

Mountain Biodiversity

A Global Assessment



Edited by Ch. Körner and E.M. Spehn



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Preface

What is a mountain? Even in the context of this assessment, views may differ widely on this. For some, it is the 8000-m tops of the Himalayas, for others a 100-m hill in a coastal area. For some, a mountain starts where the cable car starts, for others it is where rivers shed their sediments into the ocean. With the latter concept, the world would consist only of mountains, not an appropriate definition for a new research agenda. An obvious need to focus on a coherent, practical convention led a consortium of scientists during a 1999 planning meeting in Glion, Switzerland to define a high elevation focus of the Global Mountain Biodiversity Assessment (GMBA), as described below.

For this assessment NOT to become a general 'slope' research network, it was agreed that the principal interest of GMBA is threefold:

- (1) The alpine life zone above the climatic treeline,
- (2) The treeline ecotone itself (the transition from the forest zone to the alpine zone), and
- (3) The uppermost mountain forests (close to the natural treeline) or their man-made substitutes (highland pastures).

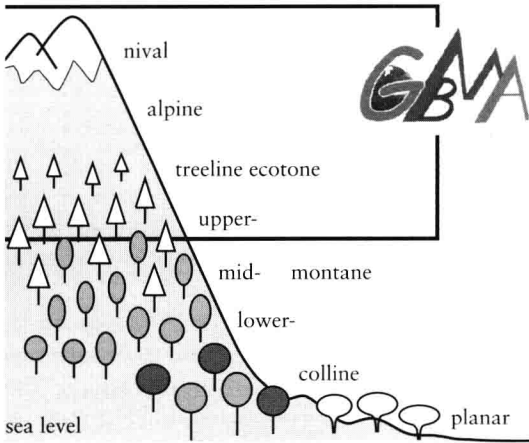
The terminology used here follows that of the classical literature, and differentiates between the naturally forested montane zone, the treeline ecotone, i.e. the upper end of the closed montane forest (should it still be in place) up to the tree limit, and the treeless alpine life zone. The word 'alpine' has pre-Indogermanic roots, probably coming from Asia, with 'alpo' referring to steep slopes in the Basque language today. The word 'alpine' is applied here strictly as a 'terminus technicus' for the life zone above the treeline worldwide (with no special reference to the European Alps). This also contrasts with

the common language where 'alpine' is often used to indicate mountainous regions in general (Körner, 1999).

With this pragmatic focus on the highlands, the consortium did not overlook the enormous ecological problems at lower elevations; the heavily used and overpopulated lower montane zone in particular. It was felt, however, that the impact of land use, deforestation and intense agriculture at mid to lower elevations already receives a lot of attention (though never enough!), whereas the life zone above never became a focus of international concern. There was no other reason than this for this book and the GMBA network focus on the highest elevation biota. Lower elevations were included only as part of elevational gradients in comparative approaches. The high elevation climatic treeline (not its regionally anthropogenically depressed position) has been selected as a bioclimatological reference line because it occurs worldwide at similar temperatures, irrespective of latitude (Körner, 1998). Therefore, the Mexican altiplano at ca. 2000 m elevation is far below the GMBA core region, but the Scandinavian alpine tundra above the 600 m treeline is well within it.

In other words, this volume deals with the biological richness, its function and change at the cool, high elevation end of the biosphere. This life zone covers nearly 5% of the global terrestrial land area (or twice as much if cold and hot deserts are disregarded). The treeless alpine life zone alone accounts for ca. 3% of the land area. Often considered barren, it hosts a vast biological richness, exceeding that of many low elevation biota (Körner, 1995).

The chapters of this volume have been selected in a peer reviewing process from the presentations offered during the first international conference on mountain biodiversity, its function and change, held at the Rigi-Kaltbad



A schematic representation of the elevational life zones and the GMBA focal range of altitudes

mountain resort in central Switzerland, between 7 and 10 September 2000. Within sight of ice covered peaks of 4000 m elevation, roofing the traditionally managed mountain pastures of the Alps, 120 scientists from 34 different nations presented their views on how much richness in their concerned biota is present for selected groups of organisms; how they think this richness developed; and what future changes might be expected. There was a strong representation from developing countries, illustrating their difficulties in sustainably handling their uplands in view of poverty and land demand. The human dimension was present as a cross-cutting issue in almost all presentations, highlighting land use as the most important element of global change in the mountain world, exceeding the significance of atmospheric changes and climate warming.

The Rigi conference of GMBA was a start, illuminating the status of our knowledge. In

fulfilment of Chapter 13 of Agenda 21, the international network activity of GMBA should now work at both widening and deepening the understanding of upland biota in the fields of many disciplines. It appears that a greater representation of animal sciences would be desirable, given how much detailed wisdom may be latent within the community, and how little crosscutting analysis surfaced from literature surveys. Land use will certainly remain a focal point in this cooperative project.

The organisers wish to express their sincere thanks to the Swiss Academy of Sciences (SANW, Bern) and DIVERSITAS (Paris) who initiated this network and supported it with so much sympathy. We gratefully acknowledge the financial contributions of the Swiss Academy of Sciences, the Swiss Agency for the Environment, Forests and Landscape, the Swiss Federal Office for Agriculture, the Swiss Agency for Development and Cooperation, the Swiss Science Foundation, the Austrian Federal Ministry of Education, Science and Culture (Vienna), and UNU, the United Nations University (Tokyo). In person, we wish to thank Mdm Anne-Christine Clottu (SANW), without her, and Prof. Bruno Messerli's continuous encouragement and support, this project would not have happened. We hope that the GMBA initiative will flourish and will contribute to respect and sustainable use of the wild and tamed nature of the world's high mountains.

Christian Körner and Eva Spehn
Basel, September 2001

www.unibas.ch/gmba

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Part I

Introduction

Mountain Biodiversity, its Causes and Function: an Overview

Christian Körner

The high elevation biota of the world have been the subject of many synthetic approaches, including assessments of the variability and diversity of ecosystem properties and processes, ecophysiological traits and organismic functioning in general (e.g. Franz, 1979; Vuilleumier and Monasterio, 1986; Billings, 1988; Rundel *et al.*, 1994; Archibold, 1995; Wielgolaski, 1997; Körner, 1999). In this overview, questions relating to high elevation biodiversity will be specifically discussed (for previous attempts with a global perspective see for instance Chapin and Körner, 1995; Rahbek, 1995).

NAILS AND SCREWS AND THE LOWLAND-UPLAND CONTRACT OF SOCIETY

Mountainous terrain covers 24% of the global land area (Kapos *et al.*, 2000). The trivial fact that mountains have slopes causes them to directly or indirectly influence the life of half of the Earth's human population (Messerli and Ives, 1997). Slopes (and the peaks behind them) not only capture water, but guide it to the forelands and, via large river systems, feed the plains. Runoff and the sediments carried with it, both benefit (water supply and mineral nutrients) and disadvantage (floods and mud slides) downslope society. Slopes provide gravitational power to water, which can be converted to electric energy. Slopes guard and guide or constrain and endanger traffic routes. Slopes stop clouds (advection) or create them (convection), slopes exert mechanical force on any organism, installation or activity on them.

Unless made of solid rock, the only way in which loose substrates are secured to slopes is through vegetation. These living claws, screws and nails sustain slope benefits and prevent slope dangers. Slopes are only as stable and safe as the integrity and stability of their vegetation (Figure 1.1). Integrity of upslope vegetation is the centrepiece of downslope welfare in many parts of the world. There is, indeed, a too often overlooked link between far away mountains and densely populated lowlands. The recurring floods in China, for instance, which directly affected 200 million people's lives in 1999, the recent mud slides in the Philippines or the Andes, are impressive manifestations of uncontrolled upslope instability. It is obvious that there are many mutual upslope-downslope interdependencies. A substantial fraction of lowland productivity is required to cover the needs of upslope society and to maintain or enforce sustainable management in the highlands. This 'downslope-upslope contract', in essence, rests on the effectiveness of vegetation – natural or man-made – to control erosion.

BIODIVERSITY PROVIDES INSURANCE

The formula is simple: intact vegetation provides safety. Since the risks and threats on mountain slopes are manifold, they require a multitude of safeguards. The hammering of the ground by heavy raindrops or hail, the disruptive force of surface runoff, the mechanical shear of loose ground, the exploration of deep substrate moisture, the resistance against

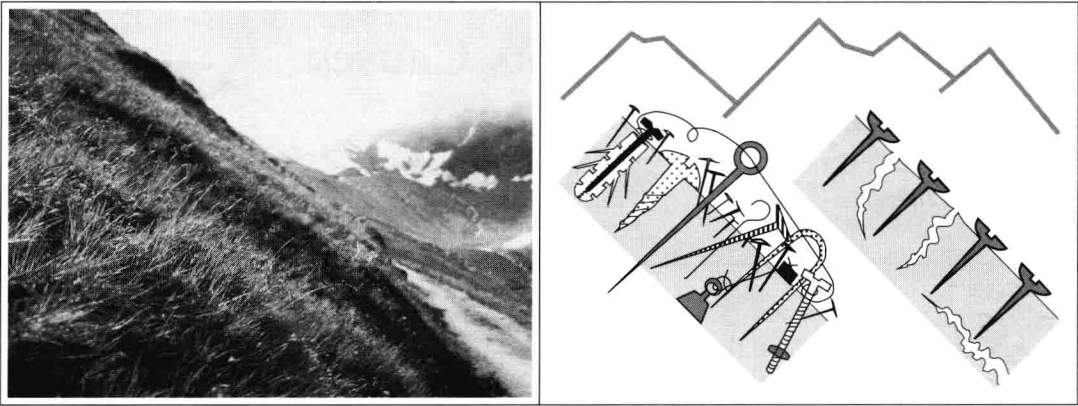


Figure 1.1 The integrity of steep alpine slopes such as this one, at 2500 m in the Swiss central Alps, is secured by plants, their belowground structures in particular. The cartoon to the right symbolises the need for a multitude of ‘tools’ to do the ‘job’

trampling and grazing by large herbivores, and snow-gliding, are among many manifestations that require different mechanical solutions (see Figure 1.1). A multitude of plant structures can and do offer these services in a concerted manner. Yet, at times, any of these ‘tools’ may fail. Natural diseases, divergent life cycles, and varying sensitivity to stress and disturbance may eliminate different players, at least periodically. Hence, it requires each key tool to be present in various combinations, so that at least one functions in case of emergency. The benefits of diversity are manifold (Mooney *et al.*, 1995). In the simplest terms, Moffat, (as quoted by Stuart Pimm 1996) said that: ‘There is a dance going on of compensatory changes. Something always benefits from a disaster, provided you have enough species’. Whether ecosystems with more species are less at risk of loss of integrity than systems with less species is not a generalizable issue, as was previously thought. It depends on the absolute number of species, the identity of the species and the circumstances under which the system is operating. Hence, the above discussion should be taken as a plausible trend, not a proven fact for any individual case.

According to the ‘insurance hypothesis’, one of the benefits of biological richness is that it insures against system failure. Functional redundancy may not play any role for long

periods of time, but a single extreme event can cause it to become the life-preserver of fragile slopes that sustain ecosystem functioning. The richness of biota includes all levels of organismic diversity from genes to landscapes, it includes all groups of organisms from microbes to the largest herbivores.

By no means should ecosystem functioning be considered the only valid reason to conserve biological richness, but prioritising on this one function appears plausible, given that all other benefits and values depend on it. Other justifications are the ethical value (the right of existence), the aesthetic value (the beauty), the economic value (potential or instrumental economic uses). Each of these has value in its own right. In high mountains, several or all of these values apply together, as this book will illustrate.

Having said all this, the reader will find this introductory note somewhat plant-biased. The reason for this is, in part, my own profession. However, having joined many discussions with zoologists, there seems to be less synthetic knowledge available in high elevation animal sciences. Perhaps we are far from even simple generalisations which may hold for animal studies. As an example, plants become smaller with increasing elevation, if the same morphotypes are compared; not so animals: birds and rodents become larger, as do some groups of