MANAGEMENT OF MOUNTAINOUS AREAS

Ulrike Tappeiner
University of Innsbruck, Austria and European Academy of Bolzano/Bozen, Italy.

Neil Bayfield
Centre for Ecology and Hydrology, Banchory, UK.

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Contents

Summary

Mountains occupy about 20% of the world's terrestrial surface. They are characterized by low population densities, and infrastructures and communications tend to be poorly developed. There is however, great variation from region to region. Mountains are of great significance not only to their inhabitants but to lowland areas as sources of water, for leisure and tourism and as relatively intact areas for biodiversity.

Important changes in use of mountains over the last half-century have included increases in skiing and outdoor recreation, construction of water abstraction, hydro generation schemes and wind farms, and large changes in the patterns of land use. These have ranged from a more intensive use of mountains (such as in parts of Africa) where population growth has been rapid, to abandonment of areas (such as parts of the Alps) where there has been depopulation.

Climate change is considered likely to have a greater impact on mountains than on lowland regions. Worldwide there has already been extensive glacier retreat, and patterns of snow deposition and thaw are having impacts on the viability of ski areas. Management of impacts requires techniques of site management and restoration, and local regional and national policies to control unsustainable land use practices and the exploitation of resources.

Local inhabitants are seen as a key to sustainable development, and policies and incentives are needed to maintain and sustain viable communities and their ways of life and values. Research needs include an integrated interdisciplinary approach to assessing and managing the impacts of social, political and ecological drivers of change. It is also necessary to encourage perspectives that take into account the linkages between mountain and lowland environments and to ensure that the use and development of mountain areas is not just dictated by lowland needs.

1. Introduction

1.1. Vulnerability of Mountain Areas

Mountain areas are characterized by steeply sloping ground, strong climatic gradients, and a well-developed altitudinal zonation of vegetation and soils. They occupy about 20% of the land surface of the earth. Population density tends to be relatively low due to the small proportion of cultivable land and infrastructures and communications are generally poorly developed. However mountains are of great significance to mankind since: they are a major source of water for about half the world's population; they are an increasing attraction for recreation and tourism; they are important and relatively intact areas for biodiversity; and they hold rich cultural diversity. Natural hazards have always been a threat, with torrents, floods, landslides, and avalanches as persistent and expected events.

In recent decades the vulnerability of mountains seems to have been accelerating, in particular due to the effects of climatic change, reducing the size of glaciers and altering patterns of rainfall and wind. In addition, there has been a general decline in agricultural populations of many mountain areas and abandonment of some formerly agricultural areas, particularly those with poor access. Such changes in land use have massive potential effects on biodiversity, slope stability, and hydrology.

There has also been a substantial increase in use of mountains for summer and winter recreation and tourism, and for nature and landscape conservation. These changes are having large impacts on the economy and infrastructures of mountain regions, and on the way of life and values of mountain peoples.

1.2. The Most Important Land Use Changes in the Last 50 Years

1.2.1. Agricultural Methods and Abandonment

In many mountain regions there have been dramatic changes in agricultural land use. In some cases these are changes in technology, such as the greater use of machine harvesting of hay or the switching from one breed of grazing animals to another. In other cases the trend has been to abandon the culture of the less productive and least accessible land (Figure 1).

In the Spanish Pyrenees for example large tracts of land that were cultivated in terraces for wheat and other crops have been converted first to grazing land and, more recently, abandoned. The collapse of terrace structures and their invasion by scrub and trees is having a dramatic impact on the landscape of such areas and this, in turn, has impacts on hydrological processes, biodiversity, and carbon sequestration.

1.2.2. Increases in Tourism and Recreation

Skiing and mountain tourism have been increasing in many parts of the world and are perceived as a quick way of wealth creation for mountain populations. Recent decades have, however, seen many marginal ski areas losing money because of unreliable snow cover or poor geographical positioning in relation to sources of skiers. There have also been increasing conflicts with other land users, particularly nature conservationists (Figure 2) so that it is increasingly difficult to get funding and permission for new developments.

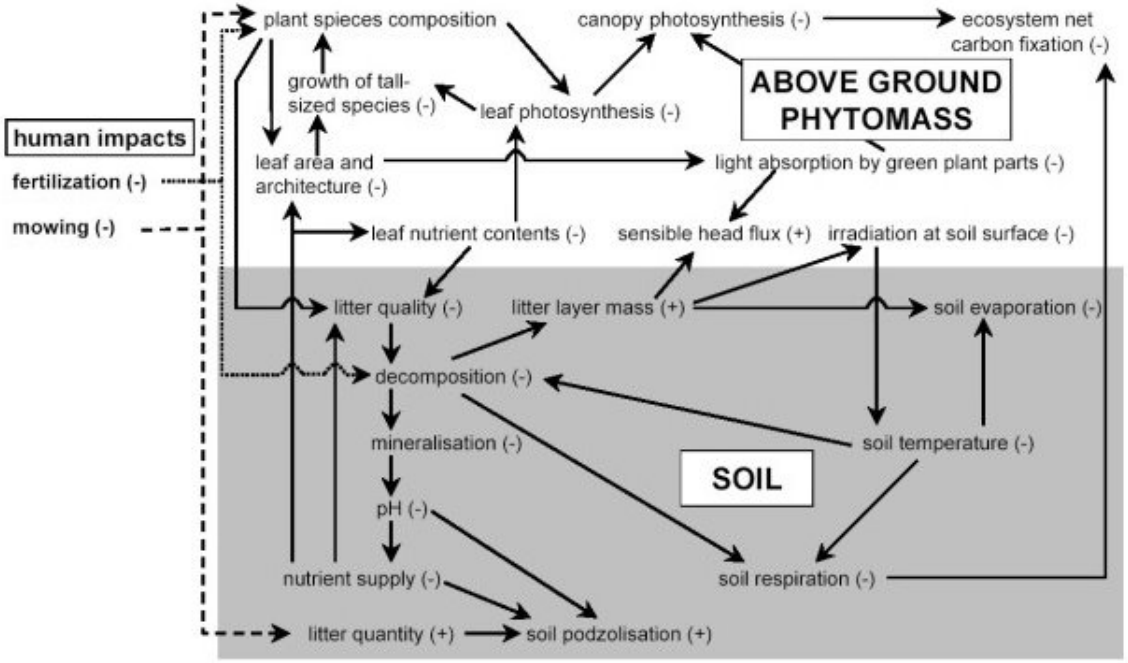

Figure 1: Effects of abandonment of mountain meadows and pastures on some major ecosystem processes. Arrows indicate relationships between parameters and (+) and (-) positive and negative effects.

1.2.3. Protected Areas

Nature and landscape conservation have become important land uses through designations, such as National Parks and Nature Reserves. The Natura 2000 Program in Europe, for example, has designated large areas of land. In 2001 the designation process was still incomplete, but 210.000 km^2 at 2920 sites were proposed for designation under the Birds Directive, and 390.000 km^2 at 12.225 sites under the Habitats Directive. This list includes all types of ecosystems, but mountain sites tend to be more extensive than those in lowlands. Non-Government Organizations such as the John Muir Trust, Royal Society for Protection of Birds, and World Wide Fund for Nature have also been acquiring and managing large tracts of land for landscape and nature conservation.

While these different types of protected areas will receive some protection from possibly damaging operations, they can also result in conflicts of interest with other land uses, and many owners regard designation as reducing the potential value of their land through constraints on development. The protection of wildlife can also result in conflicts of interest, particularly between farmers and those wanting to conserve carnivores and raptors that can prey on farm livestock or damage crops.

Figure 2: New funicular railway being built at Cairngorm, Scotland, has resulted in strong conflicts of interest with nature conservationists because of possible increases in use of adjacent mountain summits.

1.2.4. Water Abstraction and Power Generation

Since mountains provide a large proportion of the world's fresh water, it is natural that abstraction schemes and hydro-generation of electricity have been widely adopted. The majority of schemes are long established, although a small number of new schemes are being implemented. Impacts include severe disruption of the ecology of rivers and dammed lakes, and dislocation of local people. There are also frequent disagreements about the allocation of abstracted water.

The Kyoto Protocol has stimulated new interest in generation of power from renewable sources. The scope for expansion of hydro-generation is quite limited in many countries, particularly in Western Europe, but investment in wind power is accelerating. The UK, for example, has the potential to generate three times its current power requirements from offshore wind. In practice much of the wind generation is in mountain areas. Even this green technology results in conflicts, mainly with local residents concerned about noise and visual intrusion, and bird conservationists concerned about bird kills by generator rotors.

1.2.5. Political and Land Ownership Changes

Figure 3: In Georgia loss of winter grazing has reduced grazing pressures and erosion.

Major changes in national borders and land ownership have occurred over time in many parts of the world. In Georgia, for example, the borders with the Russian Federation have been largely closed since the country became independent. In the Kasbegi area this has meant loss of tourists, winter grazing for the previously large sheep flocks, and the

main market for vegetables. Greatly reduced levels of grazing have benefited vegetation biodiversity and standing biomass, as well as reducing the high rates of slope erosion (Figure 3). The economy of the area has, however, been devastated.

2. Pressures, Impacts, and their Management

2.1. Climate Change

Increases in the concentrations of so-called greenhouse gases, CO_2, CH_4, N_2O, and chlorofluorocarbons (CFCs) produced by agriculture, manufacturing, and transport are likely to result in increases in temperature of 1 to 3.5 °C by 2100 A.D. or about 0.1 °C per decade. The range 1 to 3.5 °C is representative of the upper and lower limits of current predictions but there is considerable uncertainty about the magnitude of the changes that might occur and great variations are likely between different regions of the world. The rises in temperature predicted by Global Climate Models (GCMs) suggest that snowmelt will occur earlier, because of summer warming, but there may be more snowfall in some western coastal mountains because of increased winter precipitation. Corroborative evidence is provided by declines in the areas and volumes of glaciers. The Alps are estimated to have lost about 30 to 40% of their area and 50% of their volume since 1850. Rates of mass change vary greatly in different regions and some glaciers are still advancing, but the trend over the period 1960-1990 shows a net loss of 0.25 ± 10 mm yr^{-1} in sea level equivalent.

The projected changes in snowmelt and in winter precipitation are likely to mean that there will be greater peaks and reduced summer river flows to adjacent lowlands. There will also be important implications for winter tourism. Snow cover has been erratic in the 1980s and 1990s and may become more so. Climate change is also likely to affect wind flow patterns. This will vary in different regions, but there are already indications of more extreme wind patterns in Scandinavia and Scotland since 1970.

The predicted temperature and other climate changes will probably have pronounced effects on mountain vegetation with gradual shifts in ecotones and in the altitudinal distribution of individual species. The worldwide GLORIA monitoring program is designed to monitor these changes on mountain peaks throughout the world.

Following the 1987 Montreal Protocol, the 1992 Rio Conference and the Kyoto and post-Kyoto international discussions, there have been various national and international targets for reductions in global emissions of greenhouse gases and CFCs. Some small progress has been made, but much remains to be done.

2.2. Demography

Generally, mountains are considered areas of low population density, except for some tropical highlands, that offer favorable environmental conditions (e.g. Africa, where mountains are often more productive and, thus, preferred areas of settlement, or parts of Central America and the Andes). This statement is only true, with regard to a density based on the total land surface of the mountains. Considering that in mountain regions large tracts are unsuitable for human habitation because of extreme altitude and adverse

topographic and ecological conditions, it is apparent that usable areas are in fact severely over-populated in relation to their limited usable space (Table 1). This is necessarily linked to over-exploitation of natural resources, resulting in a serious deterioration of the environment and in the marginalization of living conditions. This critical situation is further aggravated by a continuing high birth rate which is characteristic of many mountain regions.

The situation differs strongly between different mountain regions of the world. In most high mountain areas in the developing countries agriculture is the most important type of land use. One of the worldwide characteristics of mountain agriculture is the vertical arrangement of land parcels, based on the necessity to use the area's entire range of environmental potential. Over-population puts strong pressure on this traditional, sustainable type of use, due to continued fragmentation of smallholdings. This situation culminates, in extreme cases, in collective ownership of individual fruit trees by repeated inheritance (Afghan Hindu Kush). In the districts around Mount Kenya there has been a 36% population increase in the 1979-1989 period. This has resulted in rapid increases in demand for land, water, and wood products. Obviously, this has led to stress on mountain biodiversity

The situation in mountain areas in developed countries is quite different. This is shown by the example of the Alps. The demographic growth rate in the Alps was considerably lower than the European average up to the twentieth century. In 1970 this trend changed. The Alps were losing their image as a disadvantaged region, and became a favored area characterized by two antagonistic processes: urbanization and depopulation. The large urban centers in which the majority of inhabitants live (1990/1991: approx. 60%) are all situated in the valleys. Because the volume of transported goods increases roughly one and a half up to two times more than the gross domestic product (GDP), traffic and transport infrastructure are continuously expanding along important routes.

A. OLD AND RELATIVELY DENSELY SETTLED HIGH MOUNTAINS

1. Largely intact traditional subsistence agriculture and a tendency toward over-population:

a) Population of mountain peasants *(Large parts of the Himalaya-Karakorum-Hindu Kush; Andes)*

b) A population of mountain peasants, overlain by nomads *(High Atlas; mountains of the Middle East; western parts of the Hindu Kush and Himalaya)*

2. Strongly declining traditional agriculture and expanding new activities (tourism, among others) *(High mountains of* Europe, especially the Alps and Pyrenees)

3. Largely collectivized or nationalized agriculture, in parts with new activities (island-like, scattered tourism) *(High mountains of the former Soviet Union and China;*

parts of the Carpathians).
B. YOUNG AND RELATIVELY SPARSELY SETTLED HIGH MOUNTAINS
Coincides with areas of European overseas colonization, with extensive market-oriented agriculture and forestry, and with recent tourism *(High mountains of North America and New Zealand)*

Table 1: Typology of high mountain regions from a demographical to a land-use linked perspective. "Old" is defined as principally Old World mountain areas that have been settled for centuries; "young" implies New World areas settled by European immigrants (after Grötzbach and Stadel, 1997).

Almost three quarters of the Alps, though, are rural in character, and large parts of them have structural problems. These lead to a population decrease. In great parts of the uplands the population is ageing, and agricultural activity is being more and more abandoned (e.g. pasturing, but also mountain farming). Next to genuine "wilderness" areas, other, more localized, rather spectacular forms of land use occur in these alpine regions (e.g. construction of tourism infrastructure, hydroelectric installations). Once the process of depopulation is fully in progress, even the best attempts at rural development are only partly successful (Italian Mezzogiorno). Several positive examples in Europe (e.g. South Tyrol and Trentino in Italy, Carinthia in Austria) underline the necessity of implementing such programs (i.e. Regional Development Plans, EU Structural Funds) as long as migration does not damage the demographic and social structure of a region.

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Biographical Sketches

Ulrike Tappeiner is Professor of Ecology at the University of Innsbruck, Austria and is Head of the research area "Alpine Environment" of the European Academy Bolzano/Bozen, Italy. Her research and teaching interests are focused on alpine ecology as well as on the sustainable development of mountain regions. In the framework of international research and training programs she was in leading positions and has also worked as a consultant on environmental problems. Currently, her research interests include ecological and economic aspects of mountain farming as well as sustainability indicators. Of special interest for Ulrike Tappeiner is also working up research results for the public.

Neil Bayfield is a research ecologist at the Centre for Ecology and Hydrology at Banchory, Scotland. He is manager of the Cairngorms Environmental Change Network site which is also part of the arctic SCANNET and alpine GLORIA networks. His research interests include environmental decision modelling, environmental impacts on mountain areas and restoration of damaged habitats.