Mountain Biodiversity
Effects of climate change and how to manage them

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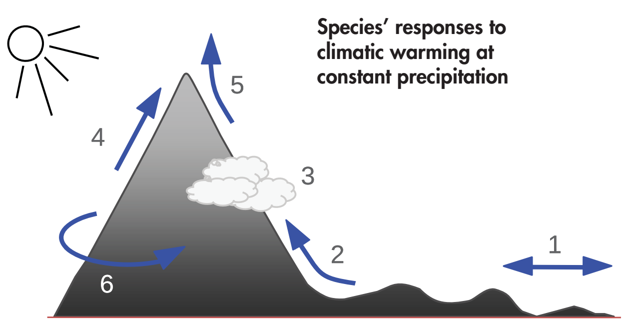
Mountain ecosystems are characterised by steep environmental gradients, including steep gradients of temperature and moisture. They are islands of high-elevation habitats, isolated by the surrounding lowlands. Changes in environmental conditions are especially threatening endemic species that occur in limited areas, such as on mountain peaks. Of these changes, shorter periods of snow cover below the tree line and changes in water availability may be more important drivers of change than temperature change itself. The likely losers from climate warming among plant species in the mountains are late successional species, species with small, restricted populations, and species confined to the summits or the plains; in comparison, ruderal species (weeds), species with large, widespread populations, and mid-slope species are likely to be winners.

Increasing temperatures have caused the early onset of spring activities in plants, such as budburst and flowering. Another widely observed phenomenon is the upward or poleward migration of plant species, which has led to an overall increase in the number of species on mountain summits (see Figure). The migration of species from lower to higher elevations changes species composition and competitive interactions among species, and, in some places, a decrease in cold adapted (subnival and nival) species has been observed. Upward migration in response to anthropogenic climate warming is taking place. Recent studies have demonstrated the upward migration of animal species, such as butterflies and the pine processionary moth, in line with increasing temperatures. As in plant and animal species, huge differences in their reaction to environmental changes have been observed. Interactions among species are also likely to be modified by climate change.

Filling biodiversity data gaps for better decision-making

To improve the forecasting of the effects of climate warming on mountain biodiversity, the quality of predictive models needs to be enhanced. However, available biodiversity data are generally sparse, poorly collected, statistically insufficient, and biased. An alternative is to use the increasingly available geo-referenced species occurrence and natural history databases. The Global Biodiversity Information Facility (GBIF) has catalysed agreements on the standards and protocols required to make datasets compatible and accessible (www.gbif.org). Over 195 million records from over

Schematic presentation of the migration of organisms in response to climatic warming



1 Lowland species lack nearby opportunities to escape from too-warm conditions
2 Foothill species migrate upslope
3 High-elevation species migrate towards summit regions
4 Summit species with no possibility to escape upslope suffer from increasing competition from immigrants from lower elevations
5 Some highland taxa are able to escape short distances by taking advantage of microhabitat diversity in rugged terrain, changing community mosaics at the given elevation

Source: Körner 2009

Rising temperatures are leading to migration of species from lower to higher elevations

8,000 datasets produced by 260 institutions worldwide are now accessible online through the GBIF data portal. Additionally, the Global Mountain Biodiversity Assessment (GMBA) of DIVERSITAS recently launched a thematic mountain portal for GBIF data on mountains (www.mountainbiodiversity.org). This portal allows specific searches of species or taxonomic groups in mountains and their different thermal life belts (e.g., montane, alpine, nival) (Körner et al. 2011), which will help us to understand global mountain biodiversity patterns and inform policy for the protection of mountain biodiversity.

The Hindu Kush-Himalayan (HKH) region is rich in terms of biodiversity resources and ecosystems of global importance. However, available data in the region are sporadic, inaccessible, and not well managed or formatted. Inventory, assessment, and sharing of well-documented biodiversity information from the region is essential to improve the understanding, conservation, and management of these resources. There is an urgent need to fill the geographical and taxonomic data gaps. GMBA recently made a huge plant database of the HKH available at GBIF, the so-called 'Himalayan Upland Plant Database (HUP)' (Dickoré 2011; Nemitz et al. 2012). This database has 164,360 records of approximately 5,562 species collected over 50 years in more than 13 countries (including Afghanistan, Pakistan, Bhutan, China, India, Kazakhstan, Kyrgyzstan, Myanmar, Nepal, Russia, Tajikistan, Turkmenistan, and Uzbekistan).

ICIMOD, in cooperation with GBIF and GMBA, organised a regional workshop and hands-on training at ICIMOD's headquarters in Kathmandu, Nepal in June 2010. The aim of the workshop was to provide a global platform to publish, harvest, and use biodiversity data from the HKH region using international data, metadata standards, and geo-referencing biodiversity data. The workshop brought together 25 participants from ICIMOD's eight regional member countries: Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. The participants learned about the GBIF infrastructure and framework for primary biodiversity data, discovery, and publishing, and discussed its use in the region. As ICIMOD is the regional node of GBIF, the way forward will be to initiate regional collaboration to develop and share biodiversity information in the region.

Climate information is required to assess ecosystem vulnerability and identify adaptation options (wetland ecosystem, Bhutan)

How to manage climate change impacts and plan for necessary adaptation measures

To protect biodiversity, it is important to identify regions of high biodiversity value (based on data on species and habitats and expert evaluation) and prioritise these areas for conservation. The eight HKH regional member countries are signatories to the Convention on Biological Diversity and are committed to conservation. Towards the immediate protection of globally significant landscapes, these countries have set aside more than 39 per cent of their most biologically rich land. The region now has a total of 488 protected areas, 29 Ramsar Sites, 13 UNESCO World Heritage Sites, and 330 Important Bird Areas.

Climate change is having significant impact on biodiversity and ecosystems, and climate information is required to assess vulnerability and identify adaptation options. Experts on biodiversity and natural resource management recommend the following actions.

- Dialogue between scientists and non-scientists: It is important to organise continuous dialogue between climate scientists and biodiversity/ecosystem scientists to translate climate data into impacts on biodiversity and ecosystem services (i.e., climate services) for the benefit of users.
- Model improvement: We need to improve the representation of the functional role of biodiversity and ecosystem processes in Earth system models.
- Biodiversity monitoring: It is necessary to enhance and integrate biodiversity observing and monitoring activities and systems (such as LTER networks) through support to the Group on Earth Observations Biodiversity Observing Network (GEO BON) using Earth observation and other relevant initiatives.
- Integration of indigenous knowledge: It is important to integrate data and knowledge from indigenous and local communities, including citizen-based observations, about ecosystem responses and approaches to adaptation, in the design and implementation of climate information systems.
- Sharing of information: It is important to facilitate the sharing of information and good practices on ecosystem-based adaptation to climate change.

Approaches in mountains to adapt to climate change

The following guidelines are designed to help natural resources adapt to climate change, with a specific focus on biodiversity and mountain habitats (Baron et al. 2009; Chettri and Worboys 2009).

- Improve protected areas in mountains: Re-evaluate the management goals of protected areas, and ensure the continued protection and appropriate management of existing protected areas. Increase the size of protected areas where possible (e.g., enlarge core protection zones and buffer zones with nature-friendly land uses) and create new protected areas. Protect altitudinal gradients. Cooperate to develop common approaches with adjacent or nearby protected areas.

- Improve ecological connectivity: The safeguarding of latitudinal and altitudinal ecological continuums will be a crucial element in adaptation to changing conditions for many species and populations, mainly in areas where there is an actual or potential tree line and in urbanised areas in the Alps (Scheurer et al. 2008). However, improving ecological connectivity also improves the distribution of diseases, pests, and invasive plants along corridors. Hence, it is not yet clear where connectivity is appropriate, for which taxa, and how ecological connectivity improves biodiversity and ecological persistence.
- Retain permeable landscapes: Enhance existing incentive schemes promoting lower intensity land management and the development of greater landscape heterogeneity. Retain patches of 'semi-natural habitat', especially in urban or intensively used areas.
- Reduce anthropogenic stresses: Minimise localised human-caused disturbances (e.g., fragmentation, nitrogen addition, pollution) that hinder the ability of species or ecosystems to withstand climatic events (Baron et al. 2008, 2009). This can also mean keeping traditional land use in regions where this has been the predominant form of management in order to preserve species diversity and sensitive ecosystems (Theurillat and Guisan 2001).
- Protect key ecosystem features: Manage ecosystems so as to maintain structural characteristics, organisms, or areas that support the overall system, such as keystone organisms. Protect variant forms of a species or ecosystem, so that as the climate changes there may be populations that survive and provide a source for recovery. Maintain or establish more than one example of each ecosystem or population within a managed system, so that if one area is affected by disturbance, replicates in another area may reduce the risk of extinction and provide a source for recolonisation (Baron et al. 2008, 2009). Sustain the variables (e.g., soil resources and the species' pool) that accumulate slowly and provide buffers. Sustain both ecological legacies (e.g., old forest growth, woody debris) and cultural legacies (e.g., people's connection to the land) (Chettri and Worboys 2009).
- Restore ecosystems and species: Rehabilitate ecosystems that have been lost or compromised. Restore or facilitate the recovery of missing keystone species (e.g., wolf, beaver).
- Identify refugia: Use areas that are less affected by climate change than other areas as sources for recovery or as destinations for climate-sensitive migrants and maximise populations of rare and threatened species.
- Relocate: Transplant organisms from one location to another to bypass a barrier (e.g., an urban area). Translocate genotypes, species, and soil invertebrates or microbes, and initiate captive breeding programmes.

In relation to all of these guidelines, the availability of information from Earth observation in combination with in-situ data and flexibility in management approaches will be critical to maintaining biodiversity and ecological resilience in mountains in a changing climate.

References

Baron JS; Herrod, JS; West, JM; Joyce, LA; Blate, G; Peterson, CH; Palmer, M; Keller, BD; Kareiva, P; Scott, JM; Griffith, B (2008) 'Some guidelines for helping natural resources adapt to climate change.' *IHDP Update* 2: 46–52

Baron, JS; Gunderson, L; Allen, CD; Fleishman, E; McKenzie, D; Meyerson, LA; Oropeza, J; Stephenson, N (2009) 'Options for national parks and reserves for adapting to climate change'. *Environmental Management* 44: 1033–1042

Chettri, N; Worboys, G (2009) 'Managing landscapes using conservation corridors'. *Sustainable Mountain Development – Biodiversity and Climate Change in the Himalayas* 55: 28–30

Dickoré, WB (2011) Himalayan upland plant database of Bernhard Dickoré, Munich Herbaria, accessed on the GBIF portal. Available at: http://data.gbif.org/datasets/resource/12781

Körner, Ch (2009) 'Conservation of mountain biodiversity in the context of climate change.' In: Sharma, E (ed.) *Proceedings of the International Mountain Biodiversity Conference*. Kathmandu: ICIMOD

Körner, Ch; Paulsen, J; Spehn, EM (2011) 'A definition of mountains and their bioclimatic belts for global comparisons of biodiversity data.' *Alpine Botany* 121: 73–78

Nemitz, D; Huettmann, F; Spehn, EM; Dickoré, WB (2012) 'Mining the Himalayan Uplands Plant Database for a conservation baseline using the public GMBA webportal'. In: Huettmann, F (ed.) *Protection of the Three Poles*. Tokyo, Japan: Springer Japan (in press)

Scheurer, T; Bose, L; Künzle, I (2008) 'The continuum project – Evaluation of approaches for designing and implementing ecological networks in the Alps.' Alpine Network of Protected Areas (ALPARC), (International Scientific Committee on Research in the Alps (ISCAR), International Commission for the Protection of the Alps (CIPRA), World Wide Fund for Nature (WWF)

Theurillat, JP; Guisan, A (2001) 'Potential impact of climate change on vegetation in the European Alps: A review.' *Climatic Change* 50: 77–109