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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 km²);
- 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.

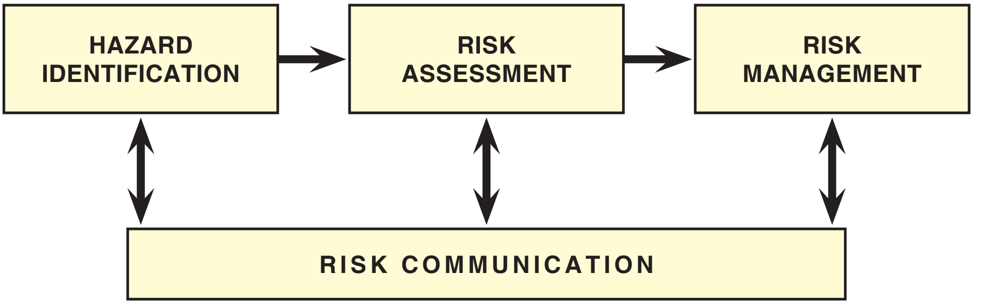

Figure A.3.1: Steps in risk analysis (OIE, 2000)

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 km^2) 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.