MRI Newsletter 8: Georeferenced Biological Databases—A Tool for Understanding Mountain Biodiversity

The Mountain Research Initiative invited Dr Eva Spehn, Director of the Global Mountain Biodiversity Assessment (GMBA), and Dr Antoine Guisan, head of the Spatial Ecology Group at the University of Lausanne, to introduce the reader to their coordinated efforts to advance understanding and prediction of mountain biodiversity. Antoine Guisan's EUROMONT project is one of the many scientific projects that may potentially provide data for the new GMBA initiative for a GIS mountain biodiversity database.

The Global Mountain Biodiversity Assessment (GMBA)

GMBA, a cross-cutting network of DIVERSITAS, aims to encourage and synthesize research on high-elevation organismic diversity, its regional and global patterns, and its causes and functions (Spehn et al 2005). Existing and emerging databases are promising tools for achieving these goals. Many research projects generate data sets that are relevant for the scientific community, governmental natural resource managers, policymakers, and the public. The Global Biodiversity Information Facility (GBIF) has a mission to make the world's primary data on biodiversity freely and universally available via the Internet. In cooperation with GBIF, GMBA encourages a global effort to mine georeferenced archive databases on mountain organisms, build new biodiversity databases, and link them with geophysical databases.

When building or analyzing database information, it is essential to include geographical coordinates and altitude specifications (georeference) for observed or collected biological species, as this makes it possible to link biological and geophysical information, particularly climate data. The amplitude of climatic conditions and topographies in the world's mountains offer unmatched test conditions for biodiversity theory.

The great diversity and endemism of mountains may have their origins in past climatic events, which allowed faster altitudinal than latitudinal migrations of species, as cooling and warming succeeded during the Quaternary or through survival of some species in high-elevation refuges (*nunataks*). But the great richness and originality of flora and fauna may also simply result from greater habitat diversity and climatic turnover over short distances or the (possibly) long isolation of mountaintops from each other (alpine species cannot migrate through low-elevation areas), which favored speciation (Chapin and Körner 1995). Furthermore, the usual decrease in species richness observed toward higher elevations may result from the conic shape of mountains and shorter growing seasons, restricting both time and space for evolution (Körner 2000; Körner 2004). Yet these theories of biodiversity are usually assessed locally, in a single mountain range (eg Chapin and Körner 1995; Theurillat et al 2003), while a wider view is often required to identify the real proximal causes of biodiversity patterns (eg for treeline, Körner 1998).

A first GMBA workshop in the Central Caucasus in July 2006 drew upon the expertise of 15 mountain biodiversity researchers and database experts, and developed a Research Agenda on the potential of georeferenced biodiversity databases for understanding mountain biodiversity and predicting changes. GMBA will follow up on these issues in a SCOPE Rapid Assessment synthesis project in order to create an overview of regional mountain biotic richness in various parts of the world.

The EUROMONT initiative: an example of potential data for GMBA

The idea of the EUROMONT workshops—which aim to assess climate threat to alpine plant diversity in Europe—began with a recent paper by Thuiller et al (2005) predicting species loss of up to 60% for mountain plant species in Europe in response to climate change. These coarse-resolution (10′×10′) projections provide valuable scenarios for anticipating risks that climate change exerts on overall biodiversity in Europe. But their accuracy may not be sufficient to assess ecological impacts in complex high-elevation mountain landscapes, where the rugged topography requires high-resolution mapping (eg 25×25 m; Guisan and Theurillat 2000). As these predictions are then used to address management issues such as the role of parks and natural reserves as reservoirs of future biodiversity (Araujo et al

Internet resources

EUROMONT: ecospat.unil.ch

DIVERSITAS: www.diversitas-international.org

GBIF (Global Biodiversity Information Facility): www.gbif.org

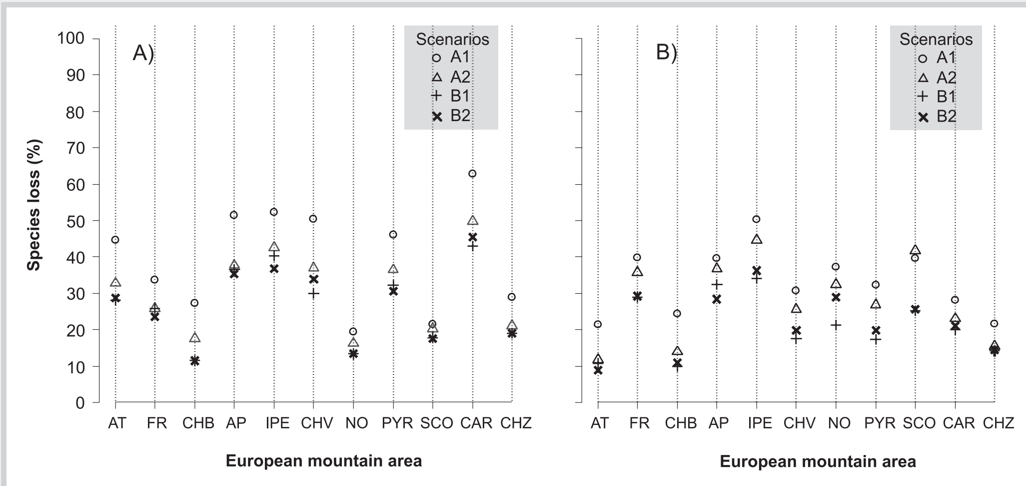
GLORIA (Global Observation Research Initiative in Alpine Environments): www.gloria.ac.at

GMBA (Global Mountain Biodiversity Assessment): www.gmba.unibas.ch

MIREN (Mountain Invasion Research Network): www.miren.ethz.ch

SCOPE (Scientific Committee on Problems of the Environment): www.icsu-scope.org

FIGURE 1 Scenarios of extinctions at the (A) EU scale (big pixels of 10′ × 10′) and (B) local scale (pixels of 100 × 100m aggregated per 10′ × 10′ pixel) across all EUROMONT big pixels (N=536). At the local scale, extinctions were considered to occur when all local pixels for a species became extinct within a big pixel. AT: Austrian Alps, FR: French Alps, CHB: Swiss Central Alps 1, AP: Apennines, IPE: Pyrenees 1, CHV: Swiss Western Alps, NO: Norway, PYR: Pyrenees 2, SCO: Scottish Mountains, CAR: Carpathians, CHZ: Swiss Central Alps 2.



2004), it has become urgent to determine whether reliable local trends can be predicted from these global projections.

This is the main aim of the EUROMONT initiative, supported by MRI and the University of Lausanne. A first workshop brought together 19 scientists from 11 countries, combining 11 data sets from 6 mountain ranges (Alps, Apennines, Pyrenees, Scandes, Scottish highlands, Carpathians). Local climate change impact scenarios were derived for mountain flora, using the same tool and IPCC projections used by Thuiller et al (2005). Preliminary results suggest lower extinction rates on average at the local scale, but higher extinction rates were also predicted for some study areas under severe climate change scenarios (Figure 1). The different study areas clearly show distinct sensitivities to climate change (Figure 1). Nonetheless, all extinction rates remain important (above 10%) and show that all mountain flora are vulnerable, especially when considering the most extreme climate change scenario (A1: up to >60% extinctions). A second workshop in December 2006 aims at a finer interpretation of these results by study area, species type, and climate change scenario.

New sources of georeferenced biodiversity data for the SCOPE/GMBA initiative

The EUROMONT initiative is one of many scientific projects that collect and use large georeferenced mountain biodiversity data sets to answer specific questions in ecology, biogeography, and conservation biology. The GLORIA project on monitoring the effects of global change on alpine plants, and the MIREN network on invasive species in mountains, are other examples. A thorough testing of biodiversity theories with comprehensive data at the global scale, as obtained through EUROMONT, GLORIA, or MIREN, would constitute a significant step in our understanding of mountain diversity patterns. Many data sets are associated with short-term projects and thus threatened by destruction at the end of the project. The new GMBA initiative for a GIS mountain biodiversity database specifically aims to collect such sets in order to prevent their destruction and initiate a first global assessment of the primary causes of mountain biodiversity patterns.

REFERENCES

Araujo MB, Cabeza M, Thuiller W, Hannah L, Williams PH. 2004. Would climate change drive species out of reserves? An assessment of existing reserve-selection methods. *Global Change Biology* 10(9):1618–1626.

Chapin FS III, Körner CE, editors. 1995. *Arctic and Alpine Biodiversity: Patterns, Causes and Ecosystem Consequences.* Ecological Studies 113. Berlin: Springer.

Guisan A, Theurillat J-P. 2000. Assessing alpine plant vulnerability to climate change: A modeling perspective. *Integrated Assessment* 1:307–320.

Körner C. 1998. A re-assessment of high-elevation treeline positions and their explanation. *Oecologia* 115:445–459.

Körner C. 2000. Why are there global gradients in species richness? Mountains might hold the answer. *Trends in Ecology & Evolution* 15:513–514.

Körner C. 2004. Mountain biodiversity, its causes and function. *In: Ambio Special Report 13.* Stockholm, Sweden: Royal Swedish Academy of Sciences, pp 11–17.

Spehn EM, Liberman M, Körner C. 2005. *Land Use Change and Mountain Biodiversity.* Boca Raton, FL: CRC Press.

Theurillat J-P, Schlüssel A, Geissler P, Guisan A, Velluti C, Wiget L. 2003. Plant and bryophyte diversity along an elevational gradient in the Alps. *In:* Nagy L, Grabherr G, Körner C, Thompson DBA, editors. *Alpine Biodiversity in Europe*. Stuttgart, Germany: Springer, pp 185–193.

Thuiller W, Lavorel S, Araujo MB, Sykes MT, Prentice IC. 2005. Climate change threats to plant diversity in Europe. *Proceedings of the National Academy of Sciences of the United States of America* 102:8245–8250.

Antoine Guisan
Department of Ecology and Evolution, UNIL Sorge, Le Biophore, Université de Lausanne, 1015 Lausanne, Switzerland.
Antoine.Guisan@unil.ch
Eva Spehn, Christian Körner
Global Mountain Biodiversity Assessment of DIVERSITAS (GMBA), Institute of Botany, University of Basel, Schönbeinstrasse 6, 4056 Basel, Switzerland.
gmba@unibas.ch