ALARM: Assessing LAarge-scale environmental Risks for biodiversity with tested Methods

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General ALARM objectives:

• develop integrated large scale biodiversity risk assessment (incl. terrestrial and freshwater ecosystems).

• focus on
  – climate change,
  – environmental chemicals,
  – rates and extent of loss of pollinators
  – biological invasions.

• develop a research network on a continental scale.
DPSIR philosophy

- Socio-economic Frame Conditions
  - Climate Change
    - Environmental Chemicals
    - Pollinator Loss
  - Biological Invasions
- Indicators of Environmental Pressures on Biodiversity
  - Ecosystems
  - Species
  - Genes
- Impacted Biodiversity
- Environmental Pressures
3 different world views are the basis for the scenarios.

Commitment to sustainable development leads to different policies under each world view.

To test the robustness/sensitivity of the outlooks, the “linear scenarios” are complemented by “shock scenarios”.
Scenarios: The objectives

• Scenarios are used to
  – explore the interactions of different drivers,
  – test the policy suggestions,
  – and illustrate their impacts.
Three Narratives

GRAS:
GRowth Applied Strategy scenario (A1 FI)

BAMBU:
Business-As-Might-Be-Usual (A2)

SEDG:
Sustainable European Development Goal (B 1)
Climatic Risk Atlas of European Butterflies


Result of ALARM & MACIS
Launching

a NEW OPEN ACCESS journal

Biodiversity and Ecosystem Risk Assessment

Josef Settele, Kong Luen Heong, Ingolf Kühn, Peter B. Sørensen, Martin T. Sykes & Lyubomir Penev
Beta version available already…

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

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

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

BioRisk 1 (Special issue)  www.pensonline.net/biorisk
Future climate change

- Climate envelope models: relate current species distribution to climatic variables and derive projected future distributions

- More factors impact future species distributions than “simply” climate alone
  - e.g. land use, dispersal or species interactions!
Methods – model development

- Distribution Atlas of the European Butterflies
- Ecological niche models (AFE grid; 50 x 50 km)
- Generalised linear models (binomial error; logit link): P/A
  - Cross-validation (80% parameterisation, 20% validation)
  - $AUC_{\text{Butterfly}}$
Methods – future projections

• Three future scenarios (FP6 project ALARM)
  • SEDG (SRES B1): moderate change; 2.4°C until 2080
  • BAMBU (SRES A2): intermediate change; 3.1°C until 2080
  • GRAS (SRES A1FI): maximum change; 4.1°C until 2080
• Downscaled projections on 10’ grid
• No or full dispersal ability of the butterfly
68920 Orbed Red-underwing Skipper *Spialia orbifer*

**Orbed Red-underwing Skipper**

The Orbed Red-underwing Skipper occurs on dry, flower rich grasslands, on mountain ranges, 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 flower heads of Salad Burnet (*Sanguisorba minor*), and in Eastern Europe, possibly also on Great Burnet (*S. officinalis*).

The round flower heads of the footplats are the caterpillars’ first food, but as they grow larger, they hide themselves between open leaves. Hibernation takes place on the ground, in the litter layer. They also pupate in rolled-up leaves of the footplats.

This skipper is double-brooded and hibernates as a caterpillar.
Apollo *Parnassius apollo*

The Apollo occurs in mountainous areas on steep, sunny slopes with sparse vegetation. In Europe, there are many different subspecies, forms and aberrations, because of the very divided nature of the distribution area. Separated by mountains, the populations develop independently of one another, so that quite marked differences arise. However, their ecology is similar. The Apollo is mostly seen flying below the tree-line, while the Small Apollo (*P. phyton*) occurs above it. The butterflies are fond of visiting hedges 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 caterpillars hibernate inside the eggshell. It emerges in the spring and starts feeding on the leaves of the foodplant. The caterpillars of later instars also eat the leaves. When it is time to pupate, the caterpillar looks for a suitable place between the stones, where they then spin a silken cocoon in which to change into a chrysalis.

The Apollo is single brooded.

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**Changes in habitat suitability present (2010)**

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<tr>
<th>Region</th>
<th>Full Dispersal</th>
<th>No Dispersal</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEIB</td>
<td>225 (35.5%)</td>
<td>456 (54.5%)</td>
</tr>
<tr>
<td>BAMBU</td>
<td>188 (29.5%)</td>
<td>468 (70.5%)</td>
</tr>
<tr>
<td>GRAS</td>
<td>325 (44.8%)</td>
<td>513 (55.2%)</td>
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<tr>
<td>SEIB</td>
<td>225 (44.8%)</td>
<td>479 (55.2%)</td>
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<tr>
<td>BAMBU</td>
<td>188 (32.0%)</td>
<td>417 (68.0%)</td>
</tr>
<tr>
<td>GRAS</td>
<td>325 (43.9%)</td>
<td>570 (56.1%)</td>
</tr>
</tbody>
</table>
70130 Moorland Clouded Yellow *Colias palaeno*

**Moorland Clouded Yellow**

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 Whorlthistle (*Echinospartum*). At first, the caterpillar only eat the upper layers of the leaf, producing "windows", but later, the whole leaf is eaten. The caterpillar hibernates among the dry leaves of the litter layer, and the next spring feeds and grows further, before finally pupating on a branch of the food plant.

It has one generation a year.
**Erynnis marloyi** (Boisduval, 1834) – Inky Skipper

![Inky Skipper Butterfly](image)

<table>
<thead>
<tr>
<th></th>
<th>Full dispersal</th>
<th>No dispersal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2050</strong></td>
<td></td>
<td></td>
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<tr>
<td>SEDG</td>
<td>-123 (-13.61%)</td>
<td>-521 (-57.63%)</td>
</tr>
<tr>
<td>BAMBU</td>
<td>-240 (-26.55%)</td>
<td>-583 (-64.49%)</td>
</tr>
<tr>
<td>GRAS</td>
<td>-222 (-24.56%)</td>
<td>-631 (-69.8%)</td>
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<tr>
<td><strong>2080</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEDG</td>
<td>-72 (-7.96%)</td>
<td>-578 (-63.94%)</td>
</tr>
<tr>
<td>BAMBU</td>
<td>-572 (-63.27%)</td>
<td>-807 (-89.27%)</td>
</tr>
<tr>
<td>GRAS</td>
<td>-658 (-72.79%)</td>
<td>-862 (-95.35%)</td>
</tr>
</tbody>
</table>

Changes in climatic niche distribution
(in 10’x10’ 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 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 x 50 km² UTM grid; black circles) and modelled actual distribution of climatic niche (orange areas)

Multidimensional climatic niche. Occurrence probability defined by accumulated growing degree days until August (Gdd) and soil water content (Swc) for combinations of minimum, lower quantile, upper quantile and maximum values of annual temperature range and annual precipitation range. Climatic conditions: orange – unsuitable; green – hostile; black line – modelled threshold.
Mean values of the following 22 climate variables for the period 1971-2000 were considered while regarding absolute values and their annual variation:

- 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);
• range in annual water deficiency;
• soil water content for upper and lower horizon retrieved from a dynamic global vegetation model (LPJ-GUESS; Rickebusch et al. 2008);
• annual cloudiness (%);
• quarterly cloudiness (%);
• accumulated growing degree days until February, April, June, and August.
Growing Degree Days – 2000
Simulated Growing Degree Days – BAMBU 2050
Simulated Growing Degree Days – BAMBU 2080
Soil Water Content – 2000
Soil Water Content – BAMBU 2050
Soil Water Content – BAMBU 2080
Range of annual precip – 2000
Range of annual precip – BAMBU 2050
Range of annual precip – BAMBU 2080
Range of annual temp – 2000
Range of annual temp – BAMBU 2050
Range of annual precip – BAMBU 2080