Climate change and biological diversity – explorative analysis for a more effective adaptation strategy in Hungary[1]

Nature conservation occupies a special position among the sectors of human activity affected by the impacts of climate change. This is mostly due to the following facts:

(1) Owing to their self-sustaining, self-regulating character, natural communities are, to a certain extent, capable of autonomous adaptation to changing environmental conditions.

(2) As a consequence of (1), conservation is intrinsically passive (adaptive), whereas all other sectors exert active (regulating) management practices.

(3) Due to the complexity of natural ecosystems and the substantial but sophisticated ways in which society relies on ecosystem services the economic impacts of ecosystem changes are difficult, almost impossible, to determine by means of classical economic evaluation.

The reduction of our vulnerability to ecosystem impacts of climate change requires two main steps: the identification of what is at risk and the identification of risk mitigation possibilities. This report primarily focuses on the first step, the identification of potential risks of climate change on ecosystems in Hungary (see “Objectives” and “Results” below). However, some aspects of the second step are considered in the “Recommendations” section below.

Objectives

The main scientific goals of this report are to give a state-of-the-art assessment of the possible effects of climatic changes across several taxonomic groups and to convey a realistic vulnerability assessment for the biological diversity of Hungary. To achieve the first objective, a detailed literature survey was performed on twelve important species groups [vascular plants, mosses, lichens, insects (Orthoptera, Neuroptera, Lepidoptera, Auchenorrhyncha and Carabidae), spiders, amphibians, birds and mammals], focusing on climate change impacts of domestic relevance. Besides phenological, distributional and compositional changes already detectable, available projections on future tendencies were also reviewed. To identify species that are (1) particularly endangered, (2) potential indicators, or (3) potential adventives on account of climate change, trait-based, semi-quantitative methods were developed and performed on the Hungarian flora/fauna of most of the taxonomic groups listed above. Special attention was paid to the climatic sensitivity of the Habitats Directive (92/43/EEC) Annex II. and IV. species. Methods to identify future potential invaders and to assess their invasive capacity were also demonstrated and tested.

The second goal of our report is to give a straightforward vulnerability assessment for Hungary’s natural and semi-natural ecosystems, calculating local exposure, sensitivity and adaptive capacity of the different habitat types. This was made possible by the existence of a detailed habitat database of Hungary, based on recent field habitat mapping[2]. Exposure was calculated using six different GCM outputs comprising four different models and three SRES scenarios, providing a cross-section of the climatic and socio-economic uncertainties within

[1] The full report (in Hungarian): http://www.botanika.hu/download-01/NES/Eghajlatvaltozas_Biodiverzitas.pdf
To cite this report, use: Czúcz, B., Kröel-Dulay, G, Rédei, T, Botta-Dukát, Z, Molnár, Z (ed.), 2007: Climate change and biological diversity – explorative analysis for a more effective adaptation strategy in Hungary. Research report, manuscript (in Hungarian with English summary). Institute of Ecology and Botany of the Hungarian Academy of Sciences, Vácrátót, Hungary.

[2] MÉTA database, http://www.novenyzetiterkep.hu/meta/en/index.shtml

the projections. To estimate the sensitivity of habitats four types (mechanisms) of climate sensitivity were identified. One of these was calculated numerically via bioclimatic modeling, while the rest were assessed semi-quantitatively. Combining results for exposure and sensitivity, maps of potential impact were produced for twelve habitat types in Hungary. The adaptive capacity of the habitat occurrences were assessed using landscape ecological evaluation of the naturalness and distribution of the habitat patches. Three main mechanisms of threat and adaptation were identified here: (1) the effect of local compositional, structural and functional diversity, (2) the refuge-providing ability of the local-regional landscape for the species of the habitat, and (3) the connectivity and permeability of the landscape for the species of the habitat. The local potential of the landscape to promote adaptation was estimated through simple landscape indices for two pilot habitat types.

Results

The most important results are the following (*with references to the corresponding parts of the report wherever possible*):

- establishing a list of species vulnerable to climate change for 12 important taxonomic groups (including vascular plants, butterflies, amphibians, birds and mammals)
- expert-based assessment of climate change impacts on the species of high conservational value (EU HD Annex II. and IV. species)
- establishing a list of common species with a high level of climate sensitivity and relatively low sensitivity to other aspects of environmental change as potential climatic indicators in future monitoring
- compilation of a meta-database on the available distribution, phenology and trait databases with relevance to Hungary on the studied species groups (*Annexes 6.9–6.11.*)
- numeric evaluation of the potential impacts of climate change on the distribution of some important invasive plants (*Solidago* spp, *Elaeagnus angustifolia*; *Annex 6.3.*)
- introduction of a new framework of global climatic analogues as a potential tool to identify sources of new invasions and calculations of climatic analogues for Budapest for the present day climate and for 2085 (*Fig. 3.4-1.*)
- overview and testing of a trait-based framework for species-level screening of potential invaders (the adaptation of the Australian invasion risk assessment framework for Central Europe; *Annex 6.4.*)
- compilation of downscaled climatic scenarios for Hungary for the 21st century based on a multitude of climate models and emission scenarios (*Tables 4.2-1–4.2-2.*)
- numerical characterization of climate sensitivity and the potential impact of climate change on the most important Pannonian (Hungarian) habitat types (*Table 4.4-2.*)
- potential impact maps on the 12 most affected habitat types for three time horizons (2025, 2050 and 2085; *Fig. 4.4-1.*)
- designing a framework for estimation of the autonomous adaptive capacity of natural systems and testing it for two habitat types of significant conservation value (mesotrophic meadows and *Artemisia* salt steppes; *Maps 1–14*)
- pointing out reasonable intervention possibilities to enhance autonomous adaptation and carrying out a detailed analysis for the two examined habitat types (*Maps 15–22*).

Recommendations

Since undisturbed ecosystems are stable, self-regulating systems, mitigation in the case of natural environments should mean enhancing autonomous adaptive capacity of ecosystems. In accordance with our conceptual model used in the "adaptive capacity" part of the vulnerability analysis discussed, this can be done on three levels:

(1) enhancing local natural status of the habitats (compositional, structural and functional diversity) by reducing additional stresses and degrading land use practices (drainage, over-harvesting, over-grazing, etc.);

(2) preserving and increasing local diversity on a small scale;

(3) preserving and increasing the connectivity and permeability of the landscape for the species of the natural habitats on a regional level.

Under stable environmental conditions, many species and habitats can be preserved by simply creating reserves of appropriate sizes. In a changing climate where species need to track the changes, the state of the agricultural and urban matrix that surrounds natural ecosystems will have crucial impact on the success of adaptation. Thus, under advancing climatic changes, biodiversity in Central Europe will not be retainable without integrating the aspects of conservation into the policies of several sectors (agriculture, forestry, hydrology, transportation, etc.). Fortunately this is already being recognized and acknowledged in many advanced sectoral policies (Water Framework Directive, Agro-environmental schemes, PRO SILVA forest management, etc.), but further advances are still desirable. Based on our analysis and literature surveys, the following recommendations are given for the different sectors:

- *Nature conservation*: prepare priority lists of climate sensitive habitats and species; design and perform necessary restoration activities; improve water retention of reserves wherever possible; preserve / enhance mosaicity of habitats and successional states wherever possible; introduce / increase network concept in reserve selection; elaborate a concept / measures for protecting networks (of hedges, tree rows, roadsides) in agricultural / industrial / urban landscapes; improve monitoring activities.
- *Water management*: develop / focus on retention oriented water management policies (instead of current drainage oriented policies); introduce ecological aspects in the management regime of reservoirs and floodplain areas; follow the prescriptions and recommendations of the EU Water Framework Directive.
- *Forestry*: emphasize natural forest management techniques providing continuous forest cover; introduce different regulations for forests with semi-natural structure and composition and timber / biofuel plantations; acknowledge forests of low canopy closure (forest–steppe mosaics) as valid management targets.
- *Agriculture*: maintain / reintroduce elements of traditional landscape management (mowing, grazing); provide buffer zones around areas of high conservational value; promote low intensity agricultural techniques; increase the heterogeneity of agricultural landscapes with networks of tree lines and hedges.
- *Transportation*: increase the number of green bridges, ecoducts and other types of wildlife crossings on national motorways; introduce / maintain wide strips of semi-natural vegetation (hedges, forests) on the margin of major roads.