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Mountain Forests in a Changing World—An Epilogue

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Note from the Guest Editor of MRD 29.2

The following epilogue concludes this Special Issue of MRD on Mountain Forests in a Changing World: Advances in Research on Sustainable Management and the Role of Academic Training. *Gerhard Glatzel tackles the question of what is different in mountain forests and what accelerated change may bring to mountain people. These fundamental issues are traced back to their very roots, based on the experience of an eminent scientist who has worked for may years in mountain forests all over the world.—Georg Gratzer, BOKU, Vienna, Austria*

Are mountain forests different?

> *Can we, with manners, ask what is the* ***difference****?*
> (Shakespeare, *Cymbeline*)

When we at the University of Natural Resources and Applied Life Sciences (BOKU), Vienna, set out to establish a curriculum in mountain forestry some 6 years ago, this was indeed the pivotal question to be answered. Are mountain forests ecologically sufficiently different from lowland forests to warrant specific lectures, and are there really differences in the management concepts and tools for these forests?

Biological and cultural diversity

An easily argued aspect is biodiversity. Soon after MacArthur and Wilson had published their equilibrium theory of island biogeography in 1963 and their groundbreaking book in 1967, mountains were compared to islands in an ocean, separated by terrain difficult to cross (Hedberg 1969). Species diversity and endemism on mountains separated by insurmountable seas of lowland vegetation or deserts can be attributed to allopatric (geographic) speciation and dispersal distance from a source, as well as the area of available habitats. The effects of past climatic fluctuations—such as ice ages—especially on dispersal and exchange were fairly easy to incorporate into the concept. More than one and a half centuries earlier, on his expedition to the Andes, Alexander von Humboldt described the vegetation zones from the tropical lowland forest to the Ando-alpine flora on the ice-capped volcanoes of Ecuador (Helferich 2004). Von Humboldt also noticed the difference between the annual seasonality of temperate and boreal mountain climates and the daily summer–winter cycle on tropical mountains and its effects on plant life, and described the diversity of habitats due to the mountain topography, the geology, and the wind patterns. The latter are powerful filters for the selection of phenotypes and for plant communities. Thus mountains are hot spots of diversity not only at the species level but at the community level, too. Taken all together, it is no surprise that mountains provide for floral and faunal diversity not encountered in lowlands of comparable climate and areal extent.

If we consider human cultural diversity, very similar concepts can be used to explain the extreme diversity found in mountain ranges. Even though humans are often better prepared to cross tracts of inhospitable terrain, in reality exchange is often limited and specific challenges of different mountain valleys promote highly adapted approaches in land use as well as in everyday life. Low population densities, combined with the need to invest nearly all available energy into life support, have often prevented the adoption and development of writing, allowing for a more rapid evolution of dialects and languages. While this may apply for isolated populations in lowland rainforests, too, extreme human cultural diversity in mountain areas must be considered when new land use concepts are to be adopted and adapted for mountain regions.

Biodiversity both at the species and phenotype level as well as the cultural diversity of mountain people must be considered in land management and in conservation. Thus special courses in mountain ecology and ecological sociology are not only justified but indispensable.

The importance of gravity

A very trivial but often neglected aspect of mountain ecosystems is gravity. In *Hamlet*, Shakespeare caught the idea perfectly in describing Ophelia's death:

> *Clambering to hang, an envious sliver broke;*
> *When down the weedy trophies and herself*
> *Fell in the weeping brook.*

Rockfall, debris flows, and avalanches are the dramatic expression of the erosion continuously at work wherever steep gradients in gravitational potential exist. At the day-to-day level, more inconspicuous processes determine mountain

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ecosystems. Leaf litter is blown or washed down the slope, and dissolved organic matter and plant nutrients are leached from the soil and enter the aquatic drainage system. Lowland ecosystems profit from the nutrient input, and fishes thrive on matter gained from the erosion of organic substances and mineral elements from mountain ecosystems (Likens et al 1977). Nutrient depletion and soil acidification due to leaching and erosion of biomass (Glatzel 1989) must be considered as powerful filters for plant communities.

Long-lasting evergreen foliage is one of the mechanisms to retain nutrients within a system. Slow release of nutrients in soils with poor turnover rates of chemically and physically extreme protected leaf litter of evergreen plants complements this. Rapid turnover communities of often nitrogen-fixing plants such as alder (*Alnus* sp) thrive only in places where erosion has exposed nutrient-rich mineral soil or where springs convey mineral-rich groundwater to the surface. In high precipitation areas waterlogging in the humic horizons further slows down the process of decomposition, as do low temperatures over permafrost. Frequent freeze–thaw cycles promote physical weathering, which adds new material to debris flows.

For mountain people gravity may be ambiguous. Working steep land requires much more energy than working level ground. Rockfall, mudflows, and avalanches, as well as extreme weather conditions, may threaten lives and property. On the other hand, the rugged topography of mountains provides retreats and shelter in the case of conflicts. The mechanical energy of tumbling waters is easy to harvest, and exposed rock facilitates the prospecting for and mining of ore and minerals. Migratory pastoralists find summer pasture above the timberline and winter shelter in the forested valleys. Diseases of mosquito-infested lowlands may not reach mountain villages, but genetic disorders may pose problems in small populations, isolated by hard-to-cross mountain passes. Safe drinking water may be more easily available from mountain springs than from polluted groundwater and rivers in densely populated lowland regions.

Considering the abiotic environment of mountains as well as the living conditions of mountain people, specific knowledge and skills are required for the sustainable management of mountain lands. A curriculum of mountain forestry not only serves to teach specific skills but also provides a platform for the exchange of ideas among students from different mountain regions of the world.

The impact of change

Now about the changing world:

> *…the spring, the summer,*
> *The childing autumn, angry winter, change*
> *Their wonted liveries; and the mazed world,*
> *By their increase, now knows not which is which…*
> (Shakespeare, *A Midsummer Night's Dream*)

Amongst the potential changes affecting mountain forests and mountain people, global warming is currently often considered the most serious threat. Plant communities will be forced up the slope; the mountaintops limit further migration, and thus plants will become locally extinct (Grabherr et al 1994). Reconstructions of climate history on a local scale (Nicolussi et al 2005) and on a more global scale (Morley 2000) show how intensely climate fluctuations have affected mountains in the past and indicate that recovery out of refugia provided by the rugged mountain topography and the variations in aspect was the rule rather than the exception. Intense exploitation of mountain ecosystems is likely to restrain the natural recovery processes that took place in the past.

Indirect effects of global climate change may hit mountain people and ecosystems just as hard as or even harder than direct effects on the local climate. Deterioration of lowland habitats as well as armed conflicts may trigger migration of people seeking shelter in the mountains. Population densities above the limited carrying capacity of mountain lands can cause the rapid loss of forests, exploited for timber and fuel, and soil degradation and erosion. One of the most valuable resources of mountains, safe drinking water, may be endangered by siltation and water pollution from overcrowded refugee camps.

Energy is another aspect. Cheap fossil fuels and the demand for an increased accessibility of mountain villages by new roads have allowed for the construction of habitation and infrastructure with energy requirements far above the local production potential of biomass fuel. When the energy needs cannot be met any longer due to exploding fuel costs or interrupted supply lines and dung or crop residues are used as fuel, overexploitation of available biomass will cause forest destruction and nutrient mining in arable land. In seasonal climates harsh winters in combination with insufficient nutrition will cause misery and suffering as relief is hampered by limited access.

Degradation of mountain watersheds is not only a problem for the local population; it also affects metropolitan areas in the lowlands. Rivers may silt up, floods may threaten low-lying areas, drinking water may become scarce, and migration from impoverished and degraded mountain regions may add new desperate people to city slums. Thus responsible management of mountain regions by mountain people under consideration of ecological constraints and cultural traditions is of crucial importance from a national as well as the global perspective. I hope that our mater curriculum "mountain forestry" at BOKU can contribute to a scientifically supported empowerment of mountain people to maintain sustainable land use in still intact systems and to restore the many degraded systems for use by future generations.

REFERENCES

Glatzel G. 1989. Internal proton generation in forest ecosystems as influenced by historic land use and modern forestry. *In:* Ulrich B, editor. *International Congress on Forest Decline Research: State of Knowledge and Perspectives.* Vol 1. Karlsruhe, Germany: Kernforschungszentrum Karlsruhe, pp 335–349.

Grabherr G, Gottfried M, Pauli H. 1994. Climate effects on mountain plants. *Nature* 369:448. http://dx.doi.org/10.1038/369448a0.

Hedberg O. 1969. Evolution and speciation in a tropical high mountain flora. *Biological Journal of the Linnean Society* 1(1/2):135–148.

Helferich G. 2004. *Humboldt's Cosmos: Alexander von Humboldt and the Latin American Journey that Changed the Way We See the World.* New York, NY: Gotham.

Likens GE, Bormann FH, Pierce RS, Eaton JS. 1977. *Biogeochemistry of a Forested Ecosystem.* New York, NY: Springer.

MacArthur RH, Wilson EO. 1963. An equilibrium theory of insular zoogeography. *Evolution* 17(4):373–387.

MacArthur RH, Wilson EO. 1967. *The Theory of Island Biogeography.* Princeton, NJ: Princeton University Press.

Morley RJ. 2000. *Origin and Evolution of Tropical Rain Forests.* New York, NY: Wiley.

Nicolussi K, Kaufmann M, Patzelt G, van der Plicht J, Thurner A. 2005. Holocene tree-line variability in the Kauner Valley, Central Eastern Alps, indicated by dendrochronological analysis of living trees and subfossil logs. *Vegetation History and Archaeobotany* 14(3):221–234. http://dx.doi.org/10.1007/s00334-005-0013-y.