Mountain Forests

Basic knowledge

The Mountain Forests Module highlights the importance of mountain forests and identifies important considerations for their sustainable management.

The module provides basic and more detailed information on the management of mountain forests, as well as links to key tools and case studies of effective management.

What are mountain forests?

Mountain forests can be defined as forests on land with an elevation of 2 500 m above sea level or higher, irrespective of slope, or on land with an elevation of 300–2 500 m and a slope with sharp changes in elevation within a short distance.

Mountain forests cover about 900 million hectares of the world's land surface, constituting 20 percent of the world's forest cover. They are hotspots of biodiversity and provide important environmental services far beyond the mountains themselves. Mountain forests exist on every continent (except Antarctica) and in every climatic zone. Mountain forests cover large proportions of (for example) the Alps, Pyrenees and Balkan and Carpathian mountain ranges in Europe, the Appalachian and Rocky mountain ranges in North America, the Australian Alps, the Guiana Highlands in South America, the mountains in Central Africa, and the Andes Mountain Range in South and Central America.

Why do they need particular attention?

Mountain forests are fragile ecosystems because of their steep slopes and often-extreme climates and weather events. Mountain forest management should aim to prevent forest overuse and degradation because this can lead to environmental problems such as soil erosion, landslides, rockfalls, increased water runoff or reduced water storage, the drying of springs and the loss of biodiversity, and it can have severe impacts on livelihoods and even cause human deaths. Special planning and adequate measures to secure the productive, protective, social and cultural functions of mountain forests may be required.

Key aspects for mountain foresters: planning and monitoring

Land-use planning needs to take into account the higher risk environment presented by mountains. Mountain forest zoning should identify areas that are especially important for certain forest functions, such as protection from hazards, nature conservation, water management, forest pastures and wood production. The purpose, type and impact of any intervention in mountain forests require careful consideration. Factors that need to be taken into account include terrain, site and environmental parameters (e.g. temperature range, precipitation, steepness, soil condition, watercourses, and exposure to the sun); accessibility; silviculture (e.g. tree species composition, increment and regeneration requirements); and biodiversity (e.g. endangered species). Forests should be monitored for the early detection of change.

Particular consideration should be given to:

- forests that protect assets from natural hazards;
- forest harvesting and regeneration in mountains; and
- mountain forests and adaptation to climate change.

Mountain forests contributes to SDGs:

Related modules

- Climate change adaptation and mitigation
- Land-use planning
- Forest and water
- Forest management planning
- Forest restoration
- Occupational health and safety in forestry
- Protected areas
- Silviculture in natural forests
- Watershed management
- Wood harvesting

In more depth

The natural environment of mountain forests

Site conditions in mountain forests can vary significantly over short distances – for example, one mountain slope might be dry and hot but, within 100 m or so, another might be cold and wet. Understanding the natural environment of mountain forests helps in making good management decisions. Mountain forests are characterized by altitudinal gradients: from the foot of a mountain to its peak, temperature decreases, precipitation – in form of rainfall, fog and snow – increases, soils become shallower and solar radiation becomes more intense. Precipitation increases with altitude because humid air arriving at the foot of a mountain condenses as it is forced to rise. In addition, evaporation also decreases with growing altitude, thus precipitation falling as snow is stored and becomes available when needed. Infrastructure, such as forest roads, should be designed to cope with high water runoff (i.e. effective drainage systems are required).

Forest soils develop more slowly on mountains than elsewhere because of the cooler climate (and therefore low vegetation growth rates) and continuous erosion. The large-scale clearfelling of mountain forests should be avoided: it can lead to high rates of erosion in extreme rainfall events and the widespread loss of seedlings in regeneration because large open areas are more prone to desiccation. Altitude and aspect are key determinants of species and stand structure composition in mountain forests, as well as of tree growth and form.

Forest growth is usually slower in mountains than in lowlands because of the harsher climatic conditions, shorter growing seasons and shallower soils. Species composition and growth differ between slopes exposed to the sun (favoured by species that can tolerate drier soils and higher solar radiation) and those oriented away from the sun (where soil moisture is higher but exposure to sunlight is lower). Mountain foresters need to consider such growth differences and species mixtures in their silvicultural planning. The altitude of the climatic tree line – beyond which trees do not grow in significant numbers – varies widely, depending on latitude and climate, for example from 700 m or below in the far north to above 4 500 m in parts of the subtropical Andes. Ecosystems at the climatic tree line may have no special economic value but can play important environmental roles, for example as habitat for endemic species and by contributing to water supply; they may need special management and protection measures.

Environmental services of mountain forests

Sustainable mountain forest management should support and improve the capacity of mountain forests to provide environmental services. It is important to quantify such services if landowners and local communities are to be rewarded for providing them. Environmental services can be categorized as either provisioning, regulating and supporting, or cultural.

Provisioning services. Mountain forests can provide lumber for use in buildings and other infrastructure, woodfuel, non-wood forest products (NWFPs) such as food (e.g. wild game, mushrooms and berries) and medicines, and grazing opportunities for livestock.

Regulating and supporting services. Mountain forests provide important services in retaining soils and reducing avalanches and rockfalls. Mountain forests (especially cloud forests) have high water-retention capacity, intercepting and storing water from rainfall, mist and snow and releasing it gradually, thereby helping maintain downstream water flows at a large scale. Thus, mountain forests limit peak stream-flow rates, reduce soil erosion and mitigate the impacts of avalanches and downstream flooding. Mountain forests are also major carbon sinks, and their ongoing sequestration of carbon is a critical element in climate-change mitigation. Due to their relative isolation from each other and their contrasting climates, mountain forests are high in endemism. Many are global hotspots for biodiversity, which provides tourism, recreation, hunting and fishing benefits.

Cultural services

Mountain forests have intrinsic spiritual and aesthetic values. They provide considerable recreational opportunities globally, and the customs and beliefs of many mountain communities are intricately linked with forest ecosystems (see also Further learning).

Mountain forests are often “protection forests”

The mass movement of rocks, soil, water, snow and ice on mountain slopes can constitute a hazard to human lives and infrastructure; mountain forests, therefore, often have an important protective function. Mountain forests protect assets (such as human settlements or roads) at lower altitudes from natural hazards such as rockfalls, avalanches, flooding and landslides. To maintain their protective function, mountain protection forests need to be managed for maximum stability and integrity. Human interventions should be reduced to a minimum to allow the undisturbed development of natural stands with their own structures, plant species composition, forest litter and microhabitats. The goals of protection forest management may be to attain: a diverse species composition; suf?cient natural regeneration; and optimal forest structure. Silvicultural or technical interventions such as counter-felling, the retention of high stumps, planting, regeneration felling, and additional terrain control structures against avalanches or rockfalls may be needed.

Harvesting in mountain forests has its limitations

Wood-harvesting in mountain forests. Harvesting intervals and wood volumes need to be adapted to the lower productivity of mountain forests. In most cases, wood-harvesting should not be permitted on hillsides with slopes greater than 30 degrees. Where appropriate, harvesting may be carried out on slopes less than 30 degrees using manual or mechanized methods. The log-extraction method should ensure minimal impacts on soil and other forest values. Depending on environmental conditions, the availability of skilled labour, and economic considerations, log extraction may be carried out using manual downhill skidding; animals; or skidders or tractors (with or without winches). In certain circumstances, trees felled on slopes greater than 30 degrees may be extracted using cable-ways (uphill or downhill) or helicopters. In general, logs should be skidded uphill, because this tends to result in less environmental damage than downhill skidding.

Clearfelling should be limited to small areas because, on a large scale, it can lead to soil erosion and make forest regeneration more difficult. Alternatives to large-scale clearfelling include patchworks of small clearfelled areas, strip-wise cuttings and single-tree extraction. Buffer zones should be respected and seed trees, harvesting debris and high stumps retained. Steps should also be taken to minimize the intrinsically high risk of accidents to workers during harvesting operations in mountains (see also the module Wood harvesting).

Non?wood forest products and forest pastures

The harvesting of NWFPs such as leaves, fruits, mushrooms, wild meat, insects and honey, and the use of forest pastures for animal production, can help improve food security and nutrition and provide income for forest communities. NWFPs may be particularly important for local livelihoods in mountain forests, where wood-harvesting may be limited due to difficult terrain. However, the excessive exploitation of NWFPs, and overgrazing by livestock, can lead to forest degradation, reduce the regenerative capacity of the forest, increase soil erosion and reduce biodiversity.

Mountain forest regeneration

Seedlings and young stands in mountainous areas often need special protection measures against such factors as snow and soil erosion (see Wood harvesting).

Climate-change adaptation

Mountains are early-warning systems for changes in the global climate, such as global warming. Increases in temperature can cause forest ecosystems and species to “shift” to higher altitudes; moreover, forest pests suited to warmer temperatures may become more prevalent at higher altitudes, damaging forest stands that previously were unaffected. Managing mountain forest ecosystems in a changing climate means supporting their natural capacity to adapt to change by encouraging a diverse composition of native species and diverse forest structures, and natural regeneration. Large clearfellings, monocultures and even-aged forest stands should be avoided (see also Climate-change adaptation).

Detailed guidance and support on mountain forests can be found in Tools and Cases.

Further learning

Brang, P., Schönenberger, W., Frehner, M., Schwitter, R., Thormann, J. & Wasser, B. 2006. Management of protection forests in the European Alps: an overview. In *Forest Snow and Landscape Research* 80 (1), pp. 23–44.

FAO. 2013. *Forests and landslides: The role of trees and forests in the prevention of landslides and rehabilitation of landslide-affected areas in Asia.* RAP Publication 2013/02

FAO. 1976. *Technical report of FAO/Austria training course on forest roads and harvesting in mountainous forests.*

Management of upland native woodlands (United Kingdom)

Olschewski, R., Bebi, P., Teich, M., Wissen Hayek, U., Grêt-Regamey, A. 2012. Avalanche protection by forests — A choice experiment in the Swiss Alps. *Forest Policy and Economics*, Volume 15, February 2012, Pages 108-113

Price, M.F., Gratzer, G., Alemayehu Duguma, L., Kohler, T., Maselli, D.l & Romeo, R.L. (Eds.) 2011. *Mountain Forests in a Changing World. Realizing values, addressing challenges.* FAO/MPS; SDC. Rome.

Price, M. F. & Butt, N. (Eds.) 2000. *Forests in sustainable mountain development: A state of knowledge report for 2000.* Task force on forest in sustainable mountain development. Wallingford: CAB International (IUFRO Research Series, 5).

Price, M. F., Kohler, T. & Wachs, T. (EDS.) 2000. *Mountain Forests and Sustainable Development.* Mountain Agenda. Berne.

Jayanath, A. 2007. Implementing participatory decision making in forest planning. Environmental Management. Volume 39, Issue 4, pp 534-544

Credits

This module was developed with the kind collaboration of the following people and/or institutions:

Initiator(s): Kata Wagner

Contributor(s): Akim Kress, Thomas Hofer - FAO, Forestry Department

Reviewer(s): IUFRO