BIODIVERSITY AND FUNTIONING OF SELECTED TERRESTRIAL ECOSYSTEMS: ALPINE AND ARCTIC ECOSYSTEMS

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Summary

Species richness generally declines with increasing latitude and altitude, whereas genetic diversity within species does not change with latitude or altitude. Greater isolation and niche differentiation promote speciation and restricted species migration in alpine regions, resulting in a higher species richness in alpine than in arctic ecosystems.

Ecosystem integrity on steep mountain slopes and in high elevation landscapes is in general a question of soil stability, which in turn depends on plant cover and rooting patterns. Terrestrial net primary production and decomposition rates in arctic and alpine ecosystems are low and revegetation after human disturbance can take centuries. Relatively few species regulate the annual input and loss of nitrogen from arctic and alpine ecosystems and changes in the abundance of these species could profoundly alter the resource base that governs rates of biogeochemical processes.

Biodiversity in arctic and alpine ecosystems is currently threatened most strongly by human-induced global change. Input of pollutants from low latitudes and altitudes have a low-level chronic impact on key functional groups. CO_2 induced climatic warming is causing upward migration of alpine species with the possible loss of some alpine ecosystems from low-altitude summits.

These changes will most likely be superseded by heavy anthropogenic impacts, such as overgrazing, complete abandonment and inappropriate land management in the short term. Of all global change impacts on mountain biodiversity, land use is the most important factor.

Diversity-driven ecosystem services, such as productivity of alpine pastures or arctic tundra, or erosion control on steep mountain slopes need to be quantified. We do need empirical evidence for the insurance hypothesis—the strongest scientific foothold for the need of diversity for the sustained integrity of arctic and alpine ecosystems.

1. Alpine and arctic biodiversity

The land area covered by arctic and alpine vegetation is roughly 11 million km^2, or 8% (5% arctic, 3% alpine) of the terrestrial surface of the globe, stretching from 80°N to 67°S and reaching elevations of more than 6000 m in the subtropics.

The alpine life zone above the climatic treeline hosts a vast biological richness, exceeding that of many low elevation biota. Steep terrain, the compression of thermal zones, and the fragmentation of landscape make mountain ecosystems unique. Many organisms adapt and specialize in these high-altitude microhabitats. The overall global vascular plant species richness of the alpine life zone alone was estimated to be around 10 000 species, 4% of the global number of higher plant species.

The Arctic (Chapin *et al*, 2005) hosts 3% of the global flora and 2% of the global fauna (Chernov 1995; Matveyeva and Chernov 2000). There are about 1800 species of vascular plants, 4000 species of cryptogams, 75 species of terrestrial mammals, 240 species of terrestrial birds, 2500 species of fungi, and 3200 species of insects (Matveyeva and Chernov 2000).

Species richness generally declines with increasing latitude and altitude. In general, the regional and local species pools are limited by extreme temperature, short growing season, low nutrient availability, low soil moisture, and frost disturbance. Animal species decline with increasing latitude more strongly than do vascular plants (often by a factor of 2.5 compared to plant species decline) (Callaghan *et al*, in press) and under most extreme conditions, major functional groups of organisms are absent. In all animal groups, the proportion of species that are carnivorous increases with latitude (Chernov 1995). Within the alpine zone, the total plant species diversity of a given region commonly declines by about 40 species of vascular plants per 100 m of elevation (Körner 1995).

However, proportional to the altitudinal reduction of species diversity there is a reduction of land area, due to the cone-shapes of mountains (Körner 2000), therefore the species richness per area remains constant with elevation. The magnitude of genetic diversity within species does not change with latitude or altitude within either the arctic or the alpine floras (McGraw 1995; Murray 1995).

Although alpine species are usually long-lived, strongly reliant on reproduction by vegetative growth, and often geographically isolated, their genetic diversity within populations is usually surprisingly high due to effective genetic and breeding systems.

Patterns of diversity differ between arctic and alpine ecosystems for both historical and current ecological reasons. Low temperature and the short growing season act as an effective filter for species colonizing arctic and alpine environments. Greater isolation and niche differentiation promoted speciation and restricted species migration in alpine regions, resulting in a higher species richness in alpine than in arctic ecosystems. Because the most widespread communities in the Arctic (and in alpine areas of low relief) have very few species, the loss of even a few species would dramatically alter species diversity.

The fragmentation and topographic diversity ("geodiversity") is strongly related to biological diversity, as it reflects the multitude of life conditions in a given area. Special microenvironments, for example habitats with insufficient or excessive snow cover, are characterized by specialist communities of organisms that may exist in close proximity to one another. In the European Alps, communities with moderate snow cover are richer in species than strongly exposed communities or snow bed sites.

High alpine plant diversity may be attributed in part also to the small size of alpine species. Alpine plants are on average one tenth of the size of their closest lowland relatives (Körner 2003), which increases the likelihood of a diverse suite of taxa occurring in a small area. Another important cause of high biological richness in mountains is a moderate disturbance regime. Disturbance can either be related to the dynamic state of the physical environment, which keeps plant communities at an early successional stage or by domestic livestock and/or natural grazing.

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Biographical Sketch

Dr. Eva Maria Spehn was born in September, 1969, in Bad Saulgau (Germany). She is married and has one son. She studied Biology at the University of Constance (Germany) and the University of Basel (Switzerland) and received an M.Sc. in Biology in 1995 and a certificate in Interdisciplinary Studies on Humans, Society & the Environment in 1997. During her PhD at the University of Basel she investigated the effects of plant diversity on ecosystem processes in experimental grassland ecosystems (2000). In

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