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Regional scale habitat-based vulnerability assessment of the natural ecosystems

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To address the pervasive risks and uncertainties pertinent to climate change, impact adaptation and vulnerability (CCIAV) studies have surged in this decade. Most studies for estimating climate impacts on ecosystems and biological diversity can be characterized by using either a correlative, or a mechanistic approach. Mechanistic models are based on the current understanding of the dynamics of energy, water, nutrient and carbon dynamics among major species groups and their physical environment. Such models are unrivalled in representing vegetation transformations on a global scale; however, for biodiversity on lower spatial levels the application of these data-hungry models is rather limited. Correlative models, on the other hand, are generally based on more readily available species distribution data, producing projections on future distribution by assuming a statistical relationship between actual distribution and climatic needs of the species (Guisan & Zimmermann, 2000). Nonetheless, due to the limitations of the model structure and the data sources applied, there is generally no straightforward way to take processes of natural adaptation into account. Such models usually apply two extreme assumptions of non-adaptive systems (usually referred to as “no dispersal” of species) and perfectly adaptive systems (“universal dispersal”), as a generalized “interval projection”. Thus, studies employing correlative models can be regarded as simple “impact assessments” (the first stage of CCIAV assessments sensu Füssel & Klein, 2006), and according to Rothmann and Robinson (1997) the evolution towards realistically adaptive agents is inevitable as assessments become increasingly integrated. A further issue is raised by uneven data coverage between taxonomical groups, showing significant imbalance towards easily observable, popular and charismatic species groups, however, modelling studies that include large numbers of species are generally accepted to reveal general tendencies for biodiversity.

To address these issues we present here a framework for regional assessment of the vulnerability of natural and semi-natural ecosystems. The framework is fundamentally based upon established techniques of correlative species distribution models. However, there are two major novelties which make it possible to upgrade the simple correlative impact models into a “first generation vulnerability assessment” (the second stage of CCIAV assessments sensu Füssel & Klein, 2006): (1) using habitats as main modelling objects (instead of species), which, due to the completeness of the classification system, allow us to (2) calculate simple indicators of local adaptive capacity. Thus the structure of the presented framework follows that of the classic CCIAV studies, quantifying local exposure, sensitivity and adaptive capacity of different exposure units.

Most models that account for ecological impacts of climate change work either with species or with major biomes as exposure units. However, neither of these approaches seems to be appropriate for regional or national level ecosystem vulnerability assessments; there are too few biomes and too many species which lack reliable data on life traits and distribution. Accordingly, as an intermediate solution, we propose habitats as exposure objects for regional studies. In this sense, habitats (habitat types) are more than just the spatial locations of species occurrences – habitats can rather be defined as communities of species living together, determined by trophic linkages and/or similar environmental (e.g. climatic) needs. Consequently, while species react individually to the external changes, climate impacts on species sharing similar climatic needs will presumably be similar – at least in the initial phase of climate change, often in the focus of policymakers’ interest. We argue that wherever local habitat classification schemes exist, owing to their local ecological relevance and the completeness of the classification system used, they can be a reasonable object for regional assessments.

As it is common practice in the evaluation of complex systems (e.g. Yohe & Tol, 2002), we propose a framework of adaptive capacity indicators that account for the most important coping options or mechanisms of the system. The proposed indicators aim at estimating the chances that the species inhabiting the studied habitat types can avoid degradation (and the resulting erosion of genetic diversity) caused by climate alteration. To this end, we distinguish three basic components (mechanisms) of ecological resilience to climate change:

- *ecosystem resilience*: habitat occurrences in more favourable (more natural) condition are more likely to be resilient to climatic stresses;
- *refuge-based adaptation*: withdrawing of species into local microclimatic refuges in a generally unfavourable environment;
- *migration-based adaptation*: large-scale movement of species following macroclimatic changes (the shift of climatic zones) by migration.

The applicability of our ecosystem vulnerability framework is illustrated with a case study (Czúcz et al., 2008) for Hungary, based on detailed habitat data available on the national level from the MÉTA database (Molnár et al. 2007). Climatic exposure was calculated using six different GCM outputs comprising of four different models and three emission scenarios, providing a cross-section of the climatic and socio-economic uncertainties within the projections. To estimate the sensitivity of habitats, four types of climate sensitivity were identified and estimated either quantitatively or semi-quantitatively. The adaptive capacity indicators mentioned above were quantified using simple landscape indices base on the quality and distribution of habitat patches. By combining results of exposure, sensitivity and adaptive capacity, climatic vulnerability maps of natural ecosystems were produced. This case study, prepared for the Hungarian National Climate Change Strategy, provides an illustration for a flexible methodology, which can potentially be applied as an "ecosystems" part of complex integrated CCIAV assessments.

References:
Czúcz B, Torda G, Molnár Zs, Horváth F, Botta-Dukát Z & Kröel-Dulay Gy in: Filho WL, Mannke F (eds): *Interdisciplinary Aspects of Climate Change.* Peter Lang, Frankfurt, 2008 (accepted).
Füssel HM & Klein RJT: *Climatic Change*, 2008, 75(3):301-329.
Guisan A & Zimmermann NE: *Ecological Modelling*, 2000, 135(2-3):147-186.
Molnár Zs, Bartha S, Seregélyes T, Illyés E, Botta-Dukát Z, Tímár G, Horváth F, Révész A, Kun A & Bölöni J: *Folia Geobotanica*, 2007, *42*:225-247.
Rothman DS & Robinson JB: *Environmental Monitoring and Assessment*, 1997, 46(1):23-43.
Yohe G & Tol RSJ: *Global Environmental Change*, 2002, 12(1):25-40.