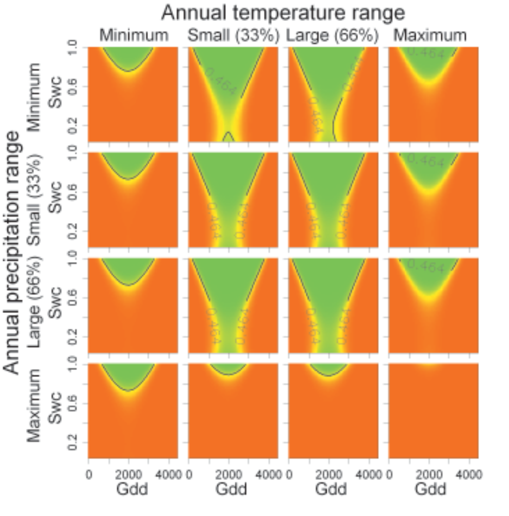
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 13958)

The Marbled White inhabits many different types of poor grassland that has not been fertilized. It is common in the southern part of its range, also on road verges and in agricultural areas. The butterflies need a lot of nectar, and are often seen on plants in bloom. Various grass species, mostly fine-leaved, are used as foodplants. The female usually just drops her eggs into the grass, sometimes while flying. The first instar caterpillar hibernates without eating first. In periods of hot weather, the other instars can also go without food. They pupate deep in the vegetation. The Marbled White has one generation a year.

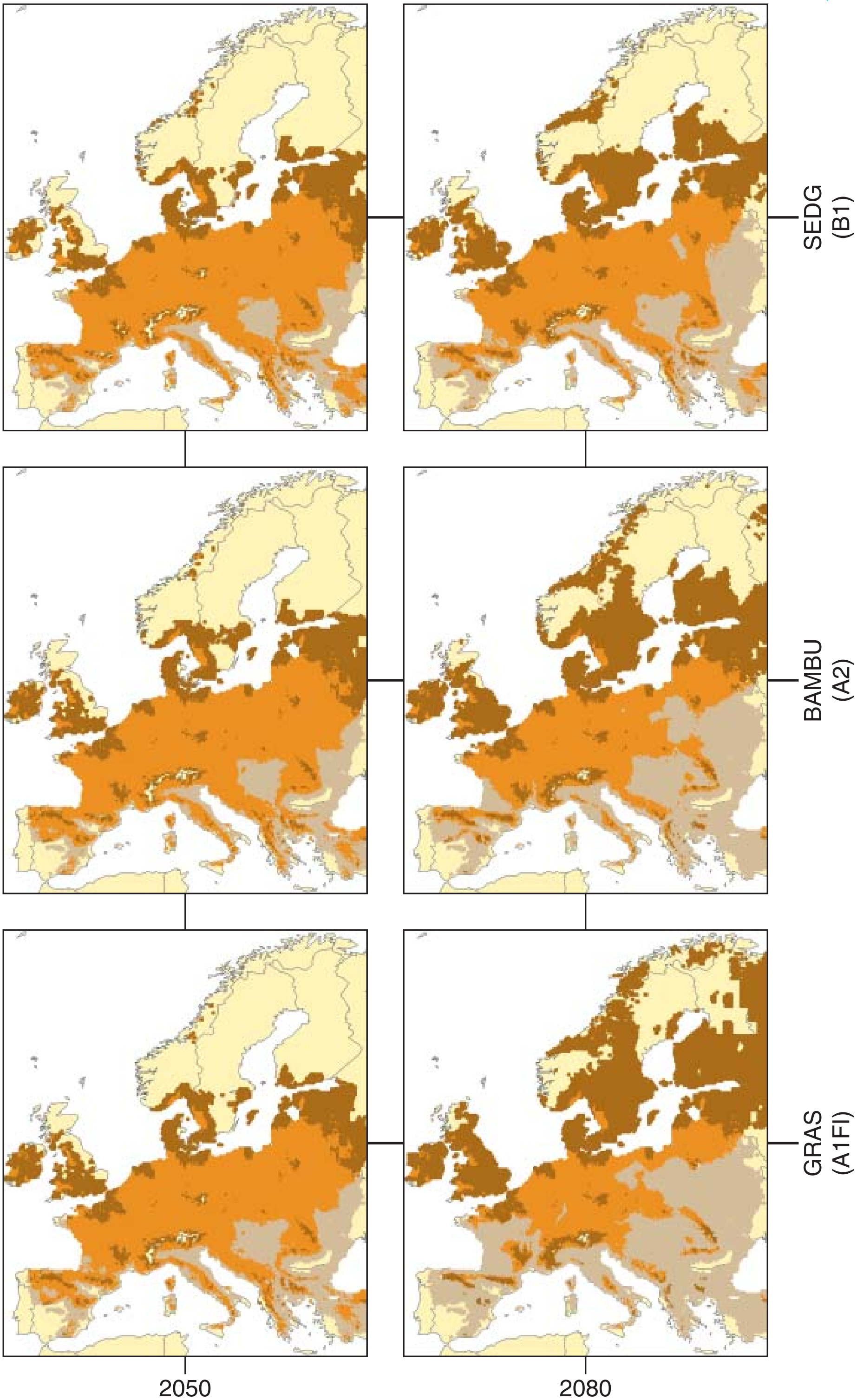
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.81). Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melanargia lachesis (Hübner 1790) – Iberian Marbled White

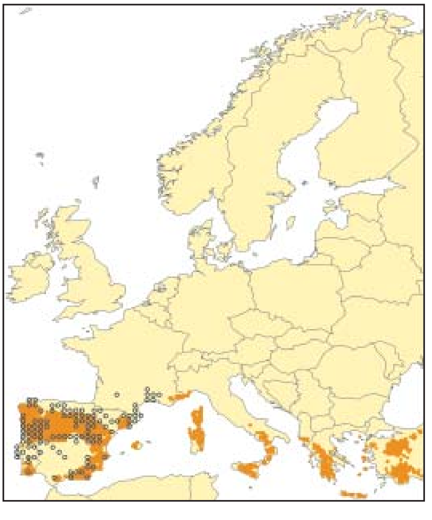
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-863 (-61.91%)	-1047 (-75.11%)
	BAMBU	-1054 (-75.61%)	-1131 (-81.13%)
	GRAS	-1045 (-74.96%)	-1232 (-88.38%)
2080	SEDG	-1055 (-75.68%)	-1324 (-94.98%)
	BAMBU	-1129 (-80.99%)	-1374 (-98.57%)
	GRAS	-910 (-65.28%)	-1394 (-100%)

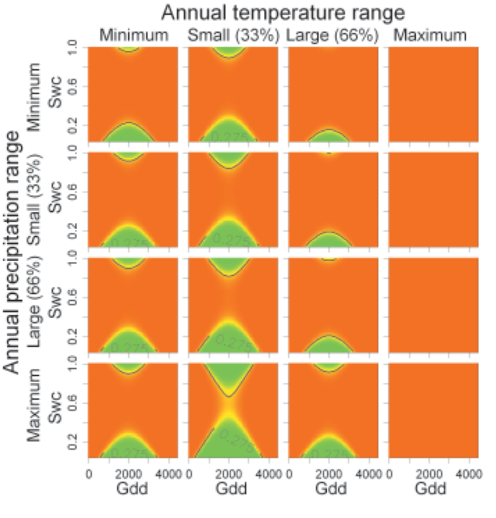
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1394)

The Iberian Marbled White occurs in flower-rich, dry to damp grasslands, near dry scrub, and along woodland edges and hedgerows. Grasses such as Annual Meadow-grass (*Poa annua*), Meadow Fescue (*Festuca pratensis*), Compact Brome (*Bromus madritensis*), and *Brachypodium retusum* are used as foodplants. This species is single-brooded and hibernates as a caterpillar.

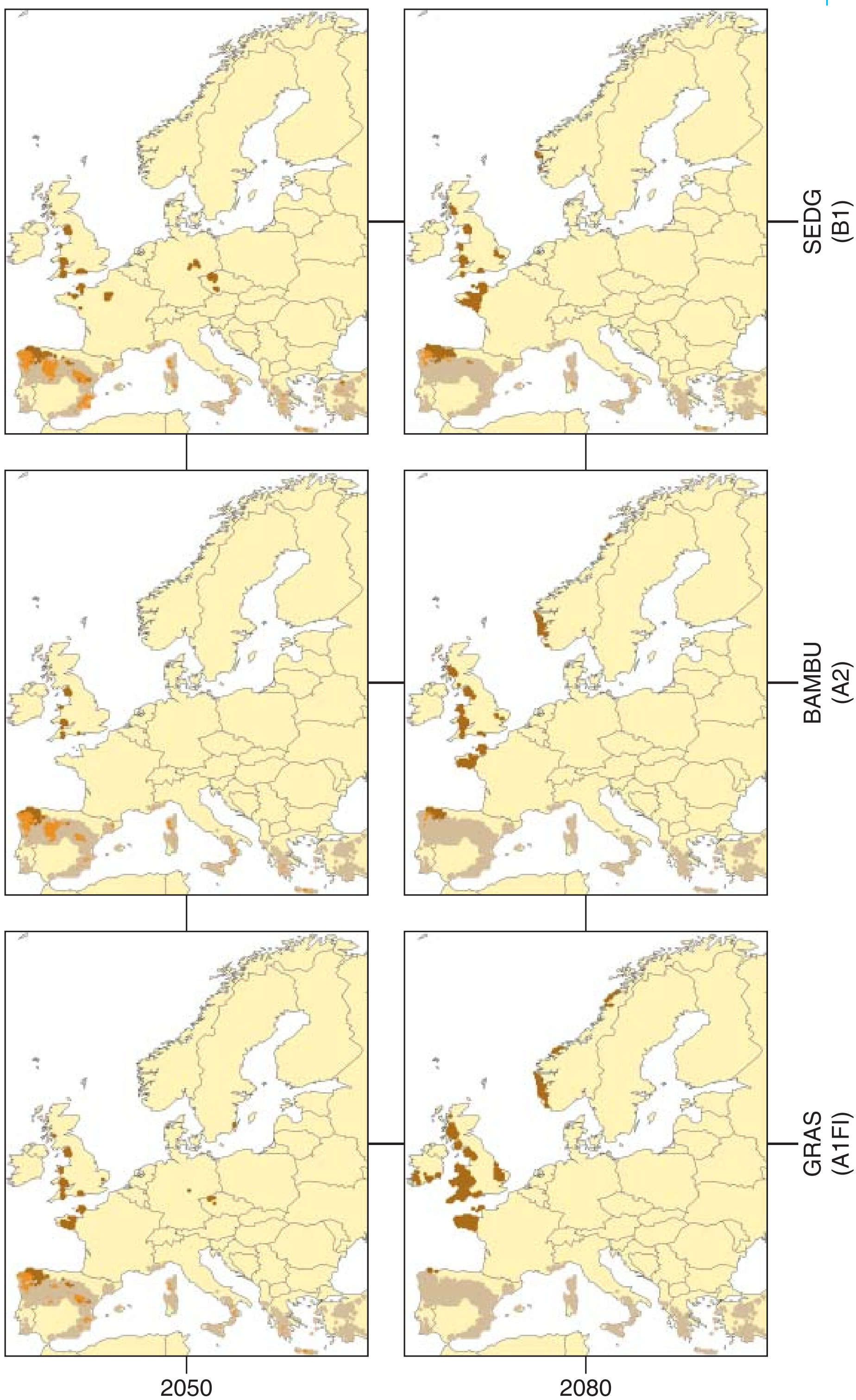
Present distribution can be well explained by climatic variables (AUC = 0.89).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melanargia larissa (Esper, 1784) – Balkan Marbled White

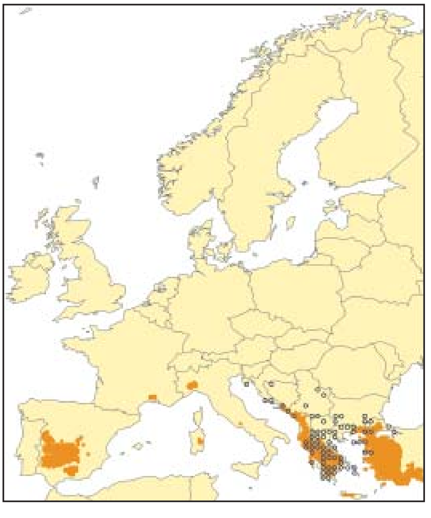
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	127 (11.33%)	-497 (-44.34%)
	BAMBU	-25 (-2.23%)	-534 (-47.64%)
	GRAS	24 (2.14%)	-598 (-53.35%)
2080	SEDG	246 (21.94%)	-586 (-52.27%)
	BAMBU	-410 (-36.57%)	-873 (-77.88%)
	GRAS	-249 (-22.21%)	-1008 (-89.92%)

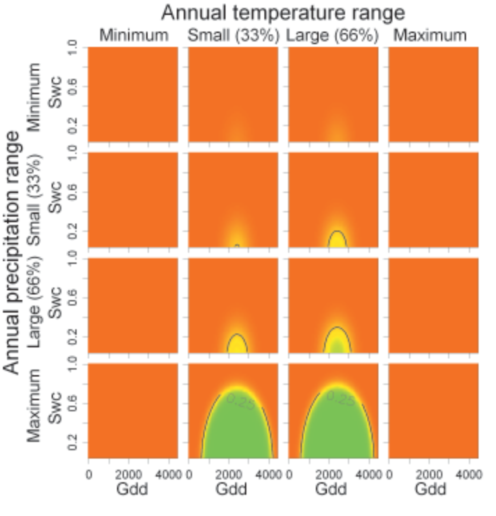
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1121)

The Balkan Marbled White occurs on dry grasslands, rocky slopes, in open scrub, and in grassy clearings in woods. Sometimes, these butterflies are even seen in villages. The caterpillars feed on different grasses. This butterfly is single-brooded and hibernates as a caterpillar.

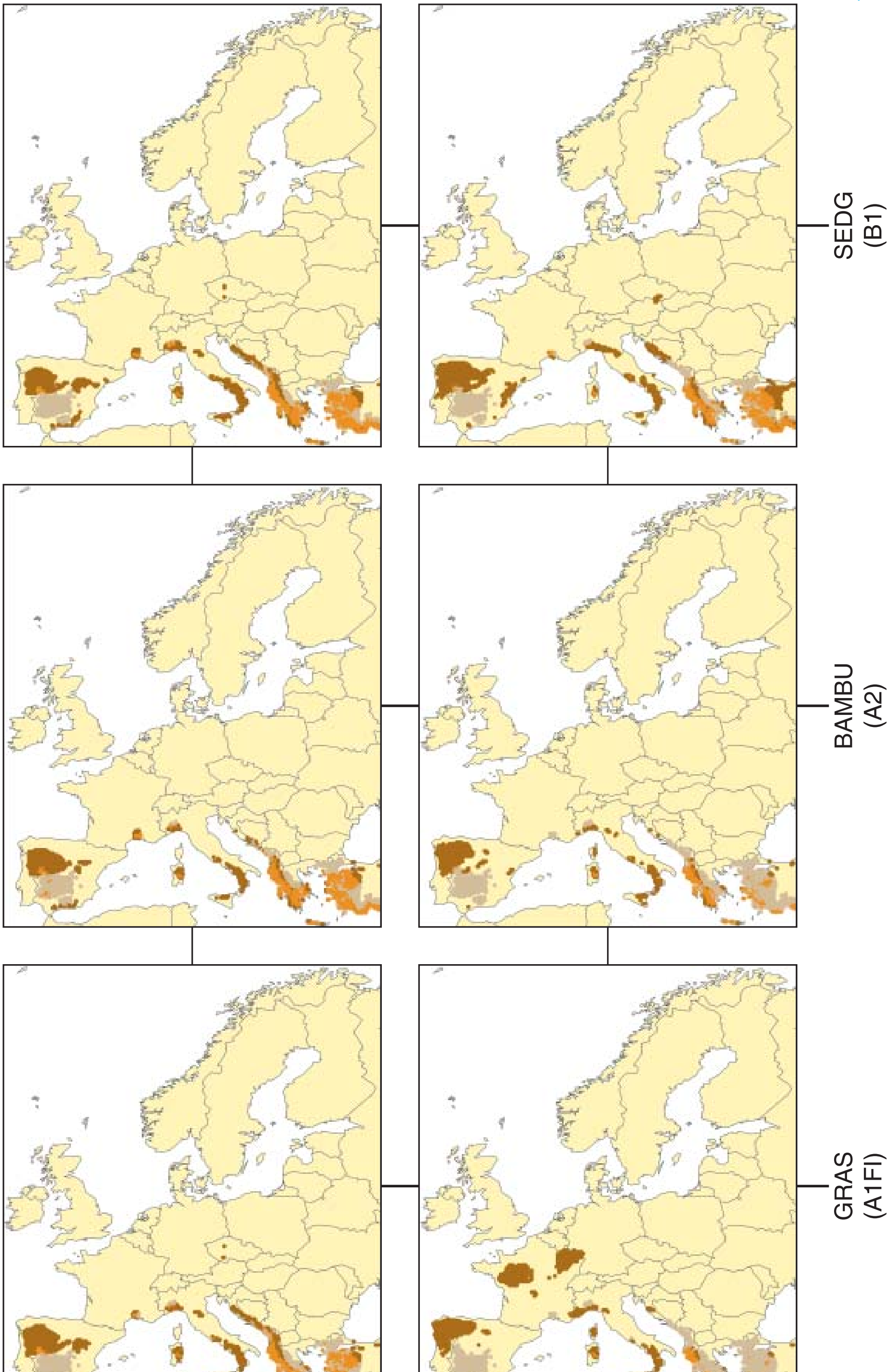
Present distribution can be well explained by climatic variables (AUC = 0.89).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melanargia arge (Sulzer, 1776) – Italian Marbled White

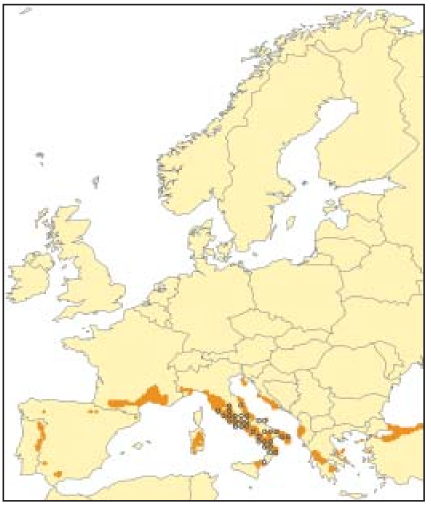
© Otakar Kudrna

		Full dispersal	No dispersal
2050	SEDG	488 (79.09%)	-281 (-45.54%)
	BAMBU	497 (80.55%)	-291 (-47.16%)
	GRAS	719 (116.53%)	-305 (-49.43%)
2080	SEDG	776 (125.77%)	-331 (-53.65%)
	BAMBU	767 (124.31%)	-409 (-66.29%)
	GRAS	655 (106.16%)	-447 (-72.45%)

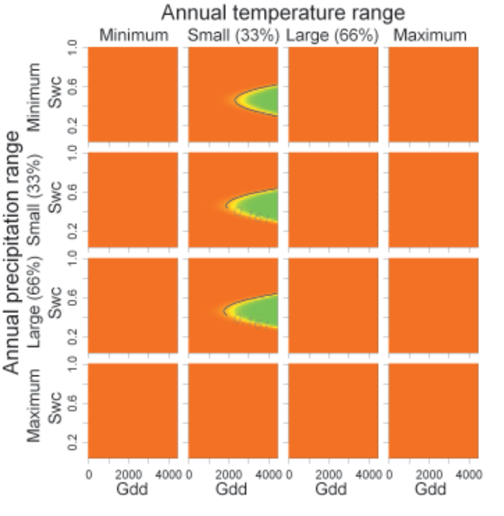
Changes in climatic niche distribution (in 10'×10' grid cells; present niche space: 617)

The Italian Marbled White occurs locally in small populations. It occurs in rocky, calcareous places on patches of dry, grassy vegetation among loose thickets of Prickly Juniper (*Juniperus oxycedrus*), *Rosa sempervirens*, the bramble *Rubus ulmifolius*, and *Thymus capitatus,* with a few scattered trees. The caterpillars feed on grasses such as Feather Grass (*Stipa pinnata*), and the false-brome *Brachypodium retusum*. The Italian Marbled White has one generation a year, and only flies for three weeks per year in any one location.
This species is listed in Annexes II and IV of the Habitats' Directive.

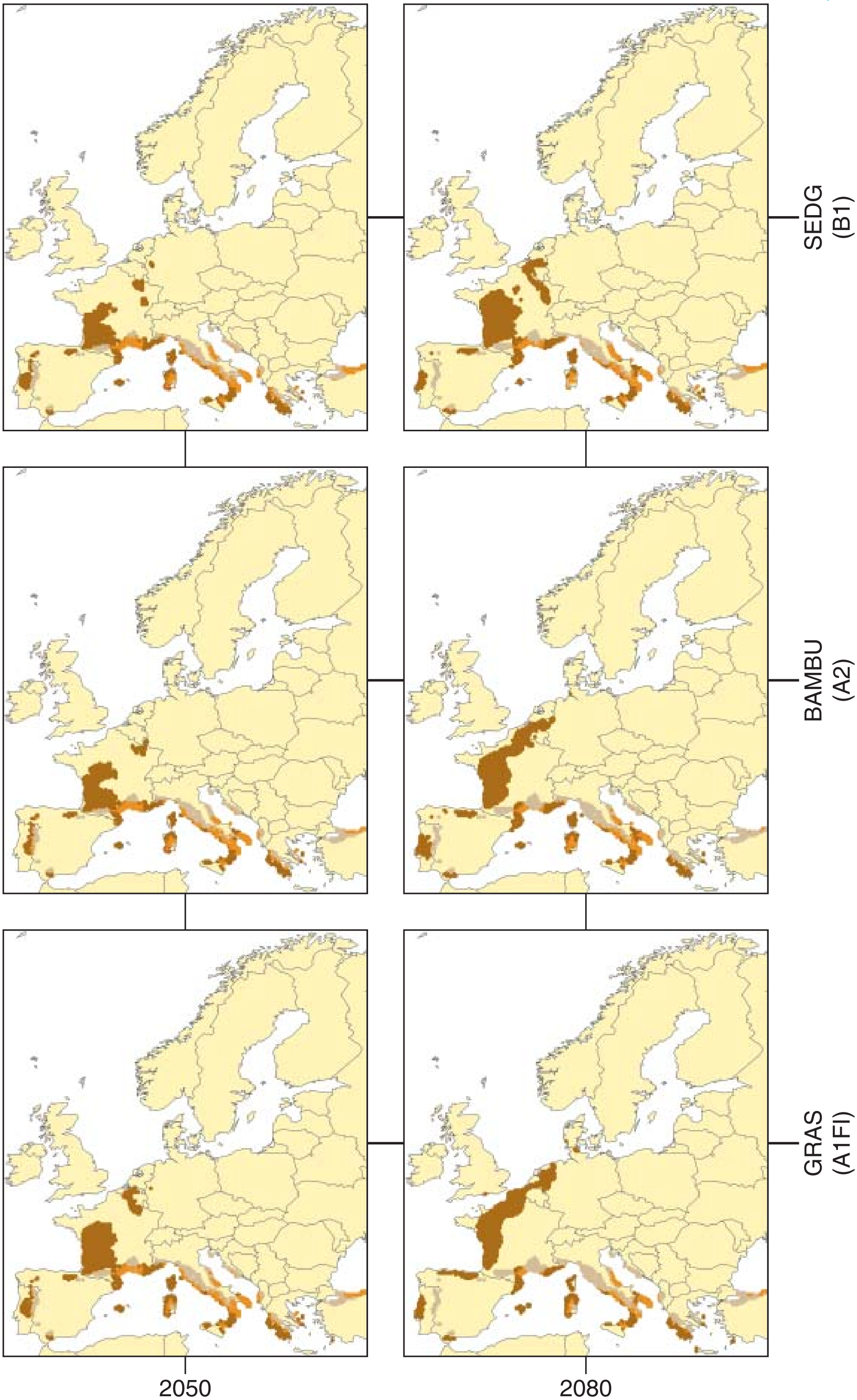
Present distribution can be very well explained by climatic variables (AUC = 0.98).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melanargia occitanica (Esper, 1793) – Western Marbled White

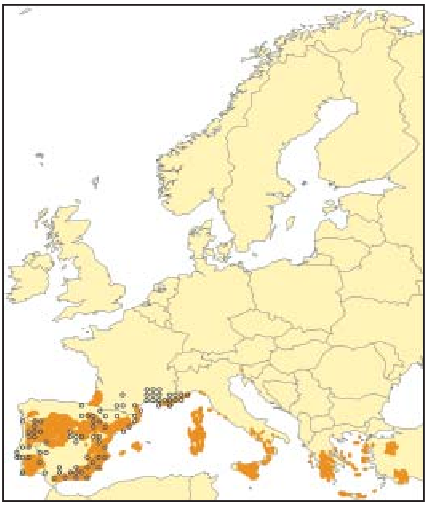
© Martin Wiemers

		Full dispersal	No dispersal
2050	**SEDG**	-958 (-68.19%)	-1076 (-76.58%)
	BAMBU	-1081 (-76.94%)	-1137 (-80.93%)
	GRAS	-1141 (-81.21%)	-1246 (-88.68%)
2080	**SEDG**	-1081 (-76.94%)	-1345 (-95.73%)
	BAMBU	-1196 (-85.12%)	-1402 (-99.79%)
	GRAS	-1014 (-72.17%)	-1405 (-100%)

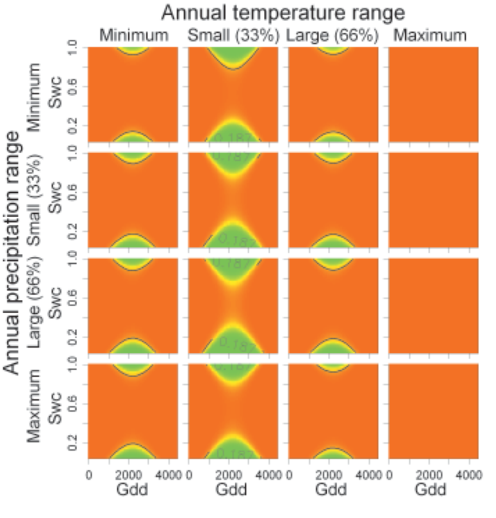
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 1405)

The Western Marbled White is mostly found in dry, rocky places with grassy vegetation and scattered rocks, although it is also seen in damper locations. Its foodplants are various grasses, such as Tor-grass (*Brachypodium pinnatum*), Bermuda-grass (*Cynodon dactylon*), and Cock’s-foot (*Dactylus glomerata*). This species is single-brooded and hibernates as a caterpillar.

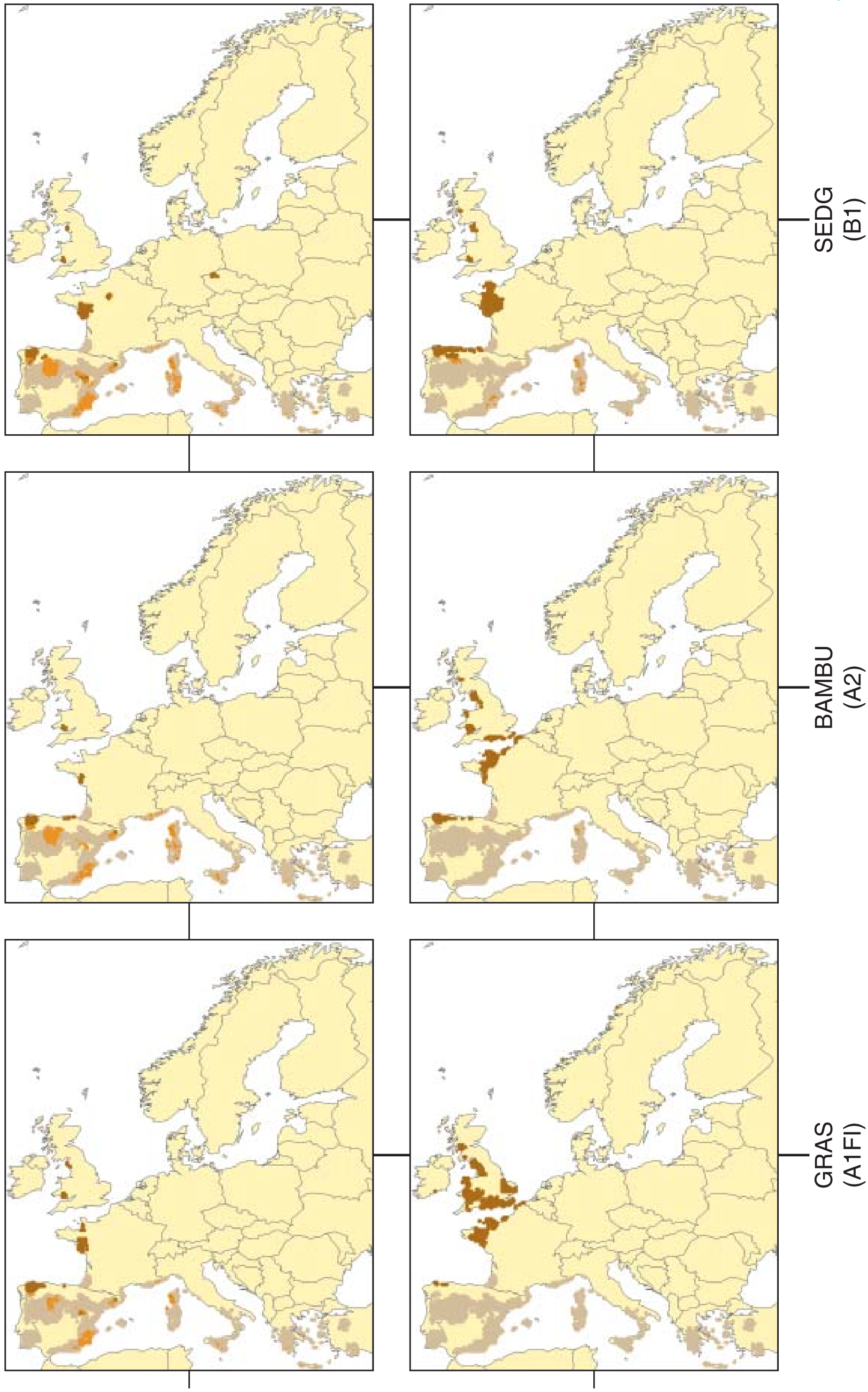
Present distribution can be well explained by climatic variables (AUC = 0.86).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Melanargia ines (Hoffmansegg, 1804) – Spanish Marbled White

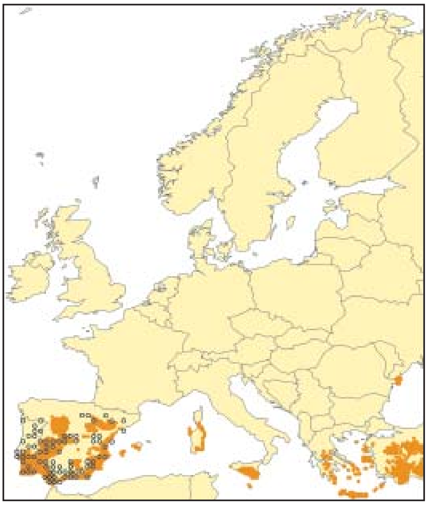
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-460 (-41.52%)	-547 (-49.37%)
	BAMBU	-648 (-58.48%)	-659 (-59.48%)
	GRAS	-657 (-59.3%)	-690 (-62.27%)
2080	SEDG	-794 (-71.66%)	-833 (-75.18%)
	BAMBU	-1019 (-91.97%)	-1019 (-91.97%)
	GRAS	-1073 (-96.84%)	-1073 (-96.84%)

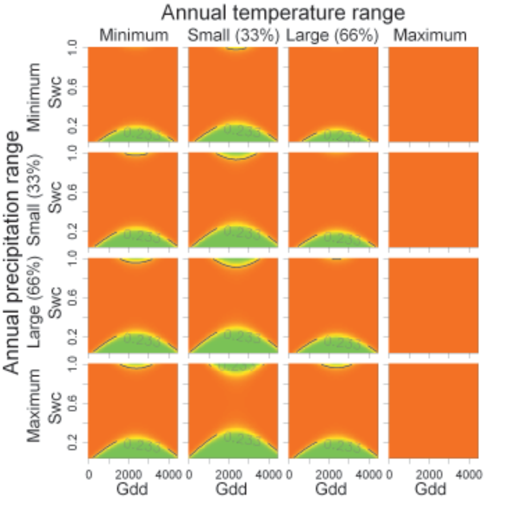
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1108)

The Spanish Marbled White is found in warm, dry places with low vegetation on rocky slopes, on flower-rich grassy vegetation, and in scrub. Its foodplants are grasses, such as Tor-grass (*Brachypodium pinnatum*) and Compact Brome (*Bromus madritensis*). The caterpillars hibernate, pupating on the ground in the early spring.

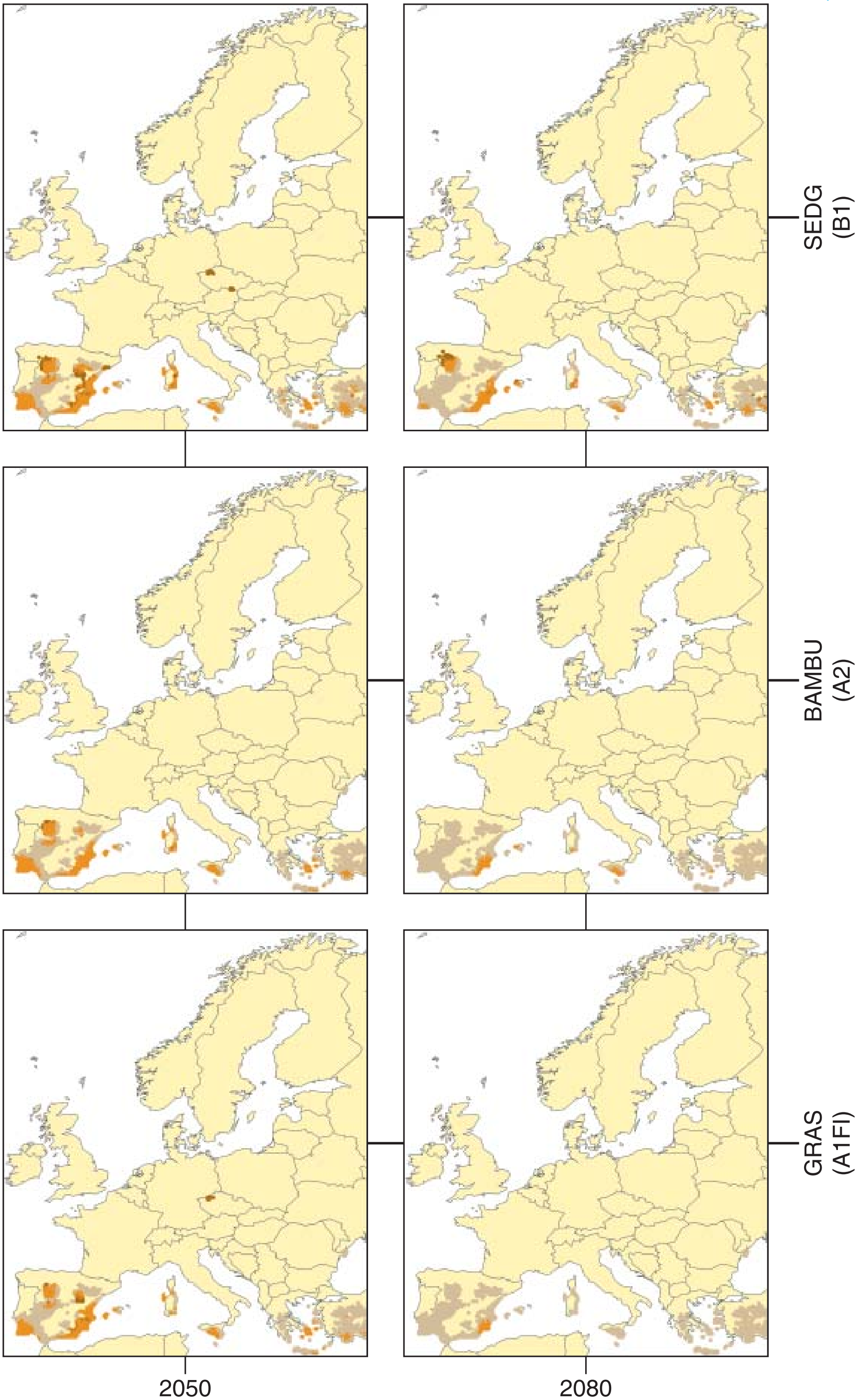
Present distribution can be well explained by climatic variables (AUC = 0.95).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

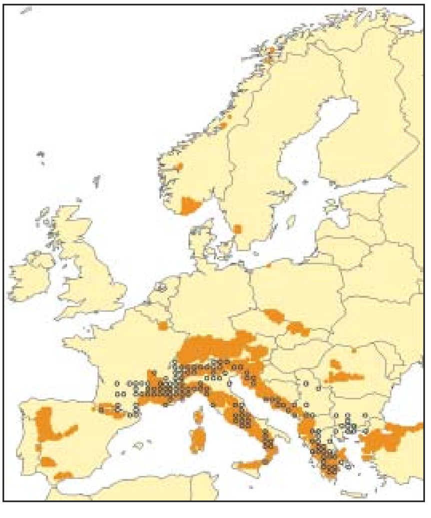
Satyrus ferula (Fabricius, 1793) – Great Sooty Satyr

		Full dispersal	No dispersal
2050	SEDG	-703 (-31.91%)	-1206 (-54.74%)
	BAMBU	-741 (-33.64%)	-1333 (-60.51%)
	GRAS	-941 (-42.71%)	-1572 (-71.36%)
2080	SEDG	-378 (-17.16%)	-1706 (-77.44%)
	BAMBU	-601 (-27.28%)	-1846 (-83.79%)
	GRAS	-631 (-28.64%)	-2036 (-92.42%)

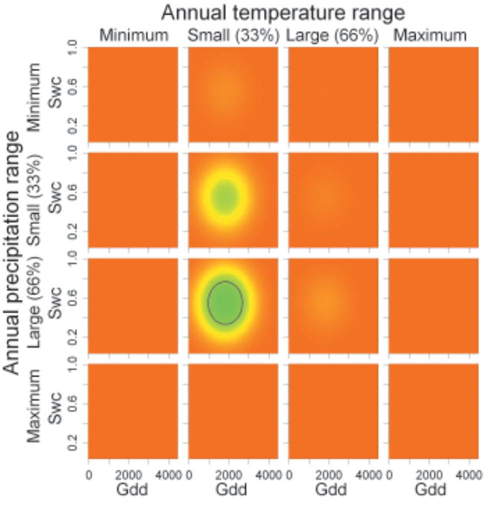
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2203)

In the mountains, the Great Sooty Satyr is mostly found in open, dry, rocky places with grassy vegetation. At lower altitudes, the butterflies occur in open clearings in woods, or at wood edges. They can often be seen drinking nectar on such flowers as thistles and scabious (*Knautia* spp.). The female lays her eggs low down on dry grass stems. The caterpillars hibernate when still quite small, and pupate in May or June. Sheep's-fescue (*Festuca ovina*) is the most important foodplant, but other fescues (*Festuca* spp.), false-bromes (*Brachypodium* spp.), and bromes (*Bromus* spp.) are probably also used.

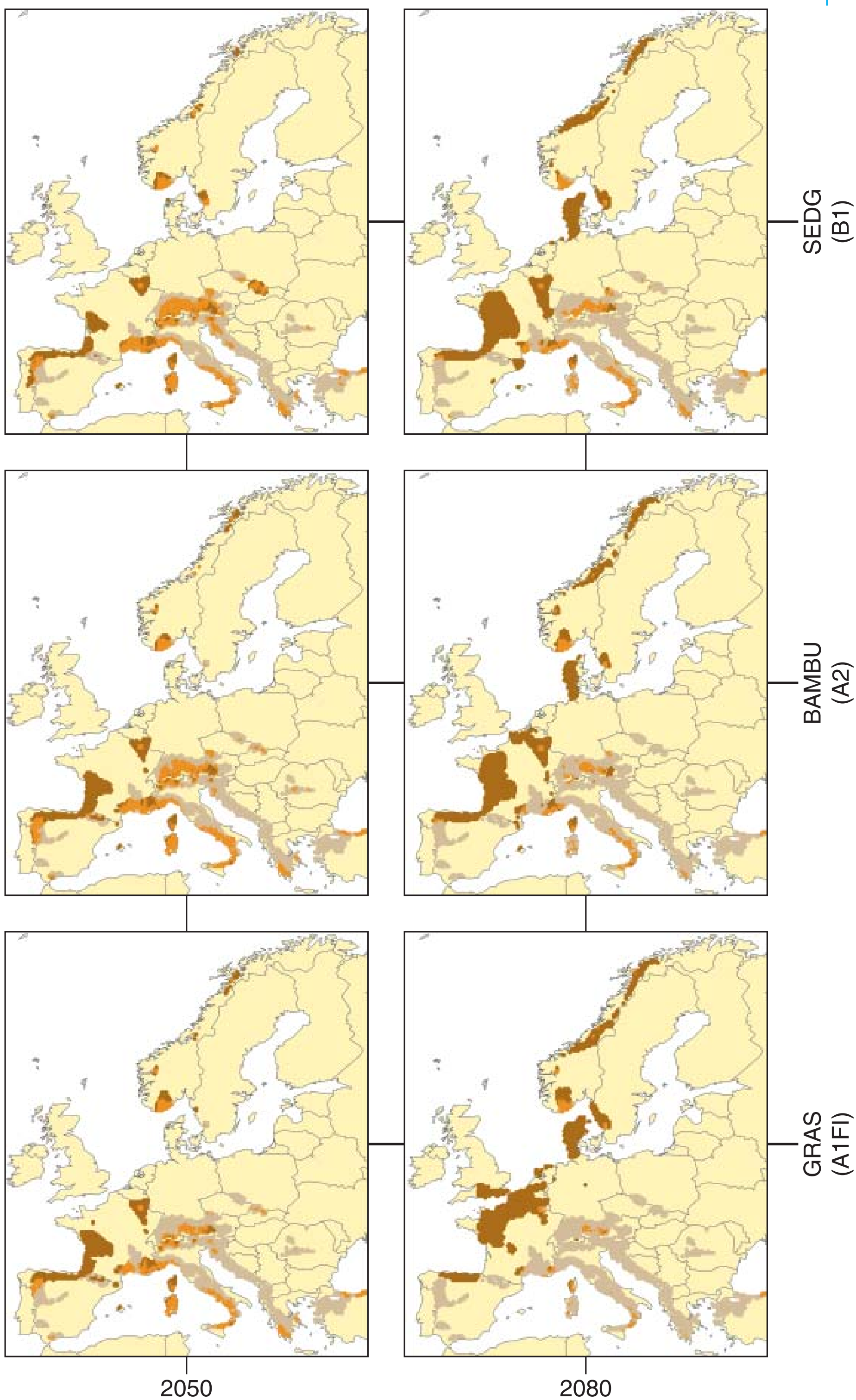
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.76).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Satyrus actaea (Esper, 1780) – Black Satyr

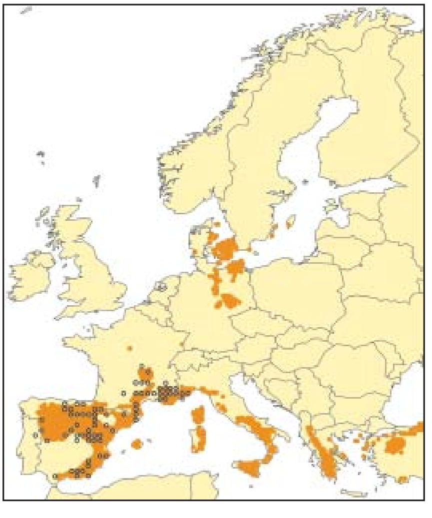
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	-200 (-12.36%)	-1171 (-72.37%)
	BAMBU	-1060 (-65.51%)	-1317 (-81.4%)
	GRAS	-669 (-41.35%)	-1373 (-84.86%)
2080	SEDG	-749 (-46.29%)	-1522 (-94.07%)
	BAMBU	-1016 (-62.79%)	-1579 (-97.59%)
	GRAS	-1015 (-62.73%)	-1611 (-99.57%)

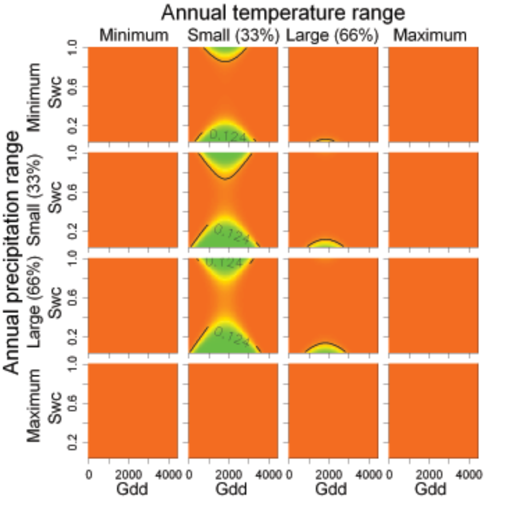
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 1618)

The Black Satyr can be found on grassy vegetation, rocky slopes, and in scrub. The caterpillars feed on various grasses, such as fescues (*Festuca* spp.), meadow-grasses (*Poa* spp.), false-bromes (*Brachypodium* spp.), and bromes (*Bromus* spp.). They hibernate and then pupate on the ground at the end of the spring in May to June. The Black Satyr is single-brooded.

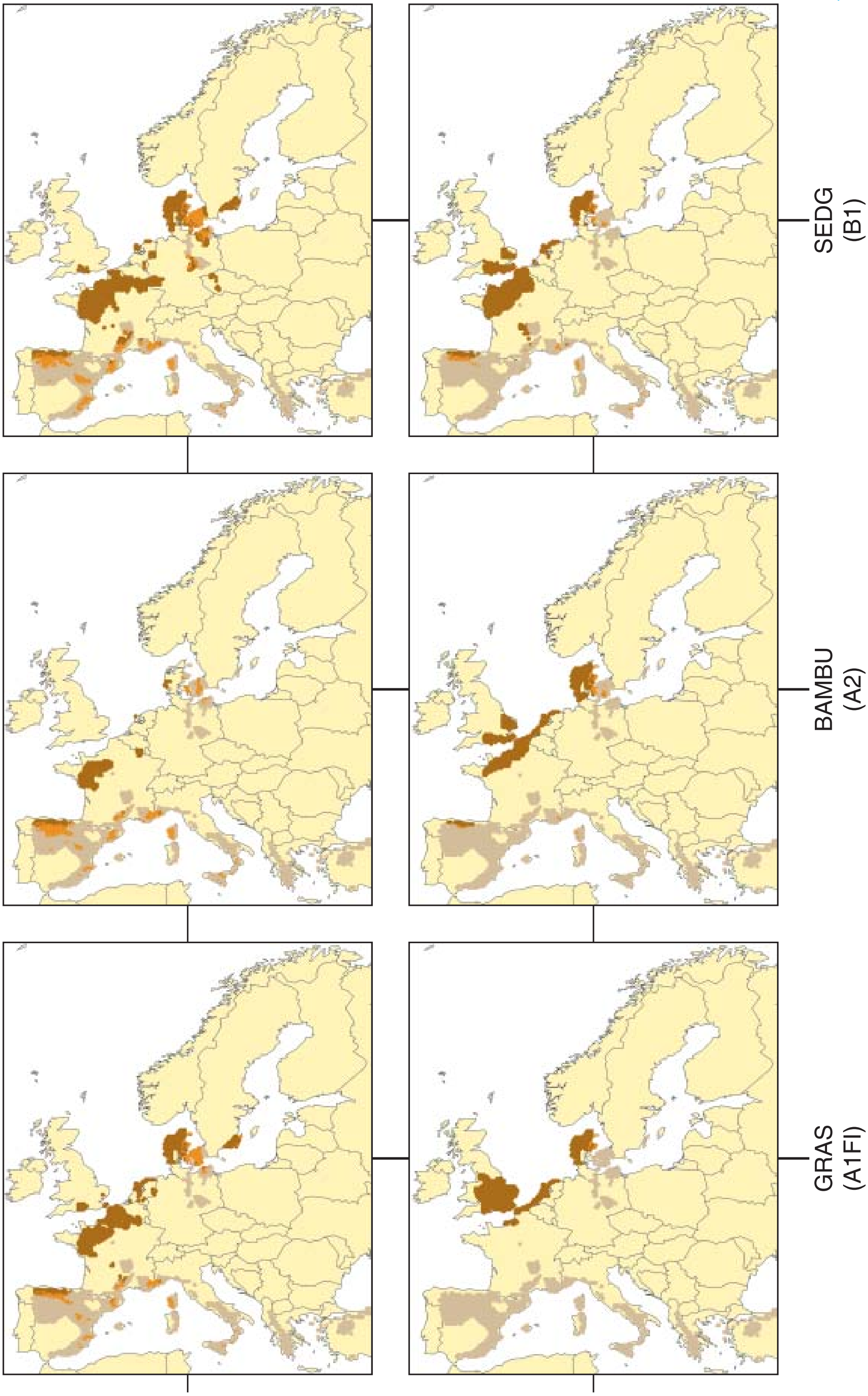
Present distribution can be well explained by climatic variables (AUC = 0.92).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Minois dryas (Scopoli, 1763) – Dryad

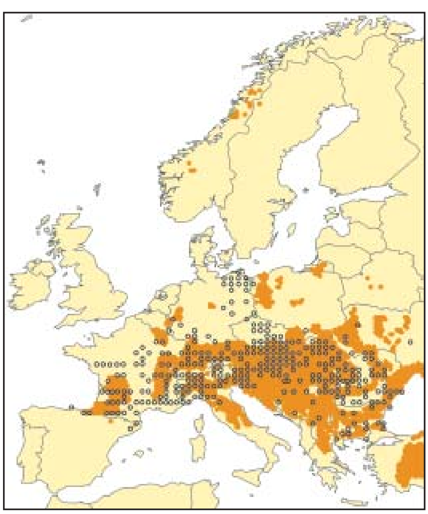
© Martin Wiemers

		Full dispersal	No dispersal
2050	SEDG	2262 (53.35%)	-1957 (-46.16%)
	BAMBU	3822 (90.14%)	-1934 (-45.61%)
	GRAS	2375 (56.01%)	-2311 (-54.5%)
2080	SEDG	3230 (76.18%)	-2611 (-61.58%)
	BAMBU	3810 (89.86%)	-3066 (-72.31%)
	GRAS	4305 (101.53%)	-3463 (-81.67%)

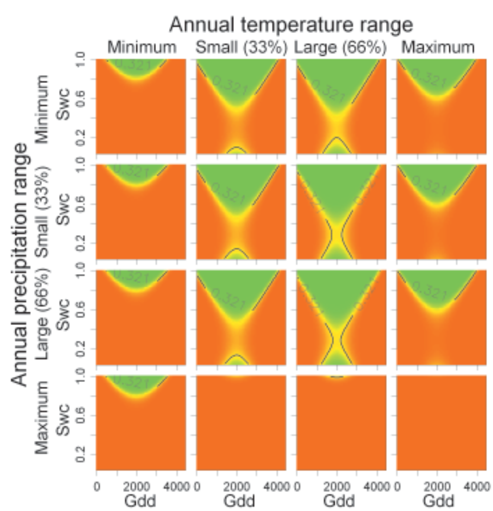
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 4240)

The Dryad inhabits grassy, rather rough vegetation, often located at the edge of woodland or scrub, and mostly quite damp. The foodplants are relatively broad-leaved, nutritious grasses, such as Purple Moor-grass (*Molinea caerulea*), small-reeds (*Calamagrostis* spp.), and bromes (*Bromus* spp.). The female drops her eggs in flight into the grass. The tiny caterpillars emerge and, without feeding, enter a period of inactivity during the summer months. In the autumn, they begin to feed, hibernating in the first or second larval instar. The caterpillars make a little hollow in the ground in which to pupate, but do not spin a cocoon. The Dryad is single-brooded.

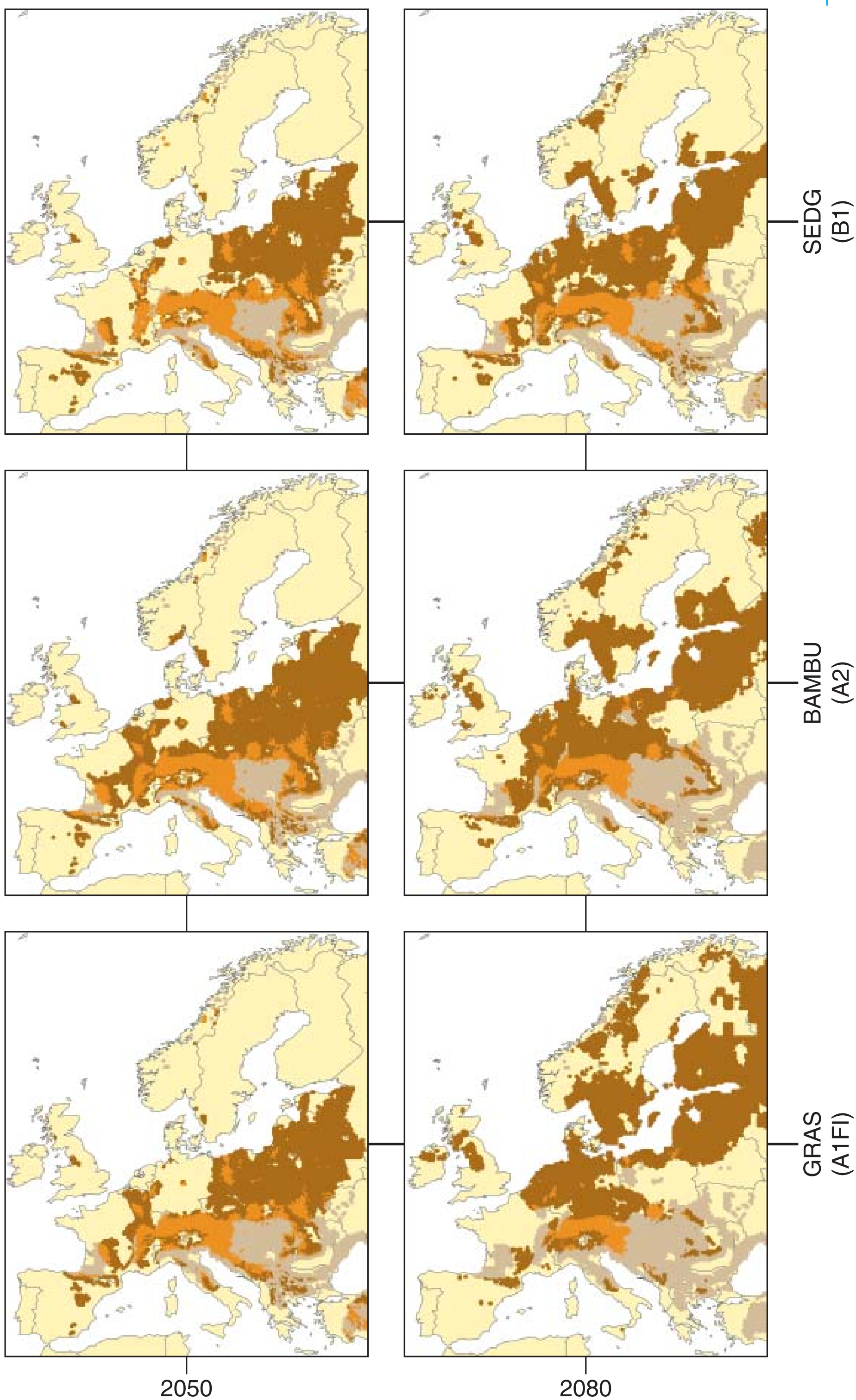
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.83). Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Hipparchia fagi (Scopoli, 1763) – Woodland Grayling

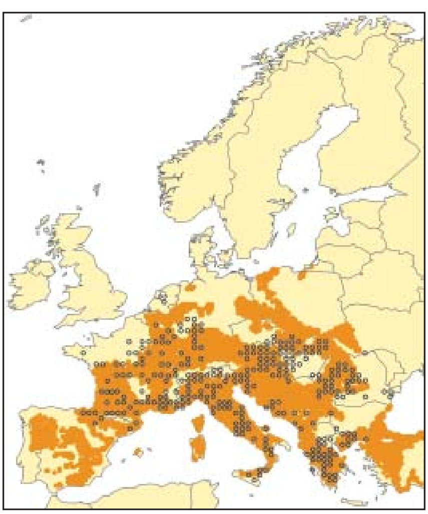
© Rudi Verovnik

		Full dispersal	No dispersal
2050	SEDG	1516 (23.19%)	-1565 (-23.94%)
	BAMBU	2258 (34.54%)	-1710 (-26.16%)
	GRAS	830 (12.7%)	-2226 (-34.05%)
2080	SEDG	2059 (31.5%)	-2487 (-38.04%)
	BAMBU	1747 (26.72%)	-3478 (-53.2%)
	GRAS	1334 (20.41%)	-4425 (-67.69%)

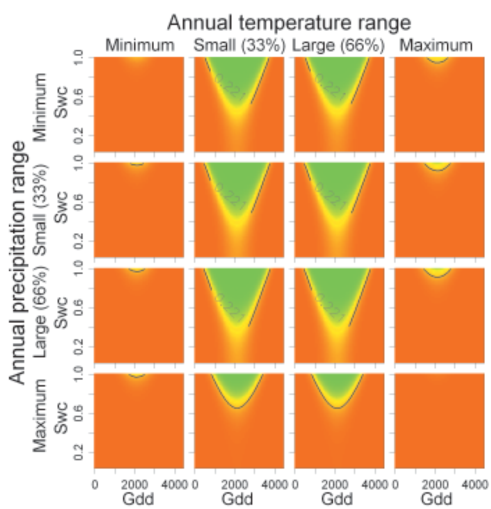
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 6537)

The Woodland Grayling is a butterfly of open woods that occurs on grassy vegetation, along woodland rides, and in woodland glades. The butterflies are fond of settling on tree trunks, head end up, where, with their wings tightly closed and the eye-spots hidden, they are very well camouflaged. The eggs are laid on the blades of such grasses as fescues (*Festuca* spp.), false-bromes (*Brachypodium* spp.), and bromes (*Bromus* spp.). The caterpillars grow very slowly and, when they are half-grown, they hibernate in the litter layer. The caterpillar pupates in a little hollow in the ground, spinning itself a sort of cocoon. The Woodland Grayling has one generation a year.

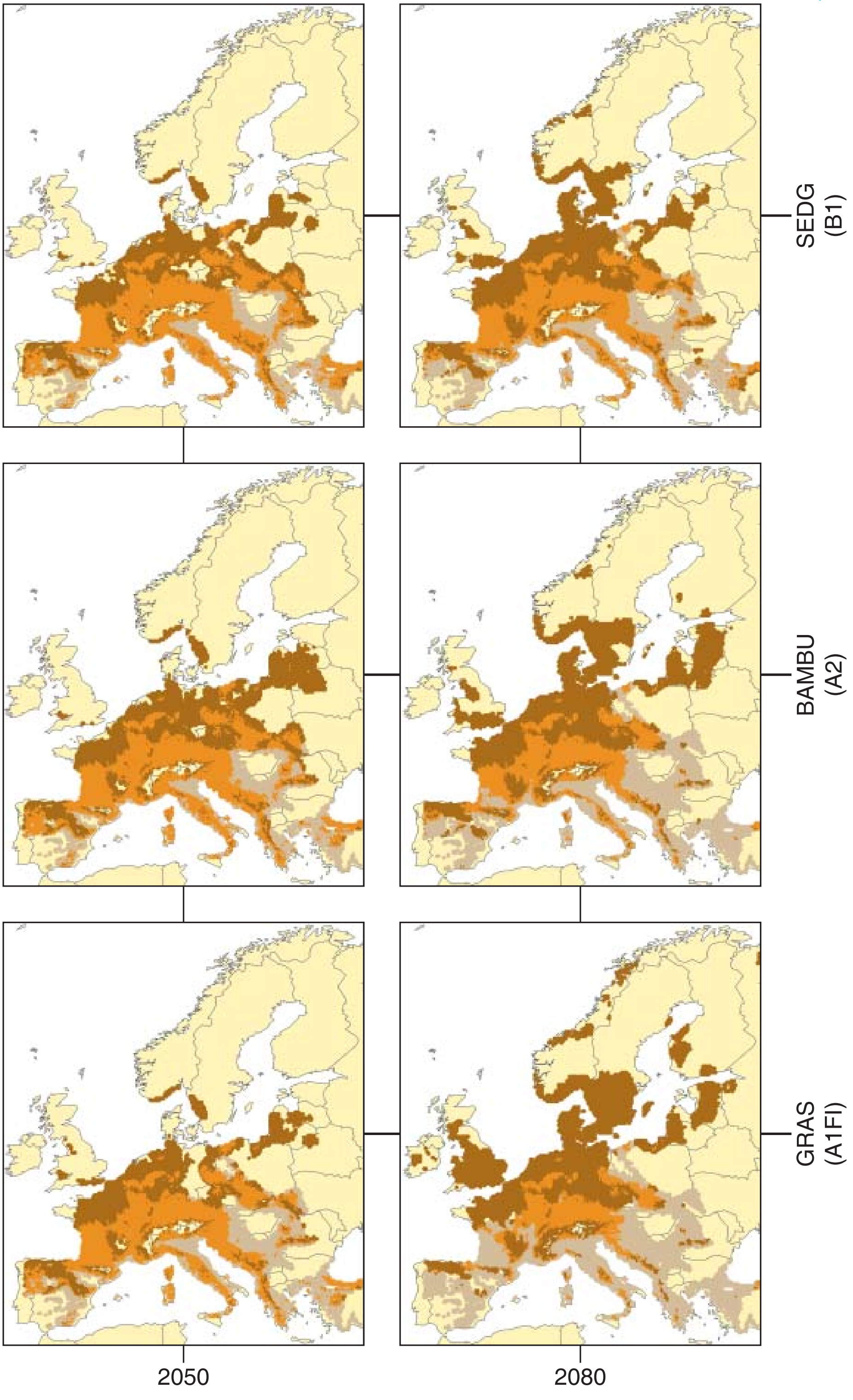
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.83). Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Hipparchia hermione (Linnaeus, 1764) – Rock Grayling

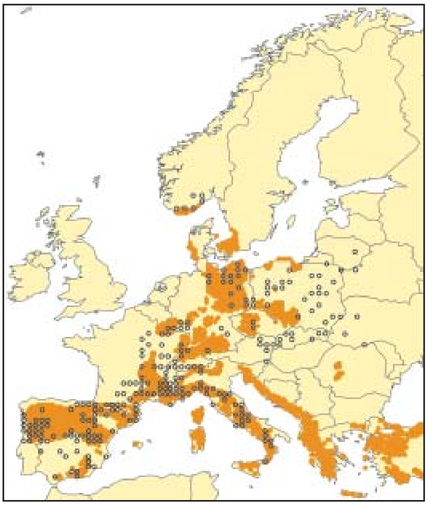
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	14 (0.42%)	-1651 (-49.89%)
	BAMBU	-1810 (-54.7%)	-2266 (-68.48%)
	GRAS	-1329 (-40.16%)	-2414 (-72.95%)
2080	SEDG	-906 (-27.38%)	-2535 (-76.61%)
	BAMBU	-2091 (-63.19%)	-2968 (-89.69%)
	GRAS	-2086 (-63.04%)	-3191 (-96.43%)

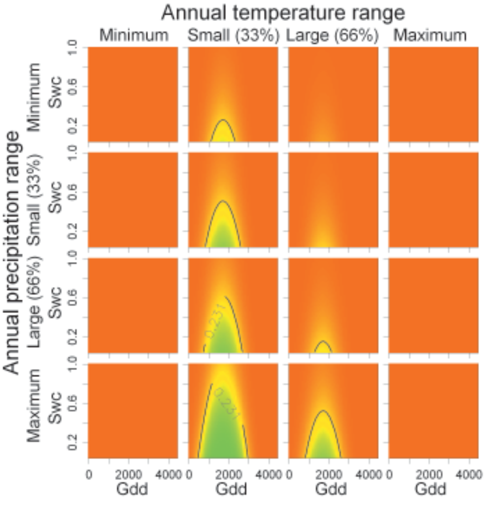
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 3309)

The Rock Grayling can be found at the edge of very open woodland on poor steppe-like grasslands, as found, for example, near open coniferous woods growing on sandy ground. In these habitats, there are usually rock masses or other sorts of open ground. The butterfly often rests on the ground or against tree trunks, where the colours and pattern of the underside of its wings provide excellent camouflage. The eggs are laid on different grasses, including fescues (*Festuca* spp.) and false-bromes (*Brachypodium* spp.). The caterpillars grow very slowly and hibernate when half-grown in the litter layer. They pupate in a little hollow in the ground, after spinning a sort of cocoon. The Rock Grayling has one brood a year.

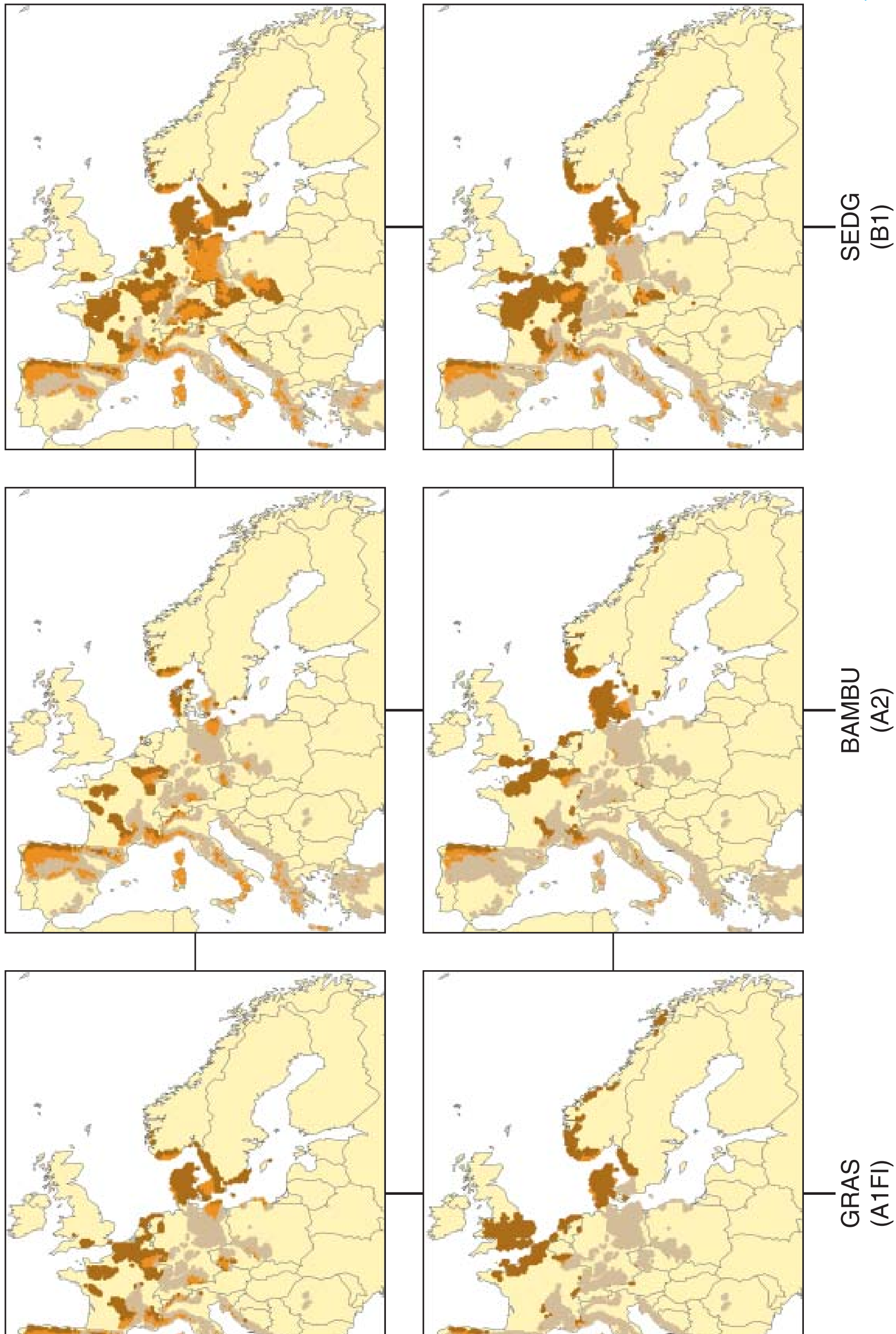
Present distribution can be explained by climatic variables to only a limited extent (AUC = 0.72).
Climate risk category: PR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

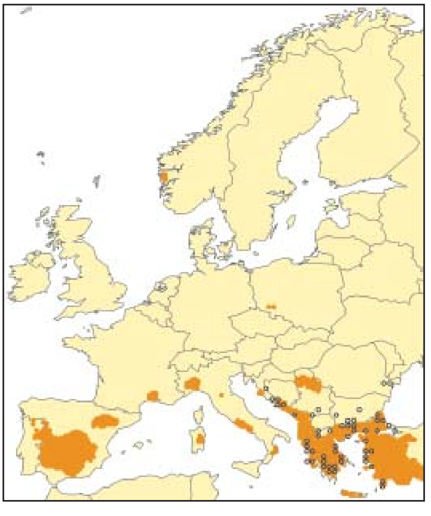
Hipparchia syriaca (Staudinger, 1871) – Eastern Rock Grayling

		Full dispersal	No dispersal
2050	SEDG	774 (40.33%)	-595 (-31.01%)
	BAMBU	481 (25.07%)	-646 (-33.66%)
	GRAS	534 (27.83%)	-773 (-40.28%)
2080	SEDG	652 (33.98%)	-893 (-46.53%)
	BAMBU	-201 (-10.47%)	-1231 (-64.15%)
	GRAS	445 (23.19%)	-1432 (-74.62%)

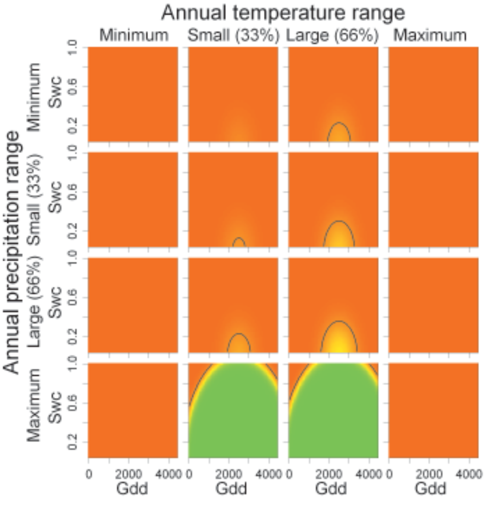
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 1919)

The Eastern Rock Grayling looks very much like the Woodland Grayling (*H. fagi*), and they occur together in some places.. This butterfly is a species of scrub and light woodland of all sorts, deciduous, coniferous and mixed. At the hottest part of the day, the butterflies hardly fly at all, resting with closed wings on the shadow side of the tree trunk, or on the ground where they blend into their surroundings. They hardly ever visit flowers. Their flight is quick and powerful. The caterpillars feed on grasses. Although single-brooded, they can be seen from May until September. The butterflies may be inactive during the hot, dry summer.

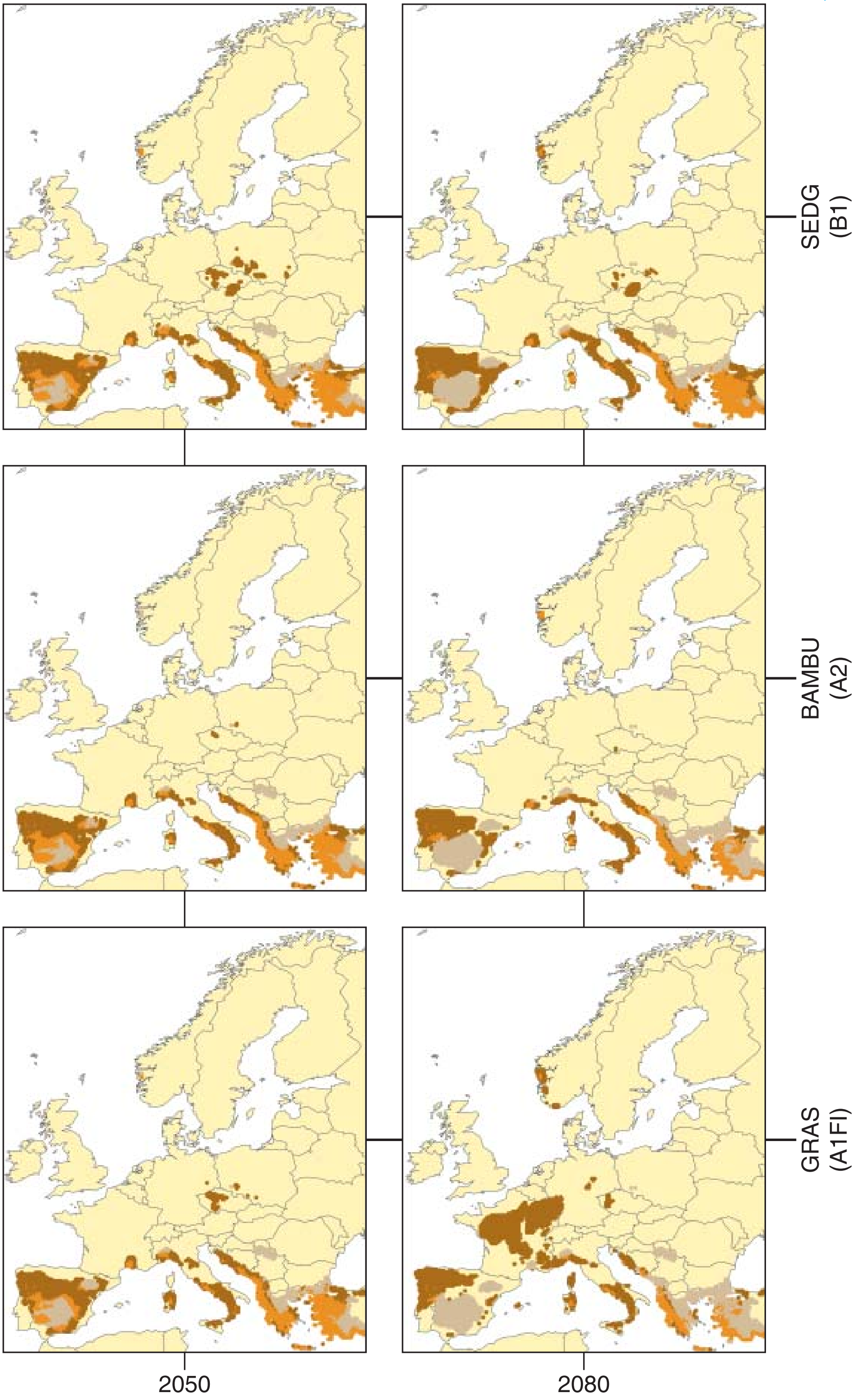
Present distribution can be well explained by climatic variables (AUC = 0.95).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Hipparchia semele (Linnaeus, 1758) – Grayling

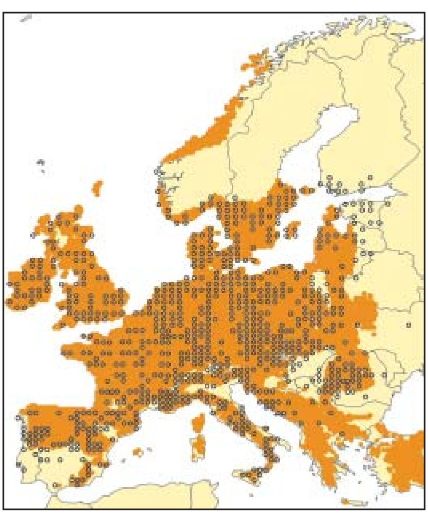
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-2284 (-16.51%)	-3095 (-22.37%)
	BAMBU	-3269 (-23.63%)	-4031 (-29.14%)
	GRAS	-3564 (-25.76%)	-4405 (-31.84%)
2080	SEDG	-5233 (-37.83%)	-6024 (-43.55%)
	BAMBU	-6634 (-47.96%)	-7748 (-56.01%)
	GRAS	-8424 (-60.9%)	-9748 (-70.47%)

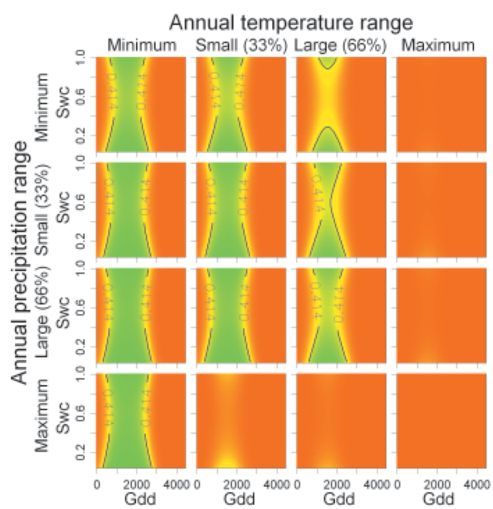
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 13833)

The Grayling is found in dry, infertile surroundings, occurring on poor, dry grasslands, dry heaths, and also often at the coast. The males and females meet each other above a solitary tree in a wide open landscape, such as a pine on heathland. The female lays her eggs on various fine-leaved grasses, including fescues (*Festuca* spp.), bents (*Agrostis* spp.), and bromes (*Bromus* spp.). Walking over the bare ground, she approaches a grass tussock, and deposits an egg on a withered grass blade a few centimetres above the ground. The caterpillar grows very slowly, feeding mostly at night. It hibernates deep down in a grass tussock. When it is ready to pupate, it spins itself a sort of cocoon in a little hollow in the ground. The Grayling has one brood a year.

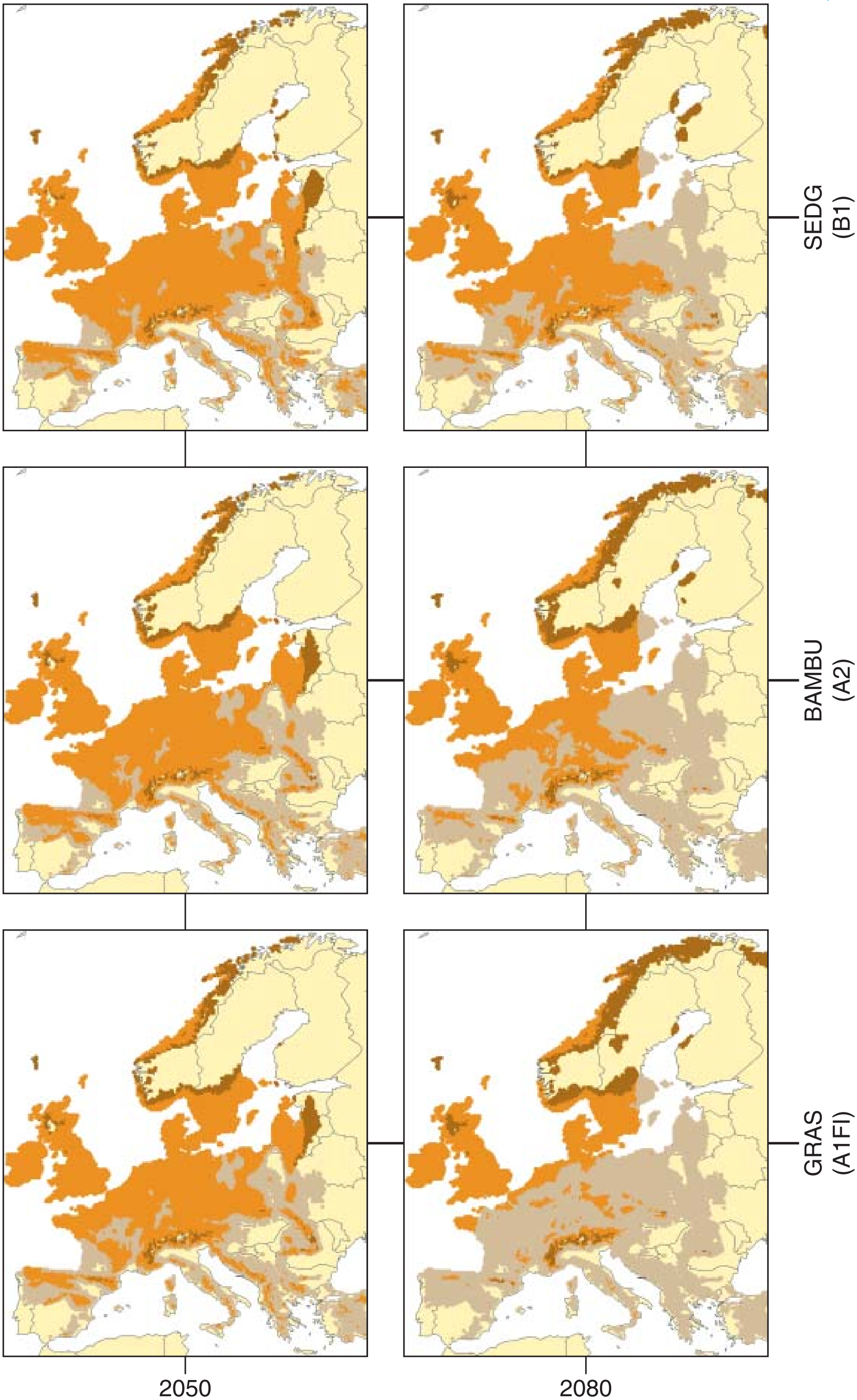
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.79).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

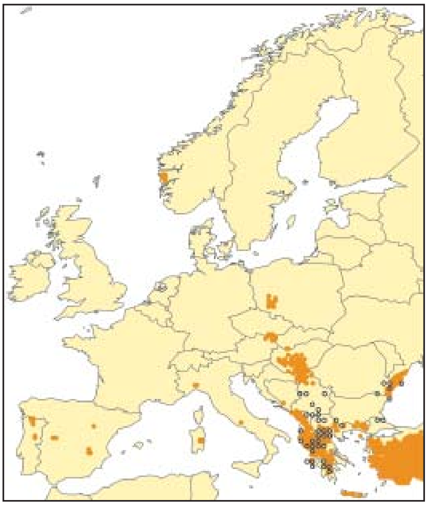
Hipparchia volgensis (Mazochin-Porshnyakov, 1952) – Delattin's Grayling

		Full dispersal	No dispersal
2050	SEDG	426 (43.43%)	-382 (-38.94%)
2050	BAMBU	-96 (-9.79%)	-549 (-55.96%)
2050	GRAS	155 (15.8%)	-575 (-58.61%)
2080	SEDG	152 (15.49%)	-465 (-47.4%)
2080	BAMBU	-432 (-44.04%)	-735 (-74.92%)
2080	GRAS	-467 (-47.6%)	-856 (-87.26%)

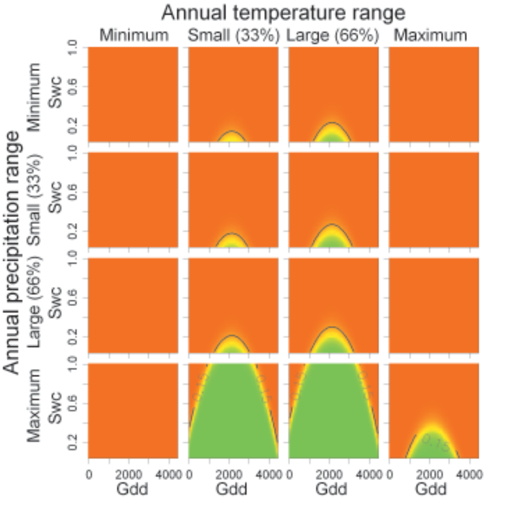
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 981)

Delattin's Grayling is a butterfly of warm and dry places. It is found on rocky slopes, on dry grasslands, and in light woodland. It is single-brooded. Adults fly from June to July. Details of the ecology of the species are unknown.

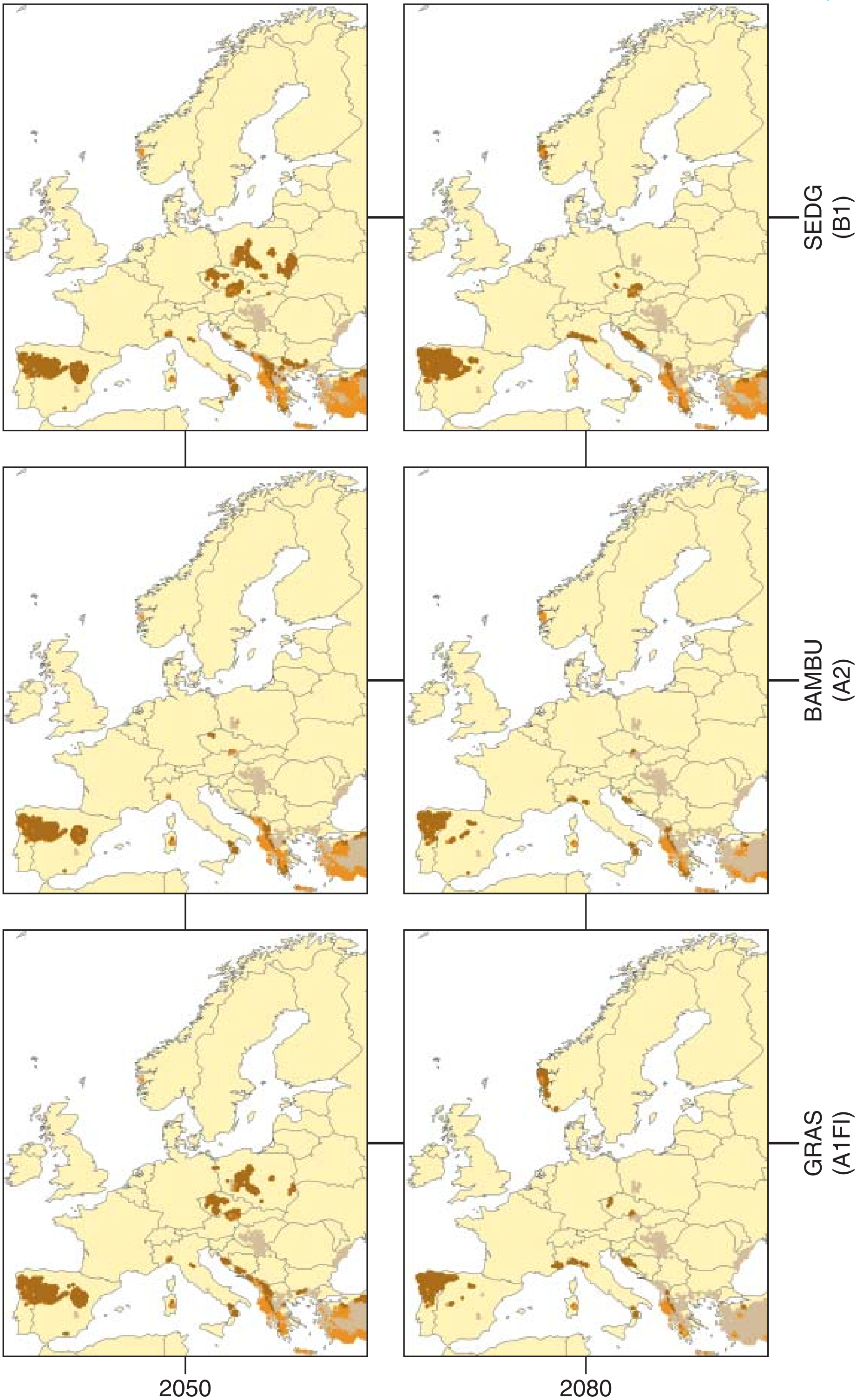
Present distribution can be well explained by climatic variables (AUC = 0.94).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Hipparchia statilinus (Hufnagel, 1766) – Tree Grayling

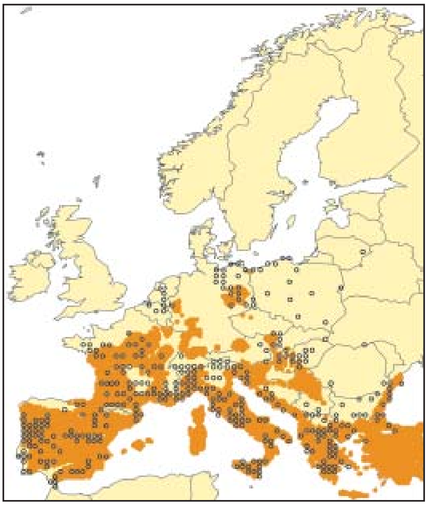
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	1004 (16.41%)	-1947 (-31.83%)
	BAMBU	-56 (-0.92%)	-2416 (-39.5%)
	GRAS	506 (8.27%)	-2640 (-43.16%)
2080	SEDG	-99 (-1.62%)	-3063 (-50.07%)
	BAMBU	-506 (-8.27%)	-4017 (-65.67%)
	GRAS	-1068 (-17.46%)	-5188 (-84.81%)

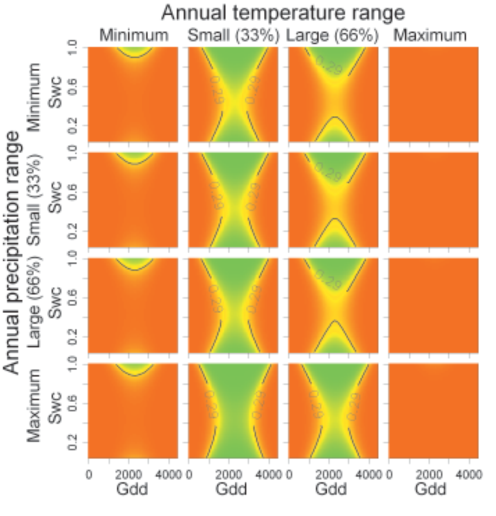
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 6117)

The Tree Grayling occurs in very warm, dry and nutrient-poor areas with much open ground and sparse vegetation. The size and markings of this butterfly are very variable. While remaining on the ground, the female deposits her eggs one by one on withered blades of grass. Grey Hair-grass (*Corynephorus canescens*), Sheep's-fescue (*Festuca ovina*), Brown Bent-grass (*Agrostis vinealis*), bromes (*Bromus* spp.), Feather grass (*Stipa pinnata*), and other grasses are used as foodplants. The small caterpillar passes the winter in a grass tussock and, if it does not freeze, remains active during the winter. However, growth only begins after hibernation. As development is very slow, the caterpillar only pupates in the summer. The flight period of the Tree Grayling, that only has one brood a year, is therefore very late.

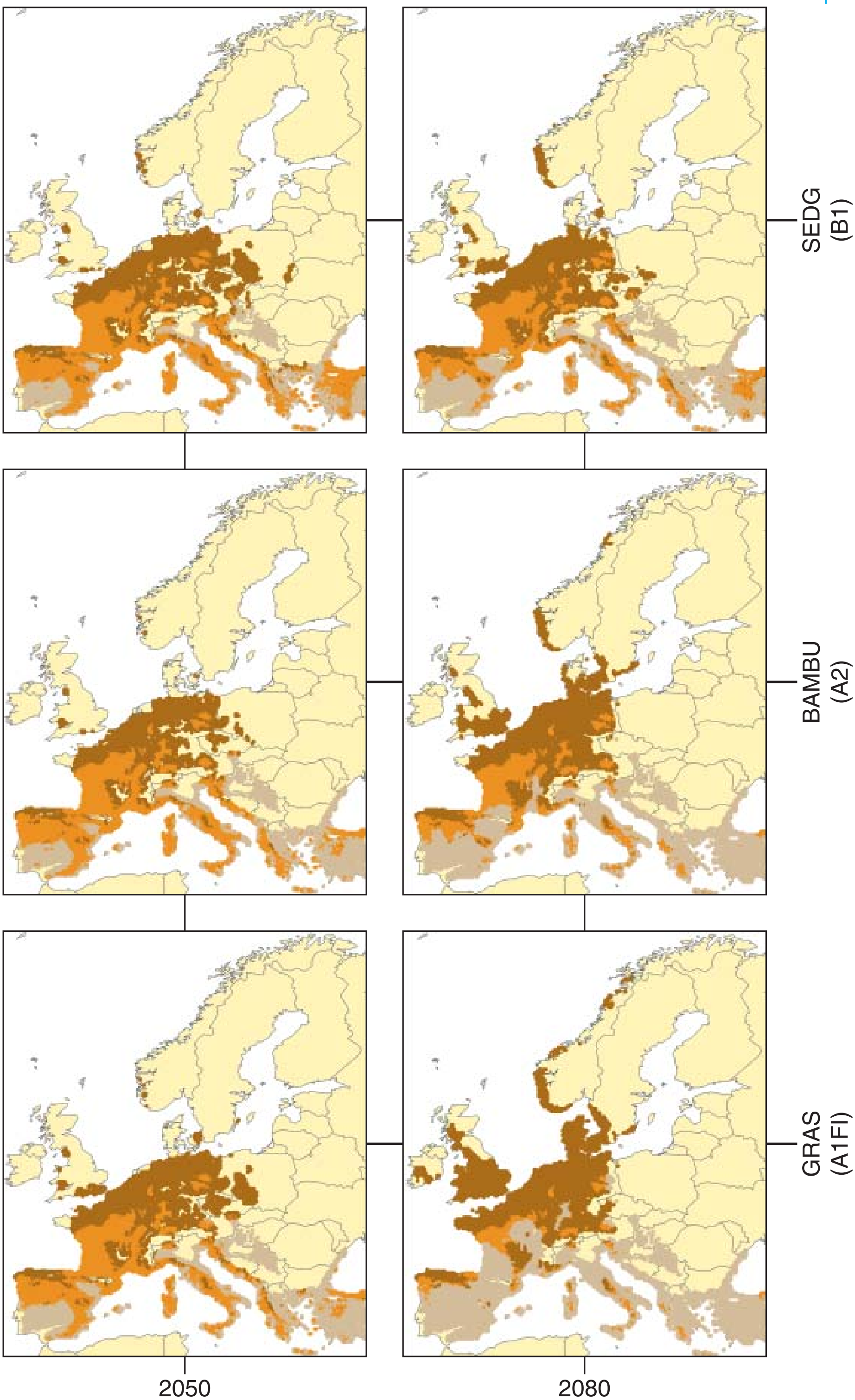
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.76).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Hipparchia fatua (Freyer, 1845) – Freyer's Grayling

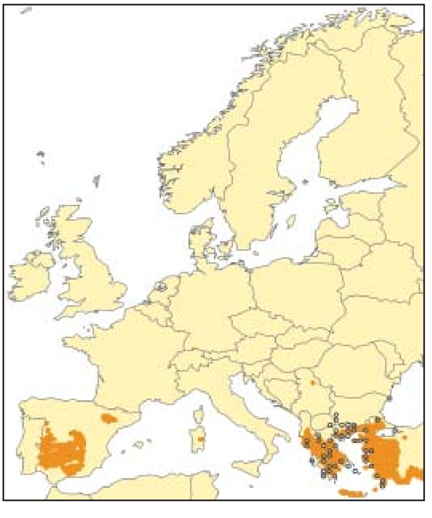
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-89 (-8.69%)	-482 (-47.07%)
	BAMBU	-46 (-4.49%)	-439 (-42.87%)
	GRAS	-92 (-8.98%)	-513 (-50.1%)
2080	SEDG	235 (22.95%)	-527 (-51.46%)
	BAMBU	-245 (-23.93%)	-693 (-67.68%)
	GRAS	-426 (-41.6%)	-827 (-80.76%)

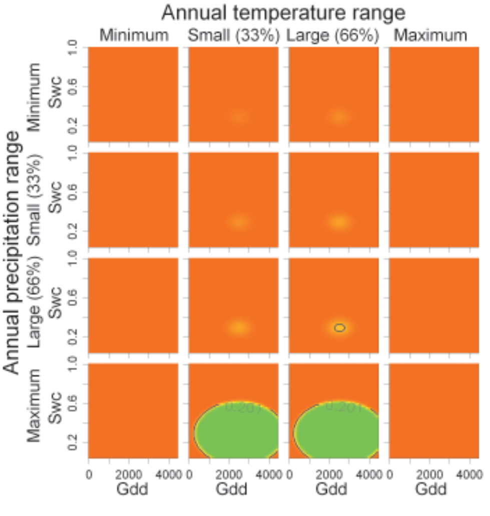
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 1024)

Freyer's Grayling can be found in dense thickets, on rocky slopes, on dry, grassy vegetation, in light woodland and in olive groves and orchards. There are trees in most habitats. In appearance and choice of biotope, Freyer's Grayling is very similar to the Tree Grayling (*H. statilinus*). The butterflies are fond of resting on the ground or on tree trunks, and hardly ever visit flowers. It uses different grasses as foodplants, and has one generation a year.

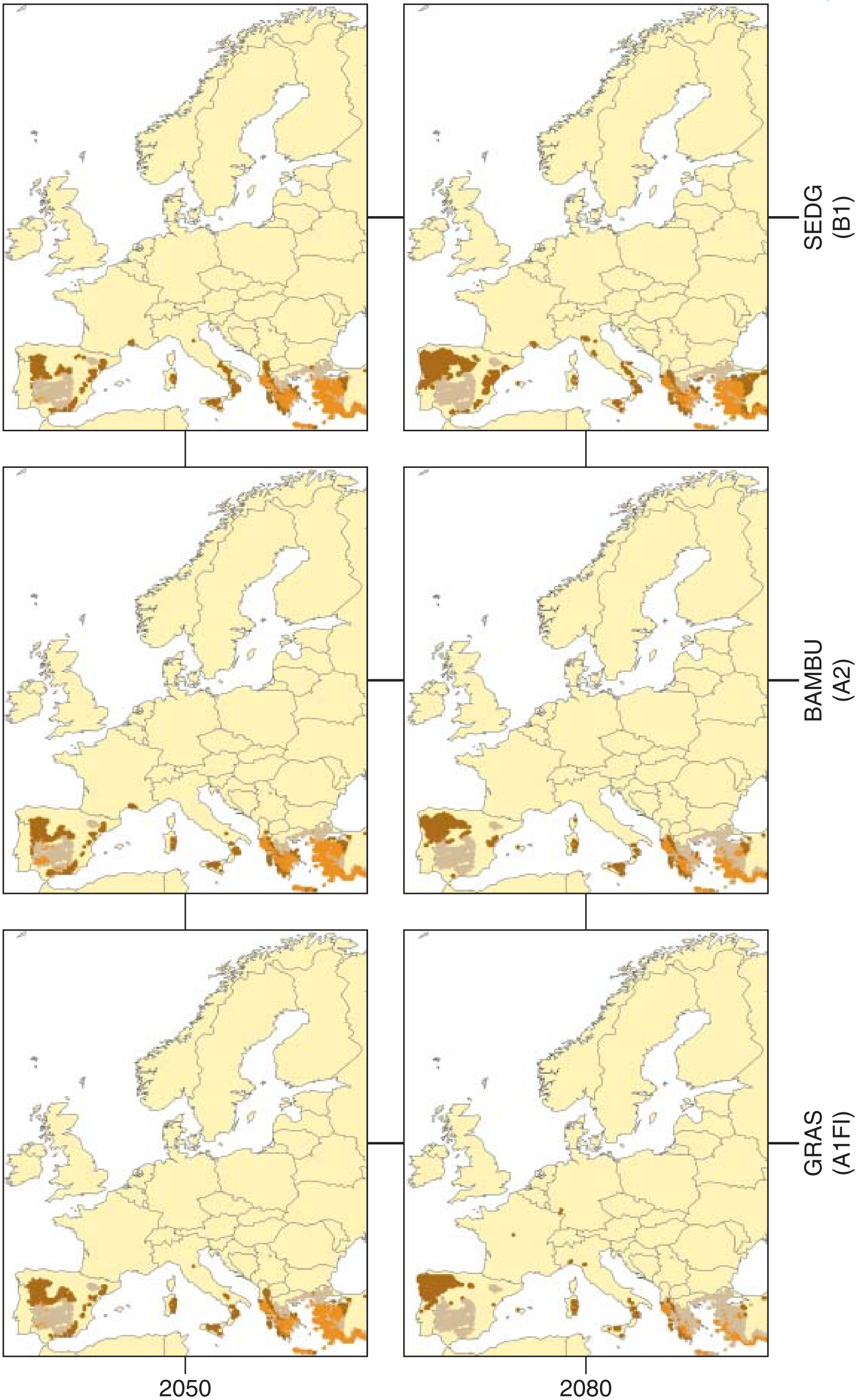
Present distribution can be very well explained by climatic variables (AUC = 0.98).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Hipparchia fidia (Linnaeus, 1767) – Striped Grayling

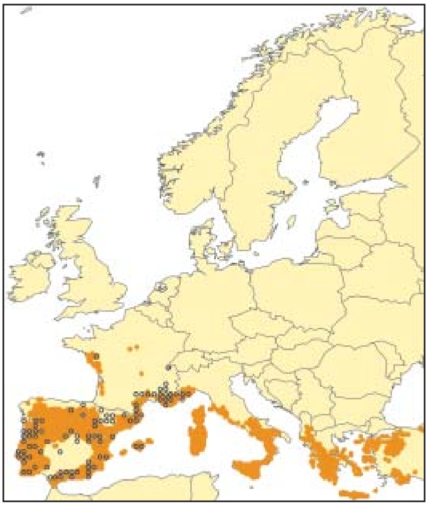
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-731 (-33.35%)	-1623 (-74.04%)
	BAMBU	-1294 (-59.03%)	-1644 (-75%)
	GRAS	-1040 (-47.45%)	-1875 (-85.54%)
2080	SEDG	-1112 (-50.73%)	-1959 (-89.37%)
	BAMBU	-1518 (-69.25%)	-2110 (-96.26%)
	GRAS	-1463 (-66.74%)	-2180 (-99.45%)

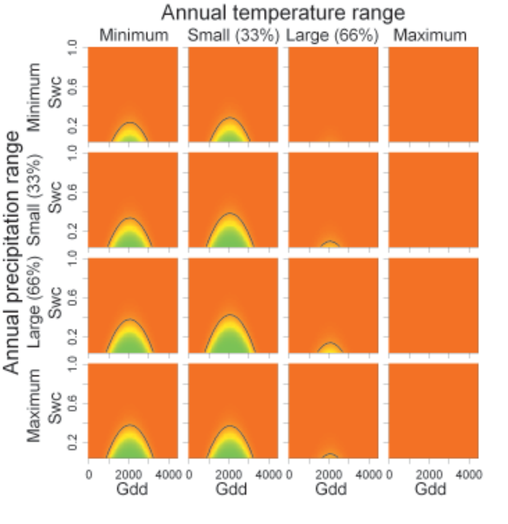
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2192)

The Striped Grayling occurs mostly on dry, rocky slopes with bushes and grassy vegetation, and in light woodland. The butterflies often rest on the ground or on tree trunks. Foodplants are various grasses, such as Bermuda-grass (*Cynodon dactylon*), Cock's-foot (*Dactylus glomerata*), meadow-grasses (*Poa* spp.), and false-bromes (*Brachypodium* spp.). This butterfly is single-brooded and hibernates as a caterpillar, on or just in the ground.

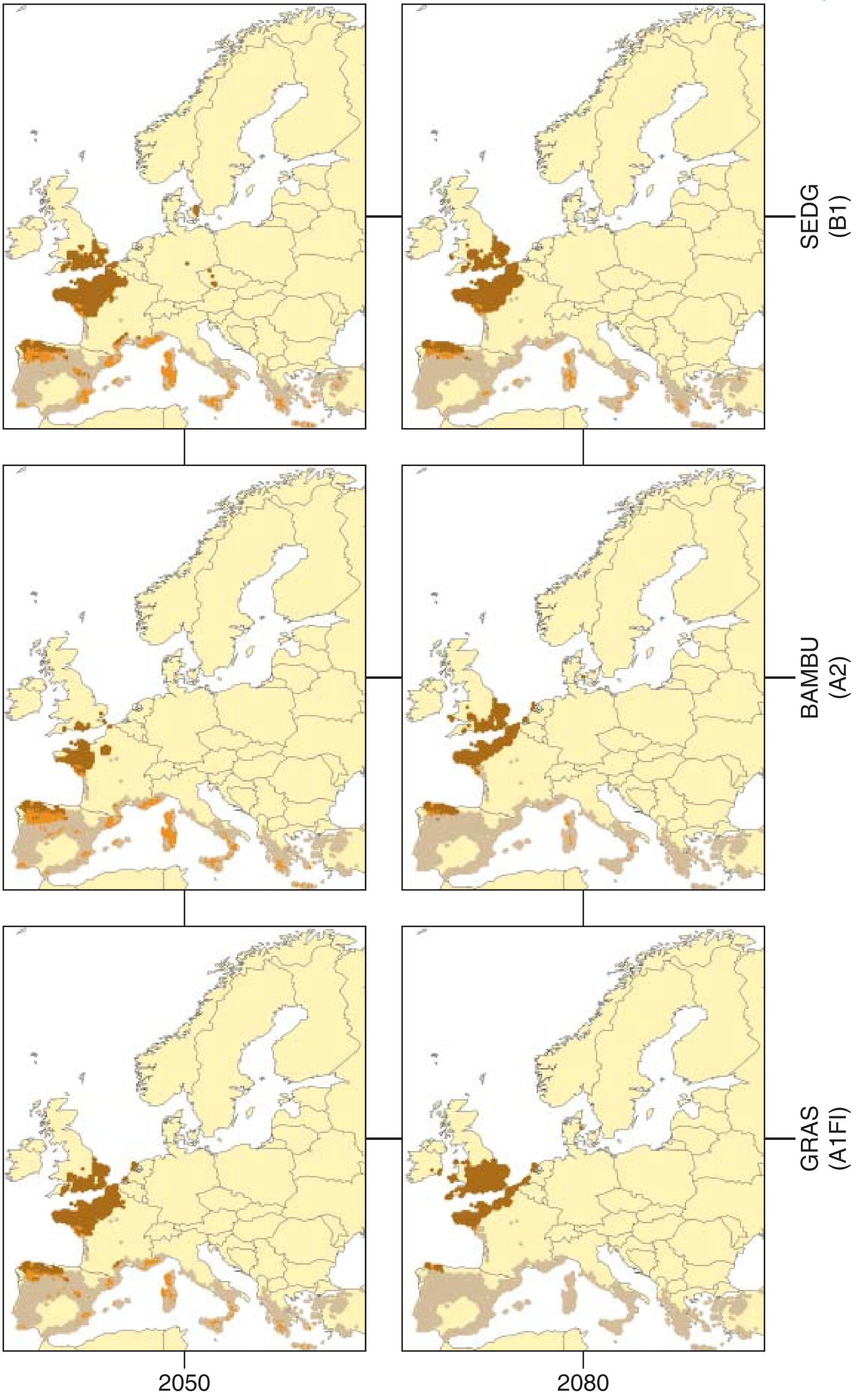
Present distribution can be well explained by climatic variables (AUC = 0.88).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Hipparchia senthes (Fruhstorfer, 1908) – Balkan Grayling

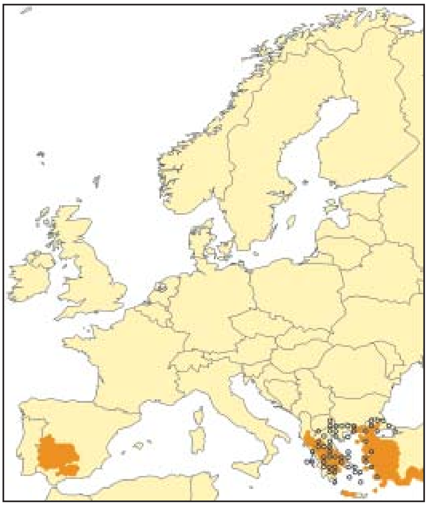
© Neil Thompson

		Full dispersal	No dispersal
2050	SEDG	-62 (-7.38%)	-350 (-41.67%)
	BAMBU	-2 (-0.24%)	-293 (-34.88%)
	GRAS	-85 (-10.12%)	-386 (-45.95%)
2080	SEDG	207 (24.64%)	-421 (-50.12%)
	BAMBU	-280 (-33.33%)	-631 (-75.12%)
	GRAS	-444 (-52.86%)	-767 (-91.31%)

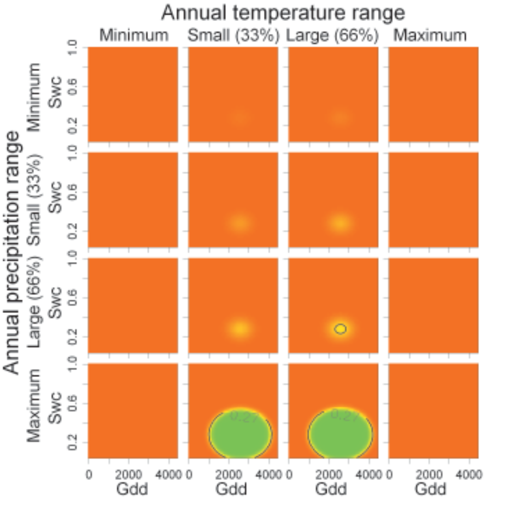
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 840)

The Balkan Grayling replaces the Grayling (*H. semele*) in the Southern Balkan Peninsula, the Greek island of Levkas and the Aegean islands. It lives in dry grasslands, scrubland, and open woodlands and occurs from 0-1600m elevation. The species has one generation per year with adults on the wing from May until October.

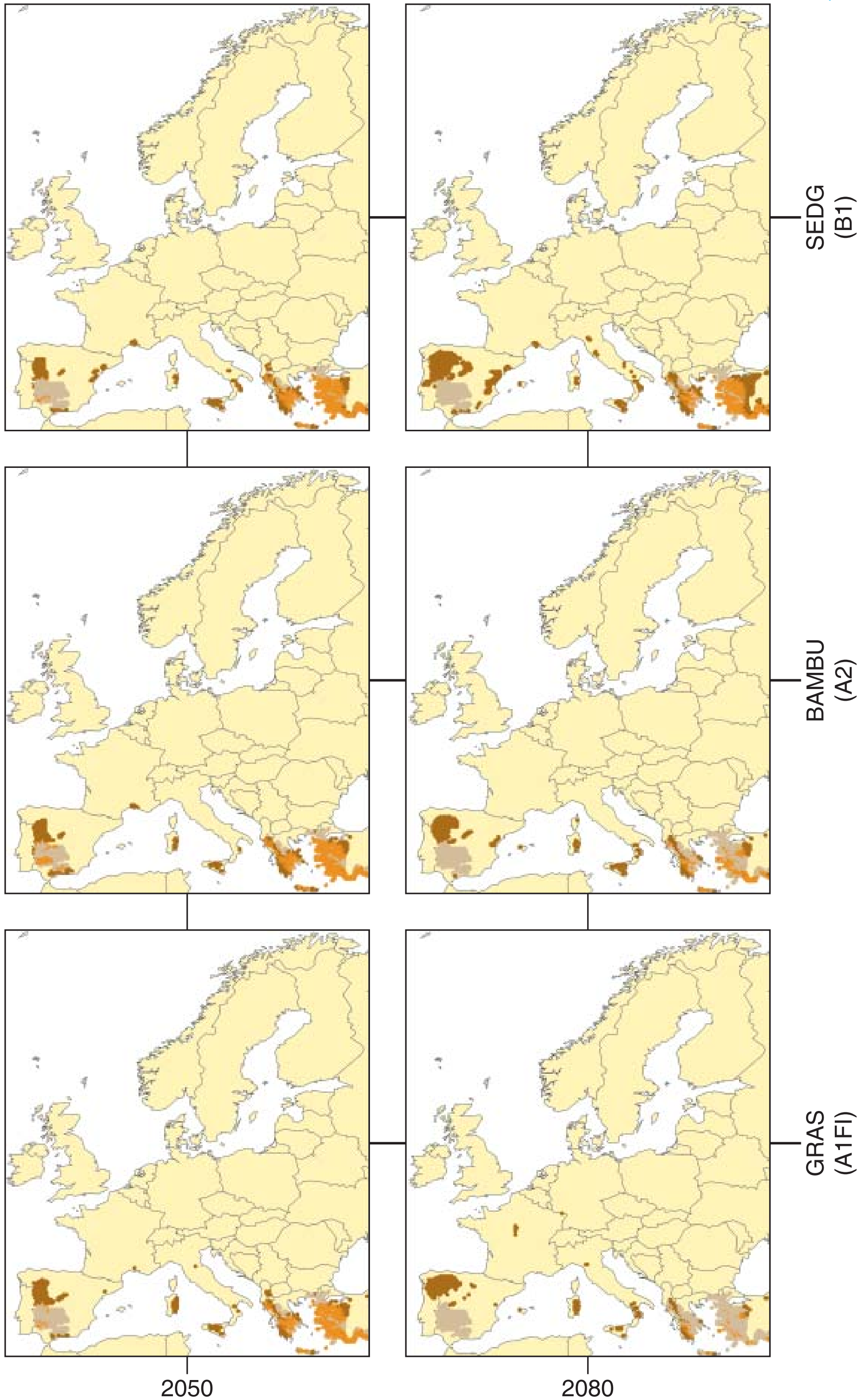
Present distribution can be well explained by climatic variables (AUC = 0.94).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Arethusana arethusa ([Schiffermüller], 1775) – False Grayling

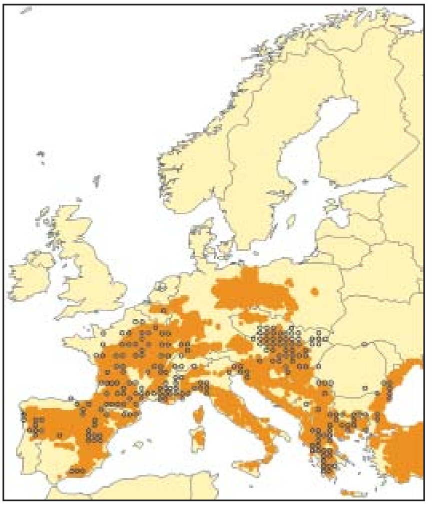
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	1068 (19%)	-2313 (-41.15%)
	BAMBU	-64 (-1.14%)	-2666 (-47.43%)
	GRAS	487 (8.66%)	-2938 (-52.27%)
2080	SEDG	-616 (-10.96%)	-3665 (-65.2%)
	BAMBU	-1332 (-23.7%)	-4595 (-81.75%)
	GRAS	-2335 (-41.54%)	-5381 (-95.73%)

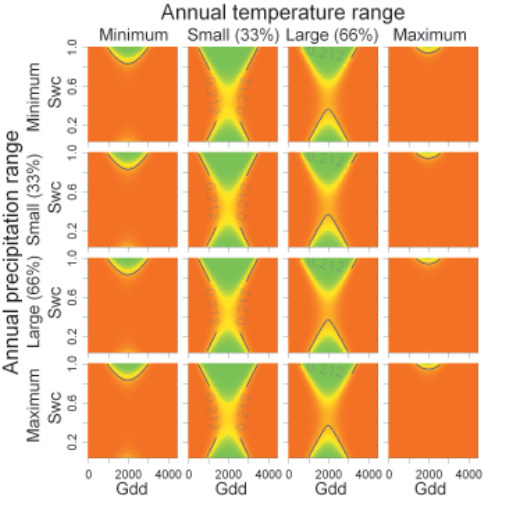
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 5621)

The False Grayling is an inconspicuous butterfly. It occurs on warm, poor grasslands, often situated near the edges of woodland or scrub, on both calcareous and acid soils. The female drops her eggs at random into the vegetation, leaving the young caterpillars to choose what to eat. They feed on different grasses, including Upright Brome (*Bromus erectus*), Gray Hair-grass (*Corynephorus canescens*), Tor-grass (*Brachypodium pinnatum*), Crested Dog's-tail (*Cynosurus cristatus*), and fescues (*Festuca* spp.). The caterpillars hibernate in the first larval instar. They pupate in a grass tussock and have one brood a year.

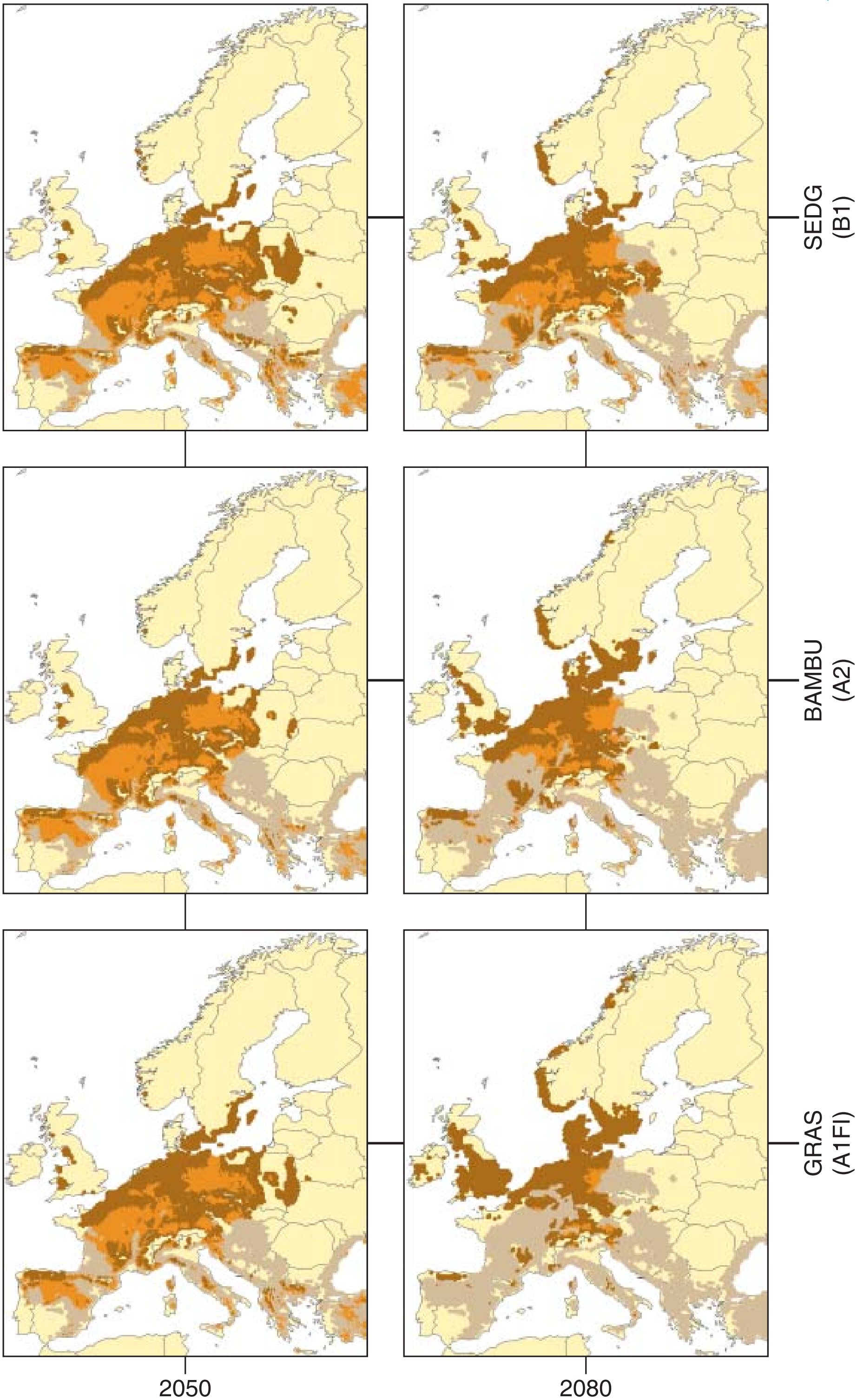
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.77).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Brintesia circe (Fabricius, 1775) – Great Banded Grayling

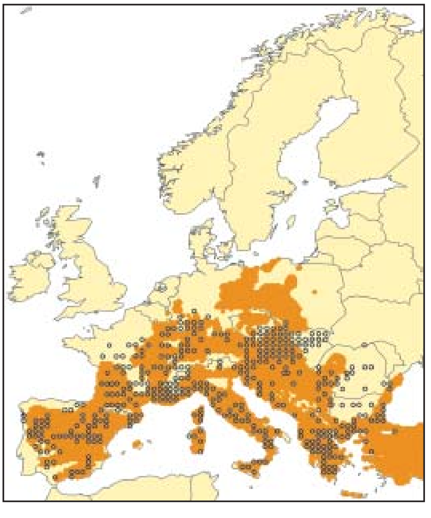
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	1057 (14.02%)	-2308 (-30.61%)
	BAMBU	-443 (-5.88%)	-2864 (-37.99%)
	GRAS	-42 (-0.56%)	-3143 (-41.69%)
2080	SEDG	185 (2.45%)	-3680 (-48.81%)
	BAMBU	-961 (-12.75%)	-5018 (-66.56%)
	GRAS	-1518 (-20.14%)	-6183 (-82.01%)

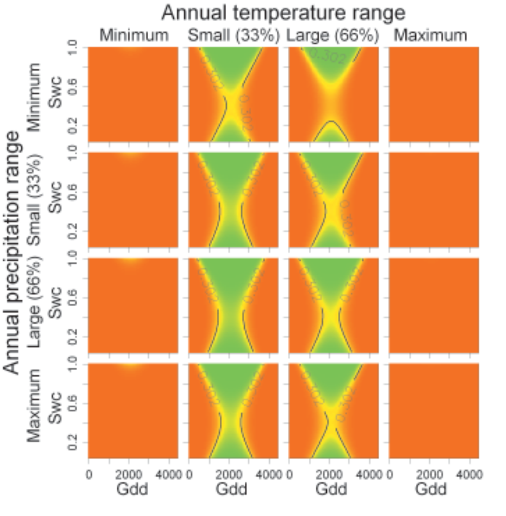
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 7539)

The Great Banded Grayling is immediately noticeable by its size, and is one of the largest butterflies of Europe. It glides more than it flies, and can be seen on dry grasslands at the edges of woodland, and on poor and moderately nutrient-rich agricultural land. The butterflies need quite a lot of nectar, and are easily observed on the purple flowers of thistles and other plants. The females release their eggs into the vegetation, sometimes while perched, often while in flight. The caterpillars can use most grasses as a foodplant. The tiny caterpillar first hibernates in a grass tussock, only in the spring beginning to feed and grow. The caterpillars pupates in a sort of cocoon in a little hollow in the ground. This butterfly species is single-brooded.

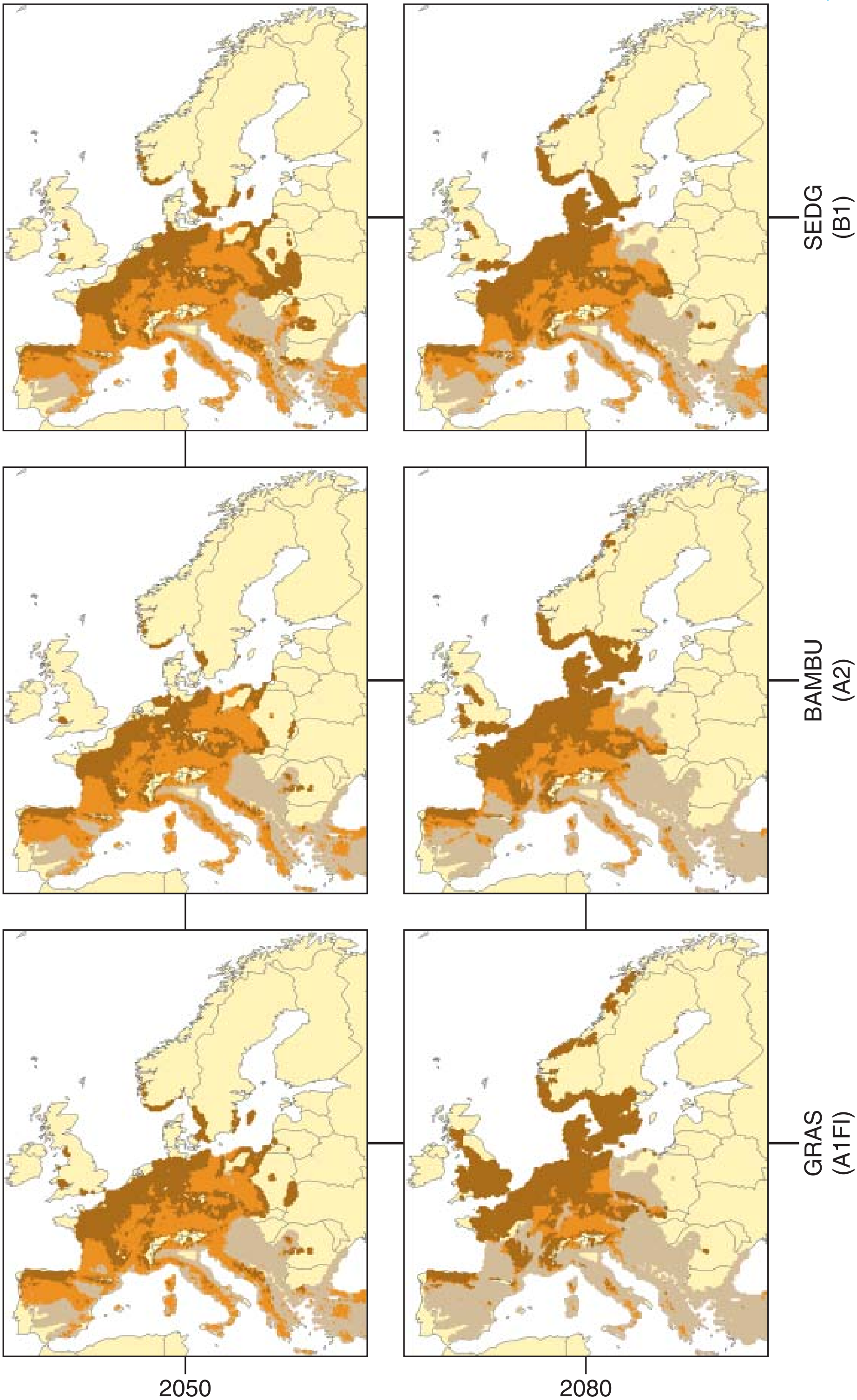
Present distribution can be explained by climatic variables to a moderate extent (AUC = 0.81).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Chazara briseis (Linnaeus, 1764) – The Hermit

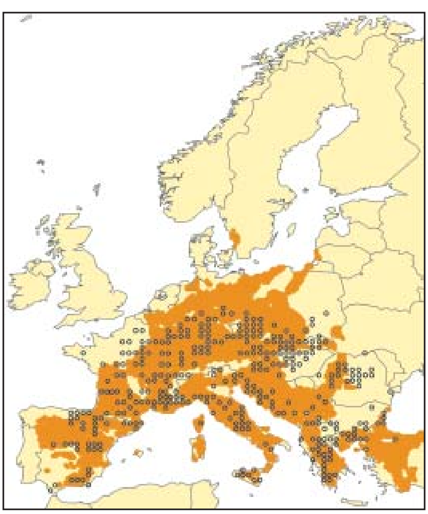
© Albert Vliegenthart

		Full dispersal	No dispersal
2050	SEDG	645 (8.85%)	-1902 (-26.08%)
	BAMBU	-27 (-0.37%)	-2256 (-30.94%)
	GRAS	-349 (-4.79%)	-2727 (-37.4%)
2080	SEDG	-402 (-5.51%)	-3226 (-44.24%)
	BAMBU	-1170 (-16.04%)	-4231 (-58.02%)
	GRAS	-2263 (-31.03%)	-5429 (-74.45%)

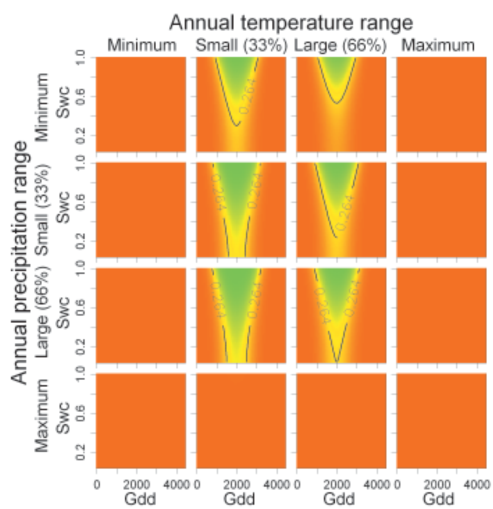
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 7292)

The Hermit inhabits steppe-like grasslands in dry, warm places. In the northern part of its distribution range, it is restricted to dry chalk hills. Although it is a very large butterfly, when its wings are closed, it blends perfectly into its surroundings. Especially when resting so on a rock, they are almost invisible. The female deposits her eggs one at a time on the withered blades of many different grasses, including false-bromes (*Brachypodium* spp.), bromes (*Bromus* spp.), and fescues (*Festuca* spp.). The caterpillars hibernate in the first larval instar. They pupate in a sort of cocoon, in a little hollow in the ground, or sometimes low down on the foodplant. The Hermit has one brood a year and is one of the most seriously threatened species in central Europe.

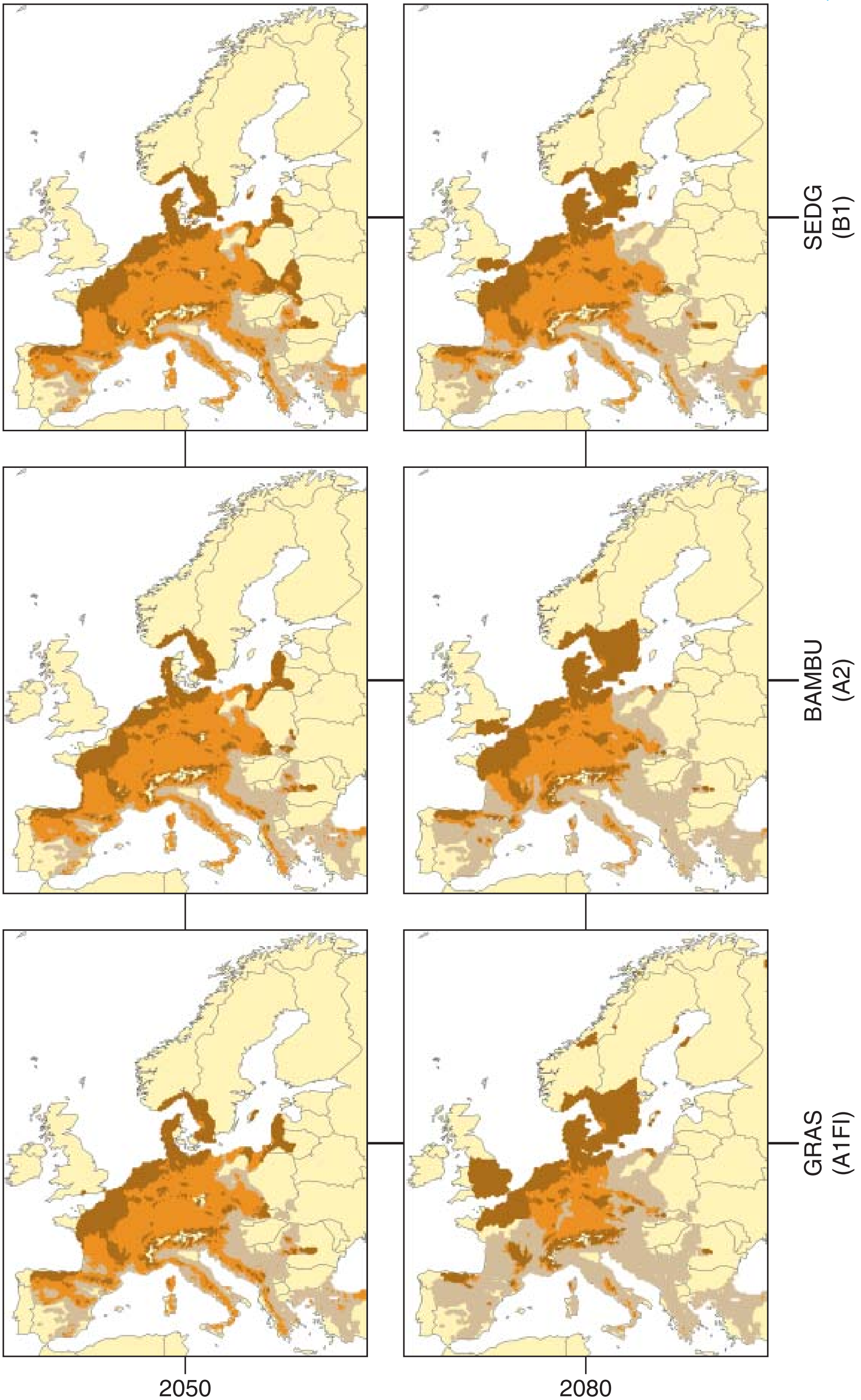
Present distribution can be explained by climatic variables to quite some extent (AUC = 0.8).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Pseudochazara anthelea (Lefebvre, 1831) – White-banded Grayling

© Albert Vliegenthart

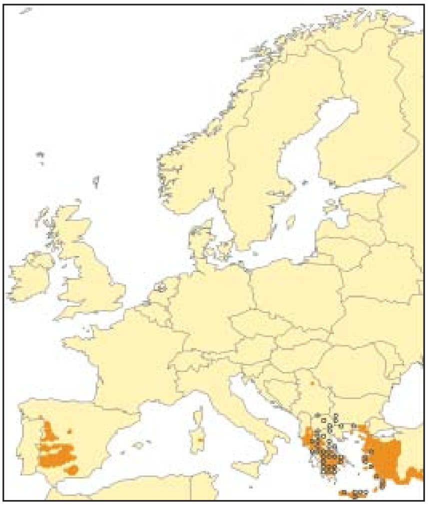
		Full dispersal	No dispersal
2050	SEDG	-175 (-21.39%)	-360 (-44.01%)
	BAMBU	-134 (-16.38%)	-332 (-40.59%)
	GRAS	-181 (-22.13%)	-385 (-47.07%)
2080	SEDG	193 (23.59%)	-379 (-46.33%)
	BAMBU	-231 (-28.24%)	-481 (-58.8%)
	GRAS	-322 (-39.36%)	-623 (-76.16%)

Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 818)

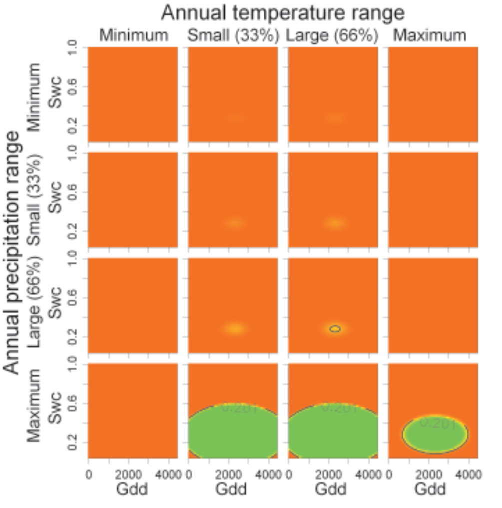
With the white bands on each wing and the dark narrow scent-brand, the males of the White-banded Grayling are unmistakable. The butterflies occur on dry, grassy vegetation in open scrub, and on rocky slopes. Sometimes, they are seen in open woods. They often drink nectar from thistle-like plants. The males defend their territory, perching on a rock or other prominent features in the surroundings. This butterfly is single-brooded.

Pseudochazara amalthea (Friwaldszky, 1845), placed by Kudrna (2002) provisionally in the genus *Hipparchia*, is a subspecies of *Pseudochazara anthelea* (Lefebvre, 1831), as it is already treated by many authors.

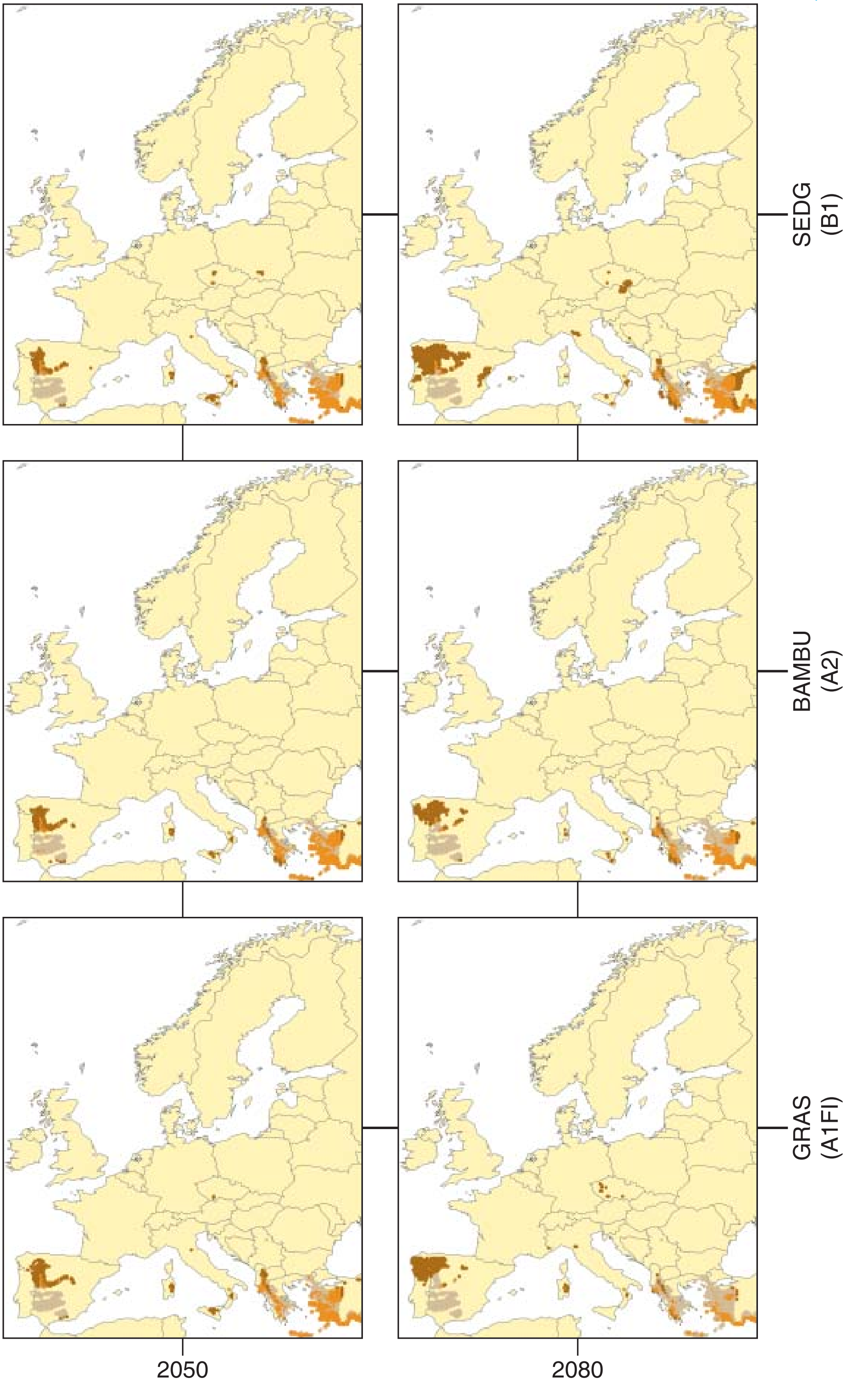
Present distribution can be well explained by climatic variables (AUC = 0.9).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Oeneis norna (Becklin, 1791) – Norse Grayling

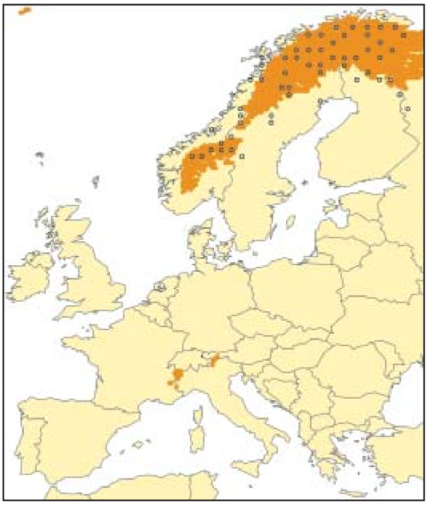
© Bernard Fransen

		Full dispersal	No dispersal
2050	SEDG	-1683 (-81.03%)	-1691 (-81.42%)
	BAMBU	-1680 (-80.89%)	-1687 (-81.22%)
	GRAS	-1729 (-83.25%)	-1737 (-83.63%)
2080	SEDG	-1899 (-91.43%)	-1909 (-91.91%)
	BAMBU	-2026 (-97.54%)	-2030 (-97.74%)
	GRAS	-2065 (-99.42%)	-2065 (-99.42%)

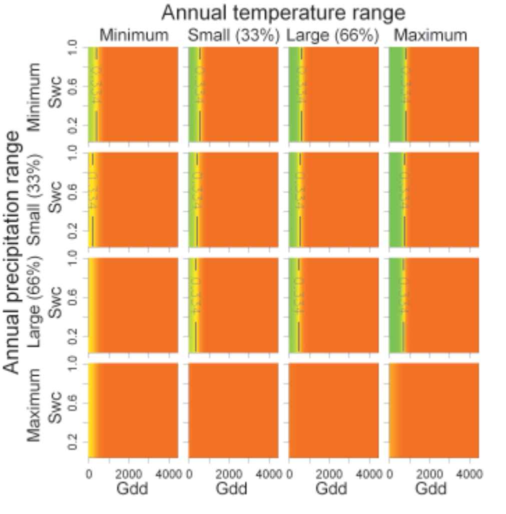
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 2077)

The Norse Grayling occurs in both dry and wet biotopes, on marshes with a vegetation of mosses and grasses, at the edges of swampy habitats and streams, in low birch scrub, on sparse vegetation in clearings in birch woods, and on sunny, rocky slopes with low shrubs. The butterflies spend much of the day resting on tree trunks or on the ground with their wings closed and are so hardly noticeable. They are quick flyers and difficult to approach. The female lays her eggs on various sedges and grasses. The egg takes two years to develop into a butterfly, and the caterpillars hibernate twice.

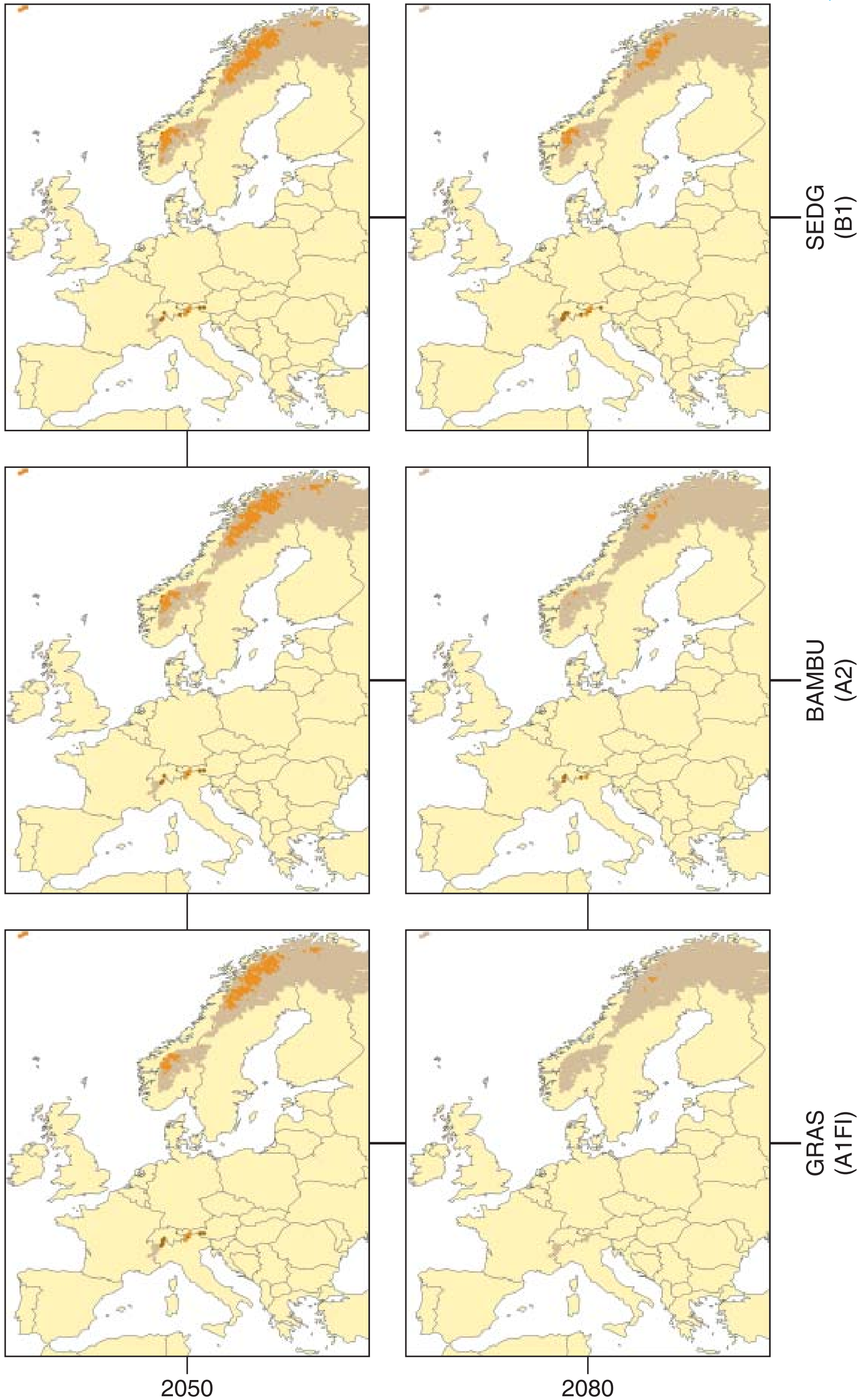
Present distribution can be very well explained by climatic variables (AUC = 0.98).
Climate risk category: HHHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Oeneis glacialis (Moll, 1785) – Alpine Grayling

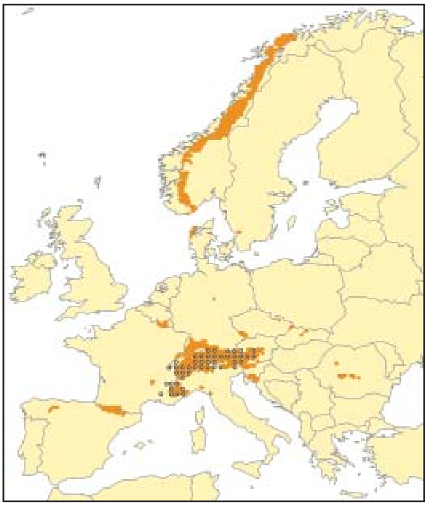
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-192 (-20.65%)	-368 (-39.57%)
	BAMBU	-114 (-12.26%)	-323 (-34.73%)
	GRAS	-247 (-26.56%)	-400 (-43.01%)
2080	SEDG	-430 (-46.24%)	-637 (-68.49%)
	BAMBU	-272 (-29.25%)	-529 (-56.88%)
	GRAS	-480 (-51.61%)	-710 (-76.34%)

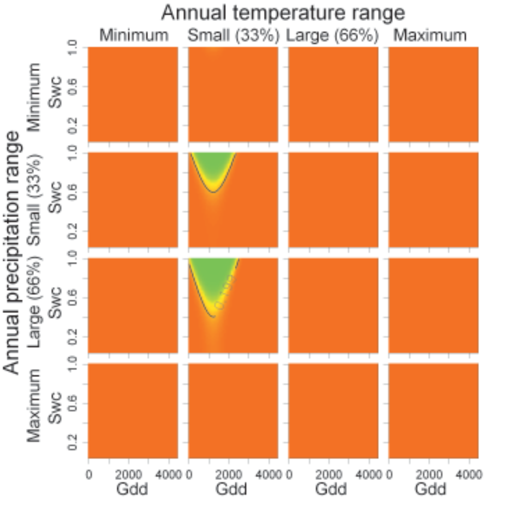
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 930)

At altitudes of about 1500 m, the Alpine Grayling occurs on dry, scrubby vegetation. Above the tree-line, they can be seen in dry, stony alpine grasslands, and on dry, open sunny slopes. Most habitats have a stream in the vicinity. Perched on a stone, the males defend their territory, chasing away other butterflies, as well as other insects. The female lays her eggs one at a time on dry grass stalks close to the ground. The caterpillar hibernates in the first larval instar, and having fed during the growing season, hibernates again in the last instar. Eventually, some time between April and June, it pupates. Its main foodplant is Sheep's-fescue (*Festuca ovina*) but other fescues are also used. This butterfly is single-brooded.

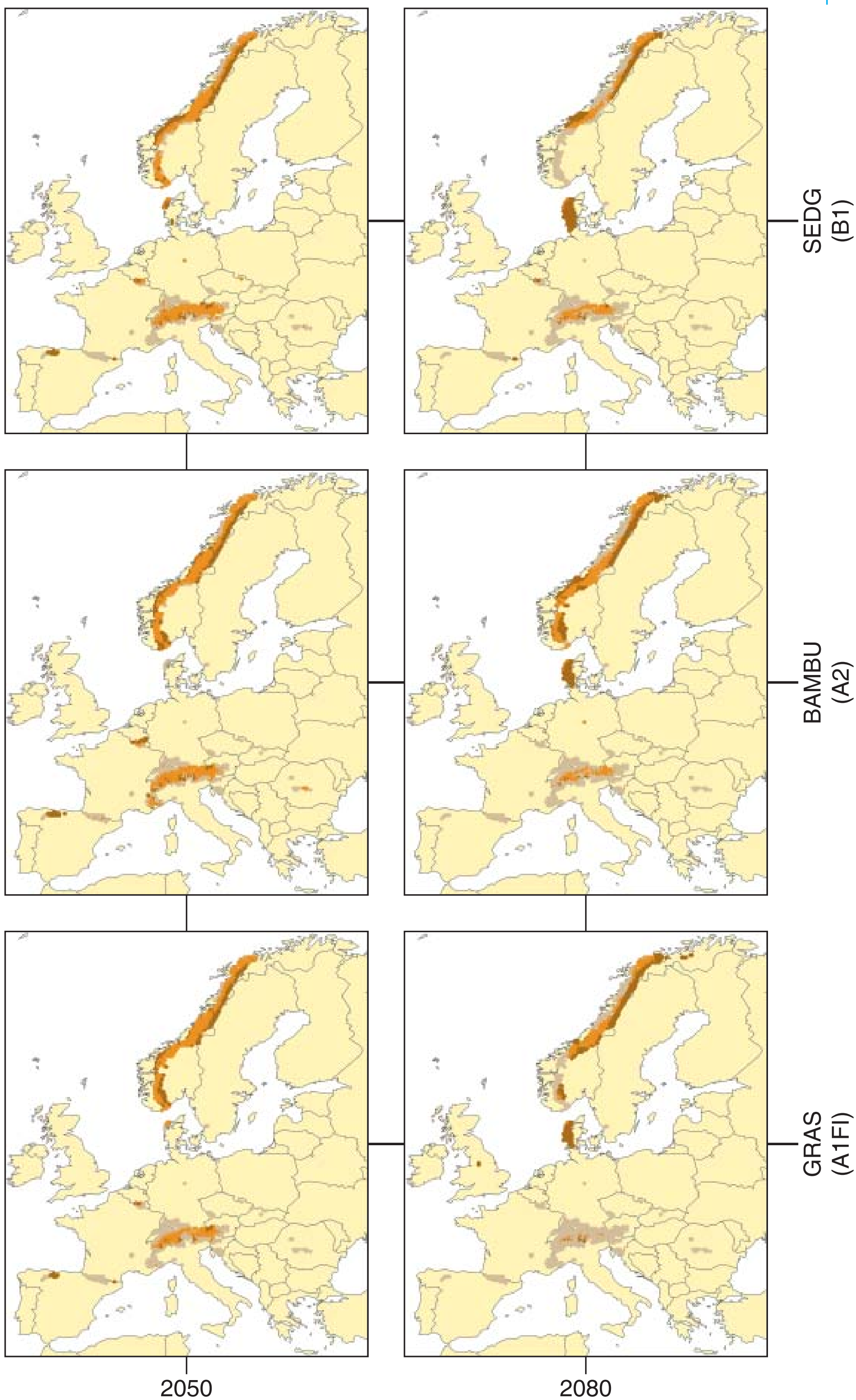
Present distribution can be very well explained by climatic variables (AUC = 0.99).
Climate risk category: HR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Oeneis jutta (HÜBNER, 1806) – Baltic Grayling

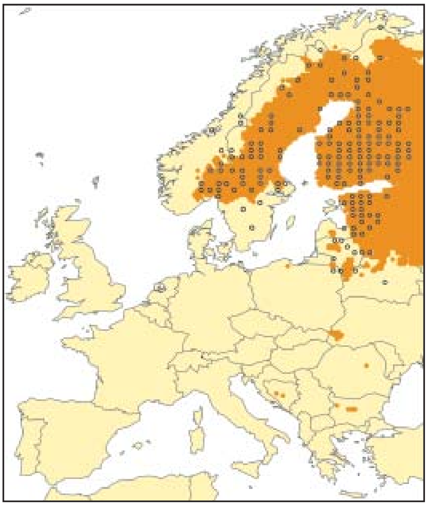
© Chris van Swaay

		Full dispersal	No dispersal
2050	SEDG	-1165 (-19.45%)	-1791 (-29.89%)
	BAMBU	-1434 (-23.94%)	-2057 (-34.33%)
	GRAS	-1446 (-24.14%)	-2091 (-34.9%)
2080	SEDG	-1820 (-30.38%)	-2670 (-44.57%)
	BAMBU	-2096 (-34.99%)	-3090 (-51.58%)
	GRAS	-2839 (-47.39%)	-3887 (-64.88%)

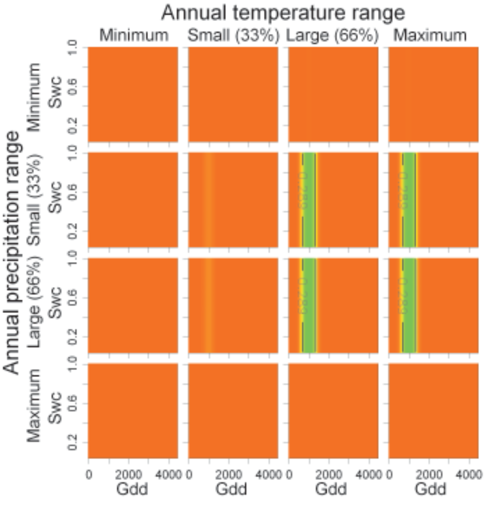
Changes in climatic niche distribution
(in 10’×10’ grid cells; present niche space: 5991)

Both in lowland and mountains, the Baltic Grayling occurs in peaty and swampy habitats. Most butterflies are found in damp habitats with a vegetation of grasses and sedges, often with open water in the middle and surrounded by coniferous woodland. The butterflies frequently visit the wood edge looking for flowers, because the peat vegetation is poor in nectar plants. They also rest on the branches or trunks of trees, or on dead wood. The Baltic Grayling shares its habitat with hardly any other butterfly. The female lays her eggs on various grasses, but which ones the caterpillars feed on is not known. The caterpillar’s development takes nearly two years.

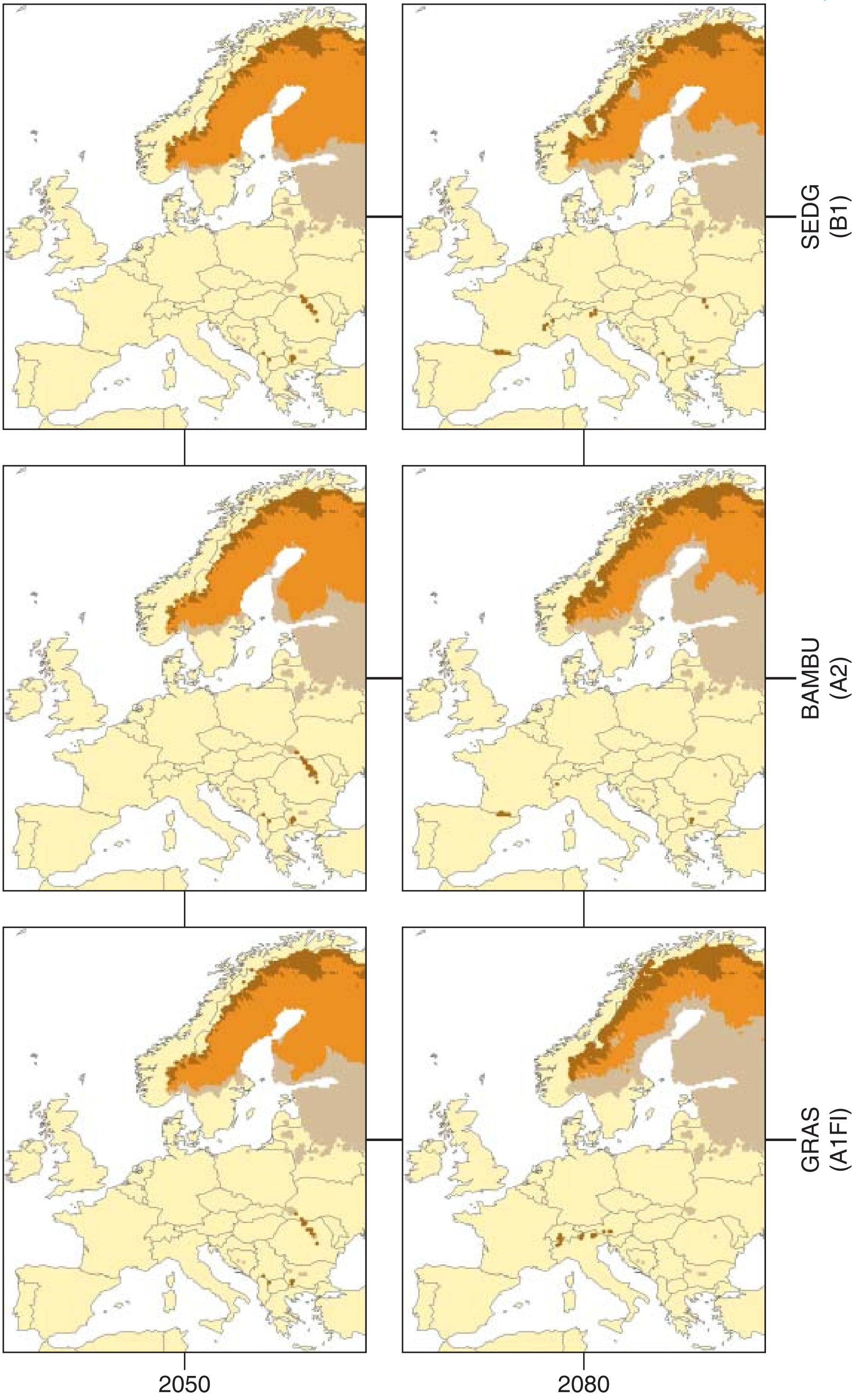
Present distribution can be very well explained by climatic variables (AUC = 0.96).
Climate risk category: R.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

Danaus chrysippus (Linnaeus, 1758) – Plain Tiger

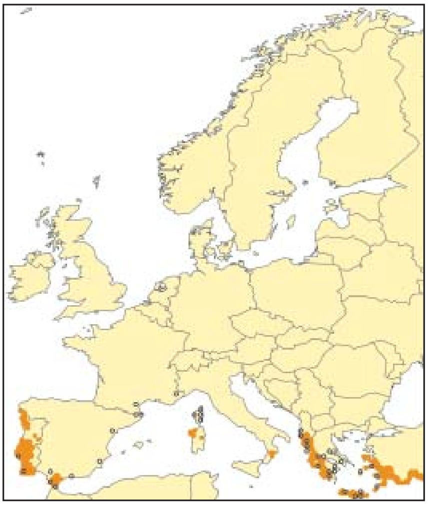
© Kars Veling

		Full dispersal	No dispersal
2050	SEDG	-204 (-49.51%)	-270 (-65.53%)
	BAMBU	-171 (-41.5%)	-262 (-63.59%)
	GRAS	-209 (-50.73%)	-304 (-73.79%)
2080	SEDG	-74 (-17.96%)	-273 (-66.26%)
	BAMBU	-195 (-47.33%)	-334 (-81.07%)
	GRAS	-203 (-49.27%)	-369 (-89.56%)

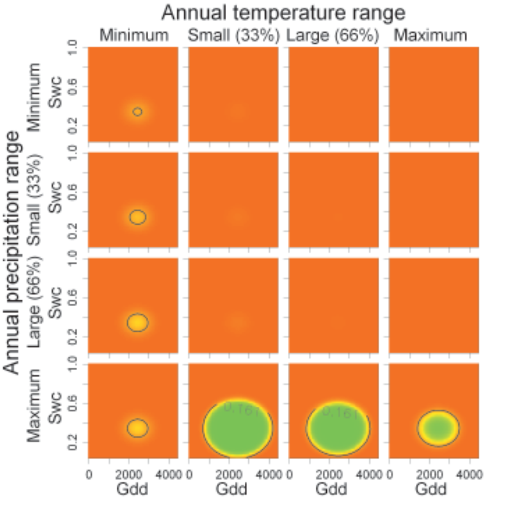
Changes in climatic niche distribution
(in 10'×10' grid cells; present niche space: 412)

The Plain Tiger occurs in coastal areas on warm, rocky places with scrub, on agricultural land and in gardens. The Plain Tiger can fly great distances, and in this way can found new populations. The caterpillars feed on the milkweeds *Asclepias curassavica* and *Cynachum procera*. It has several broods a year and does not hibernate. In areas with cold winters, populations can therefore only be temporary. It is difficult to establish whether the species is present as a resident the whole year, or as a migrant, only breeding in the summer.

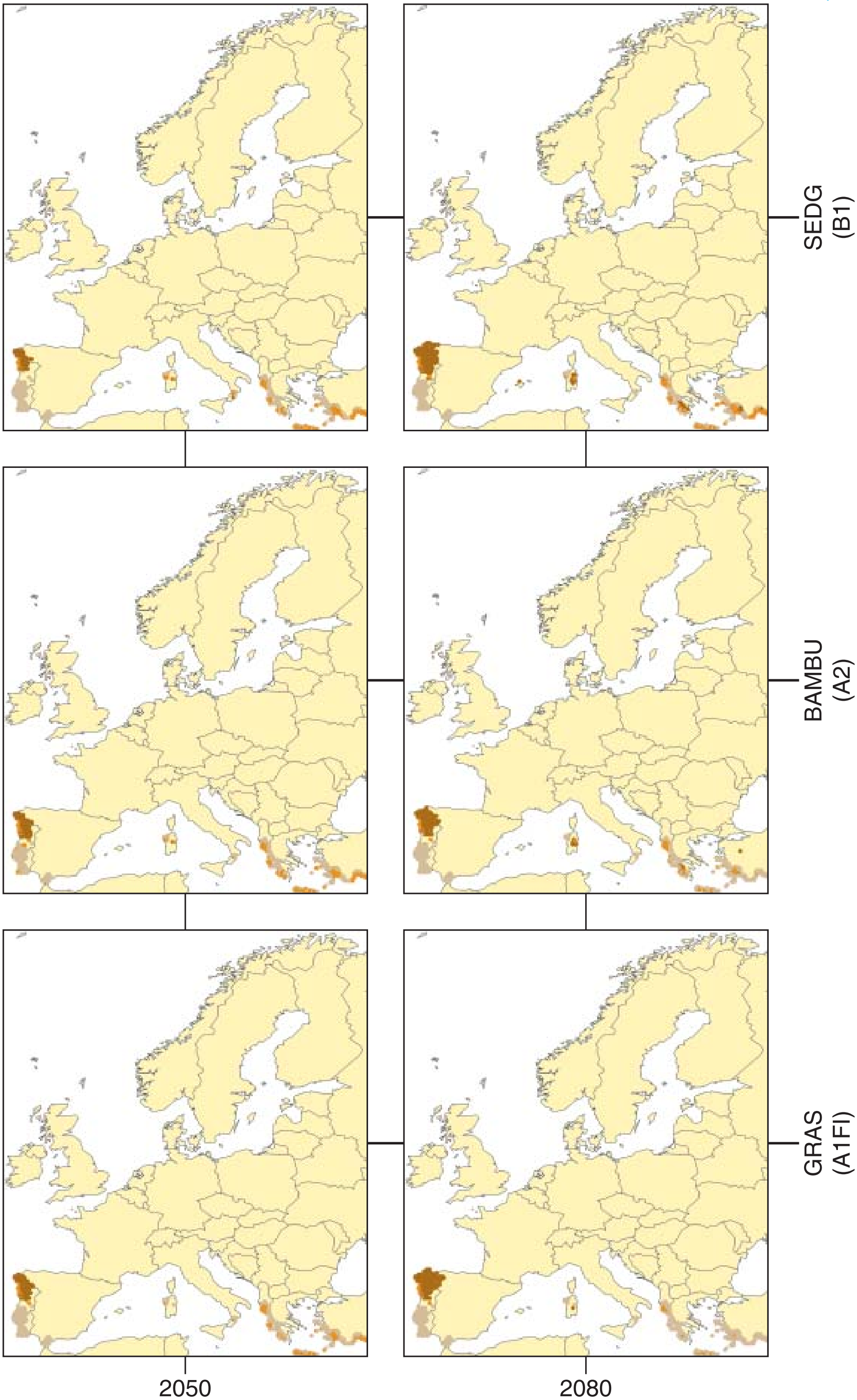
Present distribution can be well explained by climatic variables (AUC = 0.89).
Climate risk category: HHR.



Observed species distribution (50 × 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)



Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower tercile, upper tercile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold


SEDG
(B1)
BAMBU
(A2)
GRAS
(A1FI)
2050
2080

C.3 Non-modelled European butterfly species

Due to our methodological restrictions, it was not possible to model the climate change risk for a large number of species with a very restricted European distribution (149 species, see Table C.3.1). Most of these species would expect to be categorized as being at extremely high risk (HHHR) from climate change because they have such a limited distribution and because any change in climate space is likely to have a strong impact.

Better models should be developed for these species in the future, but it is important not to ignore them in the current discussion on climate change impacts on butterflies. We have therefore listed them below to highlight European endemics and give an indication of the European distribution. We also have listed the closest relative of the taxon concerned in those cases where taxonomic discussion is ongoing. In some cases, the species mentioned in the first column may eventually be included as subspecies of this closest relative.

Table C.3.1: European butterfly species which have not been modelled within this atlas (excluding the territories of Belarus, Ukraine, Moldova, and Russia)
Closest relative: Closest relative of the taxon concerned in those cases where taxonomic discussion is ongoing.
E = European endemic (I = island endemic, M = mountain endemic)
European distribution: see table C.3.2 with the country codes of European countries (ISO 3166-1 alpha-2 code)

Species	Engl. Name	Closest relative	E	European distribution
Hesperiidae				
Borbo borbonica (Boisduval, 1833)	Zeller's Skipper		–	ES: Algeciras; GI
Carcharodus stauderi (Reverdin, 1913)	False Marbled Skipper	*Carcharodus boeticus*	–	GR: Ionian islands
Pelopidas thrax (Hübner, 1821)	Millet Skipper		–	GR: Ionian islands; CY
Pyrgus cinarae (Rambur, 1840)	Sandy Grizzled Skipper		–	BG; MK; AL; GR, ES
Spialia therapne (Rambur, 1832)		*Spialia sertorius*	E: I	FR: Corsica; IT: Sardinia
Syrichtus cribrellum (Eversmann, 1841)	Spinose Skipper		–	RO; MK, BG
Thymelicus christi (Rebel, 1894)		*Thymelicus acteon*	E: I	ES: Canary Islands
Thymelicus hyrax (Lederer, 1861)	Levantine Skipper		–	GR
Papilionidae				
Archon apollinus (Herbst, 1789)	False Apollo		–	GR; TR
Papilio hospiton Gene, 1839	Corsican Swallowtail		E: I	FR: Corsica; IT: Sardinia
Zerynthia cretica (Rebel, 1904)	Cretan Festoon	*Zerynthia cerisyi*	E: I	GR: Crete
Pieridae				
Anthocharis damone (Boisduval, 1836)	Eastern Orange Tip		–	AL; IT: S Italy; GR; MK
Catopsilia florella (Fabricius, 1775)	African Migrant		–	ES: Canary Islands; MT, CY
Colias aurorina (Herrich-Schäffer, 1850)	Greek Clouded Yellow		–	GR
Colias balcanica Rebel, 1903	Balcan Clouded Yellow	*Colias caucasica*	E: M	BA; RS; AL; MK; BG; GR

Species	Engl. Name	Closest relative	E	European distribution
Colias tyche (DE BÖBER, 1812)	Pale Arctic Clouded Yellow		–	Arctic Scandinavia: NO; SE; FI
Colotis evagore (KLUG, 1829)	Desert Orange Tip		–	ES: South Spain
Euchloe charlonia (DONZEL, 1842)	Greenish Black Tip		–	ES: Canary Islands
Euchloe constantini BACK, 2008		*Euchloe belemia*	E: I	ES: Gran Canaria
Euchloe eversi STAMM, 1963		*Euchloe belemia*	E: I	ES: Tenerife
Euchloe hesperidum ROTHSCHILD, 1913		*Euchloe belemia*	E: I	ES: Fuerteventura
Euchloe insularis STAUDINGER, 1861	Corsican Dappled White	*Euchloe ausonia*	E: I	FR: Corsica; IT: Sardinia
Euchloe penia (FREYER, 1852)	Eastern Greenish Black Tip	*Euchloe charlonia*	–	MK; BG; GR; TR
Gonepteryx cleobule (HÜBNER, 1825)	Canary Brimstone		E: I	ES: Canary Islands
Gonepteryx madeirensis FELDER, 1862	Madeira Brimstone		E: I	PT: Madeira
Pieris balcana LORKOVIC, 1968		*Pieris napi*	E	BA; RS; AL; MK; BG; GR
Pieris cheiranthi (HÜBNER, 1808)	Canary Islands' Large White	*Pieris brassicae*	E: I	ES: Canary Islands
Pontia chloridice (HÜBNER, 1813)	Small Bath White		–	BG; GR; TR, MK
Lycaenidae				
Apharitis acamas (KLUG, 1834)	Levantine Leopard		–	CY
Aricia morronensis (RIBBE, 1910)	Spanish Argus	*Aricia artaxerxes*	E: M	ES; FR: Pyrenees
Azanus ubaldus (CRAMER, 1782)	Bright Babul Blue		–	ES: Gran Canaria
Chilades trochylus (FREYER, 1844)	Grass Jewel		–	CY; GR
Cupido carswelli STEMPFFER, 1927	Carswell's Littel Blue	*Cupido minimus*	E: M	ES: Murcia
Cupido lorquinii (HERRICH-SCHÄFFER, 1847)	Lorquin's Blue		–	ES, PT: Southern Iberian Peninsula
Cyclyrius webbianus (BRULLÉ, 1840)	Canary Blue		E: I	ES: Canary Islands
Glaucopsyche paphos CHAPMAN, 1920	Paphos Blue		E: I	CY
Lycaena bleusei (OBERTHÜR, 1884)		*Lycaena tityrus*	E: M	ES

Species	Engl. Name	Closest relative	E	European distribution
Lycaena subalpina (Speyer, 1851)		*Lycaena tityrus*	E: M	Alps
Lycaena thetis (Klug, 1834)	Fiery Copper		–	GR
Plebejus bellieri (Oberthür, 1910)	Bellier's Blue	*Plebejus idas*	E: I	FR: Corsica; IT: Sardinia, Elba
Plebejus dardanus (Freyer, 1832)	Gavarnie (Balkan) Blue	*Plebejus pyrenaicus*	–	BA, GR: Macedonia
Plebejus eurypilus (Freyer, 1852)	Eastern Brown Argus		–	GR
Plebejus hespericus (Rambur, 1839)		*Plebejus pylaon*	E	ES
Plebejus loewi (Zeller, 1847)	Loew's Blu		–	GR: Ionian islands
Plebejus psyloritus (Freyer, 1845)	Cretan Argus		E: I	GR: Crete
Plebejus pylaon (Fischer, 1832)	Zephyr Blue		–	UA; RU
Plebejus pyrenaicus (Boisduval, 1840)	Gavarnie Blue		E: M	FR: Pyrenees; ES: North Spain
Plebejus trappi (Verity, 1927)		*Plebejus pylaon*	E: M	Alps: CH; IT
Plebejus villai Jutzeler et al., 2005		*Plebejus idas*	E: I	IT: Elba
Plebejus zuellichi (Hemming, 1933)		*Plebejus glandon*	E: M	ES: Sierra Nevada
Polyommatus ainsae (Forster, 1961)	Forster's Furry Blue	*Polyommatus fulgens*	E	ES: North Spain
Polyommatus andronicus (Coutsis & Ghavalas, 1995)	Phalakron Blue	*Polyommatus icarus*	E: M	GR: Macedonia
Polyommatus aroaniensis (Brown, 1976)	Grecian Anomalous Blue		E: M	BG; GR, MK
Polyommatus coelestinus (Eversmann, 1848)	Pontic Blue		–	GR: Peloponnese
Polyommatus eleniae Coutsis & De Prins, 2005		*Polyommatus aroaniensis*	E: M	GR
Polyommatus exuberans (Verity, 1926)		*Polyommatus ripartii*	E: M	IT: Valle di Susa
Polyommatus fabressei (Oberthür, 1910)	Oberthur's Anomalous Blue		E	ES
Polyommatus fulgens (de Sagarra, 1925)		*Polyommatus dolus*	E	ES: Catalonia
Polyommatus galloi (Balletto & Toso, 1979)		*Polyommatus ripartii*	E	IT: South Italy
Polyommatus gennargenti (Leigheb, 1987)		*Polyommatus coridon*	E: I	IT: Sardinia
Polyommatus golgus (Hübner, 1813)	Nevada Blue		E: M	ES: Sierra Nevada

Species	Engl. Name	Closest relative	E	European distribution
Polyommatus humedasae (Toso & Balletto, 1976)	Piedmont Anomalous Blue		E: M	IT: Aosta valley
Polyommatus iphigenius (Herrich-Schäffer, 1847)	Chelmos Blue		–	GR: Mt. Chelmos
Polyommatus menalcas (Freyer, 1837)			–	TR
Polyommatus nephohiptamenos (Brown & Coutsis, 1978)	Higgins' Anomalous Blue	*Polyommatus ripartii*	E: M	BG; GR: Macedonia
Polyommatus nufrellensis (Schurian, 1977)		*Polyommatus coridon*	E: I	FR: Corsica
Polyommatus orphicus Kolev, 2005		*Polyommatus dantchenkoi*	E: M	BG
Polyommatus violetae (Gomez-Bustillo et al., 1979)	Andalusian Anomalous Blue	*Polyommatus fabressei*	E: M	ES: South Spain
Polyommatus virgilius (Oberthür, 1910)		*Polyommatus dolus*	E	IT
Satyrium ledereri (Boisduval, 1848)	Orange-Banded Hairstreak		–	GR: Samos
Scolitantides barbagiae (Prins & Poorten, 1982)	Sardinian Blue		E: I	IT: Sardinia
Tarucus balcanicus (Freyer, 1845)	Little Tiger Blue		–	HR; AL; MK; BG; GR; TR
Tarucus theophrastus (Fabricius, 1793)	Common Tiger Blue		–	ES: Southeast Spain
Tomares nogelli (Herrich-Schäffer, 1852)	Nogel´s Hairstreak		–	RO; UA
Turanana endymion (Freyer, 1850)	Odd Spot Blue		–	GR but non-Europe if *T. taygetica* is accepted as separate species.
Turanana taygetica (Rebel, 1902)		*Turanana endymion*	–	GR: Chelmos & Taygetos
Nymphalidae				
Argynnis elisa (Godart, 1823)	Corsican Fritillary		E: I	FR: Corsica; IT: Sardinia
Boloria improba (Butler, 1877)	Dusky-winged Fritillary		–	Arctic Scandinavia: NO; SE; FI
Boloria napaea (Hoffmansegg, 1804)	Mountain Fritillary		–	NO; SE; FI; Alps & Pyrenees: ES, FR, CH, IT, AT
Boloria polaris (Boisduval, 1829)	Polar Fritillary		–	Arctic Scandinavia: NO; SE; FI
Chazara prieuri (Pierret, 1837)	Southern Hermit		–	ES

Species	Engl. Name	Closest relative	E	European distribution
Coenonympha corinna (Hübner, 1806)	Corsican Heath		E: I	FR: Corsica; IT: Sardinia
Coenonympha elbana Staudinger, 1901	Elban Heath	*Coenonympha corinna*	E: I	IT: Tuscany, Elba
Coenonympha orientalis Rebel, 1910	Balkan Heath		E: M	AL; BA; GR, RS
Coenonympha thyrsis (Freyer, 1846)	Cretan Small Heath	*Coenonympha pamphilus*	E: I	GR: Crete
Danaus plexippus (Linnaeus, 1758)	Monarch, Milkweed		–	ES: Canary Islands, South coast; PT
Erebia aethiopella (Hoffmansegg, 1806)	False Mnestra Ringlet		E: M	Alps: FR; IT
Erebia calcaria Lorkovic, 1953	Lorkovic's Brassy Ringlet		E: M	Alps: IT; AT; SI
Erebia christi Rätzer, 1890	Rätzer's Ringlet		E: M	Alps: CH, IT
Erebia claudina (Borkhausen, 1789)	White Speck Ringlet		E: M	Alps: AT
Erebia flavofasciata Heyne, 1895	Yellow Banded Ringlet		E: M	Alps: CH; IT; AT
Erebia gorgone Boisduval, 1833	Gavarnie Ringlet		E: M	Pyrenees: FR; ES
Erebia hispania Butler, 1868	Spanish Brassy Ringlet		E: M	FR: Pyrenees; ES: Pyrenees & Sierra Nevada
Erebia lefebvrei Boisduval, 1828	Lefèbvre's Ringlet		E: M	Pyrenees: FR; ES
Erebia nivalis Lorkovic & Lesse, 1954	De Lesse's Brassy Ringlet		E: M	Alps: CH; IT; AT
Erebia orientalis Elwes, 1900	Bulgarian Ringlet	*Erebia epiphron*	E: M	BG, RS
Erebia palarica Chapman, 1905	Chapman's Ringlet		E: M	ES: Cantabria
Erebia polaris Staudinger, 1861	Arctic Woodland Ringlet	*Erebia medusa*	–	Arctic Scandinavia: NO; SE; FI
Erebia rhodopensis Nicholl, 1900	Nichol's Ringlet		E: M	BG; MK; GR, RS
Erebia scipio Boisduval, 1832	Larche Ringlet		E: M	Alps: FR; IT
Erebia sthennyo Graslin, 1850	False Dewy Ringlet		E: M	Pyrenees: FR; ES
Erebia stiria (Godart, 1824)	Styrian Ringlet		E: M	Alps: AT; IT; SI; HR
Erebia sudetica Staudinger, 1861	Sudetan Ringlet		E: M	CH, FR: Alps; RO; CZ
Erebia zapateri Oberthür, 1875	Zapater's Ringlet		E: M	ES: Central Spain

Species	Engl. Name	Closest relative	E	European distribution
Hipparchia aristaeus (Bonelli, 1826)	Southern Grayling		–	FR: Corsica; IT: Sardinia, Tuscany
Hipparchia azorina (Strecker, 1899)	Azores Greyling		E: I	PT: Azores
Hipparchia bacchus Higgins, 1967		*Hipparchia wyssii*	E: I	ES: El Hierro
Hipparchia blachieri (Fruhstorfer, 1908)		*Hipparchia aristaeus*	E: I	IT: Sicily
Hipparchia christenseni Kudrna, 1977			E: I	GR: Carpathos
Hipparchia cretica (Rebel, 1916)	Cretan Grayling		E: I	GR: Crete
Hipparchia cypriensis (Holik, 1949)	Cyprus Grayling	*Hipparchia pellucida*	E: I	CY
Hipparchia genava (Fruhstorfer, 1908)		*Hipparchia hermione*	E	CH; FR; IT
Hipparchia gomera Higgins, 1967		*Hipparchia wyssii*	E: I	ES: La Gomera
Hipparchia leighebi Kudrna, 1976		*Hipparchia semele*	E: I	IT: Eolian islands
Hipparchia maderensis (Bethune-Baker, 1891)		*Hipparchia aristaeus*	E: I	PT: Madeira
Hipparchia mersina (Staudinger, 1871)			–	GR: Ionian islands
Hipparchia neapolitana (Stauder, 1921)		*Hipparchia aristaeus*	E	IT: Campania
Hipparchia neomiris (Godart, 1823)	Corsican Grayling		E: I	FR: Corsica; IT: Sardinia, Elba, Capraia
Hipparchia pellucida (Stauder, 1923)			–	GR: Ionian islands
Hipparchia sbordonii Kudrna, 1984		*Hipparchia aristaeus*	E: I	IT: Ponza islands
Hipparchia tamadabae Owen & Smith, 1992		*Hipparchia wyssii*	E: I	ES: Gran Canaria
Hipparchia tilosi (Manil, 1984)		*Hipparchia wyssii*	E: I	ES: La Palma
Hipparchia wyssii (Christ, 1889)	Canary Greyling		E: I	ES: Tenerife
Maniola chia (Thomson, 1987)	Chios Meadow Brown		E: I	GR: Chios
Maniola cypricola Graves, 1928	Cyprus Meadow Brown		E: I	CY
Maniola halicarnassus Thomson, 1990	Thomson's Meadow Brown		–	GR: Nissiros island
Maniola megala (Oberthür, 1909)	Turkish Meadow Brown		–	GR: Lesbos

Species	Engl. Name	Closest relative	E	European distribution
Maniola nurag (Ghiliani, 1852)	Sardinian Meadow Brown		E: I	IT: Sardinia
Maniola telmessia (Zeller, 1847)	Aegean Meadow Brown		–	GR: Ionian islands
Melanargia pherusa (Boidsduval, 1833)	Sicilian Marbled White	*Melanargia occitanica*	E: I	IT: Sicily
Melitaea arduinna (Esper, 1784)	Freyer's Fritillary		–	RO; BG; RS; MK; GR; TR
Melitaea asteria (Freyer, 1828)	Little Fritillary		E: M	Alps: CH; IT; AT
Melitaea nevadensis (Oberthür, 1904)		*Melitaea athalia*	E: M	ES: Sierra Nevada
Aglais ichnusa (Bonelli, 1826)		*Aglais urticae*	E: I	FR: Corsica; IT: Sardinia
Oeneis bore (Schneider, 1792)	Arctic Grayling		–	Arctic Scandinavia: NO; SE; FI
Kirinia climene (Esper, 1784)	Lesser Lattice Brown		–	RO; BG; RS; MK; AL; GR; TR
Lasiommata paramegaera (Hübner, 1824)	Corsican Wall Brown	*Lasiommata megera*	E: I	FR: Corsica; IT: Sardinia
Pararge xiphia (Fabricius, 1775)	Madeiran Speckled Wood		E: I	PT: Madeira
Pararge xiphioides (Staudinger, 1871)	Canary Speckled Wood		E: I	ES: Canary Islands
Proterebia afra (Fabricius, 1787)	Dalmatian Ringlet		–	HR; GR
Pseudochazara cingovskii (Gross, 1973)	Macedonian Grayling		E: M	MK;
Pseudochazara geyeri (Herrich-Schäffer, 1845)	Grey Asian Greyling		–	MK; AL; BG; GR
Pseudochazara graeca (Staudinger, 1870)	Grecian Greyling		E: M	MK; AL; BG; GR
Pseudochazara orestes (Prins & Poorten, 1981)	Dils' Grayling		E: M	BG; GR
Pseudochazara tisiphone (Brown, 1980)	Dark Greyling	*Pseudochazara mniszechii*	E: M	AL; GR
Pseudochazara williamsi (Romei, 1927)		*Pseudochazara hippolyte*	E: M	ES: Sierra Nevada
Vanessa virginiensis (Drury, 1773)	American Painted Lady		–	PT; ES
Vanessa vulcania (Godart, 1819)	Canary Red Admiral	*Vanessa indica*	E: I	ES: Canary Islands; PT: Madeira
Ypthima asterope (Klug, 1832)	African Ringlet		–	GR: Ionian islands; CY

Table C.3.2: Country codes of European countries (ISO 3166-1 alpha-2 code)

Code	Country
AD	Andorra
AL	Albania
AT	Austria
BA	Bosnia and Herzegovina
BE	Belgium
BG	Bulgaria
BY	Belarus
CH	Switzerland
CY	Cyprus
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FO	Faroe Islands
FR	France
GB	United Kingdom
GI	Gibraltar
GR	Greece
HR	Croatia
HU	Hungary
IE	Ireland
IM	Isle Of Man

Code	Country
IS	Iceland
IT	Italy
LI	Liechtenstein
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Moldova
ME	Montenegro
MK	Macedonia (Former Yugoslav Republic)
MT	Malta
NL	The Netherlands
NO	Norway
PL	Poland
PT	Portugal
RO	Romania
RS	Serbia
RU	Russian Federation
SE	Sweden
SI	Slovenia
SK	Slovakia
SM	San Marino
TR	Turkey
UA	Ukraine

C.4 Summary results

The results of our analyses are summarized in Figures C.4.1 and C.4.2 (and in tables App. 3.1 and App. 3.2). The study shows clearly that climate change poses a considerable additional risk to European butterflies. However, the risk varies considerably under the three storylines considered in this atlas.

Under the extreme, no dispersal GRAS scenario for 2080, 24% of the modelled species lose more than 95% of their present climatic niche and 78% lose more than 50%. A further 20% are under potential risk and only 6% of species can be rated as being at lower risk.

Under the intermediate, no dispersal BAMBU scenario for 2080, 9% lose more than 95% of their climatic niche and 66% lose more than 50%. While under the best case SEDG scenario, only 3% lose more than 95% of their climatic niche and 48% lose more than 50%.

The results also show that there is a considerable time lag in the effects of climate change on European butterflies. Until 2050, the effects across different scenarios are still moderate. Under the no dispersal GRAS scenario (excluding the PR category), around 60% of species are still rated as experiencing a lower risk until 2050, while in 2080 these are a mere 6 %. The relative differences are similar across all the scenarios.

Dispersal ability is one of the major factors that will affect a species ability to survive under future climatic conditions. This ability is a proxy not only for mobility itself, but also for the availability of suitable habitats in the new areas of the respective climatic niches. Under the very moderate SEDG scenario, 33% of species could experience a net increase in climate niche space until 2050, and even 30% of the species have this option until 2080. Under the other two scenarios, around a quarter of species could experience an increase in climate space until 2050, while by 2080 this is only the case for 18%. Thus, until 2050, there may be better conditions for some warmth-loving species, provided they can respond, but these subsequently get worse.

The most striking differences in the results are the ones between the different scenarios. Considering the no dispersal scenarios again for 2080, the number of species of the lower risk category ranges between 43% for SEDG and 6% for GRAS (with 20% for BAMBU).

On page 630 we present the results of climate risk analysis for both time steps (left and right column) under the three scenarios SEDG (first row), BAMBU (second row), and GRAS (third row) for full dispersal, while on page 631 the same is shown under the assumption of no dispersal (for definition of risk categories see chapter B.4, pages 24ff.).

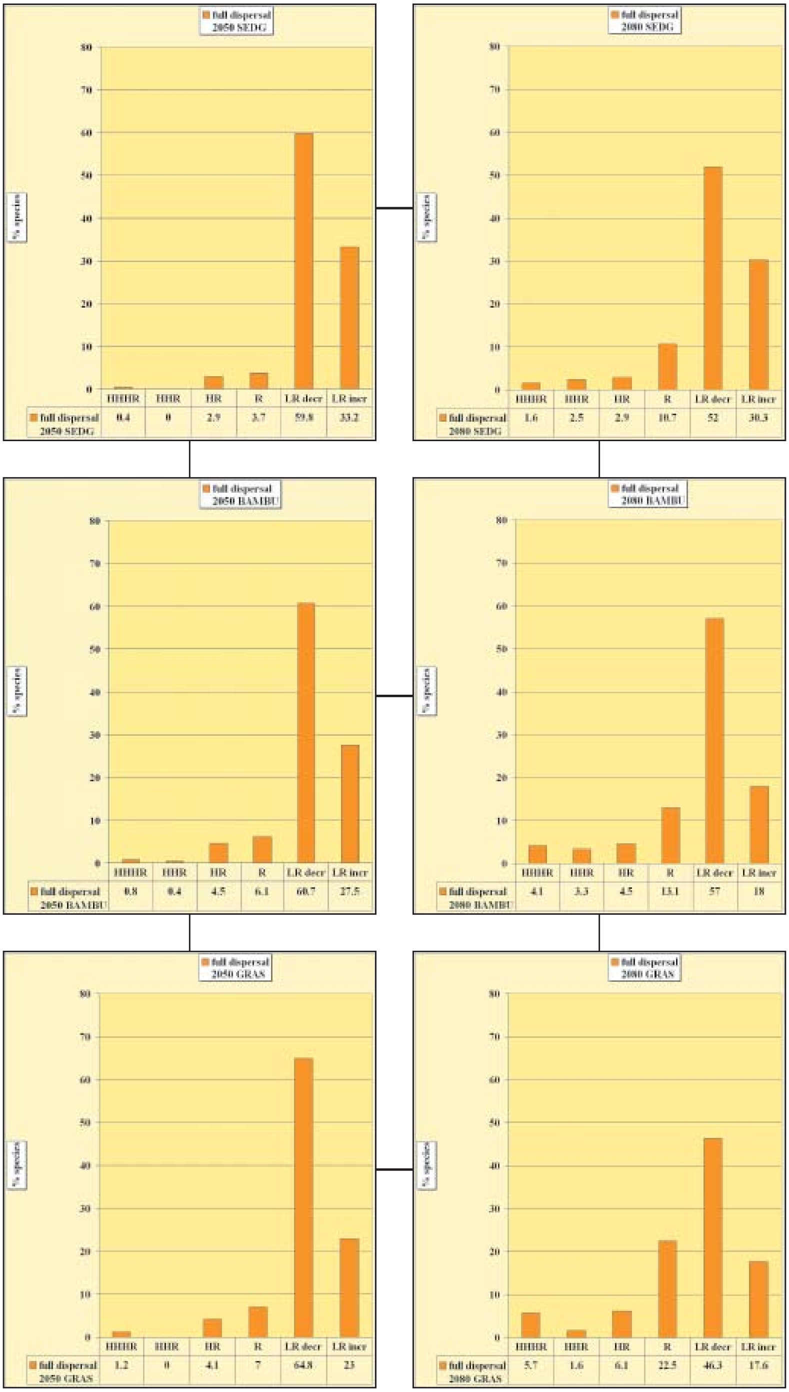


Figure C.4.1: Percentages of climate risk categories of European butterflies under the full dispersal assumption for 2050 (left column) and 2080 (right column) under the three scenarios SEDG (first row), BAMBU (second row), and GRAS (third row).
(without "PR"; for category definitions see pp. 24ff.)

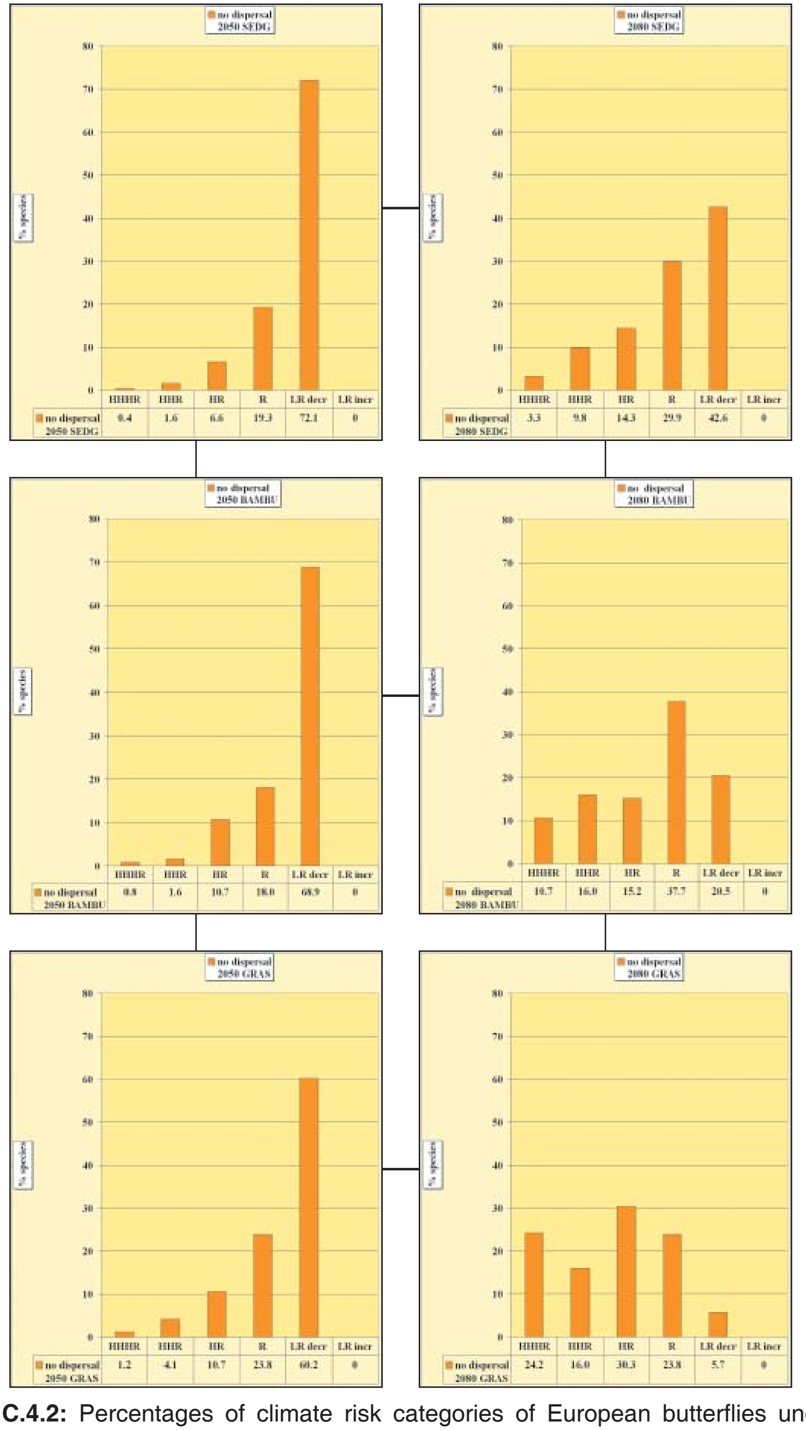


Figure C.4.2: Percentages of climate risk categories of European butterflies under the no dispersal assumption for 2050 (left column) and 2080 (right column) under the three scenarios SEDG (first row), BAMBU (second row), and GRAS (third row).
(without "PR"; for category definitions see pp. 24ff.)

D

DISCUSSION OF METHODOLOGICAL LIMITATIONS

D.1 Limitations of species distribution models and future projections

General suitability of species distribution projections

Species distribution models (Guisan & Zimmermann 2000) are widely used in assessing possible future distribution patterns. They correlate current environmental conditions with observed presences/absences (or only presences) of single species. Species distribution models are based on the assumption that a species occupies all areas with a suitable environment, i.e. the species fills its so called fundamental niche. In reality, species realize only parts of their fundamental niches and thus are rarely in equilibrium with their environment. This may be caused by several reasons, e.g. biotic interactions or dispersal ability may restrict the niche filling or slow it down in a changing environment.

Though the approach of species distribution models is purely correlative and does not imply causality, species distributions can usually be described well enough to draw some useful conclusions. Based on the assumption that the relation between environment and species distribution holds in a changing environment, distribution models are used to project the potential impacts on species distribution and biodiversity corresponding to climate and land use change scenarios.

Species distribution models are validated by comparing the fit between the modelled distribution, based on current environmental conditions, and the observed distribution. Such validation helps estimating the model reliability and uncover sources and patterns of discrepancy between modelled and real species distribution. Having assessed the modelling errors, it is possible to make a careful and sound interpretation of the results.

The most important causes of modelling errors for species distribution models are as follows:

- **Data quality:** A low sampling effort, due to low accessibility or inconspicuousness of species, underestimates the true species distribution and truncates environmental niches. Data should cover the whole range of a species and thus the full niche of species, otherwise tolerance to environmental conditions may be misjudged (Kadmon et al. 2003).
- **Data resolution:** Data resolution may not be appropriate to capture environmental conditions that are experienced by organisms (Pearson & Dawson 2003). Mean climatic conditions taken over a larger area may not reflect the local climatic conditions experienced in a species' microhabitat. For example conditions in mountains and peat bogs may change substantially

within short distances due to variations in local topography and land-form (Trivedi et al. 2008).

- **Modelling algorithm:** Choice of modelling algorithm affects prediction error (Pearson et al. 2006). Some methods may give a better fit to nonlinear data, but are subject to over-fitting (Randin et al. 2006) (i.e. they may describe calibration data well but are useless for temporal or spatial projections). To reduce the influence of the chosen technique on the modelling results Araujo & New (2007) suggested to combine the results of many different (good) models by ensemble forecasting. Ensemble methods are surely appropriate in the absence of detailed ecological knowledge of the species modelled. However, for species with known ecological requirements, model results can be judged according to their sensibility. Using ensemble methods and average across all results (including insensible models) would lead to worse instead of better model results.
- **Species' ecology:** Model performance may be influenced in a variety of ways by species characteristics (McPherson & Jetz 2007). Range characteristics resemble the ecological niche of a species in space. Species with clumped distribution and narrow niches have a good predictability; results for range size itself were ambiguous and may even be an statistical artefact (for discussion see: Hernandez et al. 2006). Species of higher trophic levels are expected to be modelled least well, since they strongly depend on other species (Huntley et al. 2004). A high temporal or spatial mobility (e.g. good dispersal, migratory behaviour) may lead to reduced detectability or misjudgement of habitat preferences (Pulliam 2000). Low performance of inconspicuousness or scarce species is opposed by a good performance of large and easily detectable species (Seoane et al. 2005).
- **Intraspecific variation:** In species distribution models (and usually in dynamic models as well) it is assumed that species are not differentiated and do not have phenotypic or behavioural plasticity. Ignoring the adaptation to local conditions leads to overestimation of the environmental niche (Harte et al. 2004).
- **Evolutionary adaptation:** Usually, both types of modelling approaches ignore the ability of species for (micro-)evolutionary changes, i.e. species can adapt to novel conditions only within the limits of their genetically predetermined potential. However, it was shown that species have the evolutionary potential to adapt to novel environmental conditions (Thomas et al. 2001). This will underestimate the potential environmental niche in the future.
- **Lacking parameters:** Limited knowledge on environmental conditions influencing species distribution seriously reduces modelling performance (Barry & Elith 2006). Inclusion of land use increased model performance on small scale (Luoto et al. 2007) as well as large scale (Pompe et al. 2008). The influence of biotic interactions (e.g. competition, facilitation, diseases, prey) are generally ignored in species distribution models though they are assumed

to play a large role in shaping species distribution. Recent applications are promising at least to describe simple interactions (Heikkinen et al. 2007, Schweiger et al. in press).

- **Changing biotic and environmental interactions.** Species distribution models based on correlations between current distribution environment may be invalidated by uncoupling and rearrangement of biotic interactions (see above) or the appearance of unprecedented environmental conditions (e.g. CO_2 fertilization of plants). For example, increased environmental CO_2 may lead to increased stomatal conductance and hence to less evapotranspiration and subsequently higher soil water availability than can be assumed from purely climatic conditions. Ignoring this can largely affect species distribution models (Rickebusch et al. 2008).

This list makes clear that biodiversity models are not able to replicate all the complex patterns of reality and are valid only under its simplifying assumptions. The extent of this limitation might question the usefulness of such models. However, the aim of such modelling procedures is not to capture the full complexity of the systems but to gain a better understanding of the basic patterns and underlying natural processes. The simplifications allow us to reduce the complexity of the real world to a level that can be handled with the available techniques and knowledge. It is better to achieve some limited knowledge, even with imperfect methods and the related uncertainties, than to remain in complete ignorance.

Hence predictive species distribution models cannot forecast the future but are able to give potential reactions of species under environment change scenarios, which may help in deriving appropriate policy recommendations.

Approaches used in the present atlas

We used generalised linear models (GLMs) to relate climatic variables to species distributional data using a binomial error structure, which means that we need both reliable presence and absence data and to assess the full climatic niche of a species. It would hence be best if both northern and southern range margins are at least to some extent defined by climate and not solely by other factors such as e.g. geographical borders. To ensure high quality models we excluded countries with low levels of sampling and highly uneven coverage.

The southern range margins of many Mediterranean species (e.g. *Danaus chrysippus, Gegenes nostrodamus, Leptotes pirithous, Libythea celtis, Tomares ballus* see Figs. D.1.1-D.1.5) are, however, often limited by the geographical borders of Europe and not necessarily by climate. Here, future projections may be treated with caution; since extrapolations to future warmer and dryer climates might be overly pessimistic in some cases as such species' potential performance in such climates (e.g. species that also occur in North Africa) was not included in model parameterisation.

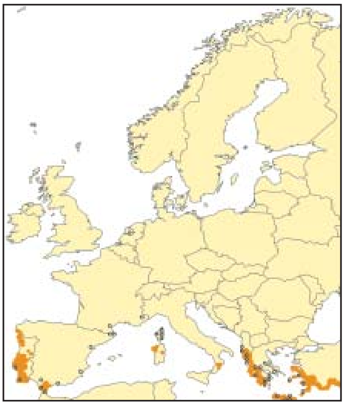


Figure D.1.1: Actual distribution and modelled present climatic niche of *Danaus chrysippus*

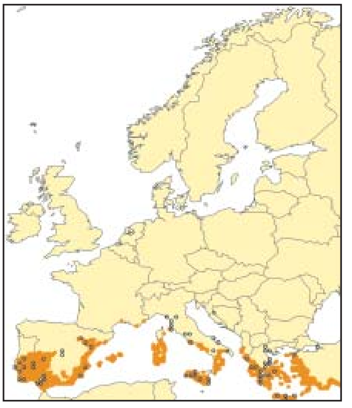


Figure D.1.2: Actual distribution and modelled present climatic niche of *Gegenes nostrodamus*

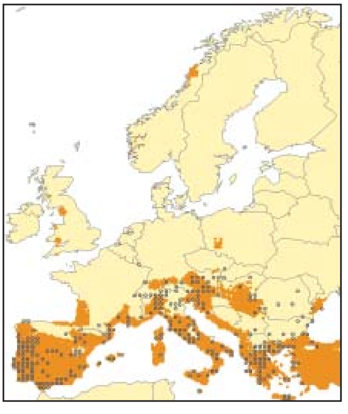


Figure D.1.3: Actual distribution and modelled present climatic niche of *Leptotes pirithous*

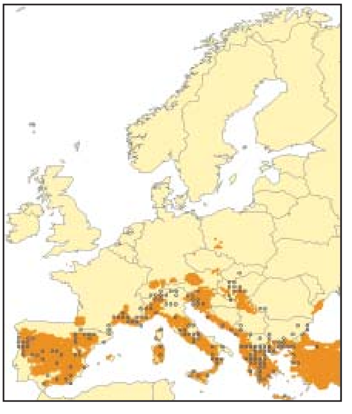


Figure D.1.4: Actual distribution and modelled present climatic niche of *Libythea celtis*

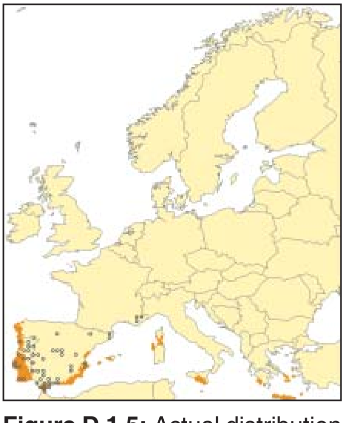


Figure D.1.5: Actual distribution and modelled present climatic niche of *Tomares ballus*

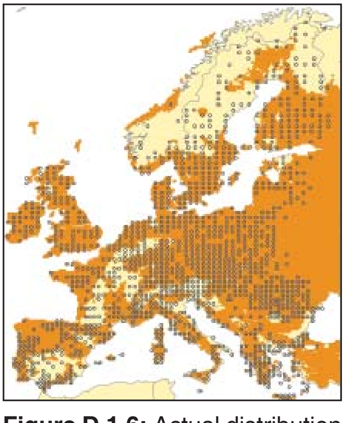


Figure D.1.6: Actual distribution and modelled present climatic niche of *Vanessa cardui*

Vanessa cardui (Fig. D.1.6) for example, is even more difficult, as this species seems to survive the winter only in South Mediterranean regions while populations might vanish there in summer, depending on re-migrants from the North. Here it would be most important to model the future overwintering area. Unfortunately this area seems to be situated mostly outside Europe, and little is known on this (apart from the Canaries where this species can be found all year round). It therefore is of limited use to model the total area where this species can be found, because this is the whole of Europe.

Within this atlas we present ecological niche models based on climatic variables. It is crucial to note that the depicted current and future climatic niches do not represent predictions of future species distributions but are projected distributions of the potentially suitable **climate space** for the species. Of course there are many more factors that determine whether a species is actually able to occupy the potentially suitable climate spaces, including landscape structure, habitat quality, resource availability or predation and parasitic pressures and the dispersal ability of a species. However, as applied at the coarse scale across the whole of Europe, climate is usually best suited to explain such large scale distributional patterns (Thuiller et al. 2004). This is supported by the generally high accuracy of our models (i.e. high AUC values for most species). However, there are exceptions such as *Lycaena helle* (Fig. D.1.7), *Coenonympha oedippus* (Fig. D.1.8), and *Euphydryas maturna* (Fig. D.1.9), whose distributions are tied closely to particular habitat conditions. Such local habitats with specific structural and microclimatic conditions are averaged out at the resolution used in this analysis and thus do not contribute to model development. In these cases where habitat and microclimatic conditions are much more important determinants of species' distributions, large scale bioclimatic niche models often fail to adequately describe and consequently to project future species distributions. We address these concerns by taking AUC values into account when assessing species risk (see section B4).

A high temporal or spatial mobility (e.g. good dispersal, migratory behaviour, invasive species) may lead to misjudgement of habitat preferences. This means that results for species like *Vanessa cardui* (Fig. D.1.14), *Vanessa atalanta* (Fig. D.1.10) or *Cacyreus marshalli* (Fig. D.1.11) have to be treated with caution. In many such cases it would be much better to only include the range of permanent populations (e.g. in *Colias croceus*, Fig. D.1.12; and *Lampides boeticus*, Fig. D.1.13). Unfortunately, this is a rather difficult task which might be tackled in the future, because it is often not known whether records represent permanent populations.

Another example is *Boloria titania* (Fig. D.1.15), where the model was not able to predict the occurrence of this species in the Baltic States. The inclusion of constraints of the larval host plant *Polygonum bistorta* in the process of model development results in much better models (Schweiger et al. in press). This shows that including other essential abiotic and biotic environmental factors can help to improve model accuracy, but in most cases we lack crucial information about the multitude of species interactions that may add to the effects of climate. Consequently, to be consistent across the species, we relied solely on climatic variables in the current atlas.

There are many different methodological approaches to develop ecological niche models and ways to deal with issues such as host-plant constraints (Guisan &

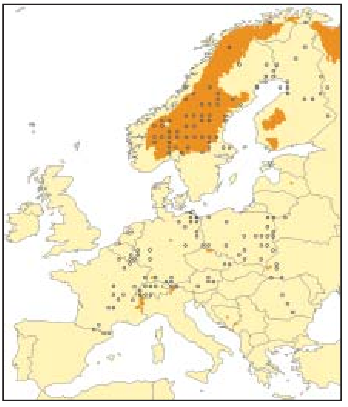


Figure D.1.7: Actual distribution and modelled present climatic niche of *Lycaena helle*

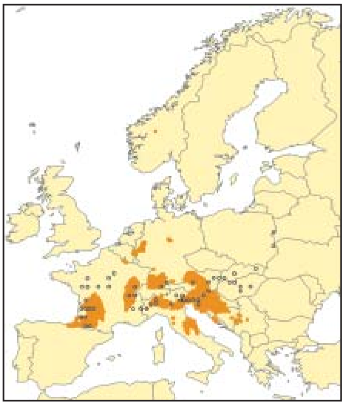


Figure D.1.8: Actual distribution and modelled present climatic niche of *Coenonympha oedippus*

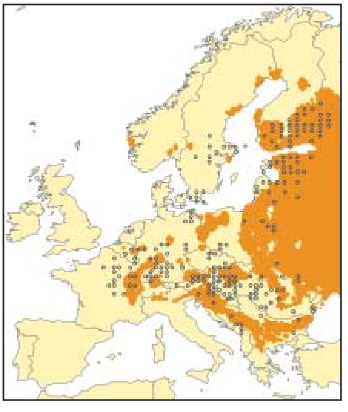


Figure D.1.9: Actual distribution and modelled present climatic niche of *Euphydryas maturna*

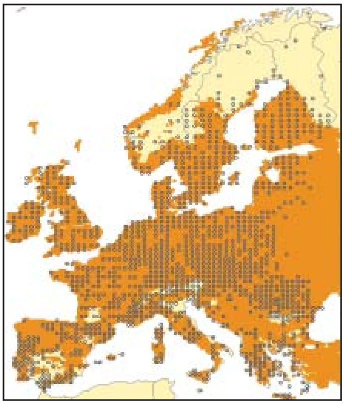


Figure D.1.10: Actual distribution and modelled present climatic niche of *Vanessa atalanta*

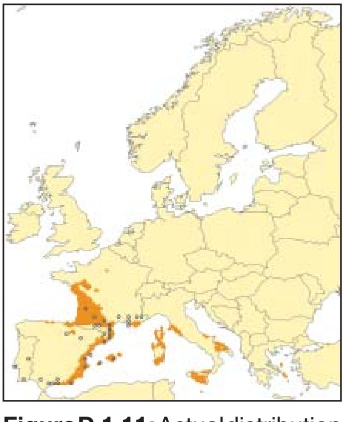


Figure D.1.11: Actual distribution and modelled present climatic niche of *Cacyreus marshalli*

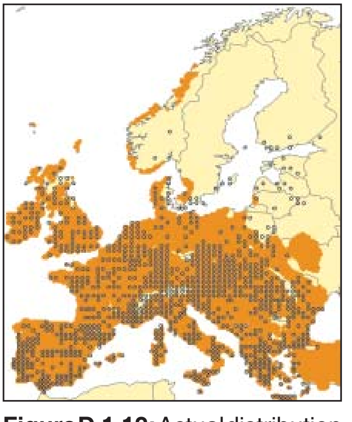


Figure D.1.12: Actual distribution and modelled present climatic niche of *Colias croceus*

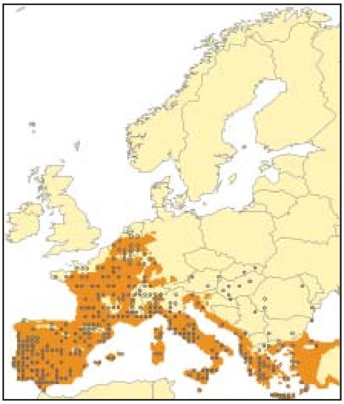


Figure D.1.13: Actual distribution and modelled present climatic niche of *Lampides boeticus*

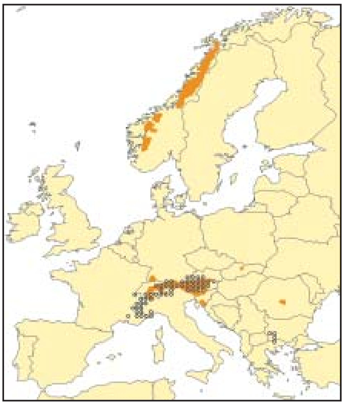


Figure D.1.14: Actual distribution and modelled present climatic niche of *Euphydryas cynthia*

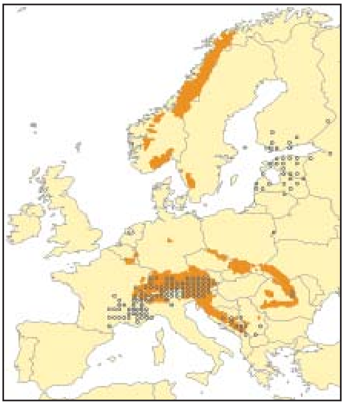


Figure D.1.15: Actual distribution and modelled present climatic niche of *Boloria titania*

Zimmermann 2000, Elith et al. 2006, Heikkinen et al. 2006, Thuiller et al. 2008). We used GLMs despite the fact that they did not always provide the best model fit for the current distribution. However, their clear and simple mathematical formulation allows highly accurate extrapolations into new environmental space (Elith et al. 2006, Kühn et al. in press).

There are also many ways to evaluate model accuracy. The most commonly accepted measures are Cohen's Kappa (Cohen 1960) and AUC (Hanley & McNeil 1982). Both measure the agreement between observed and modelled occurrence (threshold dependent occurrence for Kappa and threshold independent occurrence probability for AUC) and depend on four cases of agreement: cases where actual occurrences were modelled correctly (right presence) or incorrectly (false absence) and cases where actual absences were modelled correctly (right absences) or incorrectly (false presences). Unfortunately, all four cases are weighted equally, which may result in extraordinarily high accuracy values when accuracy is dominated by just one of the four cases (Lobo et al. 2008). For instance, a number of species like *Lycaena helle* (Fig. D.1.7) and *Coenonympha oedippus* (Fig. D.1.8), or *Euphydryas cynthia* (Fig. D.1.14) and *Boloria titania* (Fig. D.1.15) and many others (as listed in table D.1.3) have a very restricted distribution with a high number of absences and a low number of presences.

The model was able to predict most of the absences correctly (right absence rate) but not many of the presences (false absence rate). As a consequence, the models give high AUC values because of the dominating effect of the right absences. However, for ecological niche modelling, the false absence rate is of most interest since it shows how well the model fits the actual occurrence, while false presences can easily be a consequence of other interacting limiting factors. To take this into account, we provide false absence rates as well as other values for all modelled species in a table in Appendix 1 and the most extreme cases in Tables D.1.1-4.

Table D.1.1: 38 European butterflies with the highest AUC values (AUC > 0.95): (incl. overall risk categories with full and without dispersal)

page	Species	Risk categ. full disp	Risk categ. no disp	AUC
372	*Boloria chariclea* (Schneider, 1794)	HHHR	HHHR	1
410	*Euphydryas iduna* (Dalman, 1816)	HHHR	HHHR	1
286	*Plebejus aquilo* (Boisduval, 1832)	HHHR	HHHR	1
82	*Pyrgus warrenensis* (Verity, 1928)	R	HR	0.99
112	*Parnassius phoebus* (Fabricius, 1793)	LR	HR	0.99
170	*Colias hecla* Lefebvre, 1836	HHHR	HHHR	0.99
284	*Plebejus glandon* (Prunner, 1798)	R	HHR	0.99
514	*Erebia eriphyle* (Freyer, 1836)	LR	HR	0.99
530	*Erebia disa* (Becklin, 1791)	HHHR	HHHR	0.99
546	*Erebia tyndarus* (Esper, 1781)	R	HR	0.99
614	*Oeneis glacialis* (Moll, 1785)	R	HR	0.99
34	*Erynnis marloyi* (Boisduval, 1834)	HR	HHHR	0.98
158	*Pontia callidice* (Hübner, 1800)	R	HR	0.98
194	*Lycaena ottomana* (Lefebvre, 1830)	LR	HHR	0.98
288	*Plebejus orbitulus* (Prunner, 1798)	LR	LR	0.98
312	*Polyommatus nivescens* (Keferstein, 1851)	HHHR	HHHR	0.98
412	*Euphydryas cynthia* ([Schiffermüller], 1775)	R	HR	0.98
414	*Euphydryas intermedia* (Menetries, 1859)	R	HHR	0.98
458	*Apatura metis* (Freyer, 1829)	LR	HHR	0.98
522	*Erebia melampus* (Fuessli, 1775)	LR	R	0.98
536	*Erebia pluto* (Prunner, 1798)	R	HR	0.98
554	*Erebia montana* (Prunner, 1798)	R	HR	0.98
574	*Melanargia arge* (Sulzer, 1776)	LR	HR	0.98
598	*Hipparchia fatua* (Freyer, 1845)	LR	HR	0.98
612	*Oeneis norna* (Becklin, 1791)	HHHR	HHHR	0.98
134	*Zegris eupheme* (Esper, 1805)	HHHR	HHHR	0.97
336	*Polyommatus dolus* (Hübner, 1823)	LR	HHHR	0.97
486	*Coenonympha gardetta* (Prunner, 1798)	LR	HR	0.97
528	*Erebia embla* (Becklin, 1791)	R	R	0.97
64	*Pyrgus centaureae* (Rambur, 1840)	R	R	0.96
100	*Gegenes pumilio* (Hoffmansegg, 1804)	LR	HR	0.96
136	*Euchloe belemia* (Esper, 1798)	HHR	HHHR	0.96
162	*Colias phicomone* (Esper, 1780)	LR	HR	0.96
302	*Aricia anteros* (Freyer, 1838)	HR	HHHR	0.96
380	*Boloria frigga* (Becklin, 1791)	R	R	0.96
436	*Melitaea varia* (Meyer-Dür, 1851)	LR	HHR	0.96
540	*Erebia mnestra* (Esper, 1805)	R	HHR	0.96
616	*Oeneis jutta* (Hübner, 1806)	LR	R	0.96

Table D.1.2: 34 European butterflies with the highest Kappa values (> 0.54):
(incl. overall risk categories with full and without dispersal)

page	Species	Risk categ. full disp	Risk categ. no disp	Kappa
286	*Plebejus aquilo* (Boisduval, 1832)	HHHR	HHHR	0.78
170	*Colias hecla* Lefebvre, 1836	HHHR	HHHR	0.77
372	*Boloria chariclea* (Schneider, 1794)	HHHR	HHHR	0.73
530	*Erebia disa* (Becklin, 1791)	HHHR	HHHR	0.72
64	*Pyrgus centaureae* (Rambur, 1840)	R	R	0.71
528	*Erebia embla* (Becklin, 1791)	R	R	0.70
616	*Oeneis jutta* (Hübner, 1806)	LR	R	0.68
164	*Colias palaeno* (Linnaeus, 1758)	R	R	0.66
364	*Boloria eunomia* (Esper, 1799)	LR	LR	0.64
410	*Euphydryas iduna* (Dalman, 1816)	HHHR	HHHR	0.64
514	*Erebia eriphyle* (Freyer, 1836)	LR	HR	0.64
288	*Plebejus orbitulus* (Prunner, 1798)	LR	LR	0.64
380	*Boloria frigga* (Becklin, 1791)	R	R	0.64
112	*Parnassius phoebus* (Fabricius, 1793)	LR	HR	0.63
282	*Plebejus optilete* (Knoch, 1781)	R	R	0.63
284	*Plebejus glandon* (Prunner, 1798)	R	HHR	0.63
564	*Erebia pandrose* (Borkhausen, 1788)	LR	LR	0.62
374	*Boloria freija* (Becklin, 1791)	HR	HR	0.62
158	*Pontia callidice* (Hübner, 1800)	R	HR	0.61
384	*Boloria aquilonaris* (Stichel, 1908)	R	R	0.60
184	*Gonepteryx cleopatra* (Linnaeus, 1767)	LR	HR	0.60
192	*Lycaena virgaureae* (Linnaeus, 1758)	LR	HR	0.60
614	*Oeneis glacialis* (Moll, 1785)	R	HR	0.59
88	*Carterocephalus silvicolus* (Meigen, 1829)	LR	HR	0.59
358	*Brenthis ino* (Rottemburg, 1775)	R	HR	0.59
554	*Erebia montana* (Prunner, 1798)	R	HR	0.58
502	*Aphantopus hyperantus* (Linnaeus, 1758)	LR	HR	0.58
612	*Oeneis norna* (Becklin, 1791)	HHHR	HHHR	0.58
408	*Araschnia levana* (Linnaeus, 1758)	LR	HR	0.58
484	*Coenonympha glycerion* (Borkhausen, 1788)	LR	R	0.57
486	*Coenonympha gardetta* (Prunner, 1798)	LR	HR	0.57
510	*Erebia ligea* (Linnaeus, 1758)	LR	R	0.55
162	*Colias phicomone* (Esper, 1780)	LR	HR	0.55
498	*Pyronia cecilia* (Vallantin, 1894)	R	HHHR	0.55

Table D.1.3: 44 European butterflies with the highest percentage of false absences (> 0.55): (incl. overall risk categories with full and without dispersal)

page	Species	Risk categ. full disp	Risk categ. no disp	false abs
256	*Scolitantides bavius* (EVERSMANN, 1832)	HR	HHR	0.90
386	*Boloria graeca* (STAUDINGER, 1870)	PR	PR	0.84
542	*Erebia epistygne* (HÜBNER, 1819)	HHHR	HHHR	0.83
44	*Carcharodus baeticus* (RAMBUR, 1840)	LR	HR	0.82
302	*Aricia anteros* (FREYER, 1838)	HR	HHHR	0.81
46	*Spialia phlomidis* (HERRICH-SCHÄFFER, 1845)	HR	HHHR	0.80
334	*Polyommatus ripartii* (FREYER, 1830)	PR	PR	0.80
480	*Coenonympha rhodopensis* ELWES, 1900	LR	HHHR	0.79
544	*Erebia ottomana* (HERRICH-SCHÄFFER, 1847)	LR	HR	0.79
202	*Lycaena candens* (HERRICH-SCHÄFFER, 1844)	LR	HHR	0.78
174	*Colias chrysotheme* (ESPER, 1780)	HR	HHHR	0.75
240	*Cupido osiris* (MEIGEN, 1829)	LR	HHHR	0.75
188	*Lycaena helle* ([SCHIFFERMÜLLER], 1775)	LR	LR	0.72
558	*Erebia melas* (HERBST, 1796)	LR	HR	0.71
212	*Tomares ballus* (FABRICIUS, 1787)	HHHR	HHHR	0.71
58	*Pyrgus sidae* (ESPER, 1782)	R	HHHR	0.70
594	*Hipparchia volgensis* (MAZOCHIN-PORSHNYAKOV, 1952)	LR	HHR	0.69
108	*Zerynthia cerisyi* (GODART, 1822)	LR	LR	0.69
124	*Leptidea duponcheli* (STAUDINGER, 1871)	PR	PR	0.69
332	*Polyommatus admetus* (ESPER, 1785)	R	HHHR	0.67
290	*Plebejus sephirus* (FRIVALDSZKY, 1835)	LR	HHR	0.67
148	*Pieris mannii* (MAYER, 1851)	LR	HHR	0.66
38	*Carcharodus lavatherae* (ESPER, 1783)	PR	PR	0.64
478	*Coenonympha oedippus* (FABRICIUS, 1787)	LR	R	0.63
492	*Coenonympha leander* (ESPER, 1784)	R	HHHR	0.63
336	*Polyommatus dolus* (HÜBNER, 1823)	LR	HHHR	0.63
194	*Lycaena ottomana* (LEFEBVRE, 1830)	LR	HHR	0.62
216	*Callophrys avis* CHAPMAN, 1909	LR	HHHR	0.62
412	*Euphydryas cynthia* ([SCHIFFERMÜLLER], 1775)	R	HR	0.62
100	*Gegenes pumilio* (HOFFMANSEGG, 1804)	LR	HR	0.62
602	*Hipparchia senthes* (FRUHSTORFER, 1908)	R	HHR	0.61
560	*Erebia oeme* (ESPER, 1805)	LR	R	0.61
416	*Euphydryas maturna* (LINNAEUS, 1758)	LR	LR	0.60
552	*Erebia styx* (FREYER, 1834)	R	HR	0.60
548	*Erebia cassioides* (REINER & HOHENWARTH, 1792) (species complex)	R	R	0.60
338	*Polyommatus damon* ([SCHIFFERMÜLLER], 1775)	R	HHR	0.60
572	*Melanargia larissa* (ESPER, 1784)	LR	HHR	0.59

page	Species	Risk categ. full disp	Risk categ. no disp	false abs
246	*Cupido alcetas* (Hoffmansegg, 1804)	LR	HR	0.58
120	*Papilio alexanor* Esper, 1799	LR	HHR	0.57
368	*Boloria titania* (Esper, 1793)	LR	R	0.57
436	*Melitaea varia* (Meyer-Dür, 1851)	LR	HHR	0.56
182	*Gonepteryx farinosa* Zeller, 1847	LR	HR	0.56
566	*Melanargia russiae* (Esper, 1784)	LR	HHHR	0.56
136	*Euchloe belemia* (Esper, 1798)	HHR	HHHR	0.56

Table D.1.4: 36 European butterflies with the highest percentage of false presences (> 0.39): (incl. overall risk categories with full and without dispersal)

page	Species	Risk categ. full disp	Risk categ. no disp	false pres
318	*Polyommatus icarus* (Rottemburg, 1775)	PR	PR	0.76
186	*Lycaena phlaeas* (Linnaeus, 1761)	PR	PR	0.73
144	*Pieris brassicae* (Linnaeus, 1758)	PR	PR	0.66
150	*Pieris rapae* (Linnaeus, 1758)	PR	PR	0.66
154	*Pieris napi* (Linnaeus, 1758)	PR	PR	0.65
466	*Pararge aegeria* (Linnaeus, 1758)	PR	PR	0.64
388	*Vanessa atalanta* (Linnaeus, 1758)	PR	PR	0.62
494	*Coenonympha pamphilus* (Linnaeus, 1758)	PR	PR	0.58
248	*Celastrina argiolus* (Linnaeus, 1758)	PR	PR	0.54
504	*Maniola jurtina* (Linnaeus, 1758)	PR	PR	0.54
118	*Papilio machaon* Linnaeus, 1758	PR	PR	0.54
214	*Callophrys rubi* (Linnaeus, 1758)	PR	PR	0.54
142	*Aporia crataegi* (Linnaeus, 1758)	PR	PR	0.52
66	*Pyrgus malvae* (Linnaeus, 1758) (species complex)	PR	PR	0.52
390	*Vanessa cardui* (Linnaeus, 1758)	PR	PR	0.51
32	*Erynnis tages* (Linnaeus, 1758)	PR	PR	0.50
396	*Nymphalis c-album* (Linnaeus, 1758)	LR	LR	0.49
296	*Aricia agestis* ([Schiffermüller], 1775)	PR	PR	0.48
402	*Nymphalis polychloros* (Linnaeus, 1758)	PR	PR	0.47
98	*Ochlodes sylvanus* (Esper, 1777)	PR	PR	0.47
122	*Leptidea sinapis* (Linnaeus, 1758) & *Leptidea reali* Reissinger, 1990 (species complex)	PR	PR	0.47
366	*Boloria euphrosyne* (Linnaeus, 1758)	PR	PR	0.46
276	*Plebejus argus* (Linnaeus, 1758)	PR	PR	0.46
168	*Colias croceus* (Geoffroy, 1785)	LR	LR	0.45
262	*Glaucopsyche alexis* (Poda, 1761)	PR	PR	0.45
90	*Thymelicus lineola* (Ochsenheimer, 1806)	PR	PR	0.45

page	Species	Risk categ. full disp	Risk categ. no disp	false pres
180	*Gonepteryx rhamni* (Linnaeus, 1758)	PR	PR	0.44
352	*Argynnis niobe* (Linnaeus, 1758)	PR	PR	0.43
468	*Lasiommata megera* (Linnaeus, 1767)	PR	PR	0.43
238	*Cupido minimus* (Fuessly, 1775)	LR	R	0.42
422	*Melitaea cinxia* (Linnaeus, 1758)	PR	PR	0.41
208	*Favonius quercus* (Linnaeus, 1758)	PR	PR	0.41
324	*Polyommatus bellargus* (Rottemburg, 1775)	PR	PR	0.41
392	*Aglais io* (Linnaeus, 1758)	LR	R	0.40
36	*Carcharodus alceae* (Esper, 1870)	PR	PR	0.40
348	*Argynnis aglaja* (Linnaeus, 1758)	LR	R	0.40

D.2 Interaction of taxonomic status and modelling results

A special problem in niche modelling is presented by sister species or sibling species. They typically occupy very similar niches because they originated from the same ancestors, but are normally allopatric in distribution (no overlap in their areas). If we take the present distribution of just one of such a pair, we are bound to experience problems in the modelling, as the niche model will encompass the entire distribution of the climate space which may be occupied by the sister species. This leads to rather poor modelling results. If the distribution of these species is pooled, the model fits are normally much better.

Within this atlas we repeatedly came across this problem. The selection of some species was already affected, for example when some of the sister species had a very limited distribution (below our threshold of 20 UTM grids) and thus have been excluded from our analysis. However, their climate space might have been modelled through the other sister or sibling species.

We have selected the following examples to illustrate some of the effects:

First we have a more detailed look at the *Euchloe ausonia* complex. The maps and results presented in part C.2 include *Euchloe ausonia* (s.str.), *Euchloe crameri*, and *Euchloe simplonia*. If we differentiate between the results for the complex and the two three included here, we can see substantial differences in the output. These are summarized in table D.2.1 and also presented as maps (Figures D.2.1-4).

The results suggest that *E. ausonia* (s.str.) would suffer much less from climate change and under all scenarios would gain in climate space assuming full dispersal. In contrast, the climate space of *E. crameri* and *E. simplonia* would decrease under nearly all scenarios. The models for the three species together lies in between these results. Although there are large areas of false presences, these are compensated by right presences and right absences in *E. crameri* and *E. ausonia*

Table D.2.1: Results of climate modelling for the *Euchloe ausonia* complex and *Euchloe ausonia* (in the strict sense), *Euchloe crameri* and *Euchloe simplonia* separately

		Euchloe ausonia complex		*Euchloe ausonia* s.str.		*Euchloe crameri*		*Euchloe simplonia*	
Presently occupied grid cells		4483		2392		4174		529	
AUC		0.85		0.90		0.84		0.91	
		Full dispersal	No dispersal	Full dispersal	No dispersal	Full dispersal	No dispersal	Full dispersal	No dispersal
2050	SEDG	742 (16.55%)	-802 (-17.89%)	804 (33.61%)	-283 (-11.83%)	-571 (-13.68%)	-1986 (-47.58%)	-10 (-1.89%)	-329 (-62.19%)
	BAMBU	-91 (-2.03%)	-1080 (-24.09%)	778 (32.53%)	-232 (-9.7%)	-1436 (-34.4%)	-2201 (-52.73%)	61 (11.53%)	-301 (-56.9%)
	GRAS	586 (13.07%)	-1029 (-22.95%)	1026 (42.89%)	-296 (-12.37%)	-1142 (-27.36%)	-2389 (-57.24%)	-92 (-17.39%)	-358 (-67.67%)
2080	SEDG	338 (7.54%)	-1439 (-32.1%)	1760 (73.58%)	-419 (-17.52%)	-2045 (-48.99%)	-2897 (-69.41%)	-187 (-35.35%)	-443 (-83.74%)
	BAMBU	-327 (-7.29%)	-2058 (-45.91%)	1783 (74.54%)	-626 (-26.17%)	-2492 (-59.7%)	-3478 (-83.33%)	-113 (-21.36%)	-402 (-75.99%)
	GRAS	-265 (-5.91%)	-2472 (-55.14%)	2771 (115.84%)	-787 (-32.9%)	-2936 (-70.34%)	-4001 (-95.86%)	-235 (-44.42%)	-446 (-84.31%)

(s.str.). In the *E. ausonia* complex and in *E. simplonia* there are less false presences but more false absences. This leads to the effect that the AUC values are rather similar in all cases.

Few false absences

In many instances we come across sister species that can be modelled quite well independently from each other, with little overlap between the derived climate niches. A good example is *Scolitantides baton* and *Scolitantides vicrama*, (Table D.2.2. and Figures D.2.5 & 6). Here the models show differences in climate requirements which suggests different evolutionary histories for the two species.

Similar in terms of output statistics are the sister species *Lycaena hippothoe* and *Lycaena candens* (Table D.2.3; Figures D.2.7-8). However the map of the absolute distribution is very different between the two species and the distribution points of *L. candens* are to a large extent included in the climate space of *L. hippothoe*. This contributes to the large number of false presences which in general lead to the low AUC. The climate space model of *L. candens* is relatively poor if we look at right presences as well as false absences and the high AUC is due to the many right absences across Europe. Here a combination of both species would clearly lead to an improvement of the climate models and highlights the "disadvantage" of the separate modelling of sister species which we can observe in several other cases. Two other examples of sister species are shown below: a) *Spialia sertorius* and *Spialia orbifer* (Table D.2.4; Figures D.2.9-10); and b) *Hipparchia semele* and *Hipparchia senthes* (Table D.2.5; Figures D.2.11-12).

Table D.2.2: Results of climate modelling for the sister species *Scolitantides baton* and *Scolitantides vicrama*

		Scolitantides baton		*Scolitantides vicrama*	
Presently occupied grid cells		**2643**		**5393**	
AUC		**0.83**		**0.85**	
		Full dispersal	**No dispersal**	**Full dispersal**	**No dispersal**
2050	**SEDG**	-226 (-8.55%)	-1037 (-39.24%)	2985 (55.35%)	-353 (-6.55%)
	BAMBU	15 (0.57%)	-964 (-36.47%)	383 (7.1%)	-1599 (-29.65%)
	GRAS	-401 (-15.17%)	-1295 (-49%)	1968 (36.49%)	-962 (-17.84%)
2080	**SEDG**	-81 (-3.06%)	-1179 (-44.61%)	2198 (40.76%)	-1457 (-27.02%)
	BAMBU	-88 (-3.33%)	-1433 (-54.22%)	309 (5.73%)	-2974 (-55.15%)
	GRAS	-847 (-32.05%)	-2209 (-83.58%)	2622 (48.62%)	-3135 (-58.13%)

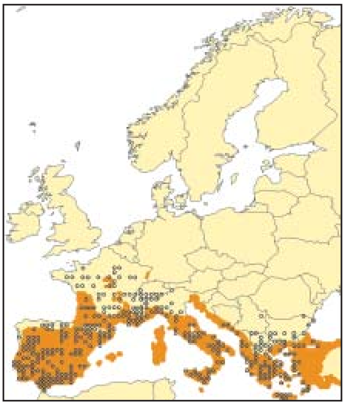


Figure D.2.1: Actual distribution and modelled present climatic niche of the *Euchloe ausonia* complex

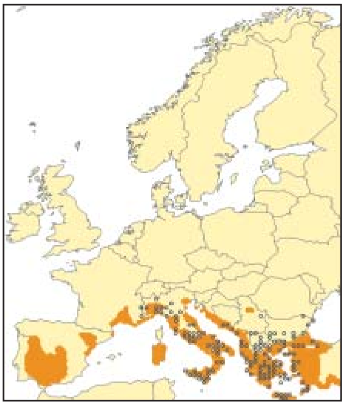


Figure D.2.2: Actual distribution and modelled present climatic niche of *Euchloe ausonia* (in the strict sense)

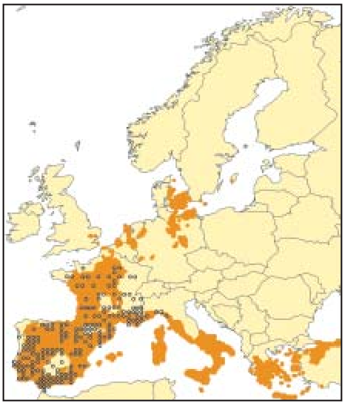


Figure D.2.3: Actual distribution and modelled present climatic niche of *Euchloe crameri*

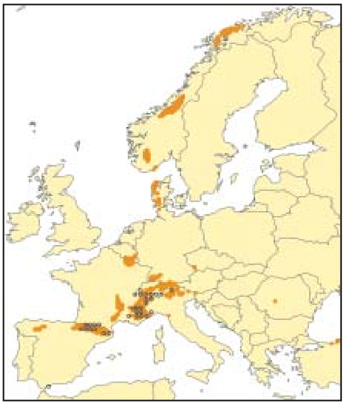


Figure D.2.4: Actual distribution and modelled present climatic niche of *Euchloe simplonia*

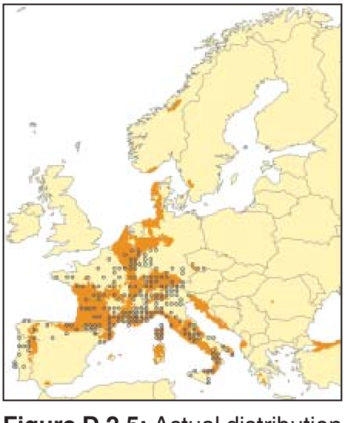


Figure D.2.5: Actual distribution and modelled present climatic niche of *Scolitantides baton*

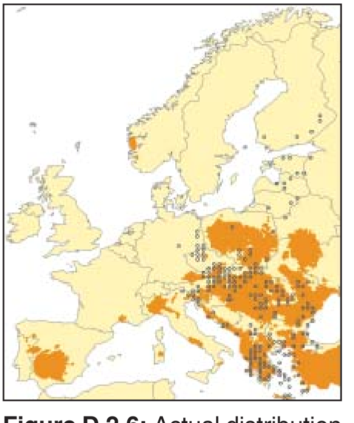


Figure D.2.6: Actual distribution and modelled present climatic niche of *Scolitantides vicrama*

Table D.2.3: Results of climate modelling for the sister species *Lycaena hippothoe* and *Lycaena candens*

		Lycaena hippothoe		*Lycaena candens*	
Presently occupied grid cells		14109		657	
AUC		0.85		0.86	
		Full dispersal	No dispersal	Full dispersal	No dispersal
2050	SEDG	-4111 (-29.14%)	-5600 (-39.69%)	192 (29.22%)	-289 (-43.99%)
	BAMBU	-3282 (-23.26%)	-4839 (-34.3%)	-161 (-24.51%)	-376 (-57.23%)
	GRAS	-4808 (-34.08%)	-6020 (-42.67%)	-75 (-11.42%)	-414 (-63.01%)
2080	SEDG	-5935 (-42.07%)	-7427 (-52.64%)	70 (10.65%)	-343 (-52.21%)
	BAMBU	-6505 (-46.11%)	-8317 (-58.95%)	-391 (-59.51%)	-564 (-85.84%)
	GRAS	-8606 (-61%)	-9862 (-69.9%)	-394 (-59.97%)	-624 (-94.98%)

Table D.2.4: Results of climate modelling for the sister species *Spialia sertorius* and *Spialia orbifer*

		Spialia sertorius		*Spialia orbifer*	
Presently occupied grid cells		6768		2728	
AUC		0.77		0.89	
		Full dispersal	No dispersal	Full dispersal	No dispersal
2050	SEDG	-426 (-6.29%)	-1771 (-26.17%)	2229 (81.71%)	-341 (-12.5%)
	BAMBU	-331 (-4.89%)	-1755 (-25.93%)	528 (19.35%)	-987 (-36.18%)
	GRAS	-1114 (-16.46%)	-2425 (-35.83%)	1211 (44.39%)	-976 (-35.78%)
2080	SEDG	-553 (-8.17%)	-2424 (-35.82%)	1025 (37.57%)	-1188 (-43.55%)
	BAMBU	-1006 (-14.86%)	-3188 (-47.1%)	-59 (-2.16%)	-1848 (-67.74%)
	GRAS	-2218 (-32.77%)	-4639 (-68.54%)	1443 (52.9%)	-2000 (-73.31%)

Table D.2.5: Results of climate modelling for the sister species *Hipparchia semele* and *Hipparchia senthes*

		Hipparchia semele		*Hipparchia senthes*	
Presently occupied grid cells		13833		840	
AUC		0.79		0.94	
		Full dispersal	No dispersal	Full dispersal	No dispersal
2050	SEDG	-2284 (-16.51%)	-3095 (-22.37%)	-62 (-7.38%)	-350 (-41.67%)
	BAMBU	-3269 (-23.63%)	-4031 (-29.14%)	-2 (-0.24%)	-293 (-34.88%)
	GRAS	-3564 (-25.76%)	-4405 (-31.84%)	-85 (-10.12%)	-386 (-45.95%)
2080	SEDG	-5233 (-37.83%)	-6024 (-43.55%)	207 (24.64%)	-421 (-50.12%)
	BAMBU	-6634 (-47.96%)	-7748 (-56.01%)	-280 (-33.33%)	-631 (-75.12%)
	GRAS	-8424 (-60.9%)	-9748 (-70.47%)	-444 (-52.86%)	-767 (-91.31%)

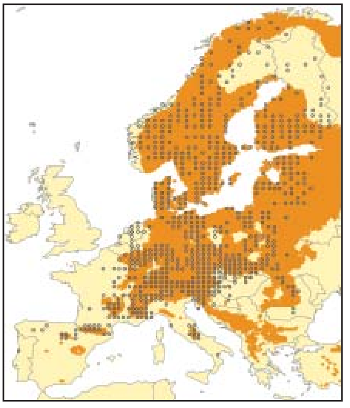


Figure D.2.7: Actual distribution and modelled present climatic niche of *Lycaena hippothoe*

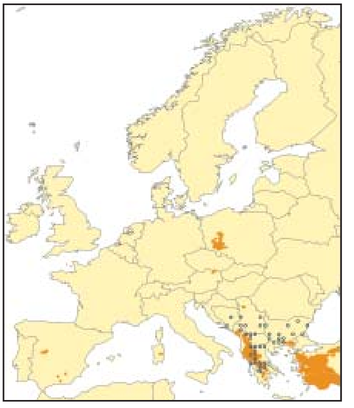


Figure D.2.8: Actual distribution and modelled present climatic niche of *Lycaena candens*

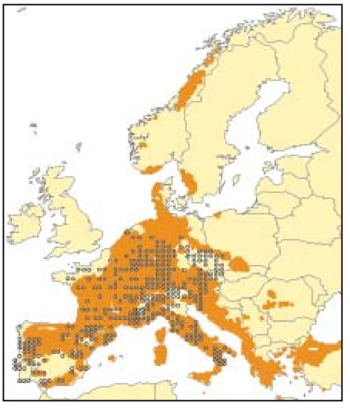


Figure D.2.9: Actual distribution and modelled present climatic niche of *Spialia sertorius*

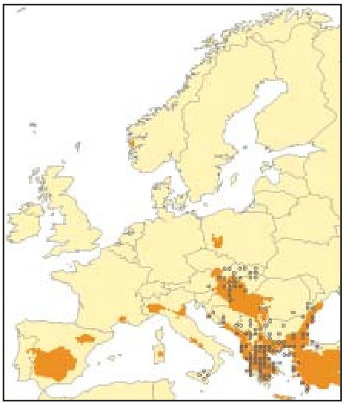


Figure D.2.10: Actual distribution and modelled present climatic niche of *Spialia orbifer*

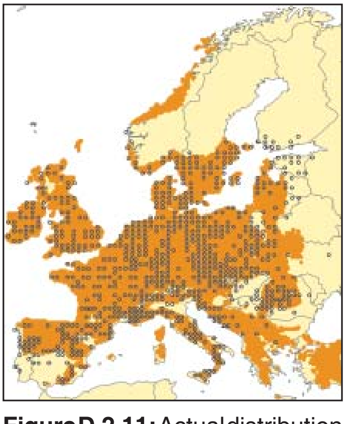


Figure D.2.11: Actual distribution and modelled present climatic niche of *Hipparchia semele*

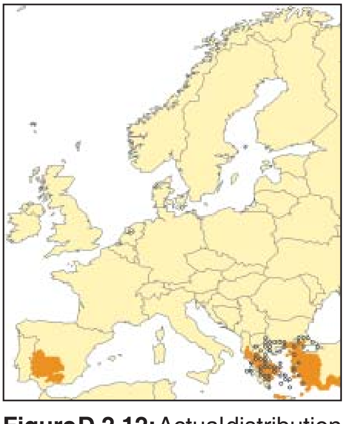


Figure D.2.12: Actual distribution and modelled present climatic niche of *Hipparchia senthes*

E

OUTLOOK: CLIMATE CHANGE AND BUTTERFLY CONSERVATION

E.1 Direct and indirect climate change impacts on butterflies and biodiversity

Climate change affects biodiversity and ecosystem processes both directly and indirectly. An example of a direct effect is when critical climate limits are altered, which directly affect species physiological mechanisms (e.g. winter temperatures or annual or seasonal precipitation patterns). Indirect effects can be through complex interactions with other processes, such as invasion of exotics, loss of pollinators and interactions with environmental chemicals. Further responses to climate are due to interactions with land use and land use change.

Habitats and trophic interactions

Biodiversity responds to the distribution of habitats as well as to climate factors (and other pressures), so understanding habitat change is also critical. Climate change may alter: (i) the distribution of climatically-suitable areas for a given species, and thus change the geographic match between otherwise suitable habitats and climate (potentially endangering the species), (ii) the distribution of suitable habitats, for example if vegetation structure is affected by climate, (iii) the distribution of land-use, and (iv) what is currently recognised as suitable habitat for a given species may change if habitat choice is at least partly determined by thermal environment. In addition, (v) land-use may change for reasons unconnected to climate.

Although we do not expect particular habitats to move with climate change as intact collections of species, climate-driven changes to the boundaries of structural elements of the vegetation (e.g., of evergreen and deciduous forest; tree lines) may be as predictable as the boundaries of individual species. Such changes would have major implications for the community structure of all taxonomic groups. A map of the changes of the potential natural vegetation (PNV) under the BAMBU scenario is shown if Figure E.1.1 for the presence and the conditions around 2080.

Many of the other habitat/trophic interactions mentioned above have been researched in recent years with the project ALARM (Settele et al. 2005, 2007, 2008). In the context of butterflies, analyses have been started to study effects of climate change in combination with other factors. An example is the study on *Boloria titania* (see page 638ff). Here the model was not able to predict the occurrence of this species in the Baltic States, but the model became far more accurate when the constraints of the larval host plant *Polygonum bistorta* were included (Schweiger et al. in press). This shows that including other essential abiotic and biotic environmental factors can help to improve model accuracy, but in most

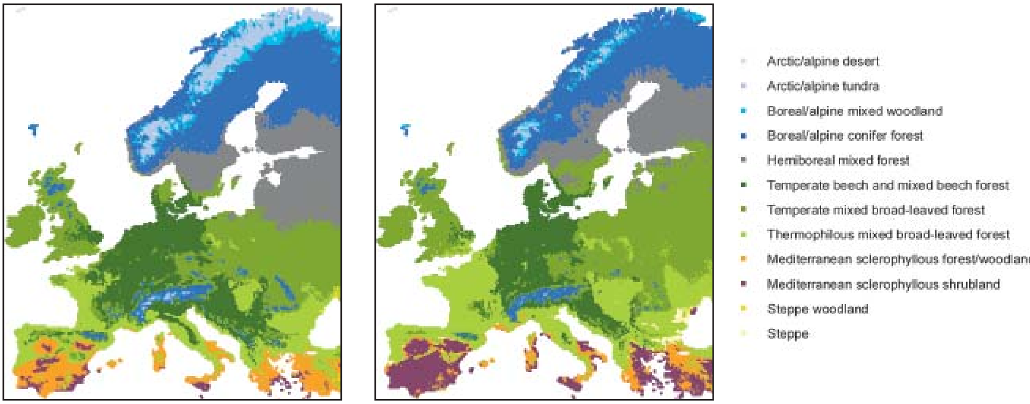


Fig. E.1.1: Modelled current (averaged for 1961-1990) and future (2071-2100) potential natural vegetation (PNV) in Europe under the BAMBU (IPCC A2; HadCM3) emission scenario; from Hickler et al. (in press, modified).

cases we lack crucial information about the multitude of species interactions that may add to the effects of climate.

Climate envelopes for European butterflies as a starting point for future research and conservation

"Pure" climate change models as presented in this atlas are only a first, but very important step. Until more sophisticated methods and models become available, we have to rely on what we have in order to draw conclusions for conservation actions. Moreover, until we determine exactly how climate change (in concert with other factors) will affect biodiversity, it is sensible to consider worst case scenarios under the cautionary principle. Consequently, we have selected the worst case result under all the given scenarios until 2080 for our classification of climate risk.

However, even under a very conservative classification of risk, the vast majority of European butterfly species has to be regarded to be at risk through climate change. An important next step will thus be to test model outputs against field data for butterflies, as these are a group of species that are expected to track climate changes quickly due to their sensitivity and short generation time. In particular, we can expect the habitat generalists and mobile species to be the first and quickest to respond.

The literature already contains many examples of apparent responses to climate change (e.g., Walther et al. 2002, Parmesan & Yohe 2003), but genuine tests against model predictions are largely lacking. If we have a closer look at our simulation results, which are based on the distribution of species from roughly 1980 to 2000, we can see that some predictions seem to have become true already. Good examples are

- *Cacyreus marshalli*, which has already spread across Italy;
- *Plebejus argiades*, which has moved northward e.g. in Southern Germany;

- *Pieris mannii*, which in 2008 has suddenly expanded its Northern range limit in Switzerland and in August 2008 has reached Germany;
- *Brenthis daphne*, which has extended its range from Alsace to Southwest Germany since the mid 1990s.

In future studies considerable attention will have to be paid to the development of a global climate change envelope model and model testing, because statistically appropriate and ecologically plausible predictive models are a key prerequisite for the assessment of the biodiversity risks resulting from the projected climate change. Models will also have to be improved to assess impacts of climate and landscape change scenarios on biodiversity at the European scale, assessing the role of species characteristics in projected susceptibility. Physiological traits (e.g., temperature thresholds for development; evapotranspiration) will have to be considered as well as functional characteristics, such as the types of habitats occupied and dispersal capacity (Warren et al. 2001, Luoto & Heikkinnen 2008).

Climate change and evolution

Recent reviews and meta-analyses of aquatic and terrestrial studies from throughout the world have revealed consistent evidence of climate change effects on species. These include the advancement of the timing of life-cycles (phenology), northward expansions, southern retractions, movement up mountain slopes, and abundance changes such that species with southerly distributions have tended to increase in the northern hemisphere, whilst northerly distributed species have declined (e.g. Parmesan 1996, Parmesan et al. 1999, Walther et al. 2001, Parmesan & Yohe 2003, Wilson et al. 2005). Furthermore, recent evolutionary shifts in phenology, habitat choice and migration direction are also consistent with a response to climate warming (Berthold et al. 1992, Berthold & Pulido 1994, Berthold 1998, Bradshaw & Holzapfel 2001, Thomas et al. 2001).

At the receding edge of a species range, local populations are forced "outside the niche". This raises the question whether sufficient evolutionary speed is available to rescue such a species which clearly faces extinction (Pease et al. 1989, Holt 1990, 2008, Gomulkiewicz & Holt 1995)? Here we need deeper insight to understand both niche *conservatism* (species seem to have much the same niche limits over a broad geographical range or over long periods of evolutionary history; Bradshaw 1991, Holt & Gaines 1992, Wiens & Graham 2005) and rapid niche *evolution* (Reznick & Ghalambor 2001).

Butterflies can evolve quite rapidly in ways that could influence their distributional limits. There are examples of species shifting host preferences over periods of less than ten years (Singer et al. 1993), and if these host species have different geographical distributions, a large shift in the butterfly's range can easily be expected. Rapid evolution of dispersal abilities is likewise known from butterflies (Hill et al. 1999), with spreading species developing both a larger thorax and a greater ability to fly in newly colonised patches. Geographical ranges reflect both niches and dispersal abilities, which can each evolve and lead to range shifts. In other cases, butterfly niches can be maintained, even over very large ranges (Crozier & Dwyer 2006). In a study of a North-American skipper, one basic aspect of the species' niche – the thermal environments in which it can persist, versus where it declines toward extinction - appears to have been conserved over an enormous distance (Holt 2008).

Understanding the reasons and mechanisms of niche conservatism, and anticipating when to expect rapid niche evolution instead, is of crucial importance. However, our current level of understanding is extremely limited. Much of the literature on niche conservatism is essentially phenomenological in nature, reporting correlations between species distributions and various environmental attributes ("ecological niche models"). This provides an essential starting point but, according to Holt (2008), what we really need is a deeper mechanistic understanding of the factors that either constrain or facilitate niche evolution. He states that "this understanding requires one to take a highly integrative approach to science, as explanations for niche conservatism can reflect a wide spectrum of forces and constraints, from limitations on genetic variation (Blows & Hoffmann 2005), to tradeoffs emerging from how organisms are engineered from the gene to the whole phenotype (Hansen & Houle 2004), to the details of demography and spatial movement patterns (Holt & Gaines 1992, Holt 1996, Kawecki 1995), to the nexus of interspecific interactions (Ackerly 2003, Case et al. 2005)." (Holt 2008, p. 3).

We sincerely hope that this atlas also serves as a tool to encourage research into these topics, as butterflies seem to be an ideal group of organisms to study. We know a lot about the species, they can be raised in the laboratory (genetic and functional studies of traits), they have short generations, they are popular and diurnal, and they are ectotherms (hence sensitive to thermal conditions). They also typically have close interactions with other species (host plants, predators, parasitoids; e.g., van Nouhuys & Hanski 2004, Anton et al. 2007, Schweiger et al. in press), which makes the interspecific dimensions of their niches amenable to quantitative modelling (e.g., Mouquet et al. 2005, Johst et al. 2006). Thus Holt (2008) suggests that these traits collectively make butterflies potentially highly useful in developing a deeper understanding of the phenomenon of niche conservatism, which not only would be a satisfying intellectual endeavour in its own right, but also of vital importance for conservation (see chapter E.3, page 658f.).

Biodiversity Risk Assessment

Our study has also shown that biodiversity risk assessment to environmental changes is heavily based on species modelling for current and future conditions (e.g. Segurado & Araújo 2004, Thuiller et al. 2003) and conservation planning for biodiversity (e.g. Araújo & Williams 2000, Araújo & Williams 2001, Araújo 2002). The first vulnerability assessments of European biodiversity were undertaken in a global change context, but the challenge is now turning these broad-scale assessments of vulnerability into probabilistic assessments of risk at the regional (e.g. national) and local scales at which mitigation strategies must be developed.

E.2 Butterflies as indicators of environmental change

Butterfly indicator developments

Government representatives at the 2002 World Summit of Sustainable Development pledged 'a significant reduction in the current rate of biodiversity loss by 2010'. The commitment of the EU to protecting biodiversity is even stronger by aiming at halting biodiversity loss by 2010 (Balmford et al. 2005, Gregory et al. 2005). Butterflies may be useful as biodiversity indicators for reporting on the development towards the EU 2010 target. Unlike most other groups of insects, butterflies have considerable resonance with both the general public and decision-makers (Kühn et al. 2008a). Butterflies are also relatively easy to recognize and data on butterflies have been collected for a long time and by many voluntary observers. The method of monitoring butterflies is well described, extensively tested and scientifically sound (Pollard 1977, Pollard & Yates 1993).

As a result butterflies are the only invertebrate taxon for which it is currently possible to estimate rates of decline in many parts of the world (de Heer et al. 2005, Thomas 2005). However, butterflies can only be regarded as good biodiversity indicators if it is possible to generalise their trends to a broader set of species groups (Gregory et al. 2005). There is still some debate on how well butterflies meet this criterion. Hambler & Speight (1996, 2004) claimed that this group is likely to experience greater declines than other organisms due to their herbivorous life strategies and thermophily, but Thomas & Clarke (2004) convincingly rejected both arguments. Based on a comprehensive review of studies into their life-history traits, relative sensitivity to climate change, and adjusted extinction rates, Thomas (2005) concluded that butterflies may be considered representative indicators of trends observed in most other terrestrial insects, which together form a major part of biodiversity.

Trends per butterfly species can be combined into a unified measure of biodiversity. To achieve this, Van Swaay et al. (in press) followed Gregory et al. (2005) in averaging indices of species to give each species an equal weight in the resulting indicators. When positive and negative changes of indices are in balance, we would expect their mean to remain stable. If more species decline than increase, the mean should go down and vice versa. Thus, the mean of such an index is considered a measure of biodiversity change.

The results of national butterfly monitoring schemes may be combined to create an indicator at a supra-national level (see also Henry et al. in press). Based on the procedure described for European birds (see Gregory et al. 2005), a preliminary grassland butterfly indicator has been developed (Van Swaay & Van Strien 2005). The countries covered were mainly from Western Europe. The results showed that average grassland butterfly abundance has declined by almost 50% during the last 15 years, which is most probably linked with the agricultural intensification in Western Europe (Van Swaay & Warren 1999, Gregory et al. 2005). The decline is much stronger than the decline of the farmland bird indicator, which has fallen by 19% in the same period (Gregory et al. 2008). This corresponds with the findings in the UK where butterflies have experienced greater losses than birds (Thomas et al. 2004).

The European Environmental Agency has already recommended the development of **European butterfly indicators** (EEA 2007a), and these may lead to indicators that are comparable to the farmland bird indicator, which has been adopted as a biodiversity indicator by the EU (Gregory et al. 2005). The addition of a butterfly indicator would be valuable to complement the bird indicator to report against political targets (e.g. the EU's 2010 target), because butterflies operate at smaller spatial scales and more closely represent insects.

The grassland butterfly indicator offers the possibility to detect large scale effects of either abandonment of agricultural land (especially occurring in Eastern and Southern Europe) or intensification of agricultural practices, a process that has slowed in parts of Western Europe, but is ongoing in many other European regions.

Butterflies as climate change indicators

Recent climate change has already affected the distributions of many species (Hill et al. 2001, Walther et al. 2002, Parmesan & Yohe 2003, Wilson et al. 2005, Franco et al. 2006, Hickling et al. 2006) but future changes are likely to have even more severe impacts (Sala et al. 2000, Thomas et al. 2004, Thuiller et al. 2005, Araujo et al. 2006, Broenniman et al. 2006). These impacts are often assessed with bioclimatic envelope models which relate the current distribution of species to climatic variables to derive projected future distributions under climate change (e.g. Huntley et al. 2004, Heikkinen et al. 2006).

The restriction of studies just to climatic variables has been criticized by some authors (e.g. Davis et al. 1998, Pearson & Dawson 2003) and there have been calls for the consideration of other factors that determine species distributions such as dispersal, land cover, and biotic interactions (Guisan & Thuiller 2005, Ohlemuller et al. 2006, Ibanez et al. 2006, Heikkinen et al. 2006, Schweiger et al. in press). However, we decided to base the current atlas entirely on climatic variables in order to provide a complete overview of potential climate change impacts for a group of ectothermic insects which are expected to react relatively quickly on climatic changes.

In addition to the grassland butterfly indicator, there is a good possibility of producing a **climate change indicator** for European butterflies that would summarise trends in species whose distributions may be most affected by climate change. Similar indicators are also in progress for European birds (Gregory et al. 2007).

The development of the indicator can, among others, be based on the results of the present atlas, which highlights species for which we might expect changes within longer time periods. As the relationship between abundance and distribution of species is well supported scientifically, we can test whether species that are expected to gain niche space actually increase in abundance within their core areas of distribution, and where there are decreases in abundance towards the trailing (mostly southerly or low altitude) edge of distribution.

E.3 Climate change and butterfly conservation

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

1) Maintain large populations in diverse habitats

In order to allow species to adapt and give them more time to evolve, we should adjust land use and management practices to maintain large populations of butterflies and create or maintain diverse microclimatic conditions which could mitigate climate change effects on the larger scale. There are many examples of how microclimatic conditions are able to support populations of butterflies in areas that are by macroclimatic standards far out of their climatic niche. Good examples are species like *Lycaena helle*, *Conenonympha oedippus*, *Boloria eunomia* and *Boloria aquilonaris*. We need to ensure effective conservation of existing protected areas and important habitats and manage them to maintain large, diverse populations. 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. To achieve this on the ground we need well resourced and targeted agri-environment schemes, and place biodiversity at the heart of forestry and land use policies.

2) Encourage mobility across the landscape

We need to ensure that we reduce, and if possible remove, any barriers to dispersal in the landscape. Many butterfly habitats are now highly fragmented and we should place far more effort 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 – in particular in connection with the Natura 2000 network and its coherence. Well resourced and targeted agri-environment schemes are essential in delivering on the ground, together with enlightened planning policies.

3) Reduce emissions of greenhouse gasses

There is a great opportunity to influence the general policy on reducing greenhouse gas emissions (as generally described in the SEDG scenario; see chapter A.2, page 13f.). As we have mentioned in the methods, the results of our scenarios are not actual predictions and we should use them for what they are most suited: to compare different overall futures. If we translate the overall pictures presented in chapter C.4 (page 629ff.) into action for conservation, the vast majority of species would have a more sustainable future under the SEDG scenario compared to the futures under GRAS.

4) Allow maximum time for species adaptation

The results show us that the climate change risks for butterflies increase much faster after a certain lag phase. This could give us hope that if we take immediate action there is a chance to avoid some of the worst effects on the majority of our butterfly species – and most probably on other aspects of biodiversity! Our hope is that we can direct environmental change to encourage as much adaptation by natural selection as possible, which might contribute to the evolutionary rescue of species. Given the pace of environmental change we are inflicting upon the rest of the diversity on the planet, the living world needs all the help it can get (Holt, 2008) – and we hope that we can contribute to this through this atlas, particularly as a risk communication tool.

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

Further research is needed so that we continue to improve our understanding of climate change and its impacts on biodiversity. The findings will be vital to improve our adaptation strategies in the future. This study is an important step in understanding the impact on butterflies, but highlights the limitations of current models. In particular, we need to develop models for the approx. 150 species that have such restricted distributions that they could not be reasonably modelled using the current method.

F

APPENDICES, REFERENCES AND INDEX

Appendix 1 – Model performance

Page		AUC	Kappa	Diag	r.abs	f.pre	r.pre	f.abs	occupied cells
32	*Erynnis tages* (Linnaeus, 1758)	0.72	0.35	0.66	0.50	0.50	0.88	0.12	17709
34	*Erynnis marloyi* (Boisduval, 1834)	0.98	0.40	0.98	0.98	0.02	0.52	0.48	904
36	*Carcharodus alceae* (Esper, 1870)	0.71	0.39	0.68	0.60	0.40	0.87	0.13	12571
38	*Carcharodus lavatherae* (Esper, 1783)	0.73	0.15	0.83	0.86	0.14	0.36	0.64	3262
40	*Carcharodus flocciferus* (Zeller, 1847)	0.79	0.30	0.81	0.87	0.13	0.47	0.53	4213
42	*Carcharodus orientalis* (Reverdin, 1913)	0.92	0.41	0.96	0.97	0.03	0.54	0.46	1232
44	*Carcharodus baeticus* (Rambur, 1840)	0.8	0.20	0.96	0.99	0.01	0.18	0.82	414
46	*Spialia phlomidis* (Herrich-Schäffer, 1845)	0.93	0.30	0.99	1.00	0.00	0.20	0.80	383
48	*Spialia sertorius* (Hoffmansegg, 1804)	0.77	0.35	0.74	0.76	0.24	0.67	0.33	6768
50	*Spialia orbifer* (Hübner, 1823)	0.89	0.40	0.91	0.93	0.07	0.57	0.43	2728
52	*Syrichtus proto* (Ochsenheimer, 1808)	0.89	0.30	0.85	0.85	0.15	0.88	0.13	3666
54	*Syrichtus tessellum* (Hübner, 1803)	0.89	0.37	0.97	0.98	0.02	0.73	0.27	1059
56	*Pyrgus carthami* (Hübner, 1813)	0.76	0.26	0.75	0.77	0.23	0.61	0.39	6563
58	*Pyrgus sidae* (Esper, 1782)	0.85	0.24	0.94	0.96	0.04	0.30	0.70	1343
60	*Pyrgus andromedae* (Wallengren, 1853)	0.87	0.43	0.94	0.96	0.04	0.57	0.43	1931
62	*Pyrgus cacaliae* (Rambur, 1840)	0.92	0.50	0.97	0.98	0.02	0.60	0.40	1153
64	*Pyrgus centaureae* (Rambur, 1840)	0.96	0.71	0.94	0.94	0.06	0.95	0.05	5760
66	*Pyrgus malvae* (Linnaeus, 1758) / *malvoides* (Elwes & Edwards, 1897) (complex)	0.71	0.35	0.68	0.48	0.52	0.87	0.13	20440
68	*Pyrgus serratulae* (Rambur, 1840)	0.82	0.34	0.77	0.81	0.19	0.61	0.39	6215
70	*Pyrgus onopordi* (Rambur, 1840)	0.78	0.22	0.87	0.89	0.11	0.46	0.54	2169
72	*Pyrgus carlinae* (Rambur, 1840)	0.9	0.35	0.97	0.97	0.03	0.63	0.37	818
74	*Pyrgus cirsii* (Rambur, 1840)	0.9	0.24	0.83	0.83	0.17	0.76	0.24	4352
76	*Pyrgus armoricanus* (Oberthür, 1910)	0.78	0.27	0.74	0.76	0.24	0.60	0.40	6658
78	*Pyrgus alveus* (Hübner, 1803) (complex)	0.73	0.27	0.70	0.74	0.26	0.56	0.44	10912
80	*Pyrgus bellieri* (Oberthür, 1910)	0.94	0.49	0.98	0.99	0.01	0.59	0.41	406
82	*Pyrgus warrenensis* (Verity, 1928)	0.99	0.43	0.96	0.96	0.04	0.97	0.03	1405
84	*Heteropterus morpheus* (Pallas, 1771)	0.78	0.27	0.74	0.76	0.24	0.64	0.36	7559

Page		AUC	Kappa	Diag	r.abs	f.pre	r.pre	f.abs	occupied cells
86	*Carterocephalus palaemon* (Pallas, 1771)	0.79	0.41	0.76	0.84	0.16	0.57	0.43	11232
88	*Carterocephalus silvicolus* (Meigen, 1829)	0.93	0.59	0.92	0.95	0.05	0.63	0.37	5493
90	*Thymelicus lineola* (Ochsenheimer, 1806)	0.75	0.42	0.70	0.55	0.45	0.87	0.13	19431
92	*Thymelicus sylvestris* (Poda, 1761)	0.72	0.39	0.69	0.64	0.36	0.76	0.24	12329
94	*Thymelicus acteon* (Rottemburger, 1775)	0.76	0.36	0.69	0.66	0.34	0.79	0.21	9801
96	*Hesperia comma* (Linnaeus, 1758)	0.77	0.41	0.71	0.71	0.29	0.70	0.30	11806
98	*Ochlodes sylvanus* (Esper, 1777)	0.75	0.42	0.72	0.53	0.47	0.88	0.12	20554
100	*Gegenes pumilio* (Hoffmansegg, 1804)	0.96	0.42	0.96	0.98	0.02	0.38	0.62	525
102	*Gegenes nostrodamus* (Fabricius, 1793)	0.94	0.30	0.92	0.94	0.06	0.57	0.43	1225
104	*Zerynthia rumina* (Linnaeus, 1767)	0.91	0.39	0.86	0.86	0.14	0.85	0.15	3500
106	*Zerynthia polyxena* ([Schiffermüller], 1775)	0.85	0.42	0.85	0.86	0.14	0.69	0.31	4899
108	*Zerynthia cerisyi* (Godart, 1822)	0.91	0.37	0.97	0.99	0.01	0.31	0.69	579
110	*Parnassius mnemosyne* (Linnaeus, 1758)	0.77	0.33	0.74	0.77	0.23	0.63	0.37	9109
112	*Parnassius phoebus* (Fabricius, 1793)	0.99	0.63	0.98	0.98	0.02	0.88	0.13	1113
114	*Parnassius apollo* (Linnaeus, 1758)	0.8	0.37	0.78	0.81	0.19	0.62	0.38	6273
116	*Iphiclides podalirius* (Linnaeus, 1758)	0.76	0.43	0.72	0.71	0.29	0.74	0.26	10378
118	*Papilio machaon* Linnaeus, 1758	0.67	0.37	0.73	0.46	0.54	0.88	0.12	21332
120	*Papilio alexanor* Esper, 1799	0.94	0.38	0.97	0.98	0.02	0.43	0.57	687
122	*Leptidea sinapis* (Linnaeus, 1758) / *reali* Reissinger, 1990 (complex)	0.63	0.26	0.64	0.53	0.47	0.73	0.27	18126
124	*Leptidea duponcheli* (Staudinger, 1871)	0.69	0.29	0.95	0.98	0.02	0.31	0.69	1117
126	*Leptidea morsei* (Fenton, 1881)	0.92	0.31	0.94	0.96	0.04	0.55	0.45	1567
128	*Anthocharis cardamines* (Linnaeus, 1758)	0.7	0.36	0.69	0.66	0.34	0.71	0.29	18795
130	*Anthocharis euphenoides* Staudinger, 1869	0.91	0.35	0.86	0.88	0.12	0.69	0.31	2970
132	*Anthocharis gruneri* Herrich-Schäffer, 1851	0.92	0.34	0.97	0.97	0.03	0.50	0.50	997
134	*Zegris eupheme* (Esper, 1805)	0.97	0.40	0.96	0.97	0.03	0.67	0.33	858
136	*Euchloe belemia* (Esper, 1798)	0.96	0.38	0.96	0.97	0.03	0.44	0.56	695
138	*Euchloe ausonia* (Hübner, 1806) (complex)	0.85	0.53	0.85	0.88	0.16	0.79	0.21	4483

Page		AUC	Kappa	Diag	r.abs	f.pre	r.pre	f.abs	occupied cells
140	*Euchloe tagis* (HÜBNER, 1804)	0.86	0.19	0.84	0.84	0.52	0.83	0.17	3152
142	*Aporia crataegi* (LINNAEUS, 1758)	0.69	0.30	0.64	0.48	0.66	0.93	0.07	18785
144	*Pieris brassicae* (LINNAEUS, 1758)	0.66	0.31	0.75	0.34	0.03	0.59	0.41	23482
146	*Pieris krueperi* (STAUDINGER, 1860)	0.91	0.40	0.96	0.97	0.06	0.34	0.66	1314
148	*Pieris mannii* (MAYER, 1851)	0.76	0.31	0.88	0.94	0.66	0.97	0.03	1710
150	*Pieris rapae* (LINNAEUS, 1758)	0.69	0.37	0.78	0.34	0.07	0.48	0.52	24143
152	*Pieris ergane* (GEYER, 1828)	0.84	0.34	0.90	0.93	0.65	0.93	0.07	2146
154	*Pieris napi* (LINNAEUS, 1758)	0.73	0.32	0.77	0.35	0.02	0.48	0.52	26459
156	*Pieris bryoniae* (HÜBNER, 1791)	0.92	0.50	0.95	0.98	0.02	0.67	0.33	1183
158	*Pontia callidice* (HÜBNER, 1800)	0.98	0.61	0.98	0.98	0.39	0.81	0.19	891
160	*Pontia daplidice* (LINNAEUS, 1758) / *edusa* (FABRICIUS, 1777) (complex)	0.72	0.42	0.71	0.61	0.03	0.66	0.34	15310
162	*Colias phicomone* (ESPER, 1780)	0.96	0.55	0.96	0.97	0.09	0.77	0.23	1423
164	*Colias palaeno* (LINNAEUS, 1758)	0.9	0.66	0.88	0.91	0.04	0.51	0.49	9886
166	*Colias erate* (ESPER, 1805)	0.92	0.45	0.93	0.96	0.45	0.89	0.11	2394
168	*Colias croceus* (GEOFFROY, 1785)	0.76	0.45	0.73	0.55	0.01	1.00	0.00	16185
170	*Colias hecla* LEFEBVRE, 1836	0.99	0.77	0.99	0.99	0.10	0.77	0.23	980
172	*Colias myrmidone* (ESPER, 1780)	0.92	0.36	0.89	0.90	0.01	0.25	0.75	4252
174	*Colias chrysotheme* (ESPER, 1780)	0.89	0.28	0.98	0.99	0.20	0.72	0.28	752
176	*Colias hyale* (LINNAEUS, 1758)	0.84	0.51	0.77	0.80	0.27	0.79	0.21	12535
178	*Colias alfacariensis* RIBBE, 1905	0.84	0.44	0.74	0.73	0.44	0.86	0.14	9648
180	*Gonepteryx rhamni* (LINNAEUS, 1758)	0.73	0.44	0.74	0.56	0.01	0.44	0.56	20599
182	*Gonepteryx farinosa* ZELLER, 1847	0.94	0.49	0.98	0.99	0.11	0.82	0.18	645
184	*Gonepteryx cleopatra* (LINNAEUS, 1767)	0.92	0.60	0.88	0.89	0.73	0.94	0.06	4249
186	*Lycaena phlaeas* (LINNAEUS, 1761)	0.65	0.25	0.74	0.27	0.05	0.28	0.72	23910
188	*Lycaena helle* ([SCHIFFERMÜLLER], 1775)	0.78	0.26	0.90	0.95	0.11	0.57	0.43	2439
190	*Lycaena dispar* (HAWORTH, 1803)	0.88	0.46	0.83	0.89	0.22	0.84	0.16	8048
192	*Lycaena virgaureae* (LINNAEUS, 1758)	0.86	0.60	0.80	0.78	0.00	0.38	0.62	14822

Page		AUC	Kappa	Diag	r.abs	f.pre	r.pre	f.abs	occupied cells
194	*Lycaena ottomana* (Lefebvre, 1830)	0.98	0.46	0.98	1.00	0.26	0.77	0.23	473
196	*Lycaena tityrus* (Poda, 1761)	0.82	0.48	0.75	0.74	0.23	0.66	0.34	11172
198	*Lycaena alciphron* (Rottemburg, 1775)	0.8	0.40	0.74	0.77	0.25	0.80	0.20	9113
200	*Lycaena hippothoe* (Linnaeus, 1761)	0.85	0.53	0.77	0.75	0.00	0.22	0.78	14109
202	*Lycaena candens* (Herrich-Schäffer, 1844)	0.86	0.30	0.98	1.00	0.09	0.58	0.42	657
204	*Lycaena thersamon* (Esper, 1784)	0.93	0.41	0.87	0.91	0.32	0.79	0.21	4545
206	*Thecla betulae* (Linnaeus, 1758)	0.79	0.42	0.72	0.68	0.41	0.81	0.19	12908
208	*Favonius quercus* (Linnaeus, 1758)	0.72	0.37	0.68	0.59	0.19	0.79	0.21	13886
210	*Laeosopis roboris* (Esper, 1793)	0.81	0.20	0.81	0.81	0.02	0.29	0.71	4024
212	*Tomares ballus* (Fabricius, 1787)	0.91	0.25	0.96	0.98	0.54	0.76	0.24	397
214	*Callophrys rubi* (Linnaeus, 1758)	0.63	0.23	0.65	0.46	0.03	0.38	0.62	21380
216	*Callophrys avis* Chapman, 1909	0.9	0.25	0.96	0.97	0.34	0.78	0.22	433
218	*Satyrium w-album* (Knoch, 1782)	0.78	0.37	0.69	0.66	0.26	0.80	0.20	11103
220	*Satyrium pruni* (Linnaeus, 1758)	0.83	0.43	0.75	0.74	0.27	0.63	0.37	12270
222	*Satyrium spini* (Fabricius, 1787)	0.71	0.31	0.70	0.73	0.37	0.75	0.25	8540
224	*Satyrium ilicis* (Esper, 1779)	0.71	0.33	0.67	0.63	0.13	0.74	0.26	10856
226	*Satyrium esculi* (Hübner, 1804)	0.82	0.32	0.87	0.87	0.26	0.68	0.32	3010
228	*Satyrium acaciae* (Fabricius, 1787)	0.76	0.32	0.73	0.74	0.20	0.80	0.20	7748
230	*Lampides boeticus* (Linnaeus, 1767)	0.83	0.48	0.80	0.80	0.04	0.48	0.52	6381
232	*Cacyreus marshalli* (Butler, 1898)	0.85	0.24	0.95	0.96	0.17	0.76	0.24	800
234	*Leptotes pirithous* (Linnaeus, 1767)	0.83	0.45	0.82	0.83	0.03	0.56	0.44	5475
236	*Zizeeria knysna* (Trimen, 1862)	0.94	0.34	0.96	0.97	0.42	0.74	0.26	822
238	*Cupido minimus* (Fuessly, 1775)	0.71	0.30	0.64	0.58	0.04	0.25	0.75	13437
240	*Cupido osiris* (Meigen, 1829)	0.76	0.22	0.91	0.96	0.37	0.88	0.12	1116
242	*Cupido argiades* (Pallas, 1771)	0.81	0.38	0.69	0.63	0.06	0.49	0.51	15026
244	*Cupido decoloratus* (Staudinger, 1886)	0.93	0.27	0.92	0.94	0.08	0.42	0.58	2040
246	*Cupido alcetas* (Hoffmansegg, 1804)	0.77	0.30	0.88	0.92	0.54	0.81	0.19	2208

Page		AUC	Kappa	Diag	r.abs	f.pre	r.pre	f.abs	occupied cells
248	*Celastrina argiolus* (Linnaeus, 1758)	0.65	0.28	0.68	0.46	0.08	0.53	0.47	20422
250	*Scolitantides baton* (Bergsträsser, 1779)	0.83	0.41	0.87	0.92	0.14	0.54	0.46	2643
252	*Scolitantides vicrama* (Moore, 1865)	0.85	0.31	0.83	0.86	0.11	0.93	0.07	5393
254	*Scolitantides abencerragus* (Pierret, 1837)	0.94	0.17	0.89	0.89	0.00	0.10	0.90	2679
256	*Scolitantides bavius* (Eversmann, 1832)	0.86	0.14	0.99	1.00	0.17	0.48	0.52	428
258	*Scolitantides orion* (Pallas, 1771)	0.78	0.25	0.79	0.83	0.06	0.61	0.39	6270
260	*Scolitantides panoptes* (Hübner, 1813)	0.87	0.27	0.94	0.94	0.45	0.75	0.25	1493
262	*Glaucopsyche alexis* (Poda, 1761)	0.7	0.25	0.61	0.55	0.15	0.79	0.21	15676
264	*Glaucopsyche melanops* (Boisduval, 1828)	0.8	0.29	0.85	0.85	0.10	0.50	0.50	3577
266	*Iolana iolas* (Ochsenheimer, 1816)	0.82	0.24	0.88	0.90	0.36	0.75	0.25	3307
268	*Phengaris arion* (Linnaeus, 1758)	0.77	0.31	0.67	0.64	0.19	0.70	0.30	13242
270	*Phengaris teleius* (Bergsträsser, 1779)	0.84	0.37	0.80	0.81	0.10	0.65	0.35	6483
272	*Phengaris nausithous* (Bergsträsser, 1779)	0.91	0.44	0.88	0.90	0.21	0.68	0.32	3619
274	*Phengaris alcon* ([Schiffermüller], 1775)	0.83	0.38	0.77	0.79	0.46	0.83	0.17	6643
276	*Plebejus argus* (Linnaeus, 1758)	0.69	0.37	0.69	0.54	0.36	0.78	0.22	19107
278	*Plebejus idas* (Linnaeus, 1761)	0.74	0.41	0.70	0.64	0.16	0.59	0.41	18438
280	*Plebejus argyrognomon* (Bergsträsser, 1779)	0.8	0.37	0.81	0.84	0.10	0.74	0.26	5588
282	*Plebejus optilete* (Knoch, 1781)	0.9	0.63	0.86	0.90	0.01	0.60	0.40	10092
284	*Plebejus glandon* (Prunner, 1798)	0.99	0.63	0.98	0.99	0.01	0.95	0.05	425
286	*Plebejus aquilo* (Boisduval, 1832)	1	0.78	0.99	0.99	0.02	0.73	0.27	695
288	*Plebejus orbitulus* (Prunner, 1798)	0.98	0.64	0.97	0.98	0.03	0.33	0.67	1242
290	*Plebejus sephirus* (FRIVALDSZKY, 1835)	0.93	0.22	0.96	0.97	0.24	0.69	0.31	1189
292	*Aricia eumedon* (Esper, 1780)	0.8	0.39	0.75	0.76	0.09	0.79	0.21	13389
294	*Aricia cramera* (Eschscholtz, 1821)	0.91	0.49	0.90	0.91	0.48	0.87	0.13	2471
296	*Aricia agestis* ([Schiffermüller], 1775)	0.7	0.34	0.65	0.52	0.21	0.56	0.44	15253
298	*Aricia artaxerxes* (Fabricius, 1793)	0.72	0.33	0.74	0.79	0.03	0.50	0.50	9668
300	*Aricia montensis* (Verity, 1928)	0.7	0.29	0.96	0.97	0.00	0.19	0.81	859

Page		AUC	Kappa	Diag	r.abs	f.pre	r.pre	f.abs	occupied cells
302	*Aricia anteros* (Freyer, 1838)	0.96	0.30	0.98	1.00	0.07	0.51	0.49	503
304	*Aricia nicias* (Meigen, 1829)	0.82	0.28	0.91	0.93	0.38	0.77	0.23	4301
306	*Cyaniris semiargus* (Rottemburg, 1775)	0.76	0.39	0.69	0.62	0.08	0.47	0.53	17359
308	*Polyommatus escheri* (Hübner, 1823)	0.8	0.33	0.88	0.92	0.13	0.51	0.49	2310
310	*Polyommatus dorylas* ([Schiffermüller], 1775)	0.81	0.36	0.81	0.87	0.02	0.54	0.46	4520
312	*Polyommatus nivescens* (Keferstein, 1851)	0.98	0.40	0.98	0.98	0.19	0.65	0.35	467
314	*Polyommatus amandus* (Schneider 1792)	0.83	0.44	0.76	0.81	0.24	0.64	0.36	10087
316	*Polyommatus thersites* (Cantener, 1834)	0.75	0.31	0.74	0.76	0.76	0.96	0.04	6959
318	*Polyommatus icarus* (Rottemburg, 1775)	0.65	0.25	0.79	0.24	0.09	0.50	0.50	25320
320	*Polyommatus eros* (Ochsenheimer, 1808)	0.71	0.26	0.90	0.91	0.24	0.73	0.27	2651
322	*Polyommatus daphnis* ([Schiffermüller], 1775)	0.84	0.35	0.76	0.76	0.41	0.79	0.21	8483
324	*Polyommatus bellargus* (Rottemburg, 1775)	0.72	0.32	0.65	0.59	0.23	0.67	0.33	12245
326	*Polyommatus coridon* (Poda, 1761)	0.82	0.41	0.74	0.77	0.04	0.54	0.46	8806
328	*Polyommatus hispanus* (Herrich-Schäffer, 1851)	0.95	0.34	0.95	0.96	0.02	0.70	0.30	792
330	*Polyommatus albicans* (Herrich-Schäffer, 1851)	0.88	0.52	0.97	0.98	0.03	0.33	0.67	950
332	*Polyommatus admetus* (Esper, 1785)	0.88	0.26	0.95	0.97	0.01	0.20	0.80	1537
334	*Polyommatus ripartii* (Freyer, 1830)	0.75	0.25	0.97	0.99	0.01	0.38	0.63	460
336	*Polyommatus dolus* (Hübner, 1823)	0.97	0.37	0.98	0.99	0.08	0.40	0.60	214
338	*Polyommatus damon* ([Schiffermüller], 1775)	0.85	0.29	0.88	0.92	0.17	0.53	0.47	2338
340	*Hamearis lucina* (Linnaeus, 1758)	0.77	0.35	0.75	0.83	0.11	0.59	0.41	6207
342	*Libythea celtis* (Laicharting, 1782)	0.8	0.37	0.86	0.89	0.38	0.85	0.15	3684
344	*Argynnis paphia* (Linnaeus, 1758)	0.78	0.47	0.74	0.62	0.15	0.62	0.38	18276
346	*Argynnis pandora* ([Schiffermüller], 1775)	0.83	0.40	0.81	0.85	0.40	0.84	0.16	5433
348	*Argynnis aglaja* (Linnaeus, 1758)	0.78	0.46	0.74	0.60	0.28	0.71	0.29	20551
350	*Argynnis adippe* ([Schiffermüller], 1775)	0.78	0.43	0.71	0.72	0.43	0.84	0.16	14199
352	*Argynnis niobe* (Linnaeus, 1758)	0.74	0.35	0.66	0.57	0.05	0.65	0.35	16539
354	*Argynnis laodice* (Pallas, 1771)	0.89	0.48	0.94	0.95	0.30	0.78	0.22	4961

Page		AUC	Kappa	Diag	r.abs	f.pre	r.pre	f.abs	occupied cells
356	*Issoria lathonia* (Linnaeus, 1758)	0.78	0.48	0.74	0.70	0.21	0.82	0.18	14060
358	*Brenthis ino* (Rottemburg, 1775)	0.87	0.59	0.80	0.79	0.19	0.57	0.43	13788
360	*Brenthis daphne* (Bergsträsser, 1780)	0.77	0.32	0.77	0.81	0.12	0.47	0.53	5509
362	*Brenthis hecate* ([Schiffermüller], 1775)	0.79	0.28	0.84	0.88	0.06	0.70	0.30	3814
364	*Boloria eunomia* (Esper, 1799)	0.89	0.64	0.90	0.94	0.46	0.85	0.15	7954
366	*Boloria euphrosyne* (Linnaeus, 1758)	0.73	0.39	0.69	0.54	0.05	0.43	0.57	21529
368	*Boloria titania* (Esper, 1793)	0.9	0.36	0.91	0.95	0.37	0.83	0.17	1910
370	*Boloria selene* ([Schiffermüller], 1775)	0.73	0.46	0.73	0.63	0.00	0.64	0.36	20468
372	*Boloria chariclea* (Schneider, 1794)	1	0.73	0.99	1.00	0.06	0.85	0.15	528
374	*Boloria freija* (Becklin, 1791)	0.95	0.62	0.93	0.94	0.17	0.65	0.35	5507
376	*Boloria dia* (Linnaeus, 1767)	0.86	0.47	0.78	0.83	0.03	0.56	0.44	8338
378	*Boloria thore* (Hübner, 1806)	0.95	0.49	0.96	0.97	0.06	0.87	0.13	1624
380	*Boloria frigga* (Becklin, 1791)	0.96	0.64	0.94	0.94	0.04	0.54	0.46	5945
382	*Boloria pales* ([Schiffermüller], 1775)	0.89	0.47	0.94	0.96	0.06	0.62	0.38	1516
384	*Boloria aquilonaris* (Stichel, 1908)	0.89	0.60	0.86	0.94	0.62	0.88	0.12	8177
386	*Boloria graeca* (Staudinger, 1870)	0.75	0.19	0.98	0.99	0.51	0.75	0.25	481
388	*Vanessa atalanta* (Linnaeus, 1758)	0.65	0.28	0.73	0.38	0.40	0.89	0.11	22574
390	*Vanessa cardui* (Linnaeus, 1758)	0.63	0.24	0.68	0.49	0.39	0.83	0.17	20136
392	*Aglais io* (Linnaeus, 1758)	0.8	0.50	0.77	0.60	0.49	0.90	0.10	20483
394	*Aglais urticae* (Linnaeus, 1758)	0.8	0.45	0.76	0.61	0.05	0.50	0.50	21818
396	*Nymphalis c-album* (Linnaeus, 1758)	0.77	0.43	0.73	0.51	0.27	0.74	0.26	21399
398	*Nymphalis egea* (Cramer, 1775)	0.94	0.44	0.91	0.95	0.47	0.83	0.17	1780
400	*Nymphalis antiopa* (Linnaeus, 1758)	0.76	0.47	0.73	0.73	0.09	0.45	0.55	16102
402	*Nymphalis polychloros* (Linnaeus, 1758)	0.7	0.34	0.66	0.53	0.07	0.46	0.54	15861
404	*Nymphalis xanthomelas* (Esper, 1781)	0.87	0.25	0.88	0.91	0.20	0.81	0.19	4111
406	*Nymphalis l-album* (Esper, 1780)	0.89	0.25	0.91	0.93	0.01	0.96	0.04	5237
408	*Araschnia levana* (Linnaeus, 1758)	0.87	0.58	0.80	0.80	0.00	0.38	0.62	12725

Page		AUC	Kappa	Diag	r.abs	f.pre	r.pre	f.abs	occupied cells
410	*Euphydryas iduna* (Dalman, 1816)	1	0.64	0.99	0.99	0.01	0.50	0.50	1320
212	*Euphydryas cynthia* ([Schiffermüller], 1775)	0.98	0.48	0.98	1.00	0.10	0.40	0.60	395
414	*Euphydryas intermedia* (Menetries, 1859)	0.98	0.52	0.99	0.99	0.08	0.59	0.41	269
416	*Euphydryas maturna* (Linnaeus, 1758)	0.79	0.26	0.84	0.90	0.18	0.54	0.46	7164
418	*Euphydryas desfontainii* (Godart, 1819)	0.88	0.20	0.92	0.92	0.41	0.82	0.18	1641
420	*Euphydryas aurinia* (Rottemburg, 1775)	0.72	0.36	0.74	0.82	0.22	0.67	0.33	6513
422	*Melitaea cinxia* (Linnaeus, 1758)	0.75	0.36	0.67	0.59	0.02	0.58	0.42	13195
424	*Melitaea phoebe* (Goeze, 1779)	0.77	0.41	0.75	0.78	0.12	0.59	0.41	7693
426	*Melitaea aetherie* (Hübner, 1826)	0.95	0.37	0.97	0.98	0.35	0.81	0.19	392
428	*Melitaea trivia* ([Schiffermüller], 1775)	0.86	0.40	0.84	0.88	0.25	0.68	0.32	5195
430	*Melitaea didyma* (Esper, 1779)	0.77	0.40	0.70	0.65	0.13	0.47	0.53	12400
432	*Melitaea diamina* (Lang, 1789)	0.84	0.37	0.73	0.75	0.01	0.44	0.56	8633
434	*Melitaea deione* (Geyer, 1832)	0.76	0.19	0.85	0.87	0.11	0.54	0.46	2426
436	*Melitaea varia* (Meyer-Dür, 1851)	0.96	0.42	0.98	0.99	0.13	0.55	0.45	506
438	*Melitaea parthenoides* (Keferstein, 1851)	0.84	0.33	0.86	0.89	0.14	0.49	0.51	3183
440	*Melitaea aurelia* (Nickerl, 1850)	0.82	0.37	0.83	0.87	0.27	0.69	0.31	4423
442	*Melitaea britomartis* (Assmann, 1847)	0.83	0.18	0.85	0.86	0.22	0.76	0.24	4280
444	*Melitaea athalia* (Rottemburg, 1775)	0.79	0.43	0.71	0.73	0.22	0.72	0.28	15482
446	*Limenitis populi* (Linnaeus, 1758)	0.84	0.49	0.78	0.78	0.17	0.64	0.36	11332
448	*Limenitis camilla* (Linnaeus, 1764)	0.81	0.45	0.76	0.78	0.06	0.63	0.37	8833
450	*Limenitis reducta* (Staudinger, 1901)	0.82	0.43	0.79	0.83	0.04	0.45	0.55	5716
452	*Neptis sappho* (Pallas, 1771)	0.92	0.44	0.93	0.94	0.08	0.76	0.24	2607
454	*Neptis rivularis* (Scopoli, 1763)	0.87	0.42	0.92	0.96	0.05	0.66	0.34	2135
456	*Charaxes jasius* (Linnaeus, 1767)	0.94	0.48	0.91	0.92	0.17	0.73	0.27	1979
458	*Apatura metis* (Freyer, 1829)	0.98	0.34	0.94	0.95	0.17	0.69	0.31	2091
460	*Apatura ilia* ([Schiffermüller], 1775)	0.86	0.53	0.80	0.83	0.02	0.53	0.47	9958
462	*Apatura iris* (Linnaeus, 1758)	0.85	0.50	0.79	0.83	0.64	0.96	0.04	8784

Page		AUC	Kappa	Diag	r.abs	f.pre	r.pre	f.abs	occupied cells
464	*Kirinia roxelana* (Cramer, 1777)	0.91	0.51	0.96	0.98	0.43	0.89	0.11	1198
466	*Pararge aegeria* (Linnaeus, 1758)	0.65	0.36	0.73	0.36	0.13	0.62	0.38	22882
468	*Lasiommata megera* (Linnaeus, 1767)	0.75	0.47	0.74	0.57	0.32	0.67	0.33	16529
470	*Lasiommata petropolitana* (Fabricius, 1787)	0.84	0.46	0.83	0.87	0.14	0.55	0.45	9156
472	*Lasiommata maera* (Linnaeus, 1758)	0.75	0.35	0.67	0.68	0.22	0.77	0.23	14684
474	*Lopinga achine* (Linnaeus, 1763)	0.81	0.35	0.82	0.86	0.03	0.37	0.63	6680
476	*Coenonympha tullia* (Müller, 1764)	0.83	0.50	0.77	0.78	0.03	0.21	0.79	13062
478	*Coenonympha oedippus* (Fabricius, 1787)	0.95	0.26	0.95	0.97	0.30	0.80	0.20	1055
480	*Coenonympha rhodopensis* Elwes, 1900	0.95	0.15	0.96	0.97	0.19	0.81	0.19	759
482	*Coenonympha arcania* (Linnaeus, 1761)	0.83	0.47	0.74	0.70	0.02	0.64	0.36	13544
484	*Coenonympha glycerion* (Borkhausen, 1788)	0.86	0.57	0.81	0.81	0.13	0.64	0.36	12835
486	*Coenonympha gardetta* (Prunner, 1798)	0.97	0.57	0.97	0.98	0.09	0.55	0.45	941
488	*Coenonympha dorus* (Esper, 1782)	0.83	0.28	0.86	0.87	0.01	0.37	0.63	2781
490	*Coenonympha hero* (Linnaeus, 1761)	0.88	0.38	0.88	0.91	0.58	0.85	0.15	3543
492	*Coenonympha leander* (Esper, 1784)	0.89	0.35	0.98	0.99	0.15	0.64	0.36	827
494	*Coenonympha pamphilus* (Linnaeus, 1758)	0.66	0.29	0.73	0.42	0.07	0.68	0.32	22310
496	*Pyronia tithonus* (Linnaeus, 1771)	0.82	0.47	0.79	0.85	0.15	0.80	0.20	6411
498	*Pyronia cecilia* (Vallantin, 1894)	0.91	0.55	0.90	0.93	0.22	0.80	0.20	2350
500	*Pyronia bathseba* (Fabricius, 1793)	0.83	0.30	0.85	0.85	0.54	0.96	0.04	3461
502	*Aphantopus hyperantus* (Linnaeus, 1758)	0.84	0.58	0.79	0.78	0.19	0.55	0.45	16672
504	*Maniola jurtina* (Linnaeus, 1758)	0.7	0.48	0.80	0.46	0.08	0.55	0.45	21820
506	*Hyponephele lycaon* (Kühn, 1774)	0.78	0.32	0.76	0.81	0.17	0.75	0.25	6884
508	*Hyponephele lupina* (Costa, 1836)	0.88	0.38	0.89	0.92	0.05	0.51	0.49	2829
510	*Erebia ligea* (Linnaeus, 1758)	0.86	0.55	0.80	0.83	0.01	0.65	0.35	12462
512	*Erebia euryale* (Esper, 1805)	0.89	0.47	0.90	0.95	0.03	0.56	0.44	2092
514	*Erebia eriphyle* (Freyer, 1836)	0.99	0.64	0.99	0.99	0.10	0.64	0.36	385
516	*Erebia manto* ([Schiffermüller], 1775)	0.9	0.48	0.95	0.97	0.03	0.75	0.25	1353

Page		AUC	Kappa	Diag	r.abs	f.pre	r.pre	f.abs	occupied cells
518	*Erebia epiphron* (Knoch, 1783)	0.84	0.38	0.88	0.90	0.03	0.79	0.21	3243
520	*Erebia pharte* (Hübner, 1804)	0.89	0.51	0.96	0.97	0.12	0.54	0.46	1356
522	*Erebia melampus* (Fuessli, 1775)	0.98	0.53	0.96	0.97	0.04	0.50	0.50	1421
524	*Erebia aethiops* (Esper, 1777)	0.82	0.40	0.82	0.88	0.02	0.76	0.24	4523
526	*Erebia triaria* (Prunner, 1798)	0.81	0.36	0.94	0.96	0.01	0.72	0.28	1169
528	*Erebia embla* (Becklin, 1791)	0.97	0.70	0.96	0.98	0.09	0.56	0.44	3804
530	*Erebia disa* (Becklin, 1791)	0.99	0.72	0.99	0.99	0.03	0.49	0.51	1475
532	*Erebia medusa* (Fabricius, 1787)	0.9	0.49	0.85	0.91	0.02	0.63	0.37	4124
534	*Erebia alberganus* (Prunner, 1798)	0.87	0.42	0.96	0.97	0.04	0.54	0.46	1025
536	*Erebia pluto* (Prunner, 1798)	0.98	0.52	0.97	0.98	0.01	0.45	0.55	883
538	*Erebia gorge* (Esper, 1805)	0.88	0.42	0.94	0.96	0.00	0.17	0.83	1706
540	*Erebia mnestra* (Esper, 1805)	0.96	0.46	0.99	0.99	0.01	0.21	0.79	280
542	*Erebia epistygne* (Hübner, 1819)	0.91	0.22	0.99	1.00	0.01	0.64	0.36	172
544	*Erebia ottomana* (Herrich-Schäffer, 1847)	0.81	0.28	0.98	0.99	0.03	0.40	0.60	631
546	*Erebia tyndarus* (Esper, 1781)	0.99	0.53	0.99	0.99	0.04	0.57	0.43	435
548	*Erebia cassioides* (Reiner & Hohenwarth, 1792) (complex)	0.8	0.35	0.95	0.97	0.01	0.40	0.60	1176
550	*Erebia pronoe* (Esper, 1780)	0.89	0.42	0.94	0.96	0.01	0.68	0.32	1680
552	*Erebia styx* (Freyer, 1834)	0.95	0.36	0.98	0.99	0.02	0.63	0.38	429
554	*Erebia montana* (Prunner, 1798)	0.98	0.58	0.98	0.99	0.01	0.29	0.71	635
556	*Erebia neoridas* (Boisduval, 1828)	0.93	0.52	0.97	0.98	0.03	0.39	0.61	677
558	*Erebia melas* (Herbst, 1796)	0.84	0.32	0.98	0.99	0.09	0.71	0.29	650
560	*Erebia oeme* (Esper, 1805)	0.89	0.38	0.95	0.97	0.05	0.73	0.27	1095
562	*Erebia meolans* (Prunner, 1798)	0.92	0.45	0.90	0.91	0.06	0.44	0.56	2758
564	*Erebia pandrose* (Borkhausen, 1788)	0.86	0.62	0.93	0.95	0.29	0.81	0.19	4493
566	*Melanargia russiae* (Esper, 1784)	0.85	0.33	0.92	0.94	0.04	0.50	0.50	1515
568	*Melanargia galathea* (Linnaeus, 1758)	0.81	0.50	0.75	0.71	0.02	0.41	0.59	13958
570	*Melanargia lachesis* (Hübner 1790)	0.89	0.44	0.94	0.96	0.02	0.64	0.36	1394

Page		AUC	Kappa	Diag	r.abs	f.pre	r.pre	f.abs	occupied cells
572	*Melanargia larissa* (Esper, 1784)	0.89	0.39	0.96	0.98	0.07	0.51	0.49	1121
574	*Melanargia arge* (Sulzer, 1776)	0.98	0.44	0.97	0.98	0.04	0.48	0.52	617
576	*Melanargia occitanica* (Esper, 1793)	0.86	0.30	0.91	0.93	0.08	0.51	0.49	1405
578	*Melanargia ines* (Hoffmansegg, 1804)	0.95	0.37	0.94	0.96	0.06	0.68	0.32	1108
580	*Satyrus ferula* (Fabricius, 1793)	0.76	0.35	0.89	0.92	0.09	0.52	0.48	2203
582	*Satyrus actaea* (Esper, 1780)	0.92	0.39	0.93	0.94	0.21	0.72	0.28	1618
584	*Minois dryas* (Scopoli, 1763)	0.83	0.43	0.84	0.91	0.11	0.45	0.55	4240
586	*Hipparchia fagi* (Scopoli, 1763)	0.83	0.39	0.78	0.79	0.06	0.67	0.33	6537
588	*Hipparchia hermione* (Linnaeus, 1764)	0.72	0.31	0.83	0.89	0.37	0.82	0.18	3309
590	*Hipparchia syriaca* (Staudinger, 1871)	0.95	0.34	0.94	0.94	0.01	0.31	0.69	1919
592	*Hipparchia semele* (Linnaeus, 1758)	0.79	0.43	0.71	0.63	0.21	0.61	0.39	13833
594	*Hipparchia volgensis* (Mazochin-Porshnyakov, 1952)	0.94	0.33	0.97	0.99	0.03	0.63	0.38	981
596	*Hipparchia statilinus* (Hufnagel, 1766)	0.76	0.33	0.76	0.79	0.10	0.70	0.30	6117
598	*Hipparchia fatua* (Freyer, 1845)	0.98	0.45	0.96	0.97	0.02	0.39	0.61	1024
600	*Hipparchia fidia* (Linnaeus, 1767)	0.88	0.32	0.89	0.90	0.18	0.63	0.37	2192
602	*Hipparchia senthes* (Fruhstorfer, 1908)	0.94	0.36	0.96	0.98	0.22	0.73	0.27	840
604	*Arethusana arethusa* ([Schiffermüller], 1775)	0.77	0.32	0.80	0.82	0.25	0.70	0.30	5621
606	*Brintesia circe* (Fabricius, 1775)	0.81	0.42	0.77	0.78	0.01	0.58	0.42	7539
608	*Chazara briseis* (Linnaeus, 1764)	0.8	0.34	0.74	0.75	0.02	0.70	0.30	7292
610	*Pseudochazara anthelea* (Lefebvre, 1831)	0.9	0.52	0.98	0.99	0.02	0.78	0.22	818
612	*Oeneis norna* (Becklin, 1791)	0.98	0.58	0.97	0.98	0.05	0.86	0.14	2077
614	*Oeneis glacialis* (Moll, 1785)	0.99	0.59	0.98	0.98	0.02	0.50	0.50	930
616	*Oeneis jutta* (Hübner, 1806)	0.96	0.68	0.94	0.95	0.05	0.86	0.14	5991
618	*Danaus chrysippus* (Linnaeus, 1758)	0.89	0.36	0.97	0.98	0.02	0.50	0.50	412

Appendix 2 – Scenario results

Page		2050 full dispersal GRAS	2050 full dispersal BAMBU	2050 full dispersal SEDG	2050 no dispersal GRAS	2050 no dispersal BAMBU	2050 no dispersal SEDG	2080 full dispersal GRAS	2080 full dispersal BAMBU	2080 full dispersal SEDG	2080 no dispersal GRAS	2080 no dispersal BAMBU	2080 no dispersal SEDG
32	*Erynnis tages* (Linnaeus, 1758)	-2873 (-16.22%)	-2385 (-13.47%)	-1786 (-10.09%)	-4268 (-24.1%)	-3834 (-21.65%)	-3203 (-18.09%)	-7225 (-40.8%)	-5429 (-30.66%)	-4695 (-26.51%)	-10729 (-60.59%)	-8408 (-47.48%)	-6615 (-37.35%)
34	*Erynnis marloyi* (Boisduval, 1834)	-222 (-24.56%)	-240 (-26.55%)	-123 (-13.61%)	-631 (-69.8%)	-583 (-64.49%)	-521 (-57.63%)	-658 (-72.79%)	-572 (-63.27%)	-72 (-7.96%)	-862 (-95.35%)	-807 (-89.27%)	-578 (-63.94%)
36	*Carcharodus alceae* (Esper, 1870)	2940 (23.39%)	2554 (20.32%)	3884 (30.9%)	-1476 (-11.74%)	-1255 (-9.98%)	-568 (-4.52%)	-1188 (-9.45%)	-222 (-1.77%)	1889 (15.03%)	-6139 (-48.83%)	-4815 (-38.3%)	-2106 (-16.75%)
38	*Carcharodus lavatherae* (Esper, 1783)	-379 (-11.62%)	-132 (-4.05%)	-21 (-0.64%)	-1893 (-58.03%)	-1578 (-48.38%)	-1482 (-45.43%)	-454 (-13.92%)	284 (8.71%)	1101 (33.75%)	-2792 (-85.59%)	-2409 (-73.85%)	-1978 (-60.64%)
40	*Carcharodus flocciferus* (Zeller, 1847)	104 (2.47%)	1228 (29.15%)	460 (10.92%)	-1661 (-39.43%)	-1188 (-28.2%)	-1148 (-27.25%)	2972 (70.54%)	2427 (57.61%)	2641 (62.69%)	-2925 (-69.43%)	-2346 (-55.68%)	-1670 (-39.64%)
42	*Carcharodus orientalis* (Reverdin, 1913)	-94 (-7.63%)	-119 (-9.66%)	-26 (-2.11%)	-695 (-56.41%)	-594 (-48.21%)	-611 (-49.59%)	-266 (-21.59%)	-435 (-35.31%)	255 (20.7%)	-1116 (-90.58%)	-972 (-78.9%)	-729 (-59.17%)
44	*Carcharodus baeticus* (Rambur, 1840)	168 (40.58%)	75 (18.12%)	88 (21.26%)	-229 (-55.31%)	-233 (-56.28%)	-239 (-57.73%)	248 (59.9%)	138 (33.33%)	106 (25.6%)	-293 (-70.77%)	-288 (-69.57%)	-275 (-66.43%)
46	*Spialia phlomidis* (Herrich-Schäffer, 1845)	-110 (-28.72%)	-88 (-22.98%)	-59 (-15.4%)	-260 (-67.89%)	-228 (-59.53%)	-195 (-50.91%)	-319 (-83.29%)	-262 (-68.41%)	27 (7.05%)	-381 (-99.48%)	-352 (-91.91%)	-229 (-59.79%)
48	*Spialia sertorius* (Hoffmansegg, 1804)	-1114 (-16.46%)	-331 (-4.89%)	-426 (-6.29%)	-2425 (-35.83%)	-1755 (-25.93%)	-1771 (-26.17%)	-2218 (-32.77%)	-1006 (-14.86%)	-553 (-8.17%)	-4639 (-68.54%)	-3188 (-47.1%)	-2424 (-35.82%)
50	*Spialia orbifer* (Hübner, 1823)	1211 (44.39%)	528 (19.35%)	2229 (81.71%)	-976 (-35.78%)	-987 (-36.18%)	-341 (-12.5%)	1443 (52.9%)	-59 (-2.16%)	1025 (37.57%)	-2000 (-73.31%)	-1848 (-67.74%)	-1188 (-43.55%)
52	*Syrichtus proto* (Ochsenheimer, 1808)	-1928 (-52.59%)	-1862 (-50.79%)	-1328 (-36.22%)	-2248 (-61.32%)	-2012 (-54.88%)	-1802 (-49.15%)	-2945 (-80.33%)	-3014 (-82.21%)	-1929 (-52.62%)	-3553 (-96.92%)	-3242 (-88.43%)	-2530 (-69.01%)
54	*Syrichtus tessellum* (Hübner, 1803)	53 (5%)	-303 (-28.61%)	305 (28.8%)	-960 (-90.65%)	-938 (-88.57%)	-806 (-76.11%)	-736 (-69.5%)	-755 (-71.29%)	-270 (-25.5%)	-1059 (-100%)	-1058 (-99.91%)	-907 (-85.65%)
56	*Pyrgus carthami* (Hübner, 1813)	-761 (-11.6%)	-770 (-11.73%)	222 (3.38%)	-2712 (-41.32%)	-2415 (-36.8%)	-1952 (-29.74%)	-3285 (-50.05%)	-1787 (-27.23%)	-1051 (-16.01%)	-5563 (-84.76%)	-4285 (-65.29%)	-3471 (-52.89%)
58	*Pyrgus sidae* (Esper, 1782)	-352 (-26.21%)	-427 (-31.79%)	33 (2.46%)	-981 (-73.05%)	-917 (-68.28%)	-831 (-61.88%)	-384 (-28.59%)	-808 (-60.16%)	-178 (-13.25%)	-1328 (-98.88%)	-1286 (-95.76%)	-1051 (-78.26%)

Page		2050	2050	2050	2050	2050	2050	2080	2080	2080	2080	2080	2080
		full dispersal	full dispersal	full dispersal	no dispersal	no dispersal	no dispersal	full dispersal	full dispersal	full dispersal	no dispersal	no dispersal	no dispersal
		GRAS	BAMBU	SEDG	GRAS	BAMBU	SEDG	GRAS	BAMBU	SEDG	GRAS	BAMBU	SEDG
60	*Pyrgus andromedae* (Wallengren, 1853)	-511 (-26.46%)	-280 (-14.5%)	-432 (-22.37%)	-546 (-28.28%)	-356 (-18.44%)	-517 (-26.77%)	-584 (-30.24%)	-306 (-15.85%)	-425 (-22.01%)	-777 (-40.24%)	-542 (-28.07%)	-586 (-30.35%)
62	*Pyrgus cacaliae* (Rambur, 1840)	-312 (-27.06%)	-207 (-17.95%)	-272 (-23.59%)	-400 (-34.69%)	-320 (-27.75%)	-368 (-31.92%)	-523 (-45.36%)	-336 (-29.14%)	-514 (-44.58%)	-719 (-62.36%)	-538 (-46.66%)	-630 (-54.64%)
64	*Pyrgus centaureae* (Rambur, 1840)	-1565 (-27.17%)	-1446 (-25.1%)	-1313 (-22.8%)	-1588 (-27.57%)	-1465 (-25.43%)	-1372 (-23.82%)	-3722 (-64.62%)	-2932 (-50.9%)	-1836 (-31.87%)	-3811 (-66.16%)	-3022 (-52.47%)	-2073 (-35.99%)
66	*Pyrgus malvae* (Linnaeus, 1758) / *malvoides* (Elwes & Edwards, 1897) (complex)	-2638 (-12.91%)	-2324 (-11.37%)	-1529 (-7.48%)	-4159 (-20.35%)	-3586 (-17.54%)	-3197 (-15.64%)	-5554 (-27.17%)	-4212 (-20.61%)	-2288 (-11.19%)	-10058 (-49.21%)	-7735 (-37.84%)	-5349 (-26.17%)
68	*Pyrgus serratulae* (Rambur, 1840)	-638 (-10.27%)	-450 (-7.24%)	52 (0.84%)	-2411 (-38.79%)	-2061 (-33.16%)	-1871 (-30.1%)	-3008 (-48.4%)	-1483 (-23.86%)	-759 (-12.21%)	-4947 (-79.6%)	-3798 (-61.11%)	-2952 (-47.5%)
70	*Pyrgus onopordi* (Rambur, 1840)	-449 (-20.7%)	-306 (-14.11%)	-279 (-12.86%)	-1312 (-60.49%)	-1069 (-49.29%)	-1032 (-47.58%)	-373 (-17.2%)	-98 (-4.52%)	88 (4.06%)	-2079 (-95.85%)	-1602 (-73.86%)	-1395 (-64.32%)
72	*Pyrgus carlinae* (Rambur, 1840)	-133 (-16.26%)	22 (2.69%)	-100 (-12.22%)	-506 (-61.86%)	-419 (-51.22%)	-481 (-58.8%)	-362 (-44.25%)	-197 (-24.08%)	-231 (-28.24%)	-703 (-85.94%)	-614 (-75.06%)	-714 (-87.29%)
74	*Pyrgus cirsii* (Rambur, 1840)	-1107 (-25.44%)	-524 (-12.04%)	-472 (-10.85%)	-1933 (-44.42%)	-1326 (-30.47%)	-1306 (-30.01%)	-3080 (-70.77%)	-1773 (-40.74%)	-947 (-21.76%)	-3713 (-85.32%)	-2764 (-63.51%)	-1936 (-44.49%)
76	*Pyrgus armoricanus* (Oberthür, 1910)	386 (5.8%)	362 (5.44%)	1076 (16.16%)	-2691 (-40.42%)	-2404 (-36.11%)	-2050 (-30.79%)	-402 (-6.04%)	67 (1.01%)	987 (14.82%)	-5276 (-79.24%)	-4177 (-62.74%)	-3082 (-46.29%)
78	*Pyrgus alveus* (Hübner, 1803) (species complex)	-1796 (-16.46%)	580 (5.32%)	-102 (-0.93%)	-3665 (-33.59%)	-2013 (-18.45%)	-2549 (-23.36%)	246 (2.25%)	1087 (9.96%)	2539 (23.27%)	-6117 (-56.06%)	-4815 (-44.13%)	-3680 (-33.72%)
80	*Pyrgus bellieri* (Oberthür, 1910)	-109 (-26.85%)	-172 (-42.36%)	-180 (-44.33%)	-369 (-90.89%)	-338 (-83.25%)	-356 (-87.68%)	-113 (-27.83%)	-60 (-14.78%)	242 (59.61%)	-406 (-100%)	-404 (-99.51%)	-395 (-97.29%)
82	*Pyrgus warrenensis* (Verity, 1928)	-537 (-38.22%)	-437 (-31.1%)	-447 (-31.81%)	-644 (-45.84%)	-541 (-38.51%)	-568 (-40.43%)	-796 (-56.65%)	-655 (-46.62%)	-725 (-51.6%)	-997 (-70.96%)	-834 (-59.36%)	-954 (-67.9%)
84	*Heteropterus morpheus* (Pallas, 1771)	2282 (30.19%)	4028 (53.29%)	1974 (26.11%)	-2646 (-35%)	-1937 (-25.63%)	-2272 (-30.06%)	819 (10.83%)	2305 (30.49%)	1760 (23.28%)	-5718 (-75.64%)	-4136 (-54.72%)	-3328 (-44.03%)
86	*Carterocephalus palaemon* (Pallas, 1771)	-1877 (-16.71%)	113 (1.01%)	-1722 (-15.33%)	-3570 (-31.78%)	-2117 (-18.85%)	-3397 (-30.24%)	-748 (-6.66%)	41 (0.37%)	696 (6.2%)	-4725 (-42.07%)	-3528 (-31.41%)	-2961 (-26.36%)

Page		2050 full dispersal GRAS	2050 full dispersal BAMBU	2050 full dispersal SEDG	2050 no dispersal GRAS	2050 no dispersal BAMBU	2050 no dispersal SEDG	2080 full dispersal GRAS	2080 full dispersal BAMBU	2080 full dispersal SEDG	2080 no dispersal GRAS	2080 no dispersal BAMBU	2080 no dispersal SEDG
88	*Carterocephalus silvicolus* (Meigen, 1829)	-599 (-10.9%)	-919 (-16.73%)	-1008 (-18.35%)	-2200 (-40.05%)	-2273 (-41.38%)	-2364 (-43.04%)	-2565 (-46.7%)	-1746 (-31.79%)	-1928 (-35.1%)	-4642 (-84.51%)	-3780 (-68.81%)	-3609 (-65.7%)
90	*Thymelicus lineola* (Ochsenheimer, 1806)	-2839 (-14.61%)	-2572 (-13.24%)	-1906 (-9.81%)	-4045 (-20.82%)	-3506 (-18.04%)	-3176 (-16.35%)	-7605 (-39.14%)	-5580 (-28.72%)	-3425 (-17.63%)	-10551 (-54.3%)	-7891 (-40.61%)	-5330 (-27.43%)
92	*Thymelicus sylvestris* (Poda, 1761)	-2283 (-18.52%)	-1880 (-15.25%)	-979 (-7.94%)	-4097 (-33.23%)	-3492 (-28.32%)	-2907 (-23.58%)	-5406 (-43.85%)	-4395 (-35.65%)	-3060 (-24.82%)	-8045 (-65.25%)	-6533 (-52.99%)	-4995 (-40.51%)
94	*Thymelicus acteon* (Rottemburger, 1775)	-445 (-4.54%)	-456 (-4.65%)	222 (2.27%)	-2359 (-24.07%)	-2089 (-21.31%)	-1744 (-17.79%)	-2860 (-29.18%)	-2148 (-21.92%)	-827 (-8.44%)	-5473 (-55.84%)	-4352 (-44.4%)	-2875 (-29.33%)
96	*Hesperia comma* (Linnaeus, 1758)	-2913 (-24.67%)	-2321 (-19.66%)	-1980 (-16.77%)	-4003 (-33.91%)	-3408 (-28.87%)	-3034 (-25.7%)	-7069 (-59.88%)	-5466 (-46.3%)	-4598 (-38.95%)	-9066 (-76.79%)	-7294 (-61.78%)	-6026 (-51.04%)
98	*Ochlodes sylvanus* (Esper, 1777)	-1398 (-6.8%)	-953 (-4.64%)	-726 (-3.53%)	-4058 (-19.74%)	-3309 (-16.1%)	-3276 (-15.94%)	-3892 (-18.94%)	-2082 (-10.13%)	-750 (-3.65%)	-9349 (-45.49%)	-6893 (-33.54%)	-4881 (-23.75%)
100	*Gegenes pumilio* (Hoffmansegg, 1804)	-39 (-7.43%)	-15 (-2.86%)	-11 (-2.1%)	-239 (-45.52%)	-201 (-38.29%)	-195 (-37.14%)	-223 (-42.48%)	-123 (-23.43%)	90 (17.14%)	-420 (-80%)	-342 (-65.14%)	-220 (-41.9%)
102	*Gegenes nostrodamus* (Fabricius, 1793)	-718 (-58.61%)	-626 (-51.1%)	-628 (-51.27%)	-927 (-75.67%)	-828 (-67.59%)	-805 (-65.71%)	-1035 (-84.49%)	-912 (-74.45%)	-731 (-59.67%)	-1216 (-99.27%)	-1142 (-93.22%)	-1005 (-82.04%)
104	*Zerynthia rumina* (Linnaeus, 1767)	-1187 (-33.91%)	-1378 (-39.37%)	-802 (-22.91%)	-2196 (-62.74%)	-1932 (-55.2%)	-1847 (-52.77%)	-1967 (-56.2%)	-2119 (-60.54%)	-1574 (-44.97%)	-3405 (-97.29%)	-3078 (-87.94%)	-2617 (-74.77%)
106	*Zerynthia polyxena* ([Schiffermüller], 1775)	3098 (63.24%)	3218 (65.69%)	3753 (76.61%)	-1499 (-30.6%)	-1107 (-22.6%)	-722 (-14.74%)	4141 (84.53%)	3432 (70.06%)	4158 (84.87%)	-3917 (-79.96%)	-3156 (-64.42%)	-1612 (-32.9%)
108	*Zerynthia cerisyi* (Godart, 1822)	2080 (359.24%)	2079 (359.07%)	1685 (291.02%)	-23 (-3.97%)	-10 (-1.73%)	-11 (-1.9%)	4073 (703.45%)	3022 (521.93%)	2970 (512.95%)	-71 (-12.26%)	-73 (-12.61%)	-35 (-6.04%)
110	*Parnassius mnemosyne* (Linnaeus, 1758)	-1983 (-21.77%)	-1793 (-19.68%)	-465 (-5.1%)	-3222 (-35.37%)	-2980 (-32.71%)	-2308 (-25.34%)	-2163 (-23.75%)	-2536 (-27.84%)	-175 (-1.92%)	-7025 (-77.12%)	-6269 (-68.82%)	-4413 (-48.45%)
112	*Parnassius phoebus* (Fabricius, 1793)	-314 (-28.21%)	-198 (-17.79%)	-275 (-24.71%)	-488 (-43.85%)	-388 (-34.86%)	-455 (-40.88%)	-574 (-51.57%)	-364 (-32.7%)	-526 (-47.26%)	-804 (-72.24%)	-645 (-57.95%)	-755 (-67.83%)
114	*Parnassius apollo* (Linnaeus, 1758)	-2915 (-46.47%)	-2609 (-41.59%)	-1887 (-30.08%)	-3479 (-55.46%)	-3126 (-49.83%)	-2568 (-40.94%)	-3972 (-63.32%)	-3319 (-52.91%)	-2234 (-35.61%)	-4758 (-75.85%)	-4177 (-66.59%)	-3431 (-54.69%)

Page		2050 full dispersal GRAS	2050 full dispersal BAMBU	2050 full dispersal SEDG	2050 no dispersal GRAS	2050 no dispersal BAMBU	2050 no dispersal SEDG	2080 full dispersal GRAS	2080 full dispersal BAMBU	2080 full dispersal SEDG	2080 no dispersal GRAS	2080 no dispersal BAMBU	2080 no dispersal SEDG
116	*Iphiclides podalirius* (LINNAEUS, 1758)	3058 (29.47%)	3818 (36.79%)	4099 (39.5%)	-1226 (-11.81%)	-852 (-8.21%)	-483 (-4.65%)	3433 (33.08%)	3105 (29.92%)	4380 (42.2%)	-4169 (-40.17%)	-3182 (-30.66%)	-1186 (-11.43%)
118	*Papilio machaon* LINNAEUS, 1758	1346 (6.31%)	1206 (5.65%)	1744 (8.18%)	-742 (-3.48%)	-428 (-2.01%)	-449 (-2.1%)	227 (1.06%)	1066 (5%)	2637 (12.36%)	-4167 (-19.53%)	-2547 (-11.94%)	-809 (-3.79%)
120	*Papilio alexanor* ESPER, 1799	-278 (-40.47%)	-277 (-40.32%)	-224 (-32.61%)	-454 (-66.08%)	-436 (-63.46%)	-404 (-58.81%)	-462 (-67.25%)	-380 (-55.31%)	-257 (-37.41%)	-592 (-86.17%)	-534 (-77.73%)	-455 (-66.23%)
122	*Leptidea sinapis* (LINNAEUS, 1758) / *reali* REISSINGER, 1990 (complex)	97 (0.54%)	236 (1.3%)	1829 (10.09%)	-3575 (-19.72%)	-2733 (-15.08%)	-2394 (-13.21%)	795 (4.39%)	1117 (6.16%)	2744 (15.14%)	-7192 (-39.68%)	-5664 (-31.25%)	-3709 (-20.46%)
124	*Leptidea duponcheli* (STAUDINGER, 1871)	22 (1.97%)	-186 (-16.65%)	221 (19.79%)	-856 (-76.63%)	-812 (-72.69%)	-712 (-63.74%)	-594 (-53.18%)	-628 (-56.22%)	32 (2.86%)	-1066 (-95.43%)	-1009 (-90.33%)	-782 (-70.01%)
126	*Leptidea morsei* (FENTON, 1881)	188 (12%)	761 (48.56%)	370 (23.61%)	-1154 (-73.64%)	-988 (-63.05%)	-893 (-56.99%)	293 (18.7%)	196 (12.51%)	-133 (-8.49%)	-1416 (-90.36%)	-1328 (-84.75%)	-1198 (-76.45%)
128	*Anthocharis cardamines* (LINNAEUS, 1758)	-2928 (-15.58%)	-2021 (-10.75%)	-1416 (-7.53%)	-4787 (-25.47%)	-3707 (-19.72%)	-3168 (-16.86%)	-6918 (-36.81%)	-4765 (-25.35%)	-2159 (-11.49%)	-10040 (-53.42%)	-7476 (-39.78%)	-4447 (-23.66%)
130	*Anthocharis euphenoides* STAUDINGER, 1869	-1374 (-46.26%)	-1299 (-43.74%)	-989 (-33.3%)	-2012 (-67.74%)	-1763 (-59.36%)	-1744 (-58.72%)	-1956 (-65.86%)	-1948 (-65.59%)	-1313 (-44.21%)	-2887 (-97.21%)	-2614 (-88.01%)	-2309 (-77.74%)
132	*Anthocharis gruneri* HERRICH-SCHÄFFER, 1851	-356 (-35.71%)	-330 (-33.1%)	-266 (-26.68%)	-696 (-69.81%)	-648 (-64.99%)	-613 (-61.48%)	-773 (-77.53%)	-666 (-66.8%)	-224 (-22.47%)	-971 (-97.39%)	-888 (-89.07%)	-695 (-69.71%)
134	*Zegris eupheme* (ESPER, 1805)	-456 (-53.15%)	-536 (-62.47%)	-411 (-47.9%)	-580 (-67.6%)	-562 (-65.5%)	-520 (-60.61%)	-849 (-98.95%)	-837 (-97.55%)	-765 (-89.16%)	-849 (-98.95%)	-837 (-97.55%)	-766 (-89.28%)
136	*Euchloe belemia* (ESPER, 1798)	-400 (-57.55%)	-424 (-61.01%)	-289 (-41.58%)	-446 (-64.17%)	-432 (-62.16%)	-377 (-54.24%)	-649 (-93.38%)	-607 (-87.34%)	-338 (-48.63%)	-670 (-96.4%)	-626 (-90.07%)	-495 (-71.22%)
138	*Euchloe ausonia* (HÜBNER, 1806) (complex)	-794 (-25.19%)	-999 (-31.69%)	-590 (-18.72%)	-1692 (-53.68%)	-1507 (-47.81%)	-802 (-17.89%)	-265 (-5.91%)	-327 (-7.29%)	338 (7.54%)	-2472 (-55.14%)	-2058 (-45.91%)	-1439 (-32.1%)
140	*Euchloe tagis* (HÜBNER, 1804)	-1530 (-8.14%)	-703 (-3.74%)	-661 (-3.52%)	-3266 (-17.39%)	-2451 (-13.05%)	-1537 (-48.76%)	-1749 (-55.49%)	-1535 (-48.7%)	-920 (-29.19%)	-2743 (-87.02%)	-2350 (-74.56%)	-1943 (-61.64%)
142	*Aporia crataegi* (LINNAEUS, 1758)	-3241 (-13.8%)	-3133 (-13.34%)	-1904 (-8.11%)	-4419 (-18.82%)	-4027 (-17.15%)	-2426 (-12.91%)	-3323 (-17.69%)	-2410 (-12.83%)	-1604 (-8.54%)	-8101 (-43.12%)	-6143 (-32.7%)	-4323 (-23.01%)

Page		2050 full dispersal GRAS	2050 full dispersal BAMBU	2050 full dispersal SEDG	2050 no dispersal GRAS	2050 no dispersal BAMBU	2050 no dispersal SEDG	2080 full dispersal GRAS	2080 full dispersal BAMBU	2080 full dispersal SEDG	2080 no dispersal GRAS	2080 no dispersal BAMBU	2080 no dispersal SEDG
144	*Pieris brassicae* (Linnaeus, 1758)	-25 (-1.9%)	11 (0.84%)	216 (16.44%)	-698 (-53.12%)	-604 (-45.97%)	-3228 (-13.75%)	-8906 (-37.93%)	-6368 (-27.12%)	-3429 (-14.6%)	-11751 (-50.04%)	-8473 (-36.08%)	-5640 (-24.02%)
146	*Pieris krueperi* (Staudinger, 1860)	222 (12.98%)	221 (12.92%)	214 (12.51%)	-803 (-46.96%)	-716 (-41.87%)	-619 (-47.11%)	36 (2.74%)	-141 (-10.73%)	446 (33.94%)	-1033 (-78.61%)	-900 (-68.49%)	-748 (-56.93%)
148	*Pieris mannii* (Mayer, 1851)	-891 (-3.69%)	-690 (-2.86%)	82 (0.34%)	-2258 (-9.35%)	-1742 (-7.22%)	-572 (-33.45%)	711 (41.58%)	639 (37.37%)	616 (36.02%)	-1497 (-87.54%)	-1318 (-77.08%)	-968 (-56.61%)
150	*Pieris rapae* (Linnaeus, 1758)	-90 (-4.19%)	-101 (-4.71%)	94 (4.38%)	-1043 (-48.6%)	-932 (-43.43%)	-1502 (-6.22%)	-4088 (-16.93%)	-3119 (-12.92%)	-670 (-2.78%)	-8043 (-33.31%)	-6008 (-24.89%)	-3296 (-13.65%)
152	*Pieris ergane* (Geyer, 1828)	-3275 (-12.38%)	-2497 (-9.44%)	-2543 (-9.61%)	-3819 (-14.43%)	-3022 (-11.42%)	-786 (-36.63%)	519 (24.18%)	223 (10.39%)	527 (24.56%)	-1894 (-88.26%)	-1684 (-78.47%)	-1157 (-53.91%)
154	*Pieris napi* (Linnaeus, 1758)	-521 (-44.04%)	-320 (-27.05%)	-421 (-35.59%)	-594 (-50.21%)	-418 (-35.33%)	-3045 (-11.51%)	-7583 (-28.66%)	-5386 (-20.36%)	-3817 (-14.43%)	-8253 (-31.19%)	-6063 (-22.91%)	-4424 (-16.72%)
156	*Pieris bryoniae* (Hübner, 1791)	-211 (-23.68%)	-97 (-10.89%)	-182 (-20.43%)	-370 (-41.53%)	-296 (-33.22%)	-520 (-43.96%)	-303 (-25.61%)	-197 (-16.65%)	-312 (-26.37%)	-844 (-71.34%)	-655 (-55.37%)	-637 (-53.85%)
158	*Pontia callidice* (Hübner, 1800)	3493 (22.82%)	1973 (12.89%)	4490 (29.33%)	-842 (-5.5%)	-918 (-6%)	-347 (-38.95%)	-481 (-53.98%)	-280 (-31.43%)	-452 (-50.73%)	-682 (-76.54%)	-509 (-57.13%)	-639 (-71.72%)
160	*Pontia daplidice* (Linnaeus, 1758) / *edusa* (Fabricius, 1777) (complex)	-432 (-30.36%)	-209 (-14.69%)	-306 (-21.5%)	-611 (-42.94%)	-450 (-31.62%)	-364 (-2.38%)	-1327 (-8.67%)	-157 (-1.03%)	3091 (20.19%)	-7478 (-48.84%)	-5708 (-37.28%)	-2391 (-15.62%)
162	*Colias phicomone* (Esper, 1780)	-3095 (-31.31%)	-2799 (-28.31%)	-2875 (-29.08%)	-3361 (-34%)	-3063 (-30.98%)	-513 (-36.05%)	-665 (-46.73%)	-426 (-29.94%)	-562 (-39.49%)	-1017 (-71.47%)	-781 (-54.88%)	-890 (-62.54%)
164	*Colias palaeno* (Linnaeus, 1758)	1982 (82.79%)	815 (34.04%)	2797 (116.83%)	-989 (-41.31%)	-1199 (-50.08%)	-3210 (-32.47%)	-5087 (-51.46%)	-4202 (-42.5%)	-3370 (-34.09%)	-5433 (-54.96%)	-4562 (-46.15%)	-3889 (-39.34%)
166	*Colias erate* (Esper, 1805)	-420 (-2.59%)	-123 (-0.76%)	1037 (6.41%)	-2931 (-18.11%)	-2525 (-15.6%)	-331 (-13.83%)	44 (1.84%)	-317 (-13.24%)	1379 (57.6%)	-2260 (-94.4%)	-2059 (-86.01%)	-1160 (-48.45%)
168	*Colias croceus* (Geoffroy, 1785)	-784 (-80%)	-767 (-78.27%)	-736 (-75.1%)	-805 (-82.14%)	-791 (-80.71%)	-1750 (-10.81%)	-4329 (-26.75%)	-3091 (-19.1%)	-962 (-5.94%)	-7460 (-46.09%)	-5896 (-36.43%)	-3518 (-21.74%)
170	*Colias hecla* Lefebvre, 1836	-1528 (-35.94%)	-2181 (-51.29%)	-329 (-7.74%)	-2196 (-51.65%)	-2616 (-61.52%)	-785 (-80.1%)	-963 (-98.27%)	-931 (-95%)	-828 (-84.49%)	-964 (-98.37%)	-949 (-96.84%)	-879 (-89.69%)

Page		2050 full dispersal GRAS	2050 full dispersal BAMBU	2050 full dispersal SEDG	2050 no dispersal GRAS	2050 no dispersal BAMBU	2050 no dispersal SEDG	2080 full dispersal GRAS	2080 full dispersal BAMBU	2080 full dispersal SEDG	2080 no dispersal GRAS	2080 no dispersal BAMBU	2080 no dispersal SEDG
172	*Colias myrmidone* (Esper, 1780)	463 (61.57%)	-246 (-32.71%)	416 (55.32%)	-559 (-74.34%)	-565 (-75.13%)	-1351 (-31.77%)	-2667 (-62.72%)	-2971 (-69.87%)	-1896 (-44.59%)	-4048 (-95.2%)	-3887 (-91.42%)	-3193 (-75.09%)
174	*Colias chrysotheme* (Esper, 1780)	-786 (-6.27%)	-305 (-2.43%)	-437 (-3.49%)	-3393 (-27.07%)	-2961 (-23.62%)	-489 (-65.03%)	-550 (-73.14%)	-490 (-65.16%)	-519 (-69.02%)	-733 (-97.47%)	-707 (-94.02%)	-665 (-88.43%)
176	*Colias hyale* (Linnaeus, 1758)	-144 (-1.49%)	32 (0.33%)	983 (10.19%)	-3278 (-33.98%)	-2997 (-31.06%)	-2793 (-22.28%)	-3035 (-24.21%)	-1777 (-14.18%)	-905 (-7.22%)	-9284 (-74.06%)	-7208 (-57.5%)	-5229 (-41.72%)
178	*Colias alfacariensis* Ribbe, 1905	-1973 (-9.58%)	-1593 (-7.73%)	-1084 (-5.26%)	-4092 (-19.87%)	-3440 (-16.7%)	-2101 (-21.78%)	-2461 (-25.51%)	-1547 (-16.03%)	-812 (-8.42%)	-6649 (-68.92%)	-5409 (-56.06%)	-4054 (-42.02%)
180	*Gonepteryx rhamni* (Linnaeus, 1758)	84 (13.02%)	75 (11.63%)	89 (13.8%)	-231 (-35.81%)	-188 (-29.15%)	-3228 (-15.67%)	-4146 (-20.13%)	-2555 (-12.4%)	-1165 (-5.66%)	-9486 (-46.05%)	-7022 (-34.09%)	-4835 (-23.47%)
182	*Gonepteryx farinosa* Zeller, 1847	-31 (-0.73%)	-595 (-14%)	-17 (-0.4%)	-1653 (-38.9%)	-1527 (-35.94%)	-189 (-29.3%)	-144 (-22.33%)	-27 (-4.19%)	334 (51.78%)	-519 (-80.47%)	-369 (-57.21%)	-210 (-32.56%)
184	*Gonepteryx cleopatra* (Linnaeus, 1767)	-3923 (-16.41%)	-4048 (-16.93%)	-2168 (-9.07%)	-4776 (-19.97%)	-4602 (-19.25%)	-1417 (-33.35%)	-1293 (-30.43%)	-1013 (-23.84%)	-143 (-3.37%)	-3250 (-76.49%)	-2621 (-61.69%)	-1918 (-45.14%)
186	*Lycaena phlaeas* (Linnaeus, 1761)	-41 (-1.68%)	229 (9.39%)	159 (6.52%)	-686 (-28.13%)	-487 (-19.97%)	-3372 (-14.1%)	-11453 (-47.9%)	-8526 (-35.66%)	-5057 (-21.15%)	-13177 (-55.11%)	-10086 (-42.18%)	-6765 (-28.29%)
188	*Lycaena helle* ([Schiffermüller], 1775)	2980 (37.03%)	3583 (44.52%)	2192 (27.24%)	-1764 (-21.92%)	-1262 (-15.68%)	-563 (-23.08%)	-466 (-19.11%)	-36 (-1.48%)	-197 (-8.08%)	-1201 (-49.24%)	-968 (-39.69%)	-1073 (-43.99%)
190	*Lycaena dispar* (Haworth, 1803)	-3078 (-20.77%)	-2665 (-17.98%)	-780 (-5.26%)	-4622 (-31.18%)	-3876 (-26.15%)	-1539 (-19.12%)	4375 (54.36%)	4992 (62.03%)	3656 (45.43%)	-4188 (-52.04%)	-3071 (-38.16%)	-2587 (-32.14%)
192	*Lycaena virgaureae* (Linnaeus, 1758)	102 (21.56%)	72 (15.22%)	103 (21.78%)	-247 (-52.22%)	-204 (-43.13%)	-2762 (-18.63%)	-7216 (-48.68%)	-5416 (-36.54%)	-2694 (-18.18%)	-10671 (-71.99%)	-8571 (-57.83%)	-6097 (-41.13%)
194	*Lycaena ottomana* (Lefebvre, 1830)	-1329 (-11.9%)	-636 (-5.69%)	119 (1.07%)	-4083 (-36.55%)	-3400 (-30.43%)	-182 (-38.48%)	-89 (-18.82%)	-54 (-11.42%)	264 (55.81%)	-405 (-85.62%)	-346 (-73.15%)	-220 (-46.51%)
196	*Lycaena tityrus* (Poda, 1761)	-2959 (-32.47%)	-2988 (-32.79%)	-503 (-5.52%)	-4292 (-47.1%)	-3855 (-42.3%)	-2721 (-24.36%)	-4194 (-37.54%)	-3278 (-29.34%)	-2294 (-20.53%)	-8250 (-73.85%)	-6816 (-61.01%)	-5357 (-47.95%)
198	*Lycaena alciphron* (Rottemburg, 1775)	-4808 (-34.08%)	-3282 (-23.26%)	-4111 (-29.14%)	-6020 (-42.67%)	-4839 (-34.3%)	-2545 (-27.93%)	-4303 (-47.22%)	-4297 (-47.15%)	-1861 (-20.42%)	-7612 (-83.53%)	-6740 (-73.96%)	-5247 (-57.58%)

Page		2050	2050	2050	2050	2050	2050	2080	2080	2080	2080	2080	2080
		full dispersal	full dispersal	full dispersal	no dispersal	no dispersal	no dispersal	full dispersal	full dispersal	full dispersal	no dispersal	no dispersal	no dispersal
		GRAS	BAMBU	SEDG	GRAS	BAMBU	SEDG	GRAS	BAMBU	SEDG	GRAS	BAMBU	SEDG
200	*Lycaena hippothoe* (Linnaeus, 1761)	-75 (-11.42%)	-161 (-24.51%)	192 (29.22%)	-414 (-63.01%)	-376 (-57.23%)	-5600 (-39.69%)	-8606 (-61%)	-6505 (-46.11%)	-5935 (-42.07%)	-9862 (-69.9%)	-8317 (-58.95%)	-7427 (-52.64%)
202	*Lycaena candens* (Herrich-Schäffer, 1844)	1838 (40.44%)	1632 (35.91%)	2941 (64.71%)	-1584 (-34.85%)	-1421 (-31.27%)	-289 (-43.99%)	-394 (-59.97%)	-391 (-59.51%)	70 (10.65%)	-624 (-94.98%)	-564 (-85.84%)	-343 (-52.21%)
204	*Lycaena thersamon* (Esper, 1784)	-2925 (-22.66%)	-1298 (-10.06%)	-2243 (-17.38%)	-4462 (-34.57%)	-3214 (-24.9%)	-757 (-16.66%)	2058 (45.28%)	574 (12.63%)	2327 (51.2%)	-3651 (-80.33%)	-3143 (-69.15%)	-1739 (-38.26%)
206	*Thecla betulae* (Linnaeus, 1758)	-3105 (-22.36%)	-2778 (-20.01%)	-2079 (-14.97%)	-4170 (-30.03%)	-3767 (-27.13%)	-3619 (-28.04%)	-5029 (-38.96%)	-3110 (-24.09%)	-3697 (-28.64%)	-9532 (-73.85%)	-6912 (-53.55%)	-5889 (-45.62%)
208	*Favonius quercus* (Linnaeus, 1758)	-1551 (-38.54%)	-1864 (-46.32%)	-912 (-22.66%)	-2621 (-65.13%)	-2456 (-61.03%)	-3083 (-22.2%)	-7703 (-55.47%)	-6242 (-44.95%)	-4962 (-35.73%)	-9184 (-66.14%)	-7466 (-53.77%)	-5822 (-41.93%)
210	*Laeosopis roboris* (Esper, 1793)	-316 (-79.6%)	-296 (-74.56%)	-285 (-71.79%)	-341 (-85.89%)	-315 (-79.35%)	-2173 (-54%)	-2757 (-68.51%)	-2535 (-63%)	-1773 (-44.06%)	-3709 (-92.17%)	-3335 (-82.88%)	-2963 (-73.63%)
212	*Tomares ballus* (Fabricius, 1787)	-4049 (-18.94%)	-3921 (-18.34%)	-2600 (-12.16%)	-4842 (-22.65%)	-4487 (-20.99%)	-309 (-77.83%)	-386 (-97.23%)	-340 (-85.64%)	-309 (-77.83%)	-394 (-99.24%)	-368 (-92.7%)	-358 (-90.18%)
214	*Callophrys rubi* (Linnaeus, 1758)	-275 (-63.51%)	-320 (-73.9%)	-283 (-65.36%)	-390 (-90.07%)	-378 (-87.3%)	-3401 (-15.91%)	-10212 (-47.76%)	-7570 (-35.41%)	-4212 (-19.7%)	-11497 (-53.77%)	-8595 (-40.2%)	-5250 (-24.56%)
216	*Callophrys avis* Chapman, 1909	-2827 (-25.46%)	-2141 (-19.28%)	-1917 (-17.27%)	-3629 (-32.68%)	-2955 (-26.61%)	-386 (-89.15%)	-243 (-56.12%)	-303 (-69.98%)	-294 (-67.9%)	-425 (-98.15%)	-415 (-95.84%)	-408 (-94.23%)
218	*Satyrium w-album* (Knoch, 1782)	-404 (-3.29%)	1089 (8.88%)	-289 (-2.36%)	-3596 (-29.31%)	-2245 (-18.3%)	-2641 (-23.79%)	-7380 (-66.47%)	-5644 (-50.83%)	-4836 (-43.56%)	-8657 (-77.97%)	-6698 (-60.33%)	-5477 (-49.33%)
220	*Satyrium pruni* (Linnaeus, 1758)	-1547 (-18.11%)	-2078 (-24.33%)	5 (0.06%)	-3552 (-41.59%)	-3494 (-40.91%)	-3101 (-25.27%)	-2244 (-18.29%)	-702 (-5.72%)	-255 (-2.08%)	-7988 (-65.1%)	-6066 (-49.44%)	-4671 (-38.07%)
222	*Satyrium spini* (Fabricius, 1787)	-966 (-8.9%)	-613 (-5.65%)	-164 (-1.51%)	-3370 (-31.04%)	-2924 (-26.93%)	-2382 (-27.89%)	-1885 (-22.07%)	-2494 (-29.2%)	-695 (-8.14%)	-6706 (-78.52%)	-5899 (-69.07%)	-4290 (-50.23%)
224	*Satyrium ilicis* (Esper, 1779)	-1549 (-51.46%)	-1649 (-54.78%)	-1000 (-33.22%)	-2151 (-71.46%)	-1938 (-64.39%)	-2441 (-22.49%)	-4333 (-39.91%)	-3154 (-29.05%)	-2100 (-19.34%)	-7136 (-65.73%)	-5618 (-51.75%)	-4264 (-39.28%)
226	*Satyrium esculi* (Hübner, 1804)	-399 (-5.13%)	-492 (-6.32%)	1205 (15.48%)	-3340 (-42.91%)	-2953 (-37.94%)	-1760 (-58.47%)	-2014 (-66.91%)	-2208 (-73.36%)	-1726 (-57.34%)	-2998 (-99.6%)	-2811 (-93.39%)	-2448 (-81.33%)

Page		2050 full dispersal GRAS	2050 full dispersal BAMBU	2050 full dispersal SEDG	2050 no dispersal GRAS	2050 no dispersal BAMBU	2050 no dispersal SEDG	2080 full dispersal GRAS	2080 full dispersal BAMBU	2080 full dispersal SEDG	2080 no dispersal GRAS	2080 no dispersal BAMBU	2080 no dispersal SEDG
228	*Satyrium acaciae* (Fabricius, 1787)	950 (14.89%)	815 (12.77%)	1279 (20.04%)	-1240 (-19.43%)	-1156 (-18.12%)	-2303 (-29.59%)	-2206 (-28.34%)	-1287 (-16.53%)	57 (0.73%)	-6127 (-78.71%)	-5311 (-68.23%)	-3942 (-50.64%)
230	*Lampides boeticus* (Linnaeus, 1767)	-310 (-38.75%)	-277 (-34.62%)	-207 (-25.87%)	-557 (-69.62%)	-464 (-58%)	-1030 (-16.14%)	-722 (-11.31%)	10 (0.16%)	885 (13.87%)	-3666 (-57.45%)	-2770 (-43.41%)	-1663 (-26.06%)
232	*Cacyreus marshalli* (Butler, 1898)	654 (11.95%)	259 (4.73%)	998 (18.23%)	-1120 (-20.46%)	-868 (-15.85%)	-437 (-54.62%)	-629 (-78.62%)	-592 (-74%)	-661 (-82.62%)	-800 (-100%)	-780 (-97.5%)	-746 (-93.25%)
234	*Leptotes pirithous* (Linnaeus, 1767)	-619 (-75.3%)	-619 (-75.3%)	-528 (-64.23%)	-666 (-81.02%)	-643 (-78.22%)	-759 (-13.86%)	838 (15.31%)	-30 (-0.55%)	800 (14.61%)	-3855 (-70.41%)	-2922 (-53.37%)	-1775 (-32.42%)
236	*Zizeeria knysna* (Trimen, 1862)	-3245 (-24.15%)	-2256 (-16.79%)	-2124 (-15.81%)	-4134 (-30.77%)	-3275 (-24.37%)	-582 (-70.8%)	-711 (-86.5%)	-759 (-92.34%)	-575 (-69.95%)	-815 (-99.15%)	-797 (-96.96%)	-708 (-86.13%)
238	*Cupido minimus* (Fuessly, 1775)	-566 (-50.72%)	-506 (-45.34%)	-470 (-42.11%)	-961 (-86.11%)	-847 (-75.9%)	-3032 (-22.56%)	-6299 (-46.88%)	-4491 (-33.42%)	-4157 (-30.94%)	-8702 (-64.76%)	-6672 (-49.65%)	-5451 (-40.57%)
240	*Cupido osiris* (Meigen, 1829)	746 (4.96%)	1387 (9.23%)	1445 (9.62%)	-2692 (-17.92%)	-2139 (-14.24%)	-810 (-72.58%)	-373 (-33.42%)	-427 (-38.26%)	-154 (-13.8%)	-1101 (-98.66%)	-1039 (-93.1%)	-1003 (-89.87%)
242	*Cupido argiades* (Pallas, 1771)	147 (7.21%)	-308 (-15.1%)	775 (37.99%)	-1582 (-77.55%)	-1568 (-76.86%)	-1822 (-12.13%)	626 (4.17%)	1482 (9.86%)	1257 (8.37%)	-7883 (-52.46%)	-5685 (-37.83%)	-3979 (-26.48%)
244	*Cupido decoloratus* (Staudinger, 1886)	473 (21.42%)	796 (36.05%)	321 (14.54%)	-933 (-42.26%)	-717 (-32.47%)	-940 (-46.08%)	-879 (-43.09%)	-933 (-45.74%)	-651 (-31.91%)	-2031 (-99.56%)	-2007 (-98.38%)	-1757 (-86.13%)
246	*Cupido alcetas* (Hoffmansegg, 1804)	-2795 (-13.69%)	-2646 (-12.96%)	-1703 (-8.34%)	-4341 (-21.26%)	-3670 (-17.97%)	-714 (-32.34%)	1325 (60.01%)	1782 (80.71%)	1589 (71.97%)	-1785 (-80.84%)	-1328 (-60.14%)	-1036 (-46.92%)
248	*Celastrina argiolus* (Linnaeus, 1758)	-401 (-15.17%)	15 (0.57%)	-226 (-8.55%)	-1295 (-49%)	-964 (-36.47%)	-3387 (-16.59%)	-6682 (-32.72%)	-5101 (-24.98%)	-2427 (-11.88%)	-10036 (-49.14%)	-7524 (-36.84%)	-4943 (-24.2%)
250	*Scolitantides baton* (Bergsträsser, 1779)	1968 (36.49%)	383 (7.1%)	2985 (55.35%)	-962 (-17.84%)	-1599 (-29.65%)	-1037 (-39.24%)	-847 (-32.05%)	-88 (-3.33%)	-81 (-3.06%)	-2209 (-83.58%)	-1433 (-54.22%)	-1179 (-44.61%)
252	*Scolitantides vicrama* (Moore, 1865)	-1074 (-40.09%)	-1287 (-48.04%)	-567 (-21.16%)	-1454 (-54.27%)	-1366 (-50.99%)	-353 (-6.55%)	2622 (48.62%)	309 (5.73%)	2198 (40.76%)	-3135 (-58.13%)	-2974 (-55.15%)	-1457 (-27.02%)
254	*Scolitantides abencerragus* (Pierret, 1837)	74 (17.29%)	36 (8.41%)	142 (33.18%)	-210 (-49.07%)	-182 (-42.52%)	-1068 (-39.87%)	-2531 (-94.48%)	-2301 (-85.89%)	-1568 (-58.53%)	-2614 (-97.57%)	-2392 (-89.29%)	-1822 (-68.01%)

Page		2050	2050	2050	2050	2050	2050	2080	2080	2080	2080	2080	2080
		full dispersal	full dispersal	full dispersal	no dispersal	no dispersal	no dispersal	full dispersal	full dispersal	full dispersal	no dispersal	no dispersal	no dispersal
		GRAS	**BAMBU**	**SEDG**	**GRAS**	**BAMBU**	**SEDG**	**GRAS**	**BAMBU**	**SEDG**	**GRAS**	**BAMBU**	**SEDG**
256	*Scolitantides bavius* (Eversmann, 1832)	-1532 (-24.43%)	-1291 (-20.59%)	-24 (-0.38%)	-2699 (-43.05%)	-2663 (-42.47%)	-170 (-39.72%)	-70 (-16.36%)	-124 (-28.97%)	307 (71.73%)	-406 (-94.86%)	-331 (-77.34%)	-230 (-53.74%)
258	*Scolitantides orion* (Pallas, 1771)	-1146 (-76.76%)	-1124 (-75.28%)	-867 (-58.07%)	-1207 (-80.84%)	-1130 (-75.69%)	-1835 (-29.27%)	-2649 (-42.25%)	-2659 (-42.41%)	-1446 (-23.06%)	-5527 (-88.15%)	-4917 (-78.42%)	-3844 (-61.31%)
260	*Scolitantides panoptes* (Hübner, 1813)	1267 (8.08%)	2034 (12.98%)	2477 (15.8%)	-2065 (-13.17%)	-1448 (-9.24%)	-971 (-65.04%)	-1493 (-100%)	-1493 (-100%)	-1324 (-88.68%)	-1493 (-100%)	-1493 (-100%)	-1344 (-90.02%)
262	*Glaucopsyche alexis* (Poda, 1761)	-1333 (-37.27%)	-1708 (-47.75%)	-720 (-20.13%)	-2464 (-68.88%)	-2238 (-62.57%)	-1128 (-7.2%)	1591 (10.15%)	1588 (10.13%)	3155 (20.13%)	-6785 (-43.28%)	-5095 (-32.5%)	-2810 (-17.93%)
264	*Glaucopsyche melanops* (Boisduval, 1828)	-974 (-29.45%)	-1610 (-48.68%)	-102 (-3.08%)	-1849 (-55.91%)	-1909 (-57.73%)	-2069 (-57.84%)	-2032 (-56.81%)	-2319 (-64.83%)	-1767 (-49.4%)	-3524 (-98.52%)	-3287 (-91.89%)	-2884 (-80.63%)
266	*Iolana iolas* (Ochsenheimer, 1816)	-2206 (-16.66%)	-330 (-2.49%)	-992 (-7.49%)	-4172 (-31.51%)	-2858 (-21.58%)	-1371 (-41.46%)	-2596 (-78.5%)	-2625 (-79.38%)	-1564 (-47.29%)	-3186 (-96.34%)	-2938 (-88.84%)	-2149 (-64.98%)
268	*Phengaris arion* (Linnaeus, 1758)	-1537 (-23.71%)	-551 (-8.5%)	-35 (-0.54%)	-3224 (-49.73%)	-2612 (-40.29%)	-3076 (-23.23%)	-3006 (-22.7%)	-1732 (-13.08%)	-1865 (-14.08%)	-8692 (-65.64%)	-6599 (-49.83%)	-5421 (-40.94%)
270	*Phengaris teleius* (Bergsträsser, 1779)	-1451 (-40.09%)	-699 (-19.31%)	-830 (-22.93%)	-2501 (-69.11%)	-1960 (-54.16%)	-2184 (-33.69%)	-2476 (-38.19%)	-1587 (-24.48%)	-1008 (-15.55%)	-5731 (-88.4%)	-4723 (-72.85%)	-3984 (-61.45%)
272	*Phengaris nausithous* (Bergsträsser, 1779)	-1388 (-20.89%)	375 (5.65%)	-800 (-12.04%)	-2689 (-40.48%)	-1448 (-21.8%)	-1999 (-55.24%)	-2334 (-64.49%)	-1716 (-47.42%)	-789 (-21.8%)	-3460 (-95.61%)	-3061 (-84.58%)	-2643 (-73.03%)
274	*Phengaris alcon* ([Schiffermüller], 1775)	-2138 (-11.19%)	-1803 (-9.44%)	-889 (-4.65%)	-4148 (-21.71%)	-3361 (-17.59%)	-2001 (-30.12%)	-2097 (-31.57%)	-1062 (-15.99%)	-741 (-11.15%)	-4883 (-73.51%)	-3525 (-53.06%)	-2794 (-42.06%)
276	*Plebejus argus* (Linnaeus, 1758)	-5296 (-28.72%)	-4401 (-23.87%)	-3965 (-21.5%)	-5309 (-28.79%)	-4419 (-23.97%)	-3151 (-16.49%)	-4123 (-21.58%)	-3038 (-15.9%)	-865 (-4.53%)	-9598 (-50.23%)	-7385 (-38.65%)	-5024 (-26.29%)
278	*Plebejus idas* (Linnaeus, 1761)	267 (4.78%)	1176 (21.05%)	995 (17.81%)	-2681 (-47.98%)	-2065 (-36.95%)	-3996 (-21.67%)	-9992 (-54.19%)	-7986 (-43.31%)	-6083 (-32.99%)	-10023 (-54.36%)	-8006 (-43.42%)	-6192 (-33.58%)
280	*Plebejus argyrognomon* (Bergsträsser, 1779)	-3065 (-30.37%)	-2803 (-27.77%)	-2975 (-29.48%)	-3153 (-31.24%)	-2907 (-28.8%)	-1883 (-33.7%)	-655 (-11.72%)	297 (5.31%)	760 (13.6%)	-4776 (-85.47%)	-4064 (-72.73%)	-3178 (-56.87%)
282	*Plebejus optilete* (Knoch, 1781)	-2 (-0.47%)	94 (22.12%)	14 (3.29%)	-237 (-55.76%)	-189 (-44.47%)	-3104 (-30.76%)	-6135 (-60.79%)	-4949 (-49.04%)	-4367 (-43.27%)	-6209 (-61.52%)	-5057 (-50.11%)	-4580 (-45.38%)

Page		2050 full dispersal GRAS	2050 full dispersal BAMBU	2050 full dispersal SEDG	2050 no dispersal GRAS	2050 no dispersal BAMBU	2050 no dispersal SEDG	2080 full dispersal GRAS	2080 full dispersal BAMBU	2080 full dispersal SEDG	2080 no dispersal GRAS	2080 no dispersal BAMBU	2080 no dispersal SEDG
284	*Plebejus glandon* (Prunner, 1798)	-497 (-71.51%)	-479 (-68.92%)	-462 (-66.47%)	-553 (-79.57%)	-537 (-77.27%)	-229 (-53.88%)	-235 (-55.29%)	-93 (-21.88%)	-221 (-52%)	-363 (-85.41%)	-283 (-66.59%)	-348 (-81.88%)
286	*Plebejus aquilo* (Boisduval, 1832)	-299 (-24.07%)	-226 (-18.2%)	-234 (-18.84%)	-397 (-31.96%)	-333 (-26.81%)	-529 (-76.12%)	-682 (-98.13%)	-646 (-92.95%)	-562 (-80.86%)	-695 (-100%)	-685 (-98.56%)	-637 (-91.65%)
288	*Plebejus orbitulus* (Prunner, 1798)	3 (0.25%)	-143 (-12.03%)	743 (62.49%)	-833 (-70.06%)	-760 (-63.92%)	-356 (-28.66%)	-493 (-39.69%)	-365 (-29.39%)	-352 (-28.34%)	-615 (-49.52%)	-489 (-39.37%)	-505 (-40.66%)
290	*Plebejus sephirus* (Frivaldszky, 1835)	-5616 (-41.94%)	-4609 (-34.42%)	-3820 (-28.53%)	-6091 (-45.49%)	-5017 (-37.47%)	-676 (-56.85%)	-100 (-8.41%)	-441 (-37.09%)	330 (27.75%)	-1115 (-93.78%)	-1020 (-85.79%)	-853 (-71.74%)
292	*Aricia eumedon* (Esper, 1780)	-1591 (-64.39%)	-1563 (-63.25%)	-1273 (-51.52%)	-1843 (-74.59%)	-1648 (-66.69%)	-4459 (-33.3%)	-7151 (-53.41%)	-6493 (-48.5%)	-3967 (-29.63%)	-7854 (-58.66%)	-7131 (-53.26%)	-4888 (-36.51%)
294	*Aricia cramera* (Eschscholtz, 1821)	-837 (-5.49%)	-354 (-2.32%)	299 (1.96%)	-3631 (-23.81%)	-3124 (-20.48%)	-1505 (-60.91%)	-1950 (-78.92%)	-2054 (-83.12%)	-1692 (-68.47%)	-2448 (-99.07%)	-2346 (-94.94%)	-2033 (-82.27%)
296	*Aricia agestis* ([Schiffermüller], 1775)	-4476 (-46.3%)	-4891 (-50.59%)	-3340 (-34.55%)	-4601 (-47.59%)	-4985 (-51.56%)	-2499 (-16.38%)	-4787 (-31.38%)	-3463 (-22.7%)	-2279 (-14.94%)	-8715 (-57.14%)	-6939 (-45.49%)	-4933 (-32.34%)
298	*Aricia artaxerxes* (Fabricius, 1793)	-593 (-69.03%)	-606 (-70.55%)	-458 (-53.32%)	-755 (-87.89%)	-683 (-79.51%)	-3708 (-38.35%)	-7886 (-81.57%)	-7110 (-73.54%)	-4943 (-51.13%)	-8037 (-83.13%)	-7262 (-75.11%)	-5186 (-53.64%)
300	*Aricia montensis* (Verity, 1928)	-70 (-13.92%)	-64 (-12.72%)	63 (12.52%)	-335 (-66.6%)	-300 (-59.64%)	-618 (-71.94%)	-464 (-54.02%)	-605 (-70.43%)	-591 (-68.8%)	-840 (-97.79%)	-819 (-95.34%)	-804 (-93.6%)
302	*Aricia anteros* (Freyer, 1838)	-1255 (-29.18%)	-1380 (-32.09%)	-434 (-10.09%)	-1467 (-34.11%)	-1528 (-35.53%)	-252 (-50.1%)	-355 (-70.58%)	-300 (-59.64%)	113 (22.47%)	-488 (-97.02%)	-445 (-88.47%)	-285 (-56.66%)
304	*Aricia nicias* (Meigen, 1829)	-1510 (-8.7%)	-349 (-2.01%)	-131 (-0.75%)	-3763 (-21.68%)	-2498 (-14.39%)	-814 (-18.93%)	-1952 (-45.38%)	-1611 (-37.46%)	-207 (-4.81%)	-2625 (-61.03%)	-2242 (-52.13%)	-1031 (-23.97%)
306	*Cyaniris semiargus* (Rottemburg, 1775)	-1243 (-53.81%)	-1061 (-45.93%)	-889 (-38.48%)	-1873 (-81.08%)	-1633 (-70.69%)	-2574 (-14.83%)	-4868 (-28.04%)	-2792 (-16.08%)	-792 (-4.56%)	-8323 (-47.95%)	-6166 (-35.52%)	-4238 (-24.41%)
308	*Polyommatus escheri* (Hübner, 1823)	-1804 (-39.91%)	-1526 (-33.76%)	-949 (-21%)	-2684 (-59.38%)	-2328 (-51.5%)	-1562 (-67.62%)	-1178 (-51%)	-1188 (-51.43%)	-788 (-34.11%)	-2268 (-98.18%)	-2116 (-91.6%)	-1988 (-86.06%)
310	*Polyommatus dorylas* ([Schiffermüller], 1775)	-446 (-95.5%)	-434 (-92.93%)	-378 (-80.94%)	-448 (-95.93%)	-434 (-92.93%)	-2030 (-44.91%)	-1903 (-42.1%)	-1383 (-30.6%)	-372 (-8.23%)	-3725 (-82.41%)	-3262 (-72.17%)	-2706 (-59.87%)

Page		2050	2050	2050	2050	2050	2050	2080	2080	2080	2080	2080	2080
		full dispersal	full dispersal	full dispersal	no dispersal	no dispersal	no dispersal	full dispersal	full dispersal	full dispersal	no dispersal	no dispersal	no dispersal
		GRAS	**BAMBU**	**SEDG**	**GRAS**	**BAMBU**	**SEDG**	**GRAS**	**BAMBU**	**SEDG**	**GRAS**	**BAMBU**	**SEDG**
312	*Polyommatus nivescens* (Keferstein, 1851)	-4505 (-44.66%)	-5353 (-53.07%)	-2889 (-28.64%)	-5013 (-49.7%)	-5575 (-55.27%)	-392 (-83.94%)	-467 (-100%)	-467 (-100%)	-466 (-99.79%)	-467 (-100%)	-467 (-100%)	-466 (-99.79%)
314	*Polyommatus amandus* (Schneider 1792)	-140 (-2.01%)	-278 (-3.99%)	787 (11.31%)	-2824 (-40.58%)	-2569 (-36.92%)	-3583 (-35.52%)	-8935 (-88.58%)	-8257 (-81.86%)	-6907 (-68.47%)	-9088 (-90.1%)	-8426 (-83.53%)	-7321 (-72.58%)
316	*Polyommatus thersites* (Cantener, 1834)	-3054 (-12.06%)	-2902 (-11.46%)	-1508 (-5.96%)	-4374 (-17.27%)	-3836 (-15.15%)	-2140 (-30.75%)	-1437 (-20.65%)	-746 (-10.72%)	279 (4.01%)	-5673 (-81.52%)	-4622 (-66.42%)	-3388 (-48.69%)
318	*Polyommatus icarus* (Rottemburg, 1775)	-1162 (-43.83%)	-968 (-36.51%)	-880 (-33.2%)	-1322 (-49.87%)	-1130 (-42.63%)	-3252 (-12.84%)	-7231 (-28.56%)	-5208 (-20.57%)	-2279 (-9%)	-10608 (-41.9%)	-7950 (-31.4%)	-5242 (-20.7%)
320	*Polyommatus eros* (Ochsenheimer, 1808)	-2615 (-30.83%)	-3054 (-36%)	-599 (-7.06%)	-3487 (-41.11%)	-3575 (-42.14%)	-1087 (-41%)	-1399 (-52.77%)	-1167 (-44.02%)	-1071 (-40.4%)	-1855 (-69.97%)	-1570 (-59.22%)	-1530 (-57.71%)
322	*Polyommatus daphnis* ([Schiffermüller], 1775)	285 (2.33%)	1018 (8.31%)	1560 (12.74%)	-3061 (-25%)	-2600 (-21.23%)	-2243 (-26.44%)	-3937 (-46.41%)	-4525 (-53.34%)	-2162 (-25.49%)	-7016 (-82.71%)	-6338 (-74.71%)	-4723 (-55.68%)
324	*Polyommatus bellargus* (Rottemburg, 1775)	-917 (-10.41%)	384 (4.36%)	304 (3.45%)	-3587 (-40.73%)	-2645 (-30.04%)	-2047 (-16.72%)	-1117 (-9.12%)	-405 (-3.31%)	411 (3.36%)	-6854 (-55.97%)	-5496 (-44.88%)	-3601 (-29.41%)
326	*Polyommatus coridon* (Poda, 1761)	145 (18.31%)	68 (8.59%)	170 (21.46%)	-608 (-76.77%)	-559 (-70.58%)	-2524 (-28.66%)	-1527 (-17.34%)	-838 (-9.52%)	-501 (-5.69%)	-6483 (-73.62%)	-5197 (-59.02%)	-4088 (-46.42%)
328	*Polyommatus hispanus* (Herrich-Schäffer, 1851)	-498 (-52.42%)	-691 (-72.74%)	-457 (-48.11%)	-707 (-74.42%)	-700 (-73.68%)	-557 (-70.33%)	151 (19.07%)	214 (27.02%)	500 (63.13%)	-787 (-99.37%)	-739 (-93.31%)	-656 (-82.83%)
330	*Polyommatus albicans* (Herrich-Schäffer, 1851)	-39 (-2.54%)	-452 (-29.41%)	568 (36.96%)	-1076 (-70.01%)	-1020 (-66.36%)	-598 (-62.95%)	-922 (-97.05%)	-946 (-99.58%)	-924 (-97.26%)	-950 (-100%)	-950 (-100%)	-926 (-97.47%)
332	*Polyommatus admetus* (Esper, 1785)	-349 (-75.87%)	-342 (-74.35%)	-290 (-63.04%)	-384 (-83.48%)	-372 (-80.87%)	-842 (-54.78%)	-915 (-59.53%)	-1004 (-65.32%)	-150 (-9.76%)	-1464 (-95.25%)	-1357 (-88.29%)	-1016 (-66.1%)
334	*Polyommatus ripartii* (Freyer, 1830)	-34 (-15.89%)	-90 (-42.06%)	-58 (-27.1%)	-202 (-94.39%)	-192 (-89.72%)	-336 (-73.04%)	-447 (-97.17%)	-406 (-88.26%)	-359 (-78.04%)	-456 (-99.13%)	-433 (-94.13%)	-408 (-88.7%)
336	*Polyommatus dolus* (Hübner, 1823)	-1112 (-47.56%)	-850 (-36.36%)	-660 (-28.23%)	-1526 (-65.27%)	-1277 (-54.62%)	-190 (-88.79%)	-79 (-36.92%)	-97 (-45.33%)	105 (49.07%)	-214 (-100%)	-214 (-100%)	-208 (-97.2%)
338	*Polyommatus damon* ([Schiffermüller], 1775)	-686 (-11.05%)	529 (8.52%)	55 (0.89%)	-2928 (-47.17%)	-2161 (-34.82%)	-1169 (-50%)	-1409 (-60.27%)	-1091 (-46.66%)	-857 (-36.66%)	-2009 (-85.93%)	-1769 (-75.66%)	-1653 (-70.7%)

Page		2050 full dispersal GRAS	2050 full dispersal BAMBU	2050 full dispersal SEDG	2050 no dispersal GRAS	2050 no dispersal BAMBU	2050 no dispersal SEDG	2080 full dispersal GRAS	2080 full dispersal BAMBU	2080 full dispersal SEDG	2080 no dispersal GRAS	2080 no dispersal BAMBU	2080 no dispersal SEDG
340	*Hamearis lucina* (Linnaeus, 1758)	-1165 (-31.62%)	-1280 (-34.74%)	-582 (-15.8%)	-2165 (-58.77%)	-1946 (-52.82%)	-2192 (-35.31%)	-1480 (-23.84%)	-452 (-7.28%)	-249 (-4.01%)	-5148 (-82.94%)	-4008 (-64.57%)	-3222 (-51.91%)
342	*Libythea celtis* (Laicharting, 1782)	-2577 (-14.1%)	-2110 (-11.55%)	-1366 (-7.47%)	-4369 (-23.91%)	-3766 (-20.61%)	-1642 (-44.57%)	-1312 (-35.61%)	-1635 (-44.38%)	-813 (-22.07%)	-3409 (-92.54%)	-3068 (-83.28%)	-2341 (-63.55%)
344	*Argynnis paphia* (Linnaeus, 1758)	-587 (-10.8%)	-1933 (-35.58%)	1193 (21.96%)	-2566 (-47.23%)	-2556 (-47.05%)	-3351 (-18.34%)	-6457 (-35.33%)	-4872 (-26.66%)	-2912 (-15.93%)	-11083 (-60.64%)	-8253 (-45.16%)	-5757 (-31.5%)
346	*Argynnis pandora* ([Schiffermüller], 1775)	-2885 (-14.04%)	-2865 (-13.94%)	-1213 (-5.9%)	-4947 (-24.07%)	-4599 (-22.38%)	-1626 (-29.93%)	-2148 (-39.54%)	-3121 (-57.45%)	-1599 (-29.43%)	-4744 (-87.32%)	-4172 (-76.79%)	-3246 (-59.75%)
348	*Argynnis aglaja* (Linnaeus, 1758)	-3720 (-26.2%)	-2493 (-17.56%)	-1589 (-11.19%)	-4865 (-34.26%)	-3556 (-25.04%)	-3328 (-16.19%)	-9906 (-48.2%)	-7493 (-36.46%)	-4162 (-20.25%)	-13024 (-63.37%)	-10512 (-51.15%)	-7016 (-34.14%)
350	*Argynnis adippe* ([Schiffermüller], 1775)	-2562 (-15.49%)	-2109 (-12.75%)	-1295 (-7.83%)	-3948 (-23.87%)	-3441 (-20.81%)	-2919 (-20.56%)	-8102 (-57.06%)	-5935 (-41.8%)	-3763 (-26.5%)	-10604 (-74.68%)	-8143 (-57.35%)	-5920 (-41.69%)
352	*Argynnis niobe* (Linnaeus, 1758)	-443 (-8.93%)	201 (4.05%)	-679 (-13.69%)	-2242 (-45.19%)	-1794 (-36.16%)	-2967 (-17.94%)	-7117 (-43.03%)	-5110 (-30.9%)	-3322 (-20.09%)	-10289 (-62.21%)	-7946 (-48.04%)	-6045 (-36.55%)
354	*Argynnis laodice* (Pallas, 1771)	-2031 (-14.45%)	-2545 (-18.1%)	-770 (-5.48%)	-3944 (-28.05%)	-4088 (-29.08%)	-2209 (-44.53%)	167 (3.37%)	960 (19.35%)	-358 (-7.22%)	-3849 (-77.59%)	-3083 (-62.14%)	-2923 (-58.92%)
356	*Issoria lathonia* (Linnaeus, 1758)	-2704 (-19.61%)	-2329 (-16.89%)	-2157 (-15.64%)	-5157 (-37.4%)	-4748 (-34.44%)	-2836 (-20.17%)	-7632 (-54.28%)	-6471 (-46.02%)	-4326 (-30.77%)	-10003 (-71.15%)	-8591 (-61.1%)	-6463 (-45.97%)
358	*Brenthis ino* (Rottemburg, 1775)	763 (13.85%)	1916 (34.78%)	1518 (27.55%)	-1779 (-32.29%)	-1365 (-24.78%)	-4631 (-33.59%)	-6908 (-50.1%)	-4906 (-35.58%)	-4126 (-29.92%)	-10472 (-75.95%)	-8460 (-61.36%)	-7216 (-52.34%)
360	*Brenthis daphne* (Bergsträsser, 1780)	-270 (-7.08%)	-589 (-15.44%)	554 (14.53%)	-2292 (-60.09%)	-2135 (-55.98%)	-1190 (-21.6%)	1929 (35.02%)	2007 (36.43%)	2653 (48.16%)	-3676 (-66.73%)	-2868 (-52.06%)	-1927 (-34.98%)
362	*Brenthis hecate* ([Schiffermüller], 1775)	-1564 (-19.66%)	-1220 (-15.34%)	-1589 (-19.98%)	-1760 (-22.13%)	-1399 (-17.59%)	-1741 (-45.65%)	-508 (-13.32%)	-554 (-14.53%)	-217 (-5.69%)	-3442 (-90.25%)	-3243 (-85.03%)	-2542 (-66.65%)
364	*Boloria eunomia* (Esper, 1799)	-5707 (-26.51%)	-3553 (-16.5%)	-4042 (-18.77%)	-5782 (-26.86%)	-3587 (-16.66%)	-1783 (-22.42%)	-3171 (-39.87%)	-2410 (-30.3%)	-1843 (-23.17%)	-3443 (-43.29%)	-2747 (-34.54%)	-2291 (-28.8%)
366	*Boloria euphrosyne* (Linnaeus, 1758)	-580 (-30.37%)	-151 (-7.91%)	-377 (-19.74%)	-874 (-45.76%)	-525 (-27.49%)	-4132 (-19.19%)	-8912 (-41.4%)	-7044 (-32.72%)	-4372 (-20.31%)	-9059 (-42.08%)	-7118 (-33.06%)	-4649 (-21.59%)

Page		2050 full dispersal GRAS	2050 full dispersal BAMBU	2050 full dispersal SEDG	2050 no dispersal GRAS	2050 no dispersal BAMBU	2050 no dispersal SEDG	2080 full dispersal GRAS	2080 full dispersal BAMBU	2080 full dispersal SEDG	2080 no dispersal GRAS	2080 no dispersal BAMBU	2080 no dispersal SEDG
368	*Boloria titania* (Esper, 1793)	-6093 (-29.77%)	-5114 (-24.99%)	-4708 (-23%)	-6442 (-31.47%)	-5424 (-26.5%)	-766 (-40.1%)	492 (25.76%)	570 (29.84%)	116 (6.07%)	-1181 (-61.83%)	-926 (-48.48%)	-863 (-45.18%)
370	*Boloria selene* ([Schiffermüller], 1775)	-518 (-98.11%)	-518 (-98.11%)	-519 (-98.3%)	-524 (-99.24%)	-521 (-98.67%)	-5037 (-24.61%)	-10443 (-51.02%)	-8549 (-41.77%)	-6291 (-30.74%)	-10927 (-53.39%)	-8996 (-43.95%)	-6771 (-33.08%)
372	*Boloria chariclea* (Schneider, 1794)	-1581 (-28.71%)	-1434 (-26.04%)	-1904 (-34.57%)	-1593 (-28.93%)	-1446 (-26.26%)	-523 (-99.05%)	-528 (-100%)	-526 (-99.62%)	-512 (-96.97%)	-528 (-100%)	-528 (-100%)	-528 (-100%)
374	*Boloria freija* (Becklin, 1791)	-2 (-0.02%)	1436 (17.22%)	1212 (14.54%)	-3190 (-38.26%)	-2450 (-29.38%)	-1930 (-35.05%)	-4189 (-76.07%)	-3324 (-60.36%)	-3654 (-66.35%)	-4197 (-76.21%)	-3340 (-60.65%)	-3670 (-66.64%)
376	*Boloria dia* (Linnaeus, 1767)	-365 (-22.48%)	-237 (-14.59%)	-200 (-12.32%)	-471 (-29%)	-370 (-22.78%)	-2342 (-28.09%)	605 (7.26%)	892 (10.7%)	1325 (15.89%)	-6394 (-76.69%)	-5229 (-62.71%)	-4030 (-48.33%)
378	*Boloria thore* (Hübner, 1806)	-1842 (-30.98%)	-1331 (-22.39%)	-1825 (-30.7%)	-1949 (-32.78%)	-1457 (-24.51%)	-396 (-24.38%)	388 (23.89%)	229 (14.1%)	579 (35.65%)	-549 (-33.81%)	-437 (-26.91%)	-405 (-24.94%)
380	*Boloria frigga* (Becklin, 1791)	-520 (-34.3%)	-286 (-18.87%)	-359 (-23.68%)	-631 (-41.62%)	-463 (-30.54%)	-1919 (-32.28%)	-3189 (-53.64%)	-2550 (-42.89%)	-3317 (-55.79%)	-3323 (-55.9%)	-2690 (-45.25%)	-3406 (-57.29%)
382	*Boloria pales* ([Schiffermüller], 1775)	-2362 (-28.89%)	-1964 (-24.02%)	-2371 (-29%)	-2625 (-32.1%)	-2230 (-27.27%)	-493 (-32.52%)	-631 (-41.62%)	-417 (-27.51%)	-533 (-35.16%)	-1002 (-66.09%)	-782 (-51.58%)	-808 (-53.3%)
384	*Boloria aquilonaris* (Stichel, 1908)	-4073 (-18.04%)	-4288 (-19%)	-2683 (-11.89%)	-5063 (-22.43%)	-4857 (-21.52%)	-2668 (-32.63%)	-4789 (-58.57%)	-3717 (-45.46%)	-3359 (-41.08%)	-5019 (-61.38%)	-4025 (-49.22%)	-3768 (-46.08%)
386	*Boloria graeca* (Staudinger, 1870)	-3350 (-16.64%)	-4224 (-20.98%)	-1792 (-8.9%)	-5180 (-25.73%)	-5073 (-25.19%)	-353 (-73.39%)	-259 (-53.85%)	-330 (-68.61%)	-197 (-40.96%)	-433 (-90.02%)	-418 (-86.9%)	-370 (-76.92%)
388	*Vanessa atalanta* (Linnaeus, 1758)	-2035 (-9.94%)	-1744 (-8.51%)	-1220 (-5.96%)	-4094 (-19.99%)	-3602 (-17.59%)	-3874 (-17.16%)	-11874 (-52.6%)	-8963 (-39.7%)	-5008 (-22.18%)	-13684 (-60.62%)	-10381 (-45.99%)	-6755 (-29.92%)
390	*Vanessa cardui* (Linnaeus, 1758)	-3835 (-17.58%)	-3394 (-15.56%)	-2522 (-11.56%)	-4718 (-21.62%)	-4153 (-19.03%)	-3883 (-19.28%)	-9272 (-46.05%)	-7054 (-35.03%)	-2799 (-13.9%)	-11805 (-58.63%)	-9170 (-45.54%)	-5567 (-27.65%)
392	*Aglais io* (Linnaeus, 1758)	-1943 (-9.08%)	-1830 (-8.55%)	-811 (-3.79%)	-3916 (-18.3%)	-3404 (-15.91%)	-3269 (-15.96%)	-5130 (-25.05%)	-3006 (-14.68%)	-1718 (-8.39%)	-10412 (-50.83%)	-7383 (-36.04%)	-5136 (-25.07%)
394	*Aglais urticae* (Linnaeus, 1758)	348 (19.55%)	309 (17.36%)	283 (15.9%)	-414 (-23.26%)	-330 (-18.54%)	-3317 (-15.2%)	-10097 (-46.28%)	-7863 (-36.04%)	-4391 (-20.13%)	-12111 (-55.51%)	-9692 (-44.42%)	-5898 (-27.03%)

Page		2050 full dispersal GRAS	2050 full dispersal BAMBU	2050 full dispersal SEDG	2050 no dispersal GRAS	2050 no dispersal BAMBU	2050 no dispersal SEDG	2080 full dispersal GRAS	2080 full dispersal BAMBU	2080 full dispersal SEDG	2080 no dispersal GRAS	2080 no dispersal BAMBU	2080 no dispersal SEDG
396	*Nymphalis c-album* (LINNAEUS, 1758)	-2083 (-12.94%)	-1047 (-6.5%)	-886 (-5.5%)	-3979 (-24.71%)	-2840 (-17.64%)	-2936 (-13.72%)	-5154 (-24.09%)	-3567 (-16.67%)	-1279 (-5.98%)	-9934 (-46.42%)	-7489 (-35%)	-5032 (-23.52%)
398	*Nymphalis egea* (CRAMER, 1775)	-2864 (-18.06%)	-2991 (-18.86%)	-1494 (-9.42%)	-4403 (-27.76%)	-4236 (-26.71%)	-368 (-20.67%)	1380 (77.53%)	709 (39.83%)	937 (52.64%)	-1161 (-65.22%)	-784 (-44.04%)	-471 (-26.46%)
400	*Nymphalis antiopa* (LINNAEUS, 1758)	-272 (-6.62%)	-155 (-3.77%)	-292 (-7.1%)	-2183 (-53.1%)	-1981 (-48.19%)	-2806 (-17.43%)	-5251 (-32.61%)	-3635 (-22.57%)	-805 (-5%)	-8017 (-49.79%)	-6079 (-37.75%)	-3615 (-22.45%)
402	*Nymphalis polychloros* (LINNAEUS, 1758)	90 (1.72%)	1514 (28.91%)	101 (1.93%)	-1836 (-35.06%)	-850 (-16.23%)	-3210 (-20.24%)	-8220 (-51.83%)	-6995 (-44.1%)	-4926 (-31.06%)	-10595 (-66.8%)	-8952 (-56.44%)	-6669 (-42.05%)
404	*Nymphalis xanthomelas* (ESPER, 1781)	-1214 (-9.54%)	-231 (-1.82%)	-750 (-5.89%)	-3737 (-29.37%)	-2980 (-23.42%)	-1789 (-43.52%)	-2297 (-55.87%)	-1738 (-42.28%)	-2210 (-53.76%)	-4031 (-98.05%)	-3683 (-89.59%)	-3846 (-93.55%)
406	*Nymphalis l-album* (ESPER, 1780)	-1086 (-82.27%)	-1047 (-79.32%)	-1047 (-79.32%)	-1095 (-82.95%)	-1057 (-80.08%)	-1761 (-33.63%)	3035 (57.95%)	3350 (63.97%)	3311 (63.22%)	-2884 (-55.07%)	-2324 (-44.38%)	-1611 (-30.76%)
408	*Araschnia levana* (LINNAEUS, 1758)	-132 (-33.42%)	-80 (-20.25%)	-77 (-19.49%)	-180 (-45.57%)	-149 (-37.72%)	-3045 (-23.93%)	-2943 (-23.13%)	-1661 (-13.05%)	-2108 (-16.57%)	-9390 (-73.79%)	-7261 (-57.06%)	-5787 (-45.48%)
410	*Euphydryas iduna* (DALMAN, 1816)	-69 (-25.65%)	-11 (-4.09%)	-24 (-8.92%)	-155 (-57.62%)	-123 (-45.72%)	-1062 (-80.45%)	-1315 (-99.62%)	-1276 (-96.67%)	-1211 (-91.74%)	-1315 (-99.62%)	-1280 (-96.97%)	-1223 (-92.65%)
212	*Euphydryas cynthia* ([SCHIFFERMÜLLER], 1775)	2526 (35.26%)	3998 (55.81%)	296 (4.13%)	-1754 (-24.48%)	-981 (-13.69%)	-147 (-37.22%)	-210 (-53.16%)	-165 (-41.77%)	-233 (-58.99%)	-327 (-82.78%)	-249 (-63.04%)	-285 (-72.15%)
414	*Euphydryas intermedia* (MENETRIES, 1859)	-1202 (-73.25%)	-1226 (-74.71%)	-1003 (-61.12%)	-1314 (-80.07%)	-1256 (-76.54%)	-127 (-47.21%)	-105 (-39.03%)	-45 (-16.73%)	-157 (-58.36%)	-233 (-86.62%)	-193 (-71.75%)	-231 (-85.87%)
416	*Euphydryas maturna* (LINNAEUS, 1758)	-543 (-8.34%)	335 (5.14%)	-276 (-4.24%)	-1292 (-19.84%)	-786 (-12.07%)	-2439 (-34.05%)	2476 (34.56%)	3987 (55.65%)	3354 (46.82%)	-3429 (-47.86%)	-2446 (-34.14%)	-1971 (-27.51%)
418	*Euphydryas desfontainii* (GODART, 1819)	-2647 (-20.06%)	-2602 (-19.72%)	-1505 (-11.41%)	-3961 (-30.02%)	-3692 (-27.98%)	-1132 (-68.98%)	-1624 (-98.96%)	-1593 (-97.07%)	-1406 (-85.68%)	-1640 (-99.94%)	-1622 (-98.84%)	-1481 (-90.25%)
420	*Euphydryas aurinia* (ROTTEMBURG, 1775)	1267 (16.47%)	1413 (18.37%)	2383 (30.98%)	-2473 (-32.15%)	-2181 (-28.35%)	-976 (-14.99%)	-2488 (-38.2%)	-1115 (-17.12%)	-1055 (-16.2%)	-3659 (-56.18%)	-2365 (-36.31%)	-1908 (-29.3%)
422	*Melitaea cinxia* (LINNAEUS, 1758)	214 (54.59%)	261 (66.58%)	51 (13.01%)	-248 (-63.27%)	-184 (-46.94%)	-2787 (-21.12%)	-6896 (-52.26%)	-5706 (-43.24%)	-4653 (-35.26%)	-8941 (-67.76%)	-7293 (-55.27%)	-5935 (-44.98%)

Page		2050 full dispersal GRAS	2050 full dispersal BAMBU	2050 full dispersal SEDG	2050 no dispersal GRAS	2050 no dispersal BAMBU	2050 no dispersal SEDG	2080 full dispersal GRAS	2080 full dispersal BAMBU	2080 full dispersal SEDG	2080 no dispersal GRAS	2080 no dispersal BAMBU	2080 no dispersal SEDG
424	*Melitaea phoebe* (Goeze, 1779)	299 (5.76%)	-715 (-13.76%)	1635 (31.47%)	-2154 (-41.46%)	-2237 (-43.06%)	-1579 (-20.53%)	1843 (23.96%)	1417 (18.42%)	2605 (33.86%)	-5324 (-69.21%)	-4209 (-54.71%)	-2630 (-34.19%)
426	*Melitaea aetherie* (Hübner, 1826)	1374 (11.08%)	1759 (14.19%)	2540 (20.48%)	-2686 (-21.66%)	-2270 (-18.31%)	-215 (-54.85%)	4348 (1109.18%)	2480 (632.65%)	642 (163.78%)	-386 (-98.47%)	-351 (-89.54%)	-318 (-81.12%)
428	*Melitaea trivia* ([Schiffermüller], 1775)	-1511 (-17.5%)	171 (1.98%)	-1169 (-13.54%)	-2780 (-32.2%)	-1648 (-19.09%)	-1421 (-27.35%)	-1070 (-20.6%)	-1820 (-35.03%)	-75 (-1.44%)	-4285 (-82.48%)	-3718 (-71.57%)	-2656 (-51.13%)
430	*Melitaea didyma* (Esper, 1779)	-1220 (-50.29%)	-1517 (-62.53%)	-832 (-34.3%)	-1824 (-75.19%)	-1792 (-73.87%)	-1554 (-12.53%)	-347 (-2.8%)	-73 (-0.59%)	1522 (12.27%)	-7258 (-58.53%)	-5816 (-46.9%)	-3397 (-27.4%)
432	*Melitaea diamina* (Lang, 1789)	-66 (-13.04%)	85 (16.8%)	-19 (-3.75%)	-298 (-58.89%)	-232 (-45.85%)	-2382 (-27.59%)	-3377 (-39.12%)	-1780 (-20.62%)	-2257 (-26.14%)	-6073 (-70.35%)	-4472 (-51.8%)	-4026 (-46.64%)
434	*Melitaea deione* (Geyer, 1832)	-805 (-25.29%)	-467 (-14.67%)	-263 (-8.26%)	-1756 (-55.17%)	-1326 (-41.66%)	-1587 (-65.42%)	-1062 (-43.78%)	-1236 (-50.95%)	-1099 (-45.3%)	-2213 (-91.22%)	-2071 (-85.37%)	-2005 (-82.65%)
436	*Melitaea varia* (Meyer-Dür, 1851)	801 (18.11%)	2241 (50.67%)	335 (7.57%)	-1641 (-37.1%)	-1117 (-25.25%)	-281 (-55.53%)	-249 (-49.21%)	-123 (-24.31%)	-232 (-45.85%)	-434 (-85.77%)	-355 (-70.16%)	-438 (-86.56%)
438	*Melitaea parthenoides* (Keferstein, 1851)	793 (18.53%)	31 (0.72%)	1268 (29.63%)	-1987 (-46.43%)	-2095 (-48.95%)	-1251 (-39.3%)	-1842 (-57.87%)	-1391 (-43.7%)	-1137 (-35.72%)	-2969 (-93.28%)	-2457 (-77.19%)	-2098 (-65.91%)
440	*Melitaea aurelia* (Nickerl, 1850)	-1391 (-8.98%)	-610 (-3.94%)	109 (0.7%)	-3658 (-23.63%)	-2730 (-17.63%)	-1527 (-34.52%)	490 (11.08%)	1372 (31.02%)	625 (14.13%)	-3288 (-74.34%)	-2361 (-53.38%)	-2076 (-46.94%)
442	*Melitaea britomartis* (Assmann, 1847)	-2695 (-23.78%)	-937 (-8.27%)	-2247 (-19.83%)	-4819 (-42.53%)	-3448 (-30.43%)	-1324 (-30.93%)	-2251 (-52.59%)	-1961 (-45.82%)	-1646 (-38.46%)	-4035 (-94.28%)	-3747 (-87.55%)	-3144 (-73.46%)
444	*Melitaea athalia* (Rottemburg, 1775)	-1369 (-15.5%)	890 (10.08%)	-1009 (-11.42%)	-3179 (-35.99%)	-1716 (-19.43%)	-2510 (-16.21%)	-2980 (-19.25%)	-1542 (-9.96%)	560 (3.62%)	-7785 (-50.28%)	-5975 (-38.59%)	-3902 (-25.2%)
446	*Limenitis populi* (Linnaeus, 1758)	161 (2.82%)	735 (12.86%)	347 (6.07%)	-1546 (-27.05%)	-1332 (-23.3%)	-4349 (-38.38%)	-3162 (-27.9%)	-1580 (-13.94%)	-1234 (-10.89%)	-8315 (-73.38%)	-6352 (-56.05%)	-5291 (-46.69%)
448	*Limenitis camilla* (Linnaeus, 1764)	1157 (44.38%)	2187 (83.89%)	1384 (53.09%)	-1389 (-53.28%)	-1038 (-39.82%)	-2600 (-29.44%)	-1447 (-16.38%)	-161 (-1.82%)	-979 (-11.08%)	-6253 (-70.79%)	-4232 (-47.91%)	-3580 (-40.53%)
450	*Limenitis reducta* (Staudinger, 1901)	-1082 (-50.68%)	-739 (-34.61%)	-655 (-30.68%)	-1391 (-65.15%)	-1113 (-52.13%)	-1259 (-22.03%)	254 (4.44%)	897 (15.69%)	1180 (20.64%)	-3262 (-57.07%)	-2390 (-41.81%)	-1764 (-30.86%)

Page		2050 full dispersal GRAS	2050 full dispersal BAMBU	2050 full dispersal SEDG	2050 no dispersal GRAS	2050 no dispersal BAMBU	2050 no dispersal SEDG	2080 full dispersal GRAS	2080 full dispersal BAMBU	2080 full dispersal SEDG	2080 no dispersal GRAS	2080 no dispersal BAMBU	2080 no dispersal SEDG
452	*Neptis sappho* (Pallas, 1771)	-840 (-42.45%)	-879 (-44.42%)	-760 (-38.4%)	-1367 (-69.08%)	-1198 (-60.54%)	-1028 (-39.43%)	1649 (63.25%)	1506 (57.77%)	876 (33.6%)	-2435 (-93.4%)	-2254 (-86.46%)	-1769 (-67.86%)
454	*Neptis rivularis* (Scopoli, 1763)	2759 (131.95%)	1346 (64.37%)	3014 (144.14%)	-488 (-23.34%)	-589 (-28.17%)	-1086 (-50.87%)	-121 (-5.67%)	-458 (-21.45%)	74 (3.47%)	-1763 (-82.58%)	-1520 (-71.19%)	-1285 (-60.19%)
456	*Charaxes jasius* (Linnaeus, 1767)	-633 (-6.36%)	1144 (11.49%)	322 (3.23%)	-3412 (-34.26%)	-2085 (-20.94%)	-1174 (-59.32%)	-1012 (-51.14%)	-1121 (-56.64%)	-795 (-40.17%)	-1918 (-96.92%)	-1737 (-87.77%)	-1504 (-76%)
458	*Apatura metis* (Freyer, 1829)	-2504 (-28.51%)	-1063 (-12.1%)	-1777 (-20.23%)	-4708 (-53.6%)	-3547 (-40.38%)	-141 (-6.74%)	787 (37.64%)	212 (10.14%)	1951 (93.3%)	-1885 (-90.15%)	-1703 (-81.44%)	-880 (-42.09%)
460	*Apatura ilia* ([Schiffermüller], 1775)	207 (17.28%)	177 (14.77%)	257 (21.45%)	-523 (-43.66%)	-438 (-36.56%)	-2420 (-24.3%)	-37 (-0.37%)	526 (5.28%)	1042 (10.46%)	-7270 (-73.01%)	-5548 (-55.71%)	-4137 (-41.54%)
462	*Apatura iris* (Linnaeus, 1758)	-845 (-3.69%)	-359 (-1.57%)	111 (0.49%)	-2662 (-11.63%)	-2025 (-8.85%)	-3899 (-44.39%)	-3732 (-42.49%)	-2969 (-33.8%)	-2825 (-32.16%)	-8007 (-91.15%)	-6641 (-75.6%)	-5511 (-62.74%)
464	*Kirinia roxelana* (Cramer, 1777)	-2133 (-12.9%)	-2401 (-14.53%)	-590 (-3.57%)	-4415 (-26.71%)	-4201 (-25.42%)	-459 (-38.31%)	491 (40.98%)	62 (5.18%)	644 (53.76%)	-882 (-73.62%)	-726 (-60.6%)	-587 (-49%)
466	*Pararge aegeria* (Linnaeus, 1758)	-3135 (-34.24%)	-3026 (-33.05%)	-2647 (-28.91%)	-3656 (-39.93%)	-3477 (-37.98%)	-1693 (-7.4%)	-3117 (-13.62%)	-2115 (-9.24%)	-686 (-3%)	-8080 (-35.31%)	-5993 (-26.19%)	-3718 (-16.25%)
468	*Lasiommata megera* (Linnaeus, 1767)	-1564 (-10.65%)	-485 (-3.3%)	-126 (-0.86%)	-3521 (-23.98%)	-2663 (-18.14%)	-3165 (-19.15%)	-7558 (-45.73%)	-6087 (-36.83%)	-3806 (-23.03%)	-9777 (-59.15%)	-8167 (-49.41%)	-5677 (-34.35%)
470	*Lasiommata petropolitana* (Fabricius, 1787)	-282 (-4.22%)	2968 (44.43%)	-645 (-9.66%)	-2207 (-33.04%)	-893 (-13.37%)	-3215 (-35.11%)	-4594 (-50.17%)	-3879 (-42.37%)	-2440 (-26.65%)	-5721 (-62.48%)	-4711 (-51.45%)	-3621 (-39.55%)
472	*Lasiommata maera* (Linnaeus, 1758)	-3802 (-29.11%)	-3047 (-23.33%)	-3534 (-27.06%)	-5109 (-39.11%)	-4287 (-32.82%)	-2562 (-17.45%)	-1106 (-7.53%)	-1019 (-6.94%)	780 (5.31%)	-7698 (-52.42%)	-6194 (-42.18%)	-4420 (-30.1%)
474	*Lopinga achine* (Linnaeus, 1763)	168 (15.92%)	1170 (110.9%)	-5 (-0.47%)	-331 (-31.37%)	-109 (-10.33%)	-2182 (-32.66%)	3726 (55.78%)	4790 (71.71%)	3110 (46.56%)	-3777 (-56.54%)	-2501 (-37.44%)	-2392 (-35.81%)
476	*Coenonympha tullia* (Müller, 1764)	197 (25.96%)	125 (16.47%)	332 (43.74%)	-603 (-79.45%)	-592 (-78%)	-4743 (-36.31%)	-6014 (-46.04%)	-4915 (-37.63%)	-4213 (-32.25%)	-8747 (-66.97%)	-7441 (-56.97%)	-6226 (-47.66%)
478	*Coenonympha oedippus* (Fabricius, 1787)	-1501 (-11.08%)	-1104 (-8.15%)	-389 (-2.87%)	-3774 (-27.86%)	-3319 (-24.51%)	-269 (-25.5%)	2236 (211.94%)	2128 (201.71%)	732 (69.38%)	-713 (-67.58%)	-481 (-45.59%)	-387 (-36.68%)

Page		2050	2050	2050	2050	2050	2050	2080	2080	2080	2080	2080	2080
		full dispersal	full dispersal	full dispersal	no dispersal	no dispersal	no dispersal	full dispersal	full dispersal	full dispersal	no dispersal	no dispersal	no dispersal
		GRAS	**BAMBU**	**SEDG**	**GRAS**	**BAMBU**	**SEDG**	**GRAS**	**BAMBU**	**SEDG**	**GRAS**	**BAMBU**	**SEDG**
480	*Coenonympha rhodopensis* Elwes, 1900	90 (0.7%)	-174 (-1.36%)	735 (5.73%)	-2849 (-22.2%)	-2688 (-20.94%)	-514 (-67.72%)	322 (42.42%)	432 (56.92%)	351 (46.25%)	-737 (-97.1%)	-705 (-92.89%)	-606 (-79.84%)
482	*Coenonympha arcania* (Linnaeus, 1761)	-207 (-22%)	-97 (-10.31%)	-167 (-17.75%)	-354 (-37.62%)	-279 (-29.65%)	-2771 (-20.46%)	-4819 (-35.58%)	-3556 (-26.26%)	-2377 (-17.55%)	-9350 (-69.03%)	-7474 (-55.18%)	-5692 (-42.03%)
484	*Coenonympha glycerion* (Borkhausen, 1788)	-856 (-30.78%)	-1152 (-41.42%)	-508 (-18.27%)	-2128 (-76.52%)	-1907 (-68.57%)	-2415 (-18.82%)	-1143 (-8.91%)	609 (4.74%)	2334 (18.18%)	-7723 (-60.17%)	-5395 (-42.03%)	-3666 (-28.56%)
486	*Coenonympha gardetta* (Prunner, 1798)	-517 (-14.59%)	941 (26.56%)	-1416 (-39.97%)	-1545 (-43.61%)	-845 (-23.85%)	-312 (-33.16%)	-466 (-49.52%)	-213 (-22.64%)	-405 (-43.04%)	-662 (-70.35%)	-475 (-50.48%)	-570 (-60.57%)
488	*Coenonympha dorus* (Esper, 1782)	-46 (-5.56%)	-399 (-48.25%)	225 (27.21%)	-571 (-69.04%)	-597 (-72.19%)	-1864 (-67.03%)	-877 (-31.54%)	-1232 (-44.3%)	-927 (-33.33%)	-2689 (-96.69%)	-2501 (-89.93%)	-2297 (-82.6%)
490	*Coenonympha hero* (Linnaeus, 1761)	-2920 (-13.09%)	-2727 (-12.22%)	-1709 (-7.66%)	-4439 (-19.9%)	-3878 (-17.38%)	-1929 (-54.45%)	-2024 (-57.13%)	-882 (-24.89%)	-1761 (-49.7%)	-3301 (-93.17%)	-2331 (-65.79%)	-2493 (-70.36%)
492	*Coenonympha leander* (Esper, 1784)	-511 (-7.97%)	-48 (-0.75%)	-385 (-6.01%)	-1691 (-26.38%)	-1437 (-22.41%)	-425 (-51.39%)	-571 (-69.04%)	-574 (-69.41%)	-168 (-20.31%)	-798 (-96.49%)	-746 (-90.21%)	-546 (-66.02%)
494	*Coenonympha pamphilus* (Linnaeus, 1758)	-939 (-39.96%)	-925 (-39.36%)	-794 (-33.79%)	-1613 (-68.64%)	-1406 (-59.83%)	-3476 (-15.58%)	-6105 (-27.36%)	-4197 (-18.81%)	-1994 (-8.94%)	-10438 (-46.79%)	-7614 (-34.13%)	-5095 (-22.84%)
496	*Pyronia tithonus* (Linnaeus, 1771)	-1151 (-33.26%)	-1440 (-41.61%)	-696 (-20.11%)	-2282 (-65.93%)	-2070 (-59.81%)	-1451 (-22.63%)	-2622 (-40.9%)	-1165 (-18.17%)	-898 (-14.01%)	-3899 (-60.82%)	-2649 (-41.32%)	-2029 (-31.65%)
498	*Pyronia cecilia* (Vallantin, 1894)	-2340 (-14.04%)	-1875 (-11.25%)	-1583 (-9.49%)	-4840 (-29.03%)	-4274 (-25.64%)	-1382 (-58.81%)	-1037 (-44.13%)	-1206 (-51.32%)	-891 (-37.91%)	-2280 (-97.02%)	-2042 (-86.89%)	-1781 (-75.79%)
500	*Pyronia bathseba* (Fabricius, 1793)	-2986 (-13.68%)	-2884 (-13.22%)	-1330 (-6.1%)	-4489 (-20.57%)	-4188 (-19.19%)	-1954 (-56.46%)	-2079 (-60.07%)	-2178 (-62.93%)	-1610 (-46.52%)	-3404 (-98.35%)	-3150 (-91.01%)	-2673 (-77.23%)
502	*Aphantopus hyperantus* (Linnaeus, 1758)	-2698 (-39.19%)	-3974 (-57.73%)	-805 (-11.69%)	-3454 (-50.17%)	-4245 (-61.66%)	-3790 (-22.73%)	-7118 (-42.69%)	-5021 (-30.12%)	-3828 (-22.96%)	-12005 (-72.01%)	-9337 (-56%)	-7230 (-43.37%)
504	*Maniola jurtina* (Linnaeus, 1758)	-981 (-34.68%)	-1228 (-43.41%)	-389 (-13.75%)	-1690 (-59.74%)	-1547 (-54.68%)	-3022 (-13.85%)	-9317 (-42.7%)	-6627 (-30.37%)	-4349 (-19.93%)	-11852 (-54.32%)	-9090 (-41.66%)	-6262 (-28.7%)
506	*Hyponephele lycaon* (Kühn, 1774)	-4075 (-32.7%)	-2415 (-19.38%)	-2958 (-23.74%)	-4737 (-38.01%)	-3187 (-25.57%)	-2069 (-30.06%)	-5461 (-79.33%)	-5739 (-83.37%)	-3582 (-52.03%)	-6406 (-93.06%)	-6138 (-89.16%)	-4792 (-69.61%)

Page		2050 full dispersal GRAS	2050 full dispersal BAMBU	2050 full dispersal SEDG	2050 no dispersal GRAS	2050 no dispersal BAMBU	2050 no dispersal SEDG	2080 full dispersal GRAS	2080 full dispersal BAMBU	2080 full dispersal SEDG	2080 no dispersal GRAS	2080 no dispersal BAMBU	2080 no dispersal SEDG
508	*Hyponephele lupina* (Costa, 1836)	-791 (-37.81%)	-435 (-20.79%)	-524 (-25.05%)	-1100 (-52.58%)	-769 (-36.76%)	-1308 (-46.24%)	-2354 (-83.21%)	-2198 (-77.7%)	-1383 (-48.89%)	-2720 (-96.15%)	-2482 (-87.73%)	-1845 (-65.22%)
510	*Erebia ligea* (Linnaeus, 1758)	-99 (-25.71%)	-33 (-8.57%)	-57 (-14.81%)	-172 (-44.68%)	-141 (-36.62%)	-3875 (-31.09%)	-5485 (-44.01%)	-4435 (-35.59%)	-2798 (-22.45%)	-6418 (-51.5%)	-5388 (-43.24%)	-3895 (-31.26%)
512	*Erebia euryale* (Esper, 1805)	-357 (-26.39%)	-165 (-12.2%)	-258 (-19.07%)	-548 (-40.5%)	-394 (-29.12%)	-825 (-39.44%)	-500 (-23.9%)	-275 (-13.15%)	-326 (-15.58%)	-1541 (-73.66%)	-1218 (-58.22%)	-1147 (-54.83%)
514	*Erebia eriphyle* (Freyer, 1836)	-980 (-30.22%)	-761 (-23.47%)	-747 (-23.03%)	-1321 (-40.73%)	-1057 (-32.59%)	-144 (-37.4%)	-121 (-31.43%)	-76 (-19.74%)	-168 (-43.64%)	-304 (-78.96%)	-251 (-65.19%)	-250 (-64.94%)
516	*Erebia manto* ([Schiffermüller], 1775)	-337 (-24.85%)	-212 (-15.63%)	-284 (-20.94%)	-542 (-39.97%)	-429 (-31.64%)	-466 (-34.44%)	-402 (-29.71%)	-228 (-16.85%)	-368 (-27.2%)	-850 (-62.82%)	-661 (-48.85%)	-668 (-49.37%)
518	*Erebia epiphron* (Knoch, 1783)	-413 (-29.06%)	-244 (-17.17%)	-333 (-23.43%)	-520 (-36.59%)	-389 (-27.38%)	-1068 (-32.93%)	-679 (-20.94%)	-717 (-22.11%)	-524 (-16.16%)	-1837 (-56.65%)	-1526 (-47.06%)	-1317 (-40.61%)
520	*Erebia pharte* (Hübner, 1804)	-1395 (-30.84%)	-519 (-11.47%)	-968 (-21.4%)	-2226 (-49.22%)	-1542 (-34.09%)	-487 (-35.91%)	-426 (-31.42%)	-269 (-19.84%)	-428 (-31.56%)	-832 (-61.36%)	-666 (-49.12%)	-679 (-50.07%)
522	*Erebia melampus* (Fuessli, 1775)	-66 (-5.65%)	7 (0.6%)	70 (5.99%)	-690 (-59.02%)	-608 (-52.01%)	-444 (-31.25%)	-588 (-41.38%)	-379 (-26.67%)	-499 (-35.12%)	-917 (-64.53%)	-686 (-48.28%)	-740 (-52.08%)
524	*Erebia aethiops* (Esper, 1777)	-806 (-21.19%)	-782 (-20.56%)	-835 (-21.95%)	-1207 (-31.73%)	-1145 (-30.1%)	-1883 (-41.63%)	548 (12.12%)	316 (6.99%)	491 (10.86%)	-2876 (-63.59%)	-2318 (-51.25%)	-1899 (-41.99%)
526	*Erebia triaria* (Prunner, 1798)	-1025 (-69.49%)	-956 (-64.81%)	-1068 (-72.41%)	-1249 (-84.68%)	-1166 (-79.05%)	-590 (-50.47%)	-285 (-24.38%)	-236 (-20.19%)	-255 (-21.81%)	-943 (-80.67%)	-847 (-72.46%)	-877 (-75.02%)
528	*Erebia embla* (Becklin, 1791)	-1416 (-34.34%)	-151 (-3.66%)	-943 (-22.87%)	-2279 (-55.26%)	-1635 (-39.65%)	-1141 (-29.99%)	-2238 (-58.83%)	-1605 (-42.19%)	-1583 (-41.61%)	-2592 (-68.14%)	-2010 (-52.84%)	-1864 (-49%)
530	*Erebia disa* (Becklin, 1791)	-244 (-23.8%)	-95 (-9.27%)	-208 (-20.29%)	-352 (-34.34%)	-258 (-25.17%)	-1242 (-84.2%)	-1405 (-95.25%)	-1347 (-91.32%)	-1285 (-87.12%)	-1472 (-99.8%)	-1470 (-99.66%)	-1446 (-98.03%)
532	*Erebia medusa* (Fabricius, 1787)	-239 (-27.07%)	-145 (-16.42%)	-189 (-21.4%)	-353 (-39.98%)	-274 (-31.03%)	-1907 (-46.24%)	-111 (-2.69%)	106 (2.57%)	304 (7.37%)	-3288 (-79.73%)	-2660 (-64.5%)	-2199 (-53.32%)
534	*Erebia alberganus* (Prunner, 1798)	-602 (-35.29%)	-375 (-21.98%)	-452 (-26.49%)	-717 (-42.03%)	-538 (-31.54%)	-328 (-32%)	-513 (-50.05%)	-276 (-26.93%)	-427 (-41.66%)	-685 (-66.83%)	-483 (-47.12%)	-585 (-57.07%)

Page		2050	2050	2050	2050	2050	2050	2080	2080	2080	2080	2080	2080
		full dispersal	full dispersal	full dispersal	no dispersal	no dispersal	no dispersal	full dispersal	full dispersal	full dispersal	no dispersal	no dispersal	no dispersal
		GRAS	BAMBU	SEDG	GRAS	BAMBU	SEDG	GRAS	BAMBU	SEDG	GRAS	BAMBU	SEDG
536	*Erebia pluto* (Prunner, 1798)	75 (26.79%)	160 (57.14%)	72 (25.71%)	-108 (-38.57%)	-68 (-24.29%)	-306 (-34.65%)	-468 (-53%)	-285 (-32.28%)	-437 (-49.49%)	-648 (-73.39%)	-467 (-52.89%)	-597 (-67.61%)
538	*Erebia gorge* (Esper, 1805)	-165 (-95.93%)	-165 (-95.93%)	-137 (-79.65%)	-170 (-98.84%)	-167 (-97.09%)	-578 (-33.88%)	-721 (-42.26%)	-534 (-31.3%)	-587 (-34.41%)	-1128 (-66.12%)	-900 (-52.75%)	-884 (-51.82%)
540	*Erebia mnestra* (Esper, 1805)	-95 (-15.06%)	-144 (-22.82%)	-69 (-10.94%)	-304 (-48.18%)	-297 (-47.07%)	-119 (-42.5%)	-185 (-66.07%)	-69 (-24.64%)	-169 (-60.36%)	-241 (-86.07%)	-173 (-61.79%)	-216 (-77.14%)
542	*Erebia epistygne* (Hübner, 1819)	-11 (-2.53%)	51 (11.72%)	-24 (-5.52%)	-204 (-46.9%)	-160 (-36.78%)	-162 (-94.19%)	-172 (-100%)	-172 (-100%)	-166 (-96.51%)	-172 (-100%)	-172 (-100%)	-172 (-100%)
544	*Erebia ottomana* (Herrich-Schäffer, 1847)	-398 (-33.84%)	-320 (-27.21%)	-337 (-28.66%)	-457 (-38.86%)	-378 (-32.14%)	-240 (-38.03%)	-118 (-18.7%)	-158 (-25.04%)	193 (30.59%)	-476 (-75.44%)	-431 (-68.3%)	-212 (-33.6%)
546	*Erebia tyndarus* (Esper, 1781)	-586 (-34.88%)	-326 (-19.4%)	-407 (-24.23%)	-692 (-41.19%)	-472 (-28.1%)	-205 (-47.13%)	-200 (-45.98%)	-80 (-18.39%)	-251 (-57.7%)	-339 (-77.93%)	-272 (-62.53%)	-357 (-82.07%)
548	*Erebia cassioides* (Reiner & Hohenwarth, 1792) (complex)	-255 (-59.44%)	-186 (-43.36%)	-200 (-46.62%)	-264 (-61.54%)	-206 (-48.02%)	-404 (-34.35%)	-647 (-55.02%)	-525 (-44.64%)	-656 (-55.78%)	-747 (-63.52%)	-630 (-53.57%)	-746 (-63.44%)
550	*Erebia pronoe* (Esper, 1780)	-112 (-17.64%)	25 (3.94%)	-77 (-12.13%)	-303 (-47.72%)	-224 (-35.28%)	-570 (-33.93%)	-466 (-27.74%)	-319 (-18.99%)	-315 (-18.75%)	-1011 (-60.18%)	-774 (-46.07%)	-721 (-42.92%)
552	*Erebia styx* (Freyer, 1834)	18 (2.66%)	-1 (-0.15%)	-10 (-1.48%)	-521 (-76.96%)	-488 (-72.08%)	-227 (-52.91%)	-287 (-66.9%)	-242 (-56.41%)	-247 (-57.58%)	-361 (-84.15%)	-280 (-65.27%)	-282 (-65.73%)
554	*Erebia montana* (Prunner, 1798)	121 (18.62%)	40 (6.15%)	179 (27.54%)	-231 (-35.54%)	-239 (-36.77%)	-282 (-44.41%)	-332 (-52.28%)	-186 (-29.29%)	-349 (-54.96%)	-512 (-80.63%)	-409 (-64.41%)	-530 (-83.46%)
556	*Erebia neoridas* (Boisduval, 1828)	-298 (-27.21%)	-32 (-2.92%)	-195 (-17.81%)	-427 (-39%)	-276 (-25.21%)	-473 (-69.87%)	-265 (-39.14%)	-162 (-23.93%)	219 (32.35%)	-605 (-89.36%)	-591 (-87.3%)	-560 (-82.72%)
558	*Erebia melas* (Herbst, 1796)	-342 (-12.4%)	-153 (-5.55%)	-89 (-3.23%)	-1389 (-50.36%)	-1103 (-39.99%)	-158 (-24.31%)	40 (6.15%)	-35 (-5.38%)	416 (64%)	-496 (-76.31%)	-434 (-66.77%)	-167 (-25.69%)
560	*Erebia oeme* (Esper, 1805)	-1212 (-26.98%)	-779 (-17.34%)	-950 (-21.14%)	-1215 (-27.04%)	-830 (-18.47%)	-357 (-32.6%)	-413 (-37.72%)	-155 (-14.16%)	-260 (-23.74%)	-732 (-66.85%)	-523 (-47.76%)	-538 (-49.13%)
562	*Erebia meolans* (Prunner, 1798)	-982 (-64.82%)	-988 (-65.21%)	-781 (-51.55%)	-1275 (-84.16%)	-1169 (-77.16%)	-1130 (-40.97%)	-1145 (-41.52%)	-644 (-23.35%)	-360 (-13.05%)	-2198 (-79.7%)	-1813 (-65.74%)	-1687 (-61.17%)

Page		2050	2050	2050	2050	2050	2050	2080	2080	2080	2080	2080	2080
		full dispersal	full dispersal	full dispersal	no dispersal	no dispersal	no dispersal	full dispersal	full dispersal	full dispersal	no dispersal	no dispersal	no dispersal
		GRAS	BAMBU	SEDG	GRAS	BAMBU	SEDG	GRAS	BAMBU	SEDG	GRAS	BAMBU	SEDG
564	*Erebia pandrose* (Borkhausen, 1788)	-12 (-0.09%)	912 (6.53%)	884 (6.33%)	-3686 (-26.41%)	-3015 (-21.6%)	-1006 (-22.39%)	-1444 (-32.14%)	-1128 (-25.11%)	-883 (-19.65%)	-1546 (-34.41%)	-1265 (-28.15%)	-1106 (-24.62%)
566	*Melanargia russiae* (Esper, 1784)	-1045 (-74.96%)	-1054 (-75.61%)	-863 (-61.91%)	-1232 (-88.38%)	-1131 (-81.13%)	-1158 (-76.44%)	-752 (-49.64%)	-1026 (-67.72%)	-752 (-49.64%)	-1504 (-99.27%)	-1441 (-95.12%)	-1352 (-89.24%)
568	*Melanargia galathea* (Linnaeus, 1758)	24 (2.14%)	-25 (-2.23%)	127 (11.33%)	-598 (-53.35%)	-534 (-47.64%)	-2681 (-19.21%)	-609 (-4.36%)	-22 (-0.16%)	483 (3.46%)	-8654 (-62%)	-6633 (-47.52%)	-4811 (-34.47%)
570	*Melanargia lachesis* (Hübner 1790)	719 (116.53%)	497 (80.55%)	488 (79.09%)	-305 (-49.43%)	-291 (-47.16%)	-1047 (-75.11%)	-910 (-65.28%)	-1129 (-80.99%)	-1055 (-75.68%)	-1394 (-100%)	-1374 (-98.57%)	-1324 (-94.98%)
572	*Melanargia larissa* (Esper, 1784)	-1141 (-81.21%)	-1081 (-76.94%)	-958 (-68.19%)	-1246 (-88.68%)	-1137 (-80.93%)	-497 (-44.34%)	-249 (-22.21%)	-410 (-36.57%)	246 (21.94%)	-1008 (-89.92%)	-873 (-77.88%)	-586 (-52.27%)
574	*Melanargia arge* (Sulzer, 1776)	-657 (-59.3%)	-648 (-58.48%)	-460 (-41.52%)	-690 (-62.27%)	-659 (-59.48%)	-281 (-45.54%)	655 (106.16%)	767 (124.31%)	776 (125.77%)	-447 (-72.45%)	-409 (-66.29%)	-331 (-53.65%)
576	*Melanargia occitanica* (Esper, 1793)	-941 (-42.71%)	-741 (-33.64%)	-703 (-31.91%)	-1572 (-71.36%)	-1333 (-60.51%)	-1076 (-76.58%)	-1014 (-72.17%)	-1196 (-85.12%)	-1081 (-76.94%)	-1405 (-100%)	-1402 (-99.79%)	-1345 (-95.73%)
578	*Melanargia ines* (Hoffmansegg, 1804)	-669 (-41.35%)	-1060 (-65.51%)	-200 (-12.36%)	-1373 (-84.86%)	-1317 (-81.4%)	-547 (-49.37%)	-1073 (-96.84%)	-1019 (-91.97%)	-794 (-71.66%)	-1073 (-96.84%)	-1019 (-91.97%)	-833 (-75.18%)
580	*Satyrus ferula* (Fabricius, 1793)	2375 (56.01%)	3822 (90.14%)	2262 (53.35%)	-2311 (-54.5%)	-1934 (-45.61%)	-1206 (-54.74%)	-631 (-28.64%)	-601 (-27.28%)	-378 (-17.16%)	-2036 (-92.42%)	-1846 (-83.79%)	-1706 (-77.44%)
582	*Satyrus actaea* (Esper, 1780)	830 (12.7%)	2258 (34.54%)	1516 (23.19%)	-2226 (-34.05%)	-1710 (-26.16%)	-1171 (-72.37%)	-1015 (-62.73%)	-1016 (-62.79%)	-749 (-46.29%)	-1611 (-99.57%)	-1579 (-97.59%)	-1522 (-94.07%)
584	*Minois dryas* (Scopoli, 1763)	-1329 (-40.16%)	-1810 (-54.7%)	14 (0.42%)	-2414 (-72.95%)	-2266 (-68.48%)	-1957 (-46.16%)	4305 (101.53%)	3810 (89.86%)	3230 (76.18%)	-3463 (-81.67%)	-3066 (-72.31%)	-2611 (-61.58%)
586	*Hipparchia fagi* (Scopoli, 1763)	534 (27.83%)	481 (25.07%)	774 (40.33%)	-773 (-40.28%)	-646 (-33.66%)	-1565 (-23.94%)	1334 (20.41%)	1747 (26.72%)	2059 (31.5%)	-4425 (-67.69%)	-3478 (-53.2%)	-2487 (-38.04%)
588	*Hipparchia hermione* (Linnaeus, 1764)	-3564 (-25.76%)	-3269 (-23.63%)	-2284 (-16.51%)	-4405 (-31.84%)	-4031 (-29.14%)	-1651 (-49.89%)	-2086 (-63.04%)	-2091 (-63.19%)	-906 (-27.38%)	-3191 (-96.43%)	-2968 (-89.69%)	-2535 (-76.61%)
590	*Hipparchia syriaca* (Staudinger, 1871)	155 (15.8%)	-96 (-9.79%)	426 (43.43%)	-575 (-58.61%)	-549 (-55.96%)	-595 (-31.01%)	445 (23.19%)	-201 (-10.47%)	652 (33.98%)	-1432 (-74.62%)	-1231 (-64.15%)	-893 (-46.53%)

Page		2050 full dispersal	2050 full dispersal	2050 full dispersal	2050 no dispersal	2050 no dispersal	2050 no dispersal	2080 full dispersal	2080 full dispersal	2080 full dispersal	2080 no dispersal	2080 no dispersal	2080 no dispersal
		GRAS	BAMBU	SEDG	GRAS	BAMBU	SEDG	GRAS	BAMBU	SEDG	GRAS	BAMBU	SEDG
592	*Hipparchia sem* (Linnaeus, 1758)	506 (8.27%)	-56 (-0.92%)	1004 (16.41%)	-2640 (-43.16%)	-2416 (-39.5%)	-3095 (-22.37%)	-8424 (-60.9%)	-6634 (-47.96%)	-5233 (-37.83%)	-9748 (-70.47%)	-7748 (-56.01%)	-6024 (-43.55%)
594	*Hipparchia volgensis* (Mazochin-Porshnyakov, 1952)	-92 (-8.98%)	-46 (-4.49%)	-89 (-8.69%)	-513 (-50.1%)	-439 (-42.87%)	-382 (-38.94%)	-467 (-47.6%)	-432 (-44.04%)	152 (15.49%)	-856 (-87.26%)	-735 (-74.92%)	-465 (-47.4%)
596	*Hipparchia statilinus* (Hufnagel, 1766)	-1040 (-47.45%)	-1294 (-59.03%)	-731 (-33.35%)	-1875 (-85.54%)	-1644 (-75%)	-1947 (-31.83%)	-1068 (-17.46%)	-506 (-8.27%)	-99 (-1.62%)	-5188 (-84.81%)	-4017 (-65.67%)	-3063 (-50.07%)
598	*Hipparchia fatua* (Freyer, 1845)	-85 (-10.12%)	-2 (-0.24%)	-62 (-7.38%)	-386 (-45.95%)	-293 (-34.88%)	-482 (-47.07%)	-426 (-41.6%)	-245 (-23.93%)	235 (22.95%)	-827 (-80.76%)	-693 (-67.68%)	-527 (-51.46%)
600	*Hipparchia fidia* (Linnaeus, 1767)	487 (8.66%)	-64 (-1.14%)	1068 (19%)	-2938 (-52.27%)	-2666 (-47.43%)	-1623 (-74.04%)	-1463 (-66.74%)	-1518 (-69.25%)	-1112 (-50.73%)	-2180 (-99.45%)	-2110 (-96.26%)	-1959 (-89.37%)
602	*Hipparchia senthes* (Fruhstorfer, 1908)	-42 (-0.56%)	-443 (-5.88%)	1057 (14.02%)	-3143 (-41.69%)	-2864 (-37.99%)	-350 (-41.67%)	-444 (-52.86%)	-280 (-33.33%)	207 (24.64%)	-767 (-91.31%)	-631 (-75.12%)	-421 (-50.12%)
604	*Arethusana arethusa* ([Schiffermüller], 1775)	-349 (-4.79%)	-27 (-0.37%)	645 (8.85%)	-2727 (-37.4%)	-2256 (-30.94%)	-2313 (-41.15%)	-2335 (-41.54%)	-1332 (-23.7%)	-616 (-10.96%)	-5381 (-95.73%)	-4595 (-81.75%)	-3665 (-65.2%)
606	*Brintesia circe* (Fabricius, 1775)	-181 (-22.13%)	-134 (-16.38%)	-175 (-21.39%)	-385 (-47.07%)	-332 (-40.59%)	-2308 (-30.61%)	-1518 (-20.14%)	-961 (-12.75%)	185 (2.45%)	-6183 (-82.01%)	-5018 (-66.56%)	-3680 (-48.81%)
608	*Chazara briseis* (Linnaeus, 1764)	-1729 (-83.25%)	-1680 (-80.89%)	-1683 (-81.03%)	-1737 (-83.63%)	-1687 (-81.22%)	-1902 (-26.08%)	-2263 (-31.03%)	-1170 (-16.04%)	-402 (-5.51%)	-5429 (-74.45%)	-4231 (-58.02%)	-3226 (-44.24%)
610	*Pseudochazara anthelea* (Lefebvre, 1831)	-247 (-26.56%)	-114 (-12.26%)	-192 (-20.65%)	-400 (-43.01%)	-323 (-34.73%)	-360 (-44.01%)	-322 (-39.36%)	-231 (-28.24%)	193 (23.59%)	-623 (-76.16%)	-481 (-58.8%)	-379 (-46.33%)
612	*Oeneis norna* (Becklin, 1791)	-1446 (-24.14%)	-1434 (-23.94%)	-1165 (-19.45%)	-2091 (-34.9%)	-2057 (-34.33%)	-1691 (-81.42%)	-2065 (-99.42%)	-2026 (-97.54%)	-1899 (-91.43%)	-2065 (-99.42%)	-2030 (-97.74%)	-1909 (-91.91%)
614	*Oeneis glacialis* (Moll, 1785)	-209 (-50.73%)	-171 (-41.5%)	-204 (-49.51%)	-304 (-73.79%)	-262 (-63.59%)	-368 (-39.57%)	-480 (-51.61%)	-272 (-29.25%)	-430 (-46.24%)	-710 (-76.34%)	-529 (-56.88%)	-637 (-68.49%)
616	*Oeneis jutta* (Hübner, 1806)	-1446 (-24.14%)	-1434 (-23.94%)	-1165 (-19.45%)	-2091 (-34.9%)	-2057 (-34.33%)	-1791 (-29.89%)	-2839 (-47.39%)	-2096 (-34.99%)	-1820 (-30.38%)	-3887 (-64.88%)	-3090 (-51.58%)	-2670 (-44.57%)
618	*Danaus chrysippus* (Linnaeus, 1758)	-209 (-50.73%)	-171 (-41.5%)	-204 (-49.51%)	-304 (-73.79%)	-262 (-63.59%)	-270 (-65.53%)	-203 (-49.27%)	-195 (-47.33%)	-74 (-17.96%)	-369 (-89.56%)	-334 (-81.07%)	-273 (-66.26%)

Appendix 3: Risk category statistics of European butterflies under different scenarios

Table App. 3.1: Number of European butterfly species in different risk categories under different scenarios

HHHR = extremely high risk (loss >95%; AUC > 0.75)
HHR = very high risk (loss >85%; AUC > 0.75)
HR = high risk (loss >70%; AUC > 0.75)
R = risk (loss >50%; AUC > 0.75)
LR = lower risk (loss < 51%; AUC > 0.75)
PR = potential risk (any loss or gain; AUC < 0.76)
LR with incr = lower risk with gain under full dispersal (AUC > 0.75)

		climate change risk categories						
		HHHR	HHR	HR	R	LR total	PR	LR with incr
2050 full dispersal (n species)	SEDG	1	0	7	9	227	50	81
	BAMBU	2	1	11	15	215	50	67
	GRAS	3	0	10	17	214	50	56
2050 no dispersal (n species)	SEDG	1	4	16	47	176	50	0
	BAMBU	2	4	26	44	168	50	0
	GRAS	3	10	26	58	147	50	0
2080 full dispersal (n species)	SEDG	4	6	7	26	201	50	74
	BAMBU	10	8	11	32	183	50	44
	GRAS (n)	14	4	15	55	156	50	43
2080 no dispersal (n species)	SEDG	8	24	35	73	104	50	0
	BAMBU	26	39	37	92	50	50	0
	GRAS	59	39	74	58	14	50	0

Table App. 3.2: Percentage of European butterfly species in different risk categories under different scenarios (excluding the PR-category)

HHHR = extremely high risk (loss >95%; AUC > 0.75)
HHR = very high risk (loss >85%; AUC > 0.75)
HR = high risk (loss >70%; AUC > 0.75)
R = risk (loss >50%; AUC > 0.75)
LR = lower risk (loss < 51%; AUC > 0.75)
LR with incr = lower risk with gain under full dispersal(AUC > 0.75)

		climate change risk categories					
		HHHR	**HHR**	**HR**	**R**	**LR total**	**LR with incr**
2050 full dispersal (% species)	SEDG %	0.4	0.0	2.9	3.7	93.0	33.2
	BAMBU %	0.8	0.4	4.5	6.1	88.1	27.5
	GRAS %	1.2	0.0	4.1	7.0	87.7	23.0
2050 no dispersal (% species)	SEDG %	0.4	1.6	6.6	19.3	72.1	0.0
	BAMBU %	0.8	1.6	10.7	18.0	68.9	0.0
	GRAS %	1.2	4.1	10.7	23.8	60.2	0.0
2080 full dispersal (% species)	SEDG %	1.6	2.5	2.9	10.7	82.4	30.3
	BAMBU %	4.1	3.3	4.5	13.1	75.0	18.0
	GRAS %	5.7	1.6	6.1	22.5	63.9	17.6
2080 no dispersal (% species)	SEDG %	3.3	9.8	14.3	29.9	42.6	0.0
	BAMBU %	10.7	16.0	15.2	37.7	20.5	0.0
	GRAS %	24.2	16.0	30.3	23.8	5.7	0.0

References

Ackerly DD (2003) Community assembly, niche conservatism, and adaptive evolution in changing environments. *International Journal of Plant Sciences* 164 (Supplement): 165-184.

Albre J, Gers C, Legal L (2008) Molecular phylogeny of the *Erebia tyndarus* species group combining CoxII and ND5 mitochondrial genes: A case of a recent radiation. *Molecular phylogenetics and Evolution* 47: 196-210.

Anton C, Zeisset I, Musche M, Durka W, Boomsma JJ, Settele J (2007) Population structure of a large blue butterfly and its specialist parasitoid in a fragmented landscape. *Molecular Ecology* 16: 3828-3838.

Araujo MB (2002) Biodiversity hotspots and zones of ecological transition. *Conservation Biology* 6: 1662-1663.

Araujo MB, New M (2007) Ensemble forecasting of species distributions. *Trends in Ecology & Evolution* 22: 42-47.

Araujo MB, Williams PH (2000) Selecting areas for species persistence using occurrence data. *Biological Conservation* 96: 331-451.

Araujo MB, Williams PH (2001) The bias of complementary hotspots toward marginal populations. *Conservation Biology* 15: 1710-1720.

Araujo MB, Thuiller W, Pearson RG (2006) Climate warming and the decline of amphibians and reptiles in Europe. *Journal of Biogeography* 33: 1712-1728.

Balmford A, Bennun L, Ten Brink B, Cooper D, Côté IM, Crane P, Dobson AP, Dudley N, Dutton I, Green RE, Gregory RD, Harrison J, Kennedy ET, Kremen C, Leader Williams N, Lovejoy TE, Mace G, May RM, Mayaux P, Morling P, Phillips J, Redford K, Ricketts TH, Rodriguez JP, Sanjayan MA, Schei PJ, Van Jaarsveld AS, Walther BA (2005a) The Convention on Biological Diversity's 2010 target. *Science* 307: 212-213.

Balmford A, Crane P, Dobson AP, Green RE, Mace G (2005b) The 2010 challenge: data availability, information needs and extraterrestrial insights. *Philosophical Transactions of the Royal Society of London Series B-Biological Sciences* 360: 221-228.

Barry S, Elith J (2006) Error and uncertainty in habitat models. *Journal of Applied Ecology* 43: 413-423.

Berthold P (1998): Bird migration: genetic programs with high adaptability. *Zoology – Analysis of Complex System* 101: 235-245.

Berthold P, Pulido F (1994) Heritability of migratory activity in a natural bird population. *Proceedings of the Royal Society of London, Series B* 257: 311-315.

Berthold P, Helbig AJ, Mohr G, Querner U (1992) Rapid microevolution of migratory behaviour in a wild bird species. *Nature* 360: 668-670.

Blows MW, Hoffmann AA (2005) A reassessment of genetic limits to evolutionary change. *Ecology* 86: 1371-1384.

Braby MF (2005) Provisional checklist of genera of the Pieridae. *Zootaxa* 832:1-16.

Bradshaw AD (1991) Genostasis and the limits to evolution. *Philosophical Transactions of the Royal Society of London B* 333: 289-305.

Bradshaw WE, Holzapfel CM (2001) Genetic shift in photoperiodic response correlated with global warming. *Proceedings of the National Academy of Sciences, USA* 98: 14509-14511.

Broenniman O, Thuiller W, Hughes G, Midgley GF, Alkemade JMR, Guisan A (2006) Do geographic distribution, niche property and life form explain plants' vulnerability to global change? *Global Change Biology* 12: 1079-1093.

Case TJ, Holt RD, McPeek M (2005) The community context of species borders: ecological and evolutionary perspectives. *Oikos* 108: 28-46.

Cohen J (1960) A coefficient of agreement for nominal scales. *Educational and Psychological Measurement* 20: 37-46.

Crozier L, Dwyer G (2006) Combining population-dynamic and ecophysiological models to predict climate-induced insect range shifts. *The American Naturalist* 167: 853-866.

Davis AJ, Jenkinson LS, Lawton JH, Shorrocks B, Wood S (1998) Making mistakes when predicting shifts in species range in response to global warming. *Nature* 391: 783-786.

de Heer M, Kapos V, ten Brink BJE (2005) Biodiversity trends in Europe: development and testing of a species trend indicator for evaluating progress towards the 2010 target. *Philosophical Transactions of the Royal Society B-Biological Sciences* 360: 297-308.

de Jong, R (1972) Systematics and geographic history of the of the genus *Pyrgus* in the Palaearctic region. *Tijdschrift voor Entomologie* 115: 1-121.

Descimon H, Mallet J (in press) Bad species – How ecology and evolution confuse butterfly taxonomy. In: Settele J, Shreeve TG, Konvicka M, Van Dyck H (eds.): *Ecology of Butterflies in Europe*. Cambridge University Press.

Dobson A (2005) Monitoring global rates of biodiversity change: challenges that arise in meeting the Convention on Biological Diversity (CBD) 2010 goals. *Philosophical Transactions of the Royal Society B-Biological Sciences* 360: 229-241.

EC [European Commission] (2001) A sustainable Europe for a better world: a European union strategy for sustainable development. COM(2001)264 final, Brussels. http://www.europa.eu.int/eur-lex/en/com/cnc/2001/com2001_0264en01.pdf.

EEA [European Environment Agency] (2005) The European environment – State and outlook: http://reports.eea.europa.eu/state_of_environment_report_2005_1/en.

EEA [European Environment Agency] (2007a) Halting the loss of biodiversity by 2010: proposal for a first set of indicators to monitor progress in Europe. Office for Official Publications of the European Communities. http://reports.eea.europa.eu. Cited 6 Dec 2007.

EEA [European Environment Agency] (2007b) Europe's environment – the fourth assessment.

Elith J, Graham CH, Anderson RP, Dudik M, Ferrier S, Guisan A, Hijmans RJ, Huettmann F, Leathwick JR, Lehmann A, Li J, Lohmann LG, Loiselle BA, Manion G, Moritz C, Nakamura M, Nakazawa Y, Overton JM, Peterson AT, Phillips SJ, Richardson K, Scachetti-Pereira R, Schapire RE, Soberon J, Williams S, Wisz MS, Zimmermann NE (2006) Novel methods improve prediction of species' distributions from occurrence data. *Ecography* 29: 129-151.

Erhardt A (1985) Diurnal lepidoptera: sensitive indicators of cultivated and abandoned grassland. *Journal of Applied Ecology* 22: 849-861.

Erhardt A, Thomas JA (1991) Lepidoptera as indicators of change in the semi-natural grasslands of lowland and upland Europe. In: Collins M, Thomas JA (eds.): *The Conservation of Insects and their Habitats*. Academic Press, London.

ESRI ArcGIS [9.2] (2006) Redlands, California, Environ. Systems Res. Inst.

Fiedler K (2006) Ant-associates of Palaearctic lycaenid butterfly larvae (Hymenoptera: Formicidae; Lepidoptera: Lycaenidae) – a review. *Myrmecologische Nachrichten* 9: 77-87 (plus „digital supplementary material" at: http://myrmecologicalnews.org/cms/images/pdf/volume9/mn9_77-87_supplement.pdf).

Fielding AH, Bell JF (1997) A review of methods for the assessment of prediction errors in conservation presence/absence models. *Environmental Conservation* 24: 38-49.

Franco AMA, Hill JK, Kitschke C, Collingham YC, Roy DB, Fox R, Huntley B, Thomas CD (2006) Impacts of climate warming and habitat loss on extinctions at species' low-latitude range boundaries. *Global Change Biology* 12: 1545-1553.

Geiger H, Scholl A (1982) *Pontia daplidice* in Südeuropa – eine Gruppe von zwei Arten. *Mitteilungen der Schweizerischen Entomologischen Gesellschaft* 55: 107-114.

Gomulkiewicz R, Holt RD (1995) When does evolution by natural-selection prevent extinction? *Evolution* 49: 201-207.

Graham MH (2003) Confronting multicollinearity in ecological multiple regression. *Ecology* 84: 2809-2815.

Gregory RD, Van Strien AJ, Vorisek P, Gmelig Meyling AW, Noble DG, Foppen RPB, Gibbons DW (2005) Developing indicators for European birds. *Philosophical Transactions of the Royal Society B-Biological Sciences* 360: 269-288.

Gregory RD, Vorisek P, Van Strien AJ, Gmelig Meyling AW, Jiguet F, Fornasari L, Reif J, Chylarecki P, Burfield IJ (2007) Population trends of widespread woodland birds in Europe. *Ibis* 49: 78-97.

Gregory RD, Vorisek P, Noble DG, Van Strien AJ, Pazderová A, Eaton ME, Gmelig Meyling AW, Joys A, Foppen RPB, Burfield IJ (2008) The generation and use of bird population indicators in Europe. *Bird Conservation International* 18: 223-244.

Guisan A, Thuiller W (2005) Predicting species distribution: offering more than simple habitat models. *Ecology Letters* 8: 993-1009.

Guisan A, Zimmermann NE (2000) Predictive habitat distribution models in ecology. *Ecological Modelling* 135: 147-186.

Hambler C, Speight MR (1996) Extinction rates in British non-marine invertebrates since 1900. *Conservation Biology* 10: 892-896.

Hambler C, Speight MR (2004) Extinction rates and butterflies. *Science* 305: 1563.

Hanley JA, McNeil BJ (1982) The meaning and use of the area under a ROC curve. *Radiology* 143: 29–36.

Hansen TF, Houle D (2004) Evolvability, stabilizing selection, and the problem of stasis. In: Pigliucci M, Preston K (eds.) *Phenotypic integration: Studying the ecology and evolution of complex phenotypes.* Oxford University Press, Oxford, pp. 130-150.

Harte J, Ostling A, Green JL, Kinzig A (2004) Biodiversity conservation – Climate change and extinction risk. *Nature* 430 DOI: 10.1038/nature02718.

Heikkinen RK, Luoto M, Araujo MB, Virkkala R, Thuiller W, Sykes MT (2006) Methods and uncertainties in bioclimatic envelope modeling under climate change. *Progress in Physical Geography* 30: 751-777.

Heikkinen RK, Luoto M, Virkkala R, Pearson RG, Korber JH (2007) Biotic interactions improve prediction of boreal bird distributions at macro-scales. *Global Ecology & Biogeography* 16: 754-763.

Henry P-Y, Lengyel S, Nowicki P, Julliard R, Clobert J, Celik T, Gruber B, Schmeller DS, Babij V, Henle K (in press) Integrating biodiversity monitoring initiatives: potential benefits and methods. *Biodiversity and Conservation*.

Hernandez PA, Graham CH, Master LL, Albert DL (2006) The effect of sample size and species characteristics on performance of different species distribution modeling methods. *Ecography* 29: 773-785.

Hickler T, Vohland K, Costa L, Cramer W, Miller PA, Smith B, Feehan J, Kühn I, Sykes M (in press) Vegetation on the move – where do conservation strategies have to be re-defined?

In: Settele J, Penev L, Georgiev T, Grabaum R, Grobelnik V, Hammen V, Klotz S, Kühn I (eds.) *Atlas of Biodiversity Risk*. Pensoft, Sofia.

Hickling R, Roy DB, Hill JK, Fox R, Thomas CD (2006) The distributions of a wide range of taxonomic groups are expanding polewards. *Global Change Biology* 12: 450-455.

Higgins LG (1976) The classification of European butterflies. Collins, London (1975).

Hill JK, Thomas CD, Lewis OT (1999) Flight morphology in fragmented populations of a rare British butterfly, *Hesperia comma*. *Biological Conservatoin* 87: 277-284.

Hill JK, Collingham YC, Thomas CD, Blakeley DS, Fox R, Moss D, Huntley B (2001) Impacts of landscape structure on butterfly range expansion. *Ecology Letters* 4: 313-321.

Holt RD (1990) The microevolutionary consequences of climate change. *Trends in Ecology and Evolution* 5: 311-315.

Holt RD (1996) Demographic constraints in evolution: Towards unifying the evolutionary theories of senescence and niche conservatism. *Evolutionary Ecology* 10: 1-11.

Holt RD (2008) IJEE Soapbox: Charismatic mesofauna: Butterflies as inspiration and test for theory that integrates ecology and evolution. *Israel Journal of Ecology and Evolution* 54: 1-5.

Holt RD, Gaines M (1992) The analysis of adaptation in heterogeneous landscapes: Implications for the evolution of fundamental niches. *Evolutionary Ecology* 6: 433-447.

Honey MR, Scoble MJ (2001) Linnaeus's butterflies. *Zoological Journal of the Linnean Society* 132: 277-399.

Huntley B, Green RE, Collingham YC, Hill JK, Willis SG, Bartlein PJ, Cramer W, Hagemeijer WJM, Thomas CJ (2004) The performance of models relating species geographical distributions to climate is independent of trophic level. *Ecology Letters* 7: 417-426.

Ibanez I, Clark JS, Dietze MC, Feeley K, Hersh M, LaDeau S, McBride A, Welch NE, Wolosin MS (2006) Predicting biodiversity change: Outside the climate envelope, beyond the species-area curve. *Ecology* 87: 1896-1906.

IPCC (Intergovernmental Panel on Climate Change; 2001) Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK.

Johst K, Drechsler M, Thomas J, Settele J (2006) Influence of mowing on the persistence of two endangered large blue butterfly species. *Journal of Applied Ecology* 43: 333-342.

Kadmon R, Farber O, Danin A (2003) A systematic analysis of factors affecting the performance of climatic envelope models. *Ecological Applications* 13: 853-867.

Kawecki TJ (1995) Demography of source-sink populations and the evolution of ecological niches. *Evolutionary Ecology* 9: 38-44.

Klots AB (1933) A generic classification of the Pieridae together with a study of the male genitalia. *Entomologica Americana* 12: 139-242.

Kudrna O (1977) *A revision of the genus Hipparchia Fabricius, 1807*. Classey, Faringdon.

Kudrna O (1984) On the taxonomy of the genus *Hipparchia* Fabricius, 1807, with descriptions of two new species from Italy. *Fragmenta Entomologica* 17: 229-243.

Kudrna O (2002) The distribution atlas of Euroopean butterflies. *Oedippus* 20: 1-342.

Kudrna O, Belicek J (2005) On the 'Wiener Verzeichnis', its authorship and the butterflies named therein. *Oedippus* 23: 1-32.

Kühn E, Feldmann R, Harpke A, Hirneisen N, Musche M, Leopold P, Settele, J (2008a) Getting the public involved into butterfly conservation – Lessons learned from a new monitoring scheme in Germany. *Israel Journal of Ecology and Evolution* 54: 89-103.

Kühn I, Sykes MT, Berry PM, Thuiller W, Piper JM, Nigmann U, Araújo MB, Balletto E, Bonelli S, Cabeza M, Guisan A, Hickler T, Klotz S, Metzger M, Midgley G, Musche M, Olofsson J, Paterson JS, Penev L, Rickebusch S, Rounsevell MDAR, Schweiger O, Wilson E, Settele J (2008b). MACIS: Minimisation of and Adaptation to Climate change Impacts on biodiverSity. *GAIA – Ecological Perspectives for Science and Society* 17/4: 393-395.

Kühn I, Böhning-Gaese K, Cramer W, Klotz S (2008c). Macroecology meets global change research. *Global Ecology & Biogeography* 17: 3-4.

Kühn I, Vohland K, Badeck F, Hanspach J, Pompe S, Klotz S (in press) Aktuelle Ansätze zur Modellierung der Auswirkungen von Klimaveränderungen auf die biologische Vielfalt. *Natur & Landschaft* 84(1).

Lobo JM, Jimenez-Valverde A, Real R (2008) AUC: a misleading measure of the performance of predictive distribution models. *Global Ecology & Biogeography* 17: 145-151.

Luoto M, Heikkinen RK (2008) Disregarding topographical heterogeneity biases species turnover assessments based on bioclimatic models. *Global Change Biology* 14: 483-494.

Luoto M, Virkkala R, Heikkinen RK (2007) The role of land cover in bioclimatic models depends on spatial resolution. *Global Ecology & Biogeography* 16: 34-42.

Manel S, Williams HC, Ormerod SJ (2001) Evaluating presence-absence models in ecology: the need to account for prevalence. *Journal of Applied Ecology* 38: 921-931.

McPherson JM, Jetz W (2007) Effects of species' ecology on the accuracy of distribution models. *Ecography* 30: 135-151.

Miller LD (1968) The higher classification, phylogeny and zoogeography of the Satyridae. *Mem. Am. Ent. Soc.* 24: 1-174.

Mitchell TD, Carter TR, Jones PD, Hulme M, New M (2004) *A comprehensive set of high-resolution grids of monthly climate for Europe and the globe: the observed record (1901-2000) and 16 scenarios (2001-2100).* Tyndall Centre for for Climate Change Research, University of East Anglia, Norwich, UK.

Mouquet N, Belrose V, Thomas JA, Elmes GW, Clarke RT, Hochberg ME (2005) Conserving community modules: a case study of the endangered lycaenid butterfly *Maculinea alcon*. *Ecology* 86: 3160-3173.

New M, Hulme M, Jones J (2000) Representing twentieth-century space-time climate variability. Part II: Development of 1901-96 monthly grids of terrestrial surface climate. *Journal of Climate* 13: 2217-2238.

Ohlemuller R, Gritti ES, Sykes MT, Thomas CD (2006) Quantifying components of risk for European woody species under climate change. *Global Change Biology* 12: 1788-1799.

Office of International Epizootics (OIE) (2000): International Animal Health Code.

Parmesan C (1996) Climate and species' range. *Nature* 382: 765-766.

Parmesan C, Yohe G (2003) A globally coherent fingerprint of climate change impacts across natural systems. *Nature* 421: 37-42.

Parmesan C, Ryrholm N, Stefanescu C, Hill JK, Thomas CD, Descimon H, Huntley B, Kaila L, Kullberg J, Tammaru T, Tennent WJ, Thomas JA, Warren MS (1999) Poleward shifts in geographical ranges of butterfly species associated with regional warming. *Nature* 399: 579-583.

Pearson RG, Dawson TP (2003) Predicting the impacts of climate change on the distribution of species: are bioclimate envelope models useful? *Global Ecology and Biogeography* 12: 361-371.

Pearson RG, Thuiller W, Araujo MB, Martinez-Meyer E, Brotons L, McClean C, Miles L, Segurado P, Dawson TP, Lees DC (2006) Model-based uncertainty in species range prediction. *Journal of Biogeography* 33: 1704-1711.

Pease CM, Lande R, Bull JJ (1989) A model of population-growth, dispersal and evolution in a changing environment. *Ecology* 70: 1657-1664.

Pech P, Fric Z, Konvicka M, Zrzavy J (2004) Phylogeny of *Maculinea* blues based on morphological and ecological characters: evolution of parasitic myrmecophily. *Cladistics* 20: 362-375.

Pena C, Wahlberg N, Weingartner E, Kodandaramaiah U, Nylin S, Freitas AVL, Brower VZ (2006) Higher level phylogeny of Satyrinae butterflies based on DNA sequence data. *Molecular Phylogenetics and Evolutin* 40: 29-49.

Pollard E (1977) A method for assessing changes in the abundance of butterflies. *Biological Conservation* 12: 115-134.

Pollard E (1988) Temperature, rainfall and butterfly numbers. *Journal of Applied Ecology* 25: 819-828.

Pollard E, Yates TJ (1993) *Monitoring butterflies for ecology and conservation: the British butterfly monitoring scheme*, 1st edn. London, Chapman, Hall.

Pompe S, Hanspach J, Badeck F, Thuiller W, Kühn I (2008) Climate and land use change impacts on plant distributions in Germany. *Biology Letters* 4: 564-567.

Porter AH, Schneider RW, Price BA (1995) Wing pattern and allozyme relationships in the *Coenonympha arcania* group, emphasising the *C. gardetta-darwiniana* contact area at Bellwald, Switzerland. *Nota lepidopterologica* 17: 155-174.

Porter AH, Wenger R, Geiger H, Scholl A, Shapiro AM (1997) The *Pontia daplidice-edusa* hybrid zone in Northwestern Italy. *Evolution* 51: 1561-1573.

Pulliam HR (2000) On the relationship between niche and distribution. *Ecology Letters* 3: 349-361.

Randin CF, Dirnböck T, Dullinger S, Zimmermann NE, Zappa M, Guisan A (2006) Are niche-based species distribution models transferable in space? *Journal of Biogeography* 33: 1689-1703.

Reznick DN, Ghalambor CK (2001) The population ecology of contemporary adaptations: what empirical studies reveal about the conditions that promote adaptive evolution. *Genetica* 112-113: 183-198.

Rickebusch S, Thuiller W, Hickler T, Araujo MB, Sykes M, Schweiger O, Lafourcade B (2008) Incorporating the effects of changes in vegetation functioning and CO2 on water availability in plant habitat models. *Biology Letters* 4: 556-559.

Roy DB, Rothery P, Moss D, Pollard E, Thomas JA (2001) Butterfly numbers and weather: predicting historical trends in abundance and the future effects of climate change. *Journal of Animal Ecology* 70: 201-217.

Sakamoto Y, Ishiguro M, Kitagawa G (1986) Akaike information criterion statistics. D. Reidel Publishing Company, Dordrecht, Tokyo.

Sala OE, Stuart Chapin III F, Armesto JJ, Berlow E, Bloomfield J, Davis F, Dirzo R, Froydis I, Huber-Sanwald E, Huenneke LF, Jackson R, Kinzig A, Leemans R, Lodge D, Malcolm J, Mooney HA, Oesterheld M, Poff L, Sykes MT, Walker BH, Walker M, Wall D (2000) Global biodiversity scenarios for the year 2100. *Science* 287: 1770-1774.

Schweiger O, Settele J, Kudrna O, Klotz S, Kühn I (in press) Climate change can cause spatial mismatch of trophically interacting species. *Ecology*.

Segurado P, Araujo MB (2004) An evaluation of methods for modelling species distributions. *Journal of Biogeography* 31: 1555-1568.

Seoane J, Carrascal LM, Alonso CL, Palomino D (2005) Species-specific traits associated to prediction errors in bird habitat suitability modelling. *Ecological Modelling* 185: 299-308.

Settele J, Hammen V, Hulme PE, Karlson U, Klotz S, Kotarac M, Kunin, Marion G, O'Connor M, Petanidou T, Peterseon K, Potts S, Pritchard H, Pyšek P, Rounsevell M, Spangenberg J, Steffan-Dewenter I, Sykes MT, Vighi M, Zobel M, Kühn I (2005) ALARM: Assesing LArge scale environmental Risks for biodiversity with tested Methods. *GAIA – Ecological Perspectives in Science, Humanities, and Economics* 14: 96-72.

Settele J, Kuhn I, Klotz S, Hammen V, Spangenberg J (2007) Is the EC afraid of its own visions? *Science* 315: 1220.

Settele J, Spangenberg J, Kühn I (2008). Large projects can create useful partnerships. *Nature* 453: 850.

Shirozu T, Yamamoto H (1956) A generic revision and phylogeny of the tribe Theclini. *Sieboldia* 1: 330-421.

Simonsen TJ (2006) Fritillary phylogeny, classification and larval hostplant: reconstructed mainly on the basis of male and female genitalic morphology. *Biological Journal of the Linnean Society* 89: 627-673.

Singer MC, Thomas CD, Parmesan C (1993) Rapid human-induced evolution of insect host associations. *Nature* 366: 681-683.

Smith B, Prentice IC, Sykes MT (2001) Representation of vegetation dynamics in modelling of terrestrial ecosystems: comparison of two contrasting approaches within European climate space. *Global Ecology and Biogeography* 10: 621-638.

Spangenberg JH (2007) Integrated scenarios for assessing biodiversity risks. *Sustainable Development* 15: 343-356.

Sykes MT, Prentice IC, Cramer W (1996) A bioclimatic model for the potential distribution of northern European tree species under present and future climates. *Journal of Biogeography* 23: 203-233.

Thomas CD (1994) Extinction, colonization, and metapopulations: Environmental tracking by rare species. *Conservation Biology* 8: 373-378.

Thomas JA (2005) Monitoring change in the abundance and distribution of insects using butterflies and other indicator groups. *Philosophical Transactions of the Royal Society B* 360: 339-57.

Thomas JA, Clarke RT (2004) Extinction rates and butterflies – Response. *Science* 305: 1563-1564.

Thomas JA, Morris MG (1994) Patterns, mechanisms and rates of extinction among invertebrates in the United Kingdom. *Philosophical Transactions of the Royal Society of London Series B-Biological Sciences* 344: 47-54.

Thomas CD, Bodsworth EJ, Wilson RJ, Simmons AD, Davies ZG, Musche M, Conradt L (2001) Ecological and evolutionary processes at expanding range margins. *Nature* 411: 577-581.

Thomas JA, Telfer MG, Roy DB, Preston CD, Greenwood JJD, Asher J, Fox R, Clarke RT, Lawton JH (2004) Comparative losses of British butterflies, birds, and plants and the global extinction crisis. *Science* 303: 1879-1881.

Thuiller W, Araujo MB, Lavorel S (2003) Generalized models versus classification tree analysis: a comparative study for predicting spatial distributions of plant species at different scales. *Journal of Vegetation Science* 14: 669-680.

Thuiller W, Araújo MB, Lavorel S (2004) Do we need land-cover data to model species distributions in Europe? *Journal of Biogeography* 31: 353-361.

Thuiller W, Lavorel S, Araújo MB (2005) Niche properties and geographical extent as predictors of species sensitivity to climate change. *Global Ecology and Biogeography* 14: 347-357.

Thuiller W, Albert C, Araujo MB, Berry PM, Cabeza M, Guisan A, Hickler T, Midgley GF, Paterson J, Schurr FM, Sykes MT, Zimmermann NE (2008) Predicting global change impacts on plant species' distributions: Future challenges. *Perspectives in Plant Ecology Evolution and Systematics* 9: 137-152.

Tolman T, Lewington R (2008) *Collins Butterfly Guide*. HarperCollins. London.

Trivedi MR, Berry PM, Morecroft MD, Dawson TP (2008) Spatial scale affects bioclimate model projections of climate change impacts on mountain plants. *Global Change Biology* 14: 1089-1103.

van Nouhuys S, Hanski I (2004) Natural enemies of checkerspot butterflies. In: Ehrlich PR, Hanski I (eds.) *On the Wings of Checkerspots: A Model system for Population Biology*. Oxford University Press, Oxford.

Van Strien AJ, van de Pevert R, Moss D, Yates TJ, Van Swaay C, Vos P (1997) The statistical power of two butterfly monitoring schemes to detect trends. *Journal of Applied Ecology* 34: 817-828.

Van Swaay CAM, Van Strien AJ (2005) Using butterfly monitoring data to develop a European grassland butterfly indicator. In: Kühn E, Feldmann R, Thomas JA, Settele J (eds.) *Studies on the Ecology and Conservation of Butterflies in Europe*. Vol. 1, General Concepts and Case studies. Pensoft, Sofia-Moscow.

Van Swaay CAM, Warren MS (1999) *Red Data book of European butterflies (Rhopalocera) Nature and the Environment, No. 99*. Council of Europe Publishing, Strasbourg.

Van Swaay CAM, Warren MS, Lois G (2006) Biotope use and trends of European butterflies. *Journal of Insect Conservation* 10: 189-209.

Van Swaay CAM, Nowicki P, Settele J, Van Strien AJ (in press). Butterfly Monitoring in Europe – methods, applications and perspectives. *Biodiversity and Conservation*.

Vodolazhsky DI, Stradomsyk BV (2008a) Phylogenetic analysis of subgenus *Polyommatus* (s. str) Latreille, 1804 (Lepidoptera: Lycaenidae) based on mtDNA markers. Part I. *Caucasian Entomological Bulletin* 4(1): 123-130.

Vodolazhsky DI, Stradomsyk BV (2008b) Phylogenetic analysis of subgenus *Polyommatus* (s. str) Latreille, 1804 (Lepidoptera: Lycaenidae) based on mtDNA markers. Part II. *Caucasian Entomological Bulletin* 4(2): 237-242.

Wahlberg N, Nylin S (2003) Morphology versus molecules: resolution of the positions of *Nymphalis, Polygonia* and related genera. *Cladistics* 19: 213-223.

Walther GR, Post E, Convey P, Menzel A, Parmesan C, Beebee TJC, Fromentin JM, Hoegh-Guldberg H, Bairlein F (2002) Ecological responses to recent climate change. *Nature* 416: 389-395.

Walther GR, Burga CA, Edwards PJ (eds.) (2001) *"Fingerprints" of Climate Change – Adapted behaviour and shifting species ranges.* Kluwer Academic/Plenum Publishers, New York / London. 329 pp.

Warren MS, Hill JK, Thomas JA, Asher J, Fox R, Huntley B, Roy DB, Telfer MG, Jeffcoate S, Harding P, Jeffcoate G, Willis SG, Greatorex-Davies JN, Moss D, Thomas CD (2001) Rapid responses of British butterflies to opposing forces of climate and habitat change. *Nature* 414: 65-69.

Wiemers M (1998) *Coenonympha darwiniana*: A hybrid taxon? New insights through allozyme electrophoresis. *Mem. Soc. R. Belg. Ent.* 38: 41-70.

Wiemers M (2003) *Chromosome differentiation and the radiation of the butterfly subgenus Agrodiaetus (Lepidoptera: Lycaenidae: Polyommatus) – a molecular phylogenetic approach*. Dissertation. Universität Bonn.

Wiemers M (2007) Die Gattung *Coenonympha* Hübner, 1819, in Europa: Systematik, Ökologie und Schutz. *Oedippus* 25: 1-42.

Wiens JJ, Graham CH (2005) Niche conservatism: integrating evolution, ecology, and conservation biology. *Annual Review of Ecology, Evolution, and Systematics* 36: 519-539.

Wilson RJ, Gutiérrez D, Gutiérrez J, Martínez D, Agudo R, Monserrat VJ (2005) Changes to the elevation limits and extent of species ranges associated with climate change. *Ecology Letters* 8: 1138-1146.

Species index
(of modelled butterflies)