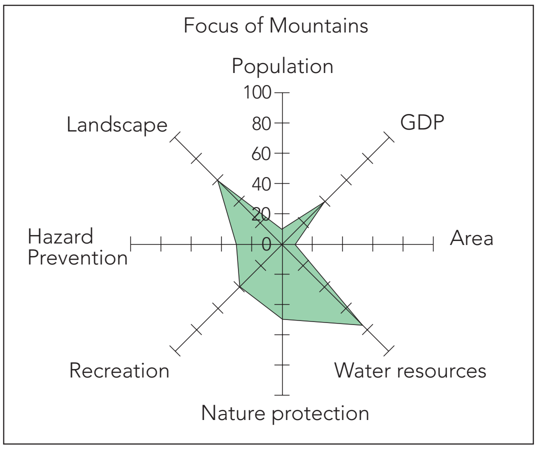
3.15. Mountain areas

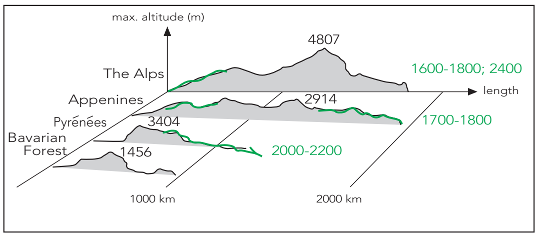
- The 'ideal world' of mountain areas is now threatened by socio-economic shifts, increasing tourism and traffic impacts, and changes in land use. In the Accession Countries more mountain areas must be expected to become endange red through rapid economic development.
- Environmental and social damage has already occurred or must be anticipated in mountain areas through significant changes in precipitation patterns, species and habitats distribution, changes in runoff rates, and water pollution, loss of soils and increase of man-made natural hazards.
- Present EU policies often exhibit inconsistency with respect to mountain areas and do not take adequate account of their special requirements.

Important Mountain Features in the European context illustrated by a qualitative estimation — Figure 3.15.1



Source: EEA

Overview of main features of some European mountain ranges — Figure 3.15.2



The top of the mountain is only part of the story. Mountain areas are systems of interlinked valleys, ridges and peaks. The phenomena of mountains is also a matter of altitude and slope. Diverse geology, geography and climate characterize European mountains. Despite their perceived remoteness, mountains offer an important dimension to rural, urban and coastal areas.

Source: EEA processing

1. Mountains – the undervalued ecological backbone of Europe

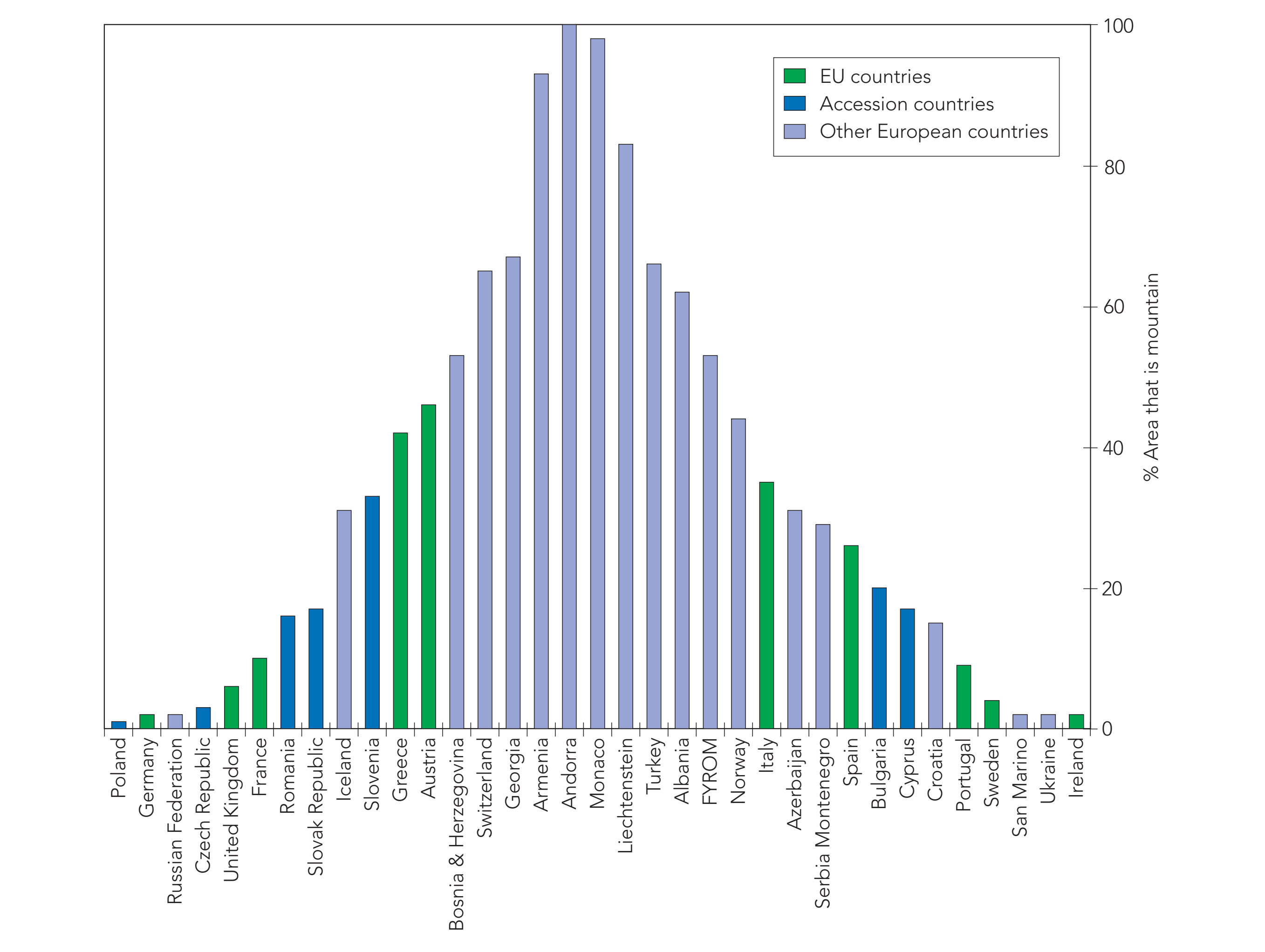
Mountains provide vital resources for the whole of Europe (Figure 3.15.1): for example, high runoff rates, and the storage and distribution of freshwater over time and space make mountains a major source for Europe's water supplies.

Mountain areas are important part of the ecological jewellery of Europe, providing aesthetic and recreational landscapes, high biodiversity of species and habitats embedded in sustainable land use systems. Extending through different altitudinal zones mountains have a wide variety of habitats, including – in the remotest regions in Europe – the last retreat for animals with large habitats. The extreme physical conditions make mountains a fragile environment, where natural phenomena, often increased by man-made land uses or misbehavior, interfere with human activities and then cause natural hazards.

Despite their remoteness, mountains suffer from direct and indirect pressures on their natural resources, many of which are interlinked, whose key factors are difficult to identify. Population change results from declining agriculture and few profitable income opportunities, furthering the trend of land abandonment. Transport networks, for which mountains constitute a barrier, tend to fragment the land, while tourism is both attracted by and damaging to mountain landscapes.

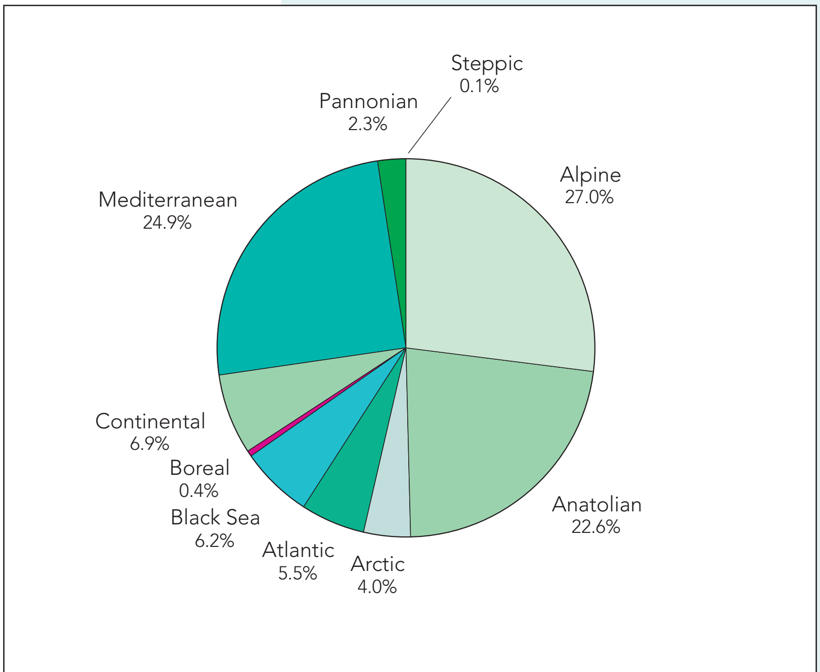
Mountain Areas vary significantly throughout Europe (Box 3.15.1). Sometimes these are isolated small mountains, often they are huge mountain massifs stretching over hundreds of kilometers, and providing an ecological backbone to much of the continent. For ther purposes of this chapter mountain areas are defined to include locations above 1 000m sea level (Figure 3.15.2), as well as all areas having a slope greater than 5 degrees, but excluding areas with a surface area less than 100 square kilometers.

Figure 3.15.3 **Mountain areas share in European countries**



Talking of mountains means 14% of the EU and 11% of the Accession Countries' land area. Only few EU countries do not have mountainous areas such as the Netherlands, Denmark and Belgium; others such as Austria and Bulgaria, have a high proportion of mountain areas.
Source: EEA

Figure 3.15.4 **Biogeographic regions of European mountains**



Distribution over biogeographic regions shows that mountains in the Mediterranean and Anatolian regions are in about the same abundance as in the Alpine region.
Source: EEA

Box 3.15.1 A glance over the thousands of European summits

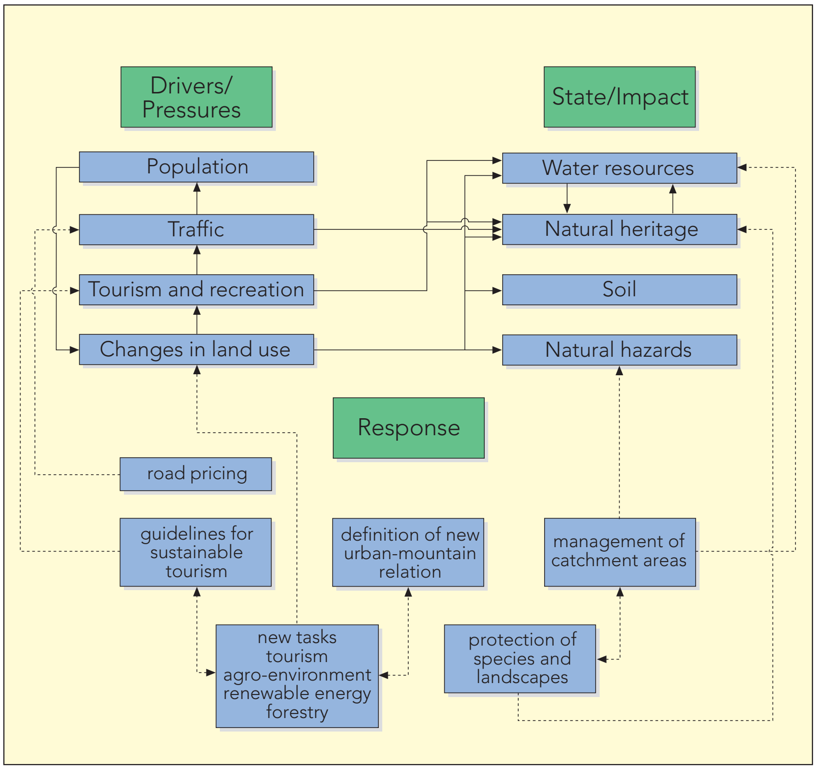
In Europe mountains are found in the geomorphological zones of the Fenno-Scandinavian Shield and the central and southern European highlands. The eastern and central Europe Accession Countries will add new mountain areas to the EU nearly the size of Austria, for instance the Bohemian Forest, Carpathian Mountains and Rhodopes.

Although much of the available information on the mountain environment relates to the Alps, Europe has a great variety of mountain regions, from Scandinavia to Mt. Etna in Sicily, and from the vast Spanish sierras to the densely wooded Carpathians (Figure 3.14.3 & 3.15.4).

Mountains are widely recognized as important and sensitive ecosystems, but little progress has been made in developing comprehensive policies, particularly at EU level, to build upon the good intentions set out in mountain charters. Although European policies were first applied to mountains in the 1970s (under the Less Favored Area, LFA, framework) and mountain areas are now subject to numerous EU, national and regional policies, there remains a lack of coordination between measures at different levels relating to various sectors.

Mountains are probably the most prominent examples where multifunctional land uses have partly still survived, but are now at risk. For mountain areas it is crucial to adopt a comprehensive, spatially integrated policy which is able to reflect and support the multifunctionality which has been the sustainable concept in mountains for many generations.

Interactions in mountain areas Figure 3.15.5



Adapting the DPSIR framework to the special needs of spatial issues, some relevant relations in mountain areas may be highlighted by this simplified model. In general every policy action should bear in mind the network of direct and indirect interactions which is affected by the relevant policy.

Source: EEA

2. How can the environment of remote mountains be threatened?

Fragile environmental conditions have brought about highly adapted and sophisticated land uses. Demographic and economic changes (and particularly the growth of tourism) have complex effects which call for holistic responses (Figure 3.15.5).

2.1. What makes population, traffic, tourism and land use change the main driving forces and pressures in mountains?

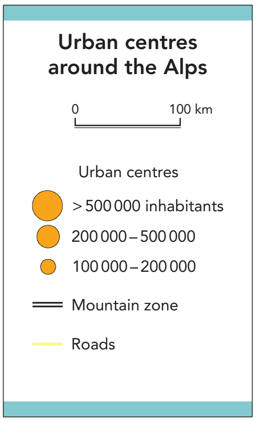
2.1.1. Population is outmigrating and overageing

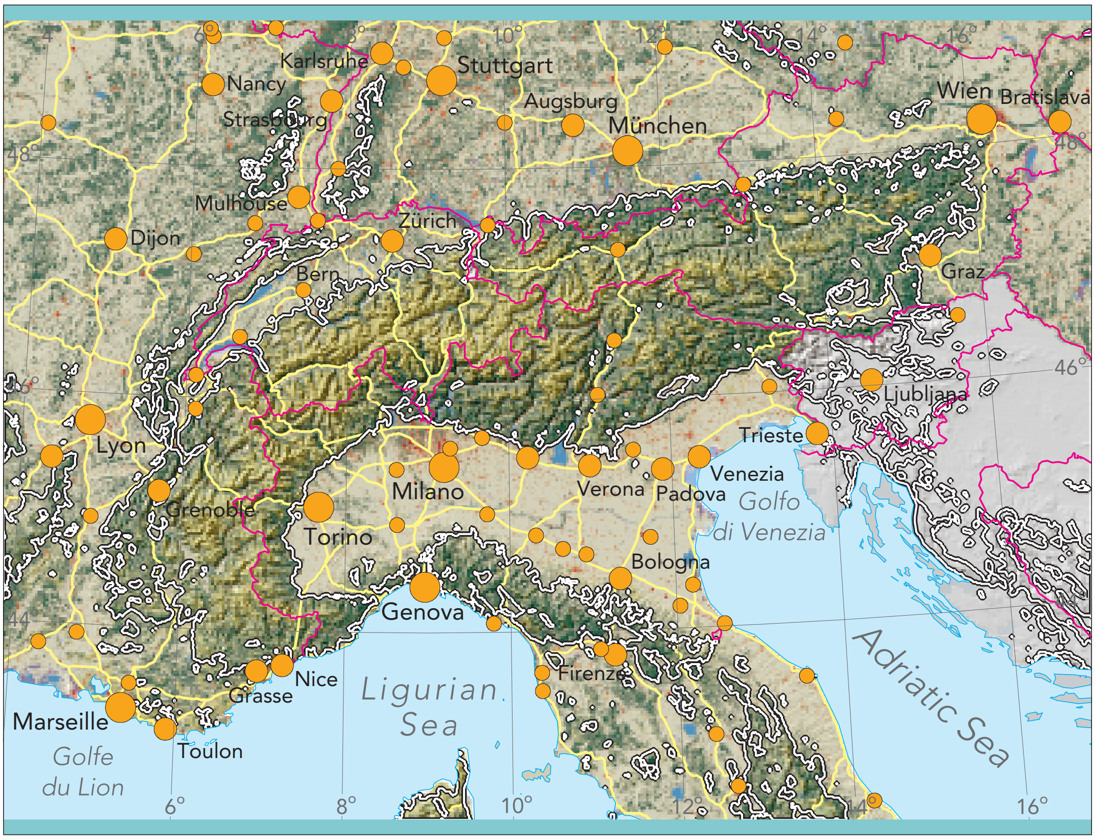
Many mountain areas have declining and ageing populations due to outmigration of workers, the use of residences as second homes, and inward migration of pensioners. Loss of population might reduce the capability for upkeeping the landscape and means an additional burden for suburban areas into which people are moving. Mountains also become subject of exploitation as a natural resource for urban consumption from lowland regions. There are at least 38 cities above 250 000 inhabitants close to mountain ranges in the EU and Accession Countries, such as Milan, Geneva, Birmingham, Rome, Granada and Thessaloniki (Map 3.15.1).

Population density varies considerably with altitude, so that some mountain areas are extremely sparsely populated, and comparable to Arctic regions, while the densely inhabited valleys have similarities with lowland regions. In 1990 the vertical distribution of total alpine population concentrated 93% below 1 000 m above sea level (a.s.l.), 53% below 500 m a.s.l., and only 7% above 1 000 m (Bätzing, 1997). Another aspect of population density is a significant variation with seasonal or daily peaks, i.e. summer and winter tourism inside mountains, international holidays or short weekend trips from surrounding city dwellers.

The shift and migration within mountain countries can be illustrated by some Alpine countries. In the period from 1870 to 1990 the Alps experienced a total population increase from 7 million up to 11 million people, but the proportion living in mountain areas dropped from 7.4% to 5.8%.

Population changes are connected to changes of employment opportunities and structures. The shift from a traditional multifunctional and multi-sectoral way of living of mountain people to external employment and enterprises is, besides insufficient infrastructure, a main reason for population changes. This means in general terms a shift





Map 3.15.1
Urban settlements around mountains; the example of the Alps

Source: EEA, GISCO – Eurostat

from the primary to the tertiary sector. This trend has special significance in mountain areas, where often traditional and sustainable activities are substituted by pure economically orientated activities. For example formerly multi-skilled mountain people working in agriculture, forestry, pastoralism or dairy farming are now employed in the tourist business or industry. Thus agriculture alone is no longer an economic pillar for mountain towns.

These changes in employment may be highlighted by the area of Aletsch in Switzerland. Here the primary sector dropped from about 70% in 1950 to 12% in 1980, tourist accommodation increased from about 65 beds in 1940 up to 7 250 beds in the 1980s. About 900 local residents now cater for about 700 000 overnight stays per year (Messerli, 1989).

2.1.2. Tourism and recreation in mountains: a double-edged sword

Promoted as an economic incentive for remote areas, tourism has in some mountain regions evolved monostructured, vulnerable economies, and generated pressures on the environment. Notwithstanding the vogue for 'green tourism', intensive, environmentally threatening tourism continues to develop; a similar trend can also be expected in Accession Countries. Tourism and recreation facilities exert pressure on the environment through land-use development and increased road traffic. Additionally, many outdoor sports affect the more undisturbed and nearly inaccessible areas such as gorges or rock faces (Garcia-Ruiz, Lasanta-Martinez, 1993; Lichtenberger, 1979).

The economic importance of mountain tourism is illustrated by a Greek study which estimated that the recreational value of mountain areas is 10 times greater than the value of forest timber (Vakrou, 1998 quoted in EOMF, 1998).

Tourism development varies considerably. In the Alps, for instance, only 10% of all Alpine communes have large monostructured tourist infrastructure and 40% have no tourism (Bätzing, 1997), and since the mid-1980s figures for tourism have been stagnating or decreasing in some Alpine regions, after several decades of steady growth (Elsasser/Frösch/Finsterle, 1990; Bätzing, 1990; Romano, 1995). Nevertheless, there are plans for further tourist facilities, such as ski runs in the Pyrenees and developments to cater for new recreation activities, particularly in the Accession Countries where tourism is important as a source of foreign exchange.

2.1.3. Traffic networks are governed by needs outside mountains

Transport infrastructure development (Figure 3.15.6) has often facilitated outmigration or commuting to urban centres and increased transit and tourist traffic, particularly day tourism in the catchment areas of big cities.

For instance nearly 150 million people a year are crossing the Alps, 83% by road and 17% by railway (Figure 3.15.7). A rapid increase in long-distance traffic crossing the Alps is expected at a rate of 100% for freight and 50% for passenger transport within the next 20 years (European Commission, 1994; CIPRA, 1998).

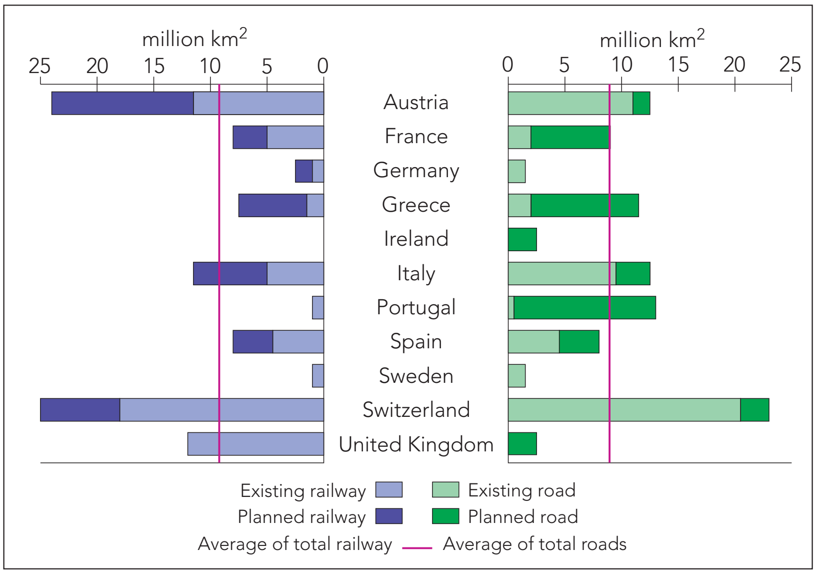
Traffic network impacts are concentrated in valleys where people live. It is therefore not surprising that two-thirds of the Alps' population suffers from traffic noise. In Tyrol 87% of high ozone levels are caused by traffic and in the 1980s lead concentration in mother's milk close to the Brenner motorway exceeded other regions by seven times (Rhomberg, 1998). Other traffic-caused impacts are fragmentation of untouched areas, deterioration of recreation areas, and socio-economic, double-edged effects such as better accessibility to mountains or changing competition between mountains and lowlands. While transport network density is higher in the Alps than in other European mountain ranges, rapid increases may be expected for Accession Countries' mountains.

There have been calls in mountain areas for better integration of transport and compensation for environmental disbenefits, and protests by local populations have resulted in highway blockades, for example on the Brenner Pass (between Austria and Italy) or the 1994 plebiscite in Switzerland on freight transport.

2.1.4. The sustainability of land uses is set at risk

Mountain agriculture has responded to economic pressures in two ways (Box 3.15.2). One reaction is intensification, in the valleys and on high mountain pastures and good accessible slopes shifting from extensive meadows to intensively grazed pastures. The other is extensification in terms of abandonment or afforestation. Both these changes cause a significant decline in biodiversity and root density. Land abandonment will induce snow gliding, changes in water storage capacity and water transport in soils, the onset of soil podzolisation and a potentially higher frequency of natural hazards (Cernusca *et al.*, 1996, Höller *et al.*, 1998).

Trans-European Network (roads and railways) in mountainous countries — Figure 3.15.6



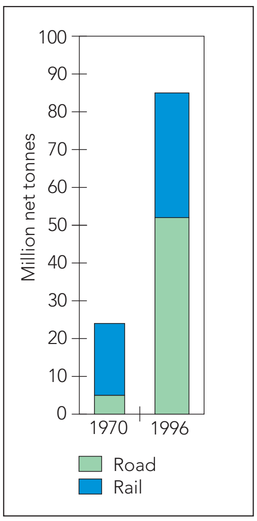
Here an index of meters of road/railway per km² of mountain area shows where increases of infrastructure and changes of modal split exist and are planned.

Source: EEA, European Commission (TEN)

Forest areas extend through natural regrowth on abandoned farmland or afforestation (Figure 3.15.8). Forests are, of course, often the main natural land cover in mountains. Depending on the new forest type, local conditions and existing biotopes, changes may positively or adversely affect species diversity, landscape attractiveness and tourism.

In the eastern and central European countries, changes are driven in particular by the transition towards a market economy.

Freight transport in the Alps (1970-1996) — Figure 3.15.7



The trend of freight transport per year through the inner Alpine arch, between Mont Cenis/Fréjus and Brenner shows an overproportional shift towards road transport.

Source: CIPRA

Box 3.15.2 Evolution and change of land use in the Alps (after Bätzing, 1990)

Over time different, highly adapted land-use systems slowly evolved the Swiss Alps, under the harsh and hostile conditions of the mountain environment, in which land mismanagement can have disastrous consequences.

Main features in the Swiss Alps as derived from Messerli (1989)

4000 B.C.	Transhumance starts (migrating shepherds). Roman and German mountain agriculture. Walser and Schwaighof economy.	
14th/15th century		Forest degradation through clear-cutting and overuse; increase of rock falls and avalanches.
16th/17th century production; wealthy communes.	Boom time of cheese and cattle overgrazing and degradation of pastures.	Population increase causes
19th century	Start of some industrialisation for use of charcoal and hydropower in eastern Alps; collapse of traditional, multi-functional land use.	Forest degradation through clear-cutting for industry (charcoal), grazing in forests and overuse; increase of floods.
20th century	From 1920 beginning of tourism in belle-epoque hotels; from 1950s broad tourism trend.	Tourism, ski tourism in particular; forest degradation through air emissions; land set-aside; cause increasing erosion.

Generally Alpine land-use systems followed principles which maintained a sustainable cultural landscape and probably achieved in modern terms 'sustainable development'. Guidelines included careful site selection, examination of the suitability for land uses, and a high proportion of land restoration and maintenance, requiring responsibility and high human labour input.

Certain environmentally relevant measures were defined, such as forest protection to prevent rock falls and avalanches (e.g. in Andermatt, Switzerland, 1397); definition of number and type of livestock for pastures at different altitudes and limitation to areas available for winter fodder in the valleys. Permanent restoration such as collecting rocks from pastures, removal of forest regrowth, seeding of open soil patches and fertilizing were practised.

Similar systems are reported also for the Pyrénées, Vosges, Black Forest, Scandinavian Mountains and Dinaric Alps.

The traditional knowledge of land management, still a living example of sustainable development, is rarely taken seriously, more appreciated as a touristic attraction and at risk of disappearing; for economic reasons, intensive land uses, such as mass tourism, do not favour sustainable development.

In future it seems likely that polarisation within mountain areas between very intensively developed, economically prosperous regions and remote, marginalised ones will continue. Certainly there are some promising attempts to promote new, multi-functional land-use models, but it remains questionable whether these will succeed as widespread solutions.

Pastures are enlarged by the cutting of subalpine forests and shrubs, notably in Albania, Bulgaria, Romania, Slovenia, Slovakia and the Ukraine. Hunting tourism causes the overgrazing of some forests by deer (Price, 1995).

2.2. The environmental state of sensitive mountain areas is a valuable indicator for the whole of Europe

2.2.1. Mountains are the first to be hit by climate change

The prospect of climate change (see Chapter 3.1) has significant implications for mountain environments. There are likely to be also indirect effects on human populations and ecosystems in adjacent plains, particularly arid and semi-arid regions with irrigated agriculture dependent on water supplied from mountain areas (Price/Barry, 1997). For Swiss mountains an accelerated structural change in mountain farming is expected with threats to the survival of small mountain communities, due to comparative disadvantages of mountains relative to valleys (Jeker, 1996; Flückiger, 1996). But effects of climate change depend on interaction with other factors and can be worsened or eased by human action. The extent of environmental and economic damage will depend on the resilience of mountain landscapes to buffer the expected extreme weather events. This can be achieved through good landscape maintenance such as through mountain forestry and pastoralism (Breiling/ Charamza/Skage, 1997).

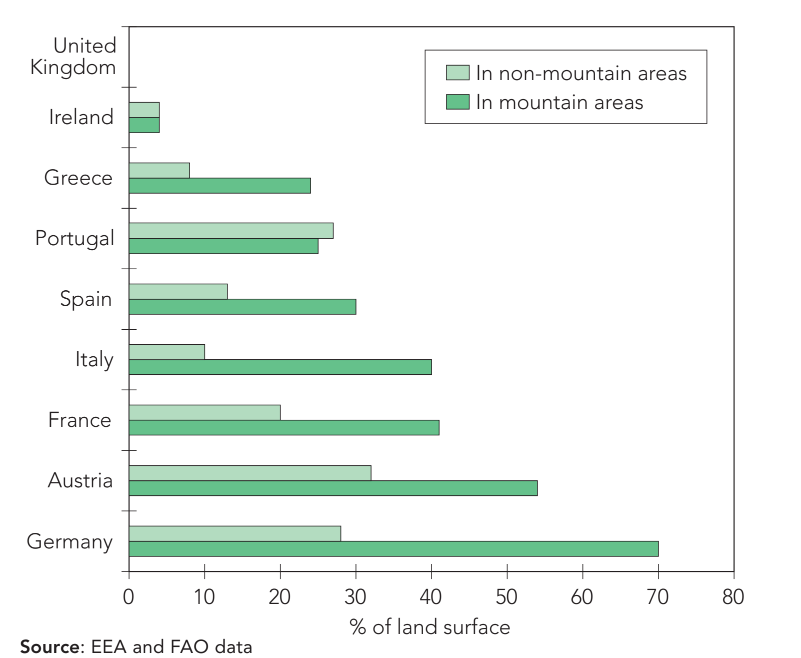
Mountain areas represent within a relatively small area different climatic belts linked to altitude, and are therefore highly sensitive to any climate change (Figure 3.15.9). With an anticipated global warming of about 2-3°C by 2100, higher-altitude ecosystems probably would suffer the greatest impact of global warming through eliminating the entire alpine belt, including the nival zone. An impoverishment of (present endemic) species and biotope fragmentation would be the result of this process. Temperature increases and changes in precipitation patterns would cause changes in snow cover and water reserves, soil instability through reduction of permafrost soils, and also influence the frequency of natural phenomena such as mudflows, floods or droughts (Guisan *et al.*, 1995; Ruberti, 1994; Dubost/ Zingari).

Variation of precipitation patterns and water supply might influence agriculture or stock breeding through changes of suitable pasture or fodder for grazing animals.

Changes in snow cover and snow duration may have severe effects on winter tourism. Also without a real change, climate variability will have serious effects (Breiling/ Charamza/Skage, 1997). One study predicts that in Switzerland the number of economically viable ski resorts and ski lifts will decline by 67% to 44% (Abegg/Elsasser, 1996). About 3% to 4.5% of Austrian GNP depends on winter tourism: it is estimated that about 10% of Austrian winter tourist revenues are directly lost by a warming of 1.5 degree Celsius (Breiling, 1994) – and that indirect losses are three times higher. On the other hand, regions at higher altitudes with better snow conditions may experience an increase of winter tourism, leading to economic disparities, uncontrolled development and increasing environmental damage (Breiling/ Charamza/Skage, 1997).

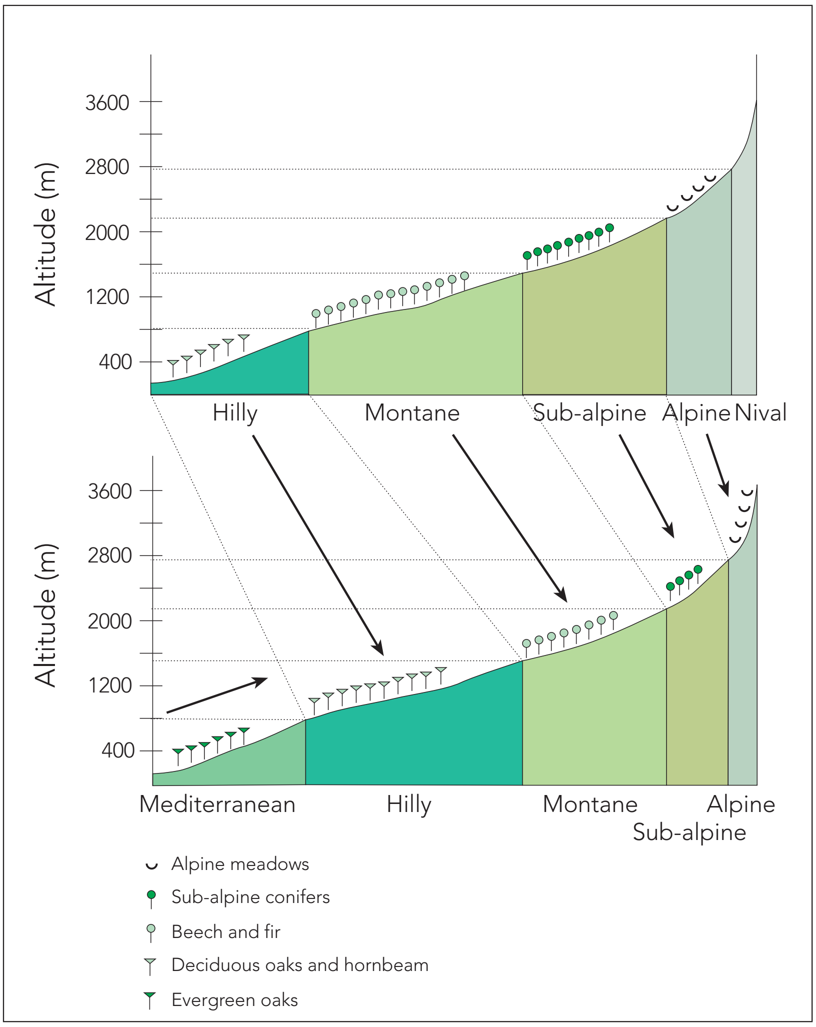
In the Fennoscandian Mountains, the potential alpine zones in Norway might be reduced to a quarter of their present size, followed by endangering of, or strong competition between animal species (e.g. lemming, red fox, arctic fox), due to the reduction of their current habitats. In the Southwestern Alps, a progressive decrease in

Forest shares inside and outside mountains Figure 3.15.8



Source: EEA and FAO data

Climate change: vegetation can be forced upwards in higher altitudinal belts Figure 3.15.9



It must be assumed that each vegetation belt would be replaced by the neighboring zone below, except for some fragmented areas in the Pyrenees and the Alps (i.e. Mont Blanc).
Source: Guisan et al. (eds.), 1995

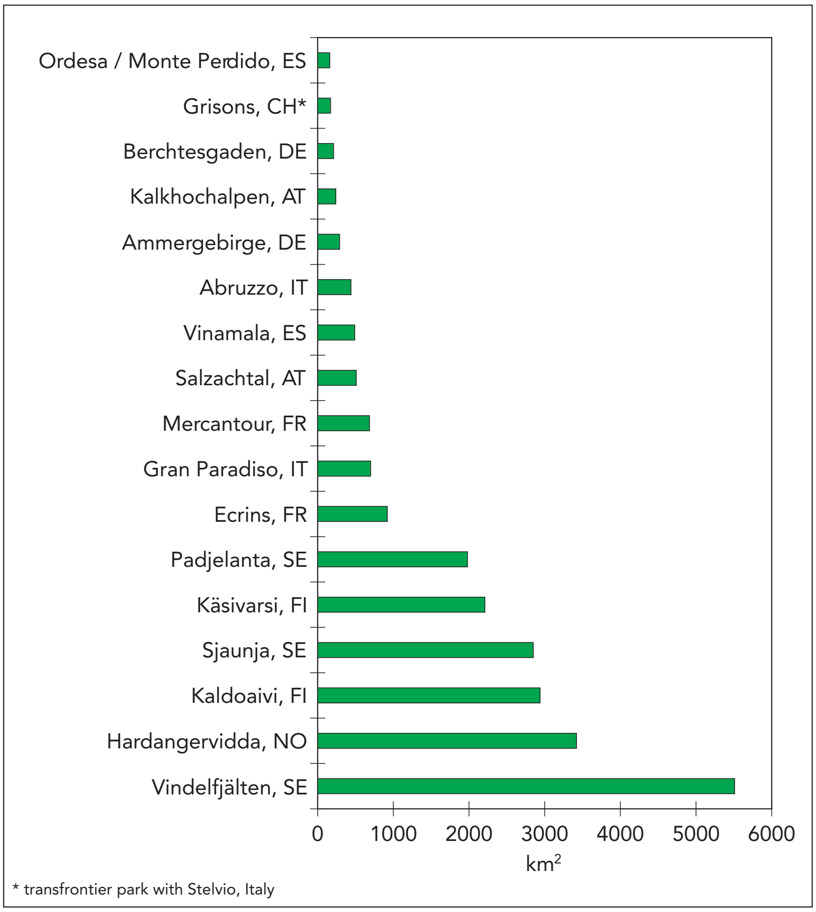
precipitation is expected with steppe-like vegetation patterns. In general, the Mediterranean climate might spread further northward and upward endangering Alpine plant communities and causing extinction of some European tree species in the Central Alps (Guisan *et al.*, 1995; Ruberti, 1994; Dubost/Zingari).

2.2.2. Mountains provide an interwoven natural and cultural heritage

Large unfragmented areas are an important but steadily declining resource, and, while some of these areas enjoy legal protection, there are considerable differences between regions (Figure 3.15.10).

Five of the largest unfragmented (and protected) areas are located at the periphery of the EU, such as in Scandinavia where pressure from population, land use and traffic is relatively low, while protected areas in Middle-Europe (Alps, Middle Mountains) are generally smaller. Unfragmented sensitive areas are often still unprotected (national parks cover only 4.2% of the Alps; CIPRA, 1998). The Accession Countries at present have large unfragmented areas.

Figure 3.15.10 **Range in size of protected mountain areas**



Sizes of selected unfragmented protected areas in different countries of alpine biogeographical region (IUCN categories I-IV serving primarily nature conservation functions, WCMC and Common Database on Designated Areas, EEA).

Source: EEA

Besides their importance for conservation of wildlife and biodiversity, large unfragmented areas offer non-material values such as areas of silence, low emissions of pollutants, natural beauty and wilderness perception. European mountains may be considered as an ecological 'green' network offering migration corridors and guidelines over long distances.

The number of areas in the Alps above 1 500 km^2 not touched by major transport infrastructure dropped from 31 to 14 between 1963 and 1993 (CIPRA, 1998) implying the loss of characteristic species and of species requiring large areas to survive (see also Chapter 3.11). On the other hand, the setting-aside and abandonment of land may in some areas lead to growth of unfragmented areas, as reported from some French Alpine valleys, although land abandonment can harm biodiversity.

Human impacts have often created new ecological conditions in mountain areas, contributing not only to the diversity of landscape character but also generating ecosystems which house a high species diversity. In the Pyrénées 30% of the land below 1 600 m above sea level was cultivated in the last century (Garcia-Ruiz; Lasanta-Martinez, 1993), while approximately 70% of the Alpine region is influenced by human land use (CIPRA, 1998). Besides human impacts on natural or semi-natural landscapes (e.g. lowering timberline in mountains), different land use practices created a great variety of cultural landscapes adapted to existing physical conditions in mountains. Landscapes such as terraces, alpine pastures, Coltura Promiscua in the Appennines and in Portugal, hedge-dominated landscapes such as the 'Egartenlandschaft' in the Bavarian Alps or Chestnut woods in the southern Alps and Cévennes have arisen, giving a distinctive character to regions or local areas.

Cultural landscapes in mountains can be kept stable only by continuous farming suited to local conditions. They are declining due to worsening economic farming conditions, becoming more a subject of government maintenance than of private enterprise, but are discovered by tourism as a relevant resource. Especially endangered landscapes are traditional extensive livestock farming systems (Petit *et al.*, 1998) e.g. alpine and subalpine pastures, arctic and alpine dwarf shrubs, or transhumant grazing, which disappeared completely in the Pyrénées (Garcia-Ruiz; Lasanta-Martinez, 1993).

Mountains also house a large number of ecosystems, species and genetic variety. They have the highest concentration of habitats of most significance for conservation in the EU (Zingari, 1994), with almost 25% of habitats of European interest – of 169 habitat types (defined in Annex I of the Habitats Directive), 42 occur only in mountain areas (Hopkins, 1998). Natural and semi-natural habitats cover a large percentage of Europe's mountain area, while intensive agriculture accounts for only a small proportion (Figure 3.15.11). In Accession Countries, coverage of semi-natural and natural habitats in mountain regions is generally lower than in the EU.

Although biological diversity increased in the last century in Europe, this trend has been reversed in recent years, due to changes in traditional land use: in the Alps a tremendous reduction of species and habitats use is reported (Brugger and Messerli in Zingari/Dubost, 1996).

Mountain areas in particular have become a retreat for species originally distributed in larger areas such as brown bears, wolves, lynx and wild reindeer. The re-immigration of bears since the 1970s from southern Slovenia into the Alps has been confirmed and demonstrates the eligibility of mountains as interlinking ecological networks. Eight of the 35 mammal species listed under the EU Habitat Directive occur predominantly or entirely in mountains (Hopkins, 1998) – information concerning species diversity in mountain areas is mainly available for higher plants (Figure 3.15.12) and mammals. Isolation of populations during ice ages has caused evolution of endemic species, when species were pushed back on areas free of glaciation. For this reason some European mountain ranges (mainly Mediterranean mountains which remained free of glaciation) form centres of plant endemism. They host (predominantly or completely) two-thirds of the continent's flora (Ozenda, 1994 cit. in Dubost, Zingari).

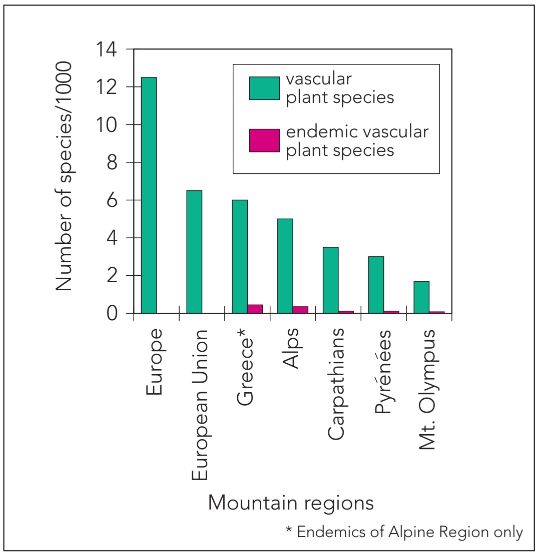
As mentioned in Chapter 3.11 the maintenance of genetic resources is important in many respects; reduction of gene pools may be a risk for the future, in view of adaptation possibilities to future environmental changes. The loss of genetic diversity by

Illustration of land-use intensity in mountains — Figure 3.15.11

Relation of agricultural and semi-natural areas inside and outside mountains, considering the relevant area.

Source: EEA

Number of vascular plant species in European mountains — Figure 3.15.12



Mountains are inhabited by a remarkable proportion of European species of vascular plants. Endemic plant species in mountains can be estimated for only the five mountain ranges in the figure to make up about 30% to 42% of the vascular plants occurring only in Europe (depending on the estimated number of these). Here one has to consider that mountain ranges in total cover only 14% of Europe.

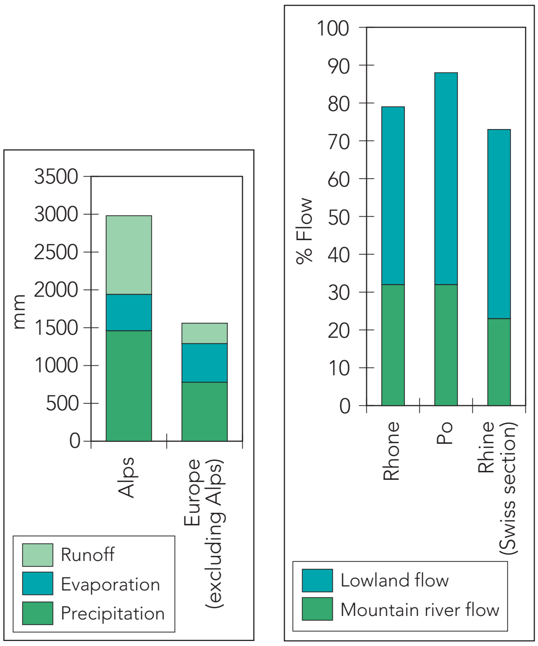
Source: Stanners & Bourdeau, 1995; Ozenda, 1988; Blandin, 1992 disturbance of gene pools also occurs in mountains, such as with the chamois subspecies cartusiana of the French Alps hybriding with the common, introduced chamois subspecies rupicapra, or hybriding between wild and domesticated reindeer in Norway.

2.2.3. Mountains are the watertowers of the lowlands

The water resources of mountains cover the most vital functions of mountain and lowland people (Figure 3.15.13). Notable functions are the provision of high-quality freshwater, irrigation water for food production, the economic value of hydropower generation, and water supply for natural wetlands in plains. But these benefits of mountain waters are threatened by degradation of water quantity and quality, and discontinuity of flow. The growing demand for water, mainly in eastern and southern European countries, as shown in Chapter 3.5, will make the preservation of these functions of paramount importance in future.

Mountain height enables water to flow to far distant areas and to serve as a source even for semi-arid areas, while seasonal differences in the flow regime of rivers are attenuated by the temporal distribution of mountain water. The rainfall in high mountains may be stored in ice, snow or mountain lakes; for instance in Switzerland 136 km^3 of rainfall are stored in lakes and reservoirs and 74 km^3 in glaciers – five times the total annual outflow from Switzerland (Mountain Agenda, 1998). In spring and summer the discharge of mountain rivers supplements the earlier high flows of the lowland section which occur in winter and autumn.

Figure 3.15.13 **Importance of the Alps for the water flow in Europe**



In the Alps precipitation is higher and evaporation is lower than in the average of Europe. Therefore the Alps produce higher runoff rates. As a result, small mountain areas are responsible for an overproportional flow of rivers in lowlands as shown for the rivers Rhône, Po and Rhine

Source: EEA; Mountain Agenda, 1998

Relatively unpolluted rivers, in terms of chemical and biological quality, generally are situated in catchments in mountainous and forested regions where the population density is low. Lakes in mountains also represent some of the least nutrient-polluted freshwater in Europe. However, high-altitude lakes are known to be subject to acidification (Stanners, Bourdeau, 1995).

Pollution of mountain rivers occurs through waste-water discharge, or water abstraction. Other impacts work indirectly such as accelerated surface runoff caused by surface sealing for infrastructure, soil changes through land-use abandonment, less water storage through deforestation or air-pollution induced forest damages. Natural extreme rainfalls then become extreme strong runoffs, which are linked to natural hazards discussed later in this chapter. But higher runoff rates do not only change the quantity but also may worsen the quality of water by diluting sediments and eroded soil.

Runoff rates are also affected by river channelisation for flood control of towns or protection of farmland in valleys, damming for water storage or hydroenergy generation. The change in water flow will be followed by alterations in physical, chemical and biological parameters, such as sediment discharge, bank erosion and reduced or altered biodiversity of riparian zones, for example if fish spawning areas are destroyed. The effects of these changes on the hydrological system call for a common watershed management framework for mountains and lowlands.

From a technical viewpoint mountain valleys are well suited for hydro-energy and water-storage reservoirs because of their steep gradient and 'natural' damming in the valley, which reduces construction requirements; however, there is often a noticeable environmental cost (Figure 3.15.14).

Reservoir construction involves the loss of farmland, changes in natural habitats and landscape, a rise in groundwater levels and a change in microclimate. The river will turn into a hybrid between river and lake and the environmental conditions such as current, nutrients and light will change. Environmental problems of reservoirs include contamination, eutrophication, difficulties of fauna migration, sediment trapping, water-level variations and a loss of biological biodiversity (Kristensen, Hansen, 1994); Leonard, Crouzet, 1998). Assessments by the European Topic Centre for Inland Waters suggest that reservoir construction in Europe is stagnant after a period of strong increase mainly in southern European countries.

2.2.4. Soils in mountains – demanding multifunctionality

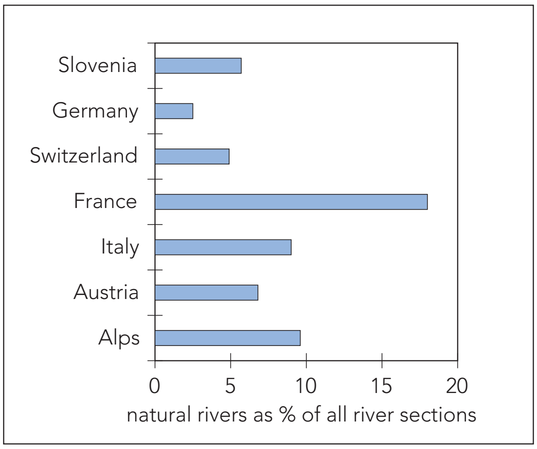
In mountains soils at higher elevations are quite different in terms of temporal development, stability, and thickness of topsoil from soils in lowlands (see also Chapter 3.6). These features make soils in mountains more sensitive to degradation and require specific adapted land-use patterns which are often met by the traditional silvo-agro-pastoral land uses.

The development of soils in high mountains shows certain characteristics different from lowland soils:

- soils develop more slowly because of lower temperatures, a short vegetation period and frequent interruption by erosion; consequently soils are not highly evolved types, such as lithosols, rankers and rendzinas which often consist of only a shallow soil layer covering the geological substrata; soil types often occur according to elevation belts;
- shallow soils allow land use mainly as grassland or forestry;
- soil generation, predominantly by physical processes, causes the so-called 'catenas' phenomenon in mountains, featuring different kinds of soils according to the gradient (Ozenda, 1988). Different geological layers and ice-age substrates serve as parent material for soil generation, which produces complex mosaics of different soils on a single mountain slope (Ellenberg, 1982, Ozenda, 1988). These features contribute to the considerable diversity of mountain ecosystems;
- in humid climates leaching of nutrients into lower soil layers is frequent where the nutrients are no longer accessible for vegetation; in the alpine and sub-alpine belt grazing, cutting and constant input of natural fertilizers balances the natural phenomenon of podzol-evolution (Messerli, 1989).

Mountain soils are mainly affected by degradation through erosion and (on acid parent material) through acidification and pollution (Stanners, Bourdeau, 1995). Mountain soils are highly sensitive to erosion because of the shallowness of soil layers, the long time frame for their development (up to 4 000 years for mature soil) and the risks of natural hazards due to increasing soil erosion. As shown in the potential risk map in the *Dobris* report, mountain areas present a large proportion of the potential high-risk areas in Spain, Portugal, Greece and Italy (Stanners, Bourdeau, 1995). In areas with non-calcareous bedrock and abundant coniferous forests or alpine shrubs, soils are more exposed to natural acidification and are thus particularly susceptible to artificial acidification.

Natural sections in Alpine rivers Figure 3.15.14



According to the criteria of pristine water quality and a nearly untouched river flow, the example of Alpine rivers highlight the loss of natural sections. Only 10% of Alpine rivers, which is about 900 km, may be regarded as natural rivers, mainly due to the absence of hydropower. The ecological quality of river courses depends – among other things – on the diversity of river beds and minimum flow.

Source: Fabrice, Dubost, 1992

Steep slopes, frequent torrential rainfalls, and pressures such as unsustainable forestry, overgrazing, loss of traditional agriculture, land abandonment and fires are most abundant in mountain areas. In addition to overgrazing due to increased livestock and clear cutting, recent causes of soil erosion and compaction include tourism and sporting and recreational activities (walking, skiing, mountain bikes, off-road vehicles, etc.). Indirectly, soil erosion may cause contamination of surface- and ground-water. Deposits of eroded materials in riverbeds, lakes and water reservoirs might increase flood risks and can damage infrastructures such as roads, railways and powerlines.

2.2.5. Living with risks – natural hazards in mountains

The extreme environment makes mountain areas prone to natural phenomena such as landslides (Table 3.15.1), rockfalls, mudslides, avalanches, floods and earthquakes (see also Chapter 3.8). The stability of the slopes is often

Table 3.15.1 **Landslide disasters 1995 - 1998**

Area affected	Frequency	Events	Victims / Costs
Switzerland: Bristen, Obwalden, Villeneuve, Tessin, Glarus, Grisons, Vaud, Ticino, Fribourg, Tödi, Randa, Lärch	12	landslides; mudflows; rockslides; rockfalls; severe storms; heavy rains; hail; forest destroyed; roads, railroads buried/blocked; houses flooded; cars damaged; power and drinkingwater supply interrupted.	injured: 8; > 71.7 M euro;
France: Salle-les-Alpes, Dieulefit, Briancon	3	landslides; rockfalls; heavy rains; severe storm; roads and railroads buried; houses, cars damaged.	injured: 2
Liechtenstein: Triesen	1	mudslide; severe storm; 50 houses affected, roads closed.	2.3 M euro
Austria: Braz, Stubachtal, Lienz	3	landslides; rockfall; heavy rains; severe storm; riverbanks burst; bridge destroyed, Intercity derailed; houses destroyed.	deaths: 3 injured: 17
Germany: Breitachklamm, Garmisch-Partenkirchen; Bayrischzell, Glottertal	4	landslides; rockfall; slow rock flow; Glotter River blocked; bank burst; trees downed; roads blocked; houses flooded; power failure.	
Norway: Finneidfjord	1	mudslide; houses destroyed; roads severly damaged.	deaths: 2
Italy: Cortina d'Ampezzo, Piedmont, Alto Adige; Milan; Sorrento, Darfo di Boario, Campania, Caserta, Salerno, Avellino, Sarno, Quindici, Siano	6	landslides; mudslides; heavy rainstorm; flash floods; high wind speeds; hail; losses to lemon and olive plantations roads, railroads damaged/blocked; hundreds of houses, cars damaged; train derailed; valleys isolated; tourist camp isolated.	deaths: 6 injured: 22
Italy: Umbria, Le Marche, Folino, Assisi, Colfiorito	1	earthquake; houses and Franziskus basilica damaged.	deaths: 164 (feared 135 more); injured: 215 homeless: 40 000 130.4 M euro
Spain: Gijón	1	landslide, heavy rain.	

Source: Munich Re, NatCatService, 1998; Schweizerische Rückversicherung, 1998

modified by human activity through disturbance of vegetation (deforestation, overgrazing) and groundwater conditions or the construction of infrastructure (see Camparia case study, Chapter 3.8). The factors which increase soil erosion (see above), may also increase the risk of land slides.

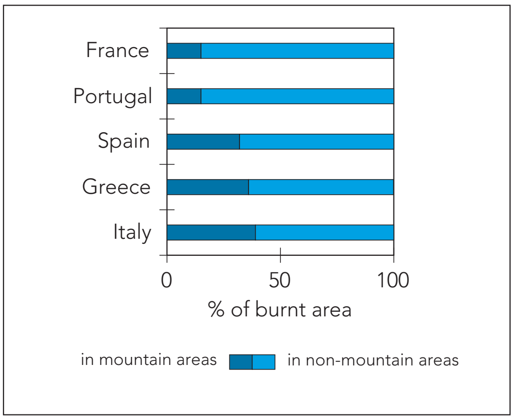
Nine out of ten earthquake disasters in Europe occur partly or wholly in mountain areas, and often in Mediterranean and sub-Mediterranean climatic regimes. Earthquakes and floods are predominant (60%) but the number and proportion of disasters identified with landslide and avalanche appear much greater (Hewitt, 1997; Mountain Agenda, 1992).

Since 1970 the reported number of natural and man-made disasters has increased due to better information and higher concentrations of population and economic activity in industrial countries (Schweizerische Rückversicherung, 1998). For a general overview see Chapter 3.8.

In the Mediterranean region, forest fires have the largest potential for altering the ecosystem. Every year, some 45 000 forest fires break out in Europe – most of them caused by humans. Many fires are lighted illegally but intentionally to gain sites for grazing livestock, construction or tourist facilities. The anticipated climate change might affect natural-fire frequency, spread and their devastating effects (European Commission, 1997a; Ghazi *et al.*, 1997). The area affected by fires has seen a downward trend, however in Spain and Portugal fires seize large areas (Figure 3.15.15).

Major road and rail tunnels, high bridges and dams are concentrated in the mountains, and are prone to widespread, frequent and financially expensive damage. Expansion of tourism in mountain villages has spread accommodation and infrastructure into risk areas; tragic proof was given in early 1999, when several big avalanches in the Alps caused death and destruction in ski resorts. Technical mitigation measures in turn affect the natural environment. These natural phenomena also create new environmental habitats but, by changing the landscape, they mainly have social and economic effects on humans.

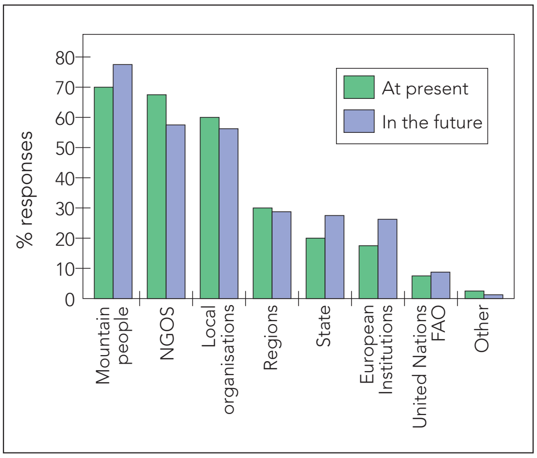
Burnt areas in mountains Figure 3.15.15



Of the total burnt areas in a country, mountains are affected by about 15-39%. The portion of burnt area must be estimated higher in countries with larger mountain areas.

Source: EEA

NGOs' perception of present policies on mountain issues in Europe Figure 3.15.16



Source: Mountain Agenda, 1997

3. Are mountains areas of marginal interest for Europe?

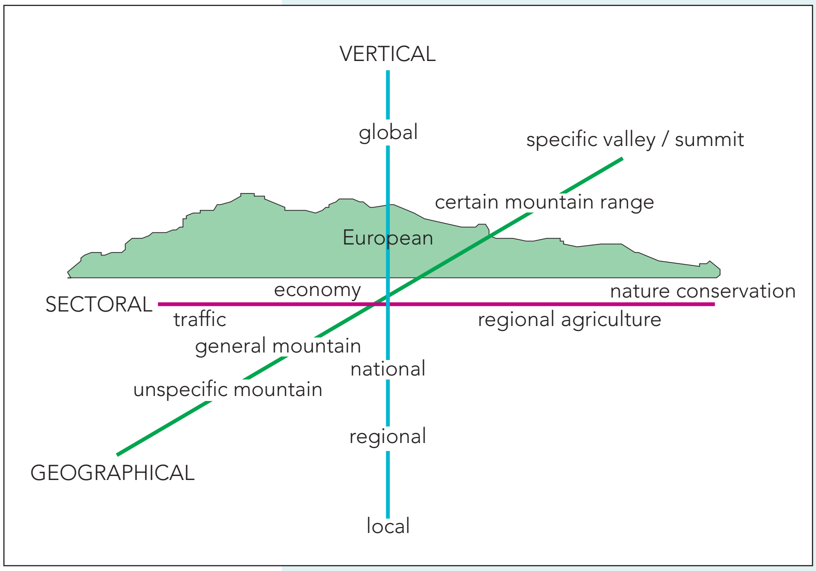
Several sectoral policies, particularly in the fields of agriculture, regions and nature conservation cover mountain areas. However, the sparse population, low economy, underestimated natural values, confounding complexity and transnational situation of many European mountain area make them regarded politically as marginal areas in terms of an integrated, comprehensive mountain policy (Figure 3.15.16 and Box 3.15.3). For these reasons integrated policy approaches such as the framework of Agenda 2000 and European spatial policy, as started with the European Spatial Development Perspective (ESDP) might be keys to integrated mountain policy – which is a vital need to be developed.

3.1. Could spatial policy integrate mountain issues?
A European spatial policy is arising, yet two different approaches still may be observed: one focusing on certain mountain ranges as European regions, particularly the Alps, the other defining mountain areas as a certain spatial category directed at a European mountain policy (Bätzing, 1997).

The regional study areas introduced in EU2000+ (European Commission, 1994), such as the Alpine Arc, are a remarkable step towards a spatial analysis. However, significant disparities remain inside the regions considered, in the Alpine Arc in particular, and do not recognize the special situation of mountain areas.

In the ESDP (European Commission, 1997b) mountain areas are characterized as unprotected and environmentally sensitive areas. Several mountain ranges are 'trans-national areas' which are geographically continuous, transcending national borders. These in particular require a European spatial policy, in terms of watershed management, risk

Figure 3.15.17 **Mountain policies in a mountain system**



Multi-dimensional ways in which policies affect mountains can be illustrated by a 'policy coordinated system'. There is a hierarchy of policy from global to local level (y-axis), sectors of policy from economy to nature conservation (x-axis) and a geography from general mountain policy to specific valleys (z-axis).

Source: EEA processing

Box 3.15.3 How does policy deal with mountains?

Mountains are subject to various types of policy measures (figure 3.15.17). Policy approaches may propose a general mountain policy, may target certain mountain ranges, may affect mountains directly without distinguishing between different mountain areas, or may have purely incidental effects on mountain areas.

Mountains have been directly addressed in few policy documents. On a global scale mountains have been recognised by Article 13 of Agenda 21 as highly sensitive ecosystems and an important source of natural resources. On the European scale the inter-governmental consultation on sustainable mountain development 1996 recommended the need to work towards an integrated policy framework for sustainable mountain development, environmentally sustainable mountain action plans and programmes as well as more sustainable sectoral policies and the assessment of impacts of existing national and European policies. All European mountains have been covered by the European charter of mountain areas (1994) to be elaborated into a European Convention of Mountain Areas. The charter covers almost every political sector which affects mountains and requires a 'comprehensive spatial policy' for mountain areas.

For the Pyrenees, a special charter has been adopted, and efforts are beginning towards the development of charters in the Carpathians and Caucasus. Underlying the Charter for the Protection of the Pyrenees (CIAPP, 1995) are three key objectives: to protect the environment, to allow access for visitors and to support environmentally sustainable economic development. Much further detailed is the framework of the Alpine Convention signed in 1991 by Germany, France, Italy, Lichtenstein, Monaco, Austria, Switzerland, Slovenia and the EU. Since 1990 several protocols which define the principles for different sectors have been drawn up, signed, or are under discussion. None have yet been ratified.

prevention, preservation of biological and landscape diversity, and recreation.

The most relevant EU policies for mountains are listed in Table 3.15.2 and have been introduced in Chapter 3.13. Some measures overlap, others appear contradictory. A first step towards assessment has been done in the European Commission study 'Integration of environmental concerns in mountain agriculture' (Euromontana, 1998). Some examples will be highlighted below, with reference to drivers and environmental problems.

3.2. Pressures of today need to be mitigated

3.2.1. Mountain crossing traffic will further increase

Due to increasing traffic flow more EU-corridors certainly will cross mountains (e.g. transalpine link Rome-Milan-Zurich/Munich; Madrid-Barcelona-Rhone Valley; Milan-Venice-Vienna-Budapest-Kiev; Bologna-Milan-Lyon; Madrid-Bordeaux-Toulouse) (European Commission, 1997b); the same will apply in the Accession Countries (Carpathian, Rhodope or Balkan) as identified in 1996.

Modal split can be sensitive to relative costs, which may in turn be modified by road pricing. This is illustrated by experience in Austria, where a reduction in infrastructure charges to comply with EU legislation was followed by a 16% increase in freight traffic in 1995 (Weissen, 1996). In contrast, as a result of the Alpine convention's traffic protocol, 70% of all goods in transit through Switzerland are transported by rail and the maximum weight for road transport is limited to 28 tonnes per truck (which is lower than in other Alpine countries).

3.2.2. Mountain tourism has learnt but a turnaround is difficult

The harmful effects of intensive tourism have led to restrictions for sport and for

Examples of how EU policy measures cover relevent mountaín issues as recognised in this chapter Table 3.15.2

D = Mountains directly addressed; I = Mountains indirectly addressed

	Population	Traffic	Tourism	Land use change	Natural heritage	Soil	Water	Hazard prevention
Environment Policy								
Birds Directive 79/409/EEC				D	D		I	
Habitats Directive 92/43/EEC				D	D			
Biodiversity Strategy COM 1998 (42)								
Community Directive on EIA , Dir. 85/337/EEC;		I	I		I		I	I
Proposal for a directive for strategic impact assessment of certain plans and programmes (COM(96)511 of December 1996)		I	I	I	I	I	I	I
Proposal for a framework directive on water (COM(97)49 of February 1997)							I	
LIFE II Nature Regulation 1404/96 (OJL 181 of 20.07.96)					D			
Nitrates Directive 91/676/EEC							I	
COM(97)88					I		I	
Regional Policy								
Cohesion Fund			D					
INTERREG II			D	D	D			
REGIS II								
PHARE, TACIS		I	I	I	I			
Common Agricultural Policy (CAP): Accompanying measures								
Agri-environmental measures Reg. 2078/92			I	I	I	I	I	
Forestry measures Reg. 2080/92				I	I	I	I	I
CAP: Structural measures								
Rural development, LFA Reg. 950/97			I	I	I	I	I	
Genetic resources, Reg. 1467/94					I			
Agricultural labels, Reg. 2081/92 and 2082/92			I	I	I			
Improving the efficiency of agricultural structures, Reg. 2328/91				I	I	I	I	
Improving conditions for marketing and processing agricultural products, Reg. 866/90 am. By Reg. 3669/93	I			I	I	I	I	
LEADER II			I	I	I			
Objectives 1 + 5b, including ERDF and EAGGF			I	I	I			
CAP: Other measures								
Organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs, Reg. 2092/91	I			I	I	I		
COM(96) 366 Council Regulation supplementing Reg. 2092/91	I			I	I	I		

Source: EEA, European Commission

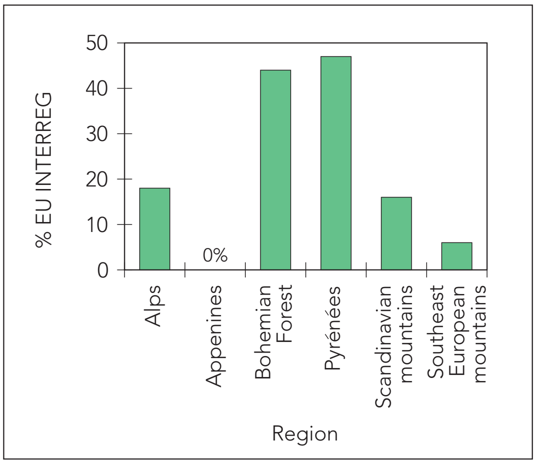
further development in sensitive zones, and – more positively – stimulated development of sustainable tourism. Over half of the budget of the Community action plan to support tourism is earmarked for sustainable tourism projects (Figure 3.15.18). In Spain, the Cohesion Fund programme includes reduction of harmful tourism effects in national parks, while the development of non-intensive tourism in the Aragon region has been co-financed under the Structural Fund 5b objectives.

3.2.3. Regarding land use changes, mainly from agriculture

Land use changes and mountain agriculture are targeted by different measures in the Common Agricultural Policy (CAP) such as the Accompanying measures (agri-environment, forestry) and Structural measures (rural development, objectives 1 + 5b, LEADER, etc.) and the regional policy, such as INTERREG II (Figure 3.15.19). A recent study of existing EU policies (Euromontana, 1998) has concluded that small and multi-functional farms do not receive sufficient aid to compensate for natural handicaps, that agri-environment measures may delay adverse developments and repair some damage but it is 'highly unlikely' that the production-oriented systems can be reoriented, and that other agricultural measures are not focused on environmental benefits. The time-scale for significant policy changes has also been expressed as a major concern of English nature-conservation groups.

Under the Less Favored Areas Regulation about 20% of the total Utilized Agricultural Area (UAA) is supported as less favoured

Figure 3.15.18 **EU support for mountain tourism**



Tourism projects have been supported in the Pyrenees and Bohemian Massif in particular. About 45% of Interreg budget in mountain projects have been spent on projects to achieve sustainable tourism.

Source: European Commission

mountain areas in the EU. These mountain areas are individually and heterogeneously defined by the Member States. It is reported that agricultural income in mountain LFAs lies 45% below the EU-average, but has increased slightly in the period 1987-1993 by 0.7%, while decreasing in other regions. Most of French mountain areas and some Spanish and Italian areas are above this EU-average income, while the situation is worsening in nearly all areas of Greece and Portugal (European Commission, 1997c).

Agricultural labels of origin may play a supportive role in encouraging farming activities which contribute to maintaining fragile ecosystems like mountains. The *'fromages d'alpage et d'estives'* are well-known examples of specific products linked to traditional practices.

Land use changes are also induced by the gravitation of urban agglomerations, and a balance is needed in the urban-mountain relationship. Therefore the general call in the ESDP (European Commission, 1997b) for a new definition of the rural-urban relationship has a particular focus on mountain areas; options include the balance between cities and country, diversification of rural areas, conservation and creative management of cultural landscapes. The benefits of an attractive, environmentally healthy hinterland have been recognised by cities but compensation patterns for the provision of this stewardship are not developed. The example of Munich shows that the high recreation values of lakes and mountains have helped the city to become a highly desired location for high-technology industry.

3.2.4. Forestry and renewable energies

Mountain areas are highly suitable for renewable energy generation such as wind and hydroelectric energy, which could offer additional, sustainable revenues for mountain economies. However, strong opposition can be expected to further hydro-powerstations (CIAPP, 1995).

Abundant forest wood, as a renewable resource, offers another option of renewable energy use for mountains. An example is the development of a low-pollution heating system fueled with forestry output in the Haut-Jura, France, financed by the LEADER fund (European Commission, 1997d).

Under afforestation measures, as supported by the CAP, and due to the 1994-97 national plans, 700 000 ha of new forest will be created and 300 000 ha of forest will be improved in the EU (European Commission, 1997c). This implementation, however, often disregards the choice of tree species and the impacts on soil, water, landscape and biodiversity, and so it has not necessarily been environmentally beneficial (Euromontana, 1998). Within objective 1 and 5b, development of forest functions in terms of erosion limitation, water protection and tourism promotion are supported.

Natural recolonisation is on average higher in mountains than nationwide averages. In France recolonisation in mountains in the past decade has been 50% above the national average (EOMF, 1998).

On the other hand increasing forest cover in mountains is becoming a conflict in some regions, where people dislike and therefore oppose the afforestation scheme, such as in the uplands of Navarra, Lorraine, Venice (Zingari, 1998). Their concerns include the safeguarding of open farmland and the protection of bird biotopes or an already densely afforestated landscape (Cammarata, 1997). In a recent study it was stated that the concerns of zonal afforestation plans, such as the selection of locally adapted tree species, have not been met and impacts on soil, water and biotopes must be expected (Euromontana, 1998).

A cornerstone of forest policy is resolution S4 of the Strasbourg Conference 'Adapting the management of mountain forests to new environmental conditions' which was adopted by 25 countries in 1990 and the EU Forestry Strategy recently adopted which stresses problems of specific regions, including mountain regions. The challenge is important as in most countries mountain forest management suffers from the insufficient implementation of forest legislation (Koch, Rasmussen, 1998).

3.2.5. Nature conservation policy

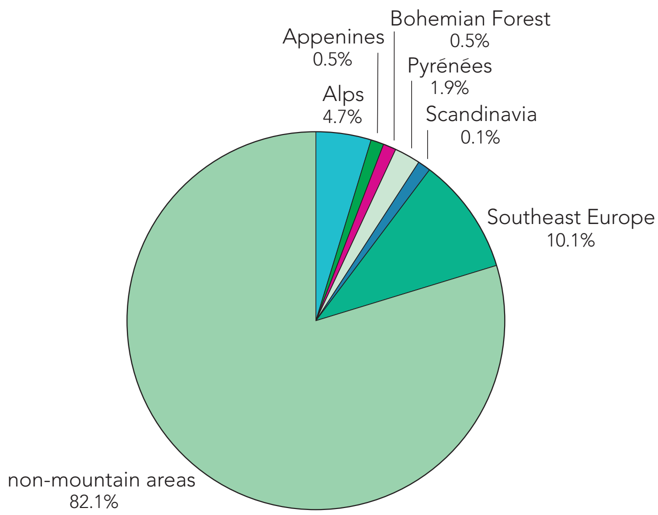
The general evolution of nature conservation policy today focuses more on sustainable development (see Chapter 3.11) and marks an important step towards the multifunctionality concept of mountain areas.

The Pan-European Biological and Landscape Diversity Strategy (PEBLDS) has dedicated in its action plan the entire 'action theme 10' on mountain ecosystems. This focuses on integration of mountains in the pan-European ecological network, establishment of sustainable practice for afforestation, mountain farming and recreation, the potential application of multilateral agreement of the Alpine Convention for the Balkan Carpathians and Caucasus regions and the establishment and strengthening of transfrontier protected areas (Council of Europe *et al.*, 1996).

The progress in implementation of the Habitat Directive, as described in Chapter 3.6, is shown by the example of the EU Alpine region where mountain areas contain 16% of the number of sites of conservation interest (SCIs), while the region area covers only 9% of the EU. In the second stage of the selection of special areas of conservation (SAC) many mountain areas may be expected to be chosen favorably. Mountains frequently meet the criteria of relationship to migration routes or as part of an ecosystem on both sides of EU frontiers and of a high number of annex I habitats and annex II species. Thus mountains as most extensive areas will probably receive an over proportional percentage of protected areas which should be reflected in national and local policies (Hopkins, 1998).

The Commission instrument for nature conservation LIFE financed about 15% of the 1996 and 25% of the 1997 nature budget in mountain areas with a focus on large carnivore species protection (European Commission, 1997d) (Figure 3.15.20).

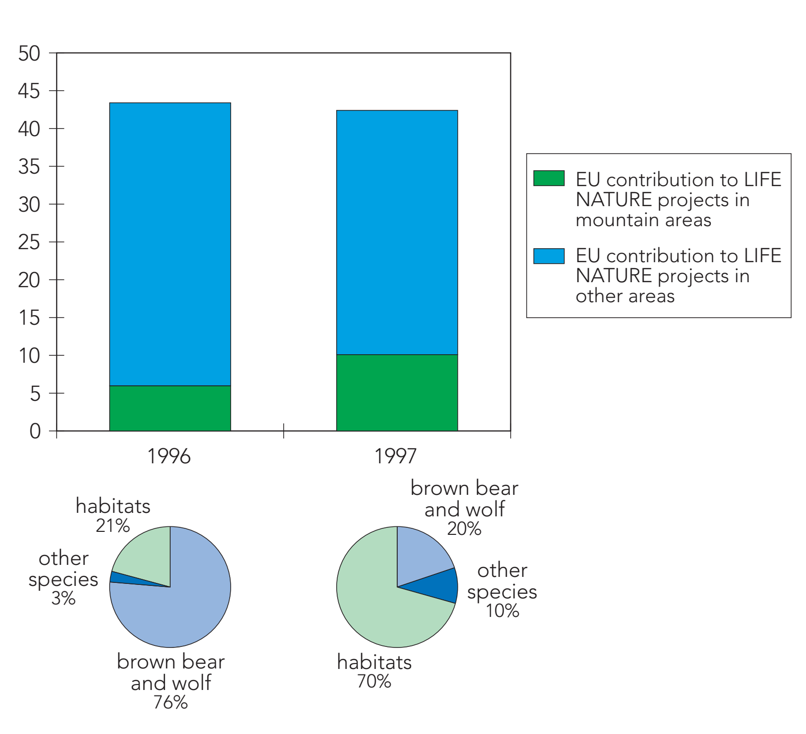
Interreg programme in mountains Figure 3.15.19



Within the INTERREG programme with a total budget of 585 M euro in the period 1994-1999 (about 17% of which goes to mountain areas) several measures are applied, with a significant focus in southeast European countries. Here one should consider that about half of EU border areas lie in mountains.

Source: European Commission, DG XVI, 1997

Figure 3.15.20 **LIFE Nature support in mountains**



About 75% of the 1996 and 20% of the 1997 EU-LIFE-funding in mountain areas was spent for conservation of the brown bear and wolf; about 3% was spent for conservation of other species.

Source: European Commission, 1997

3.2.6. Natural phenomena can not be excluded

Direct protection from natural hazards is recognised to be far more efficiently provided by mountain forests with a high proportion of natural vegetation than by artificial devices. Switzerland provided eloquent figures for the role of protection, said to be worth up to SFR 3 billion (1.8 billion euros) per year to local communities (EOMF, 1998). A risk-reducing agriculture-forestry combination which might find examples in former multi-functional land-use systems may claim to be one of the most efficient and – in terms of cost-benefit ratio – most successful approaches (Messerli, 1989).

As pointed out in Chapter 3.8 only five countries in the EU provide land-use planning criteria for hazard prevention and five countries still have not developed hazard arrangements at all. It must be strongly emphasised that for mountain areas risk assessment and land-use planning are vital instruments for hazard identification, avoidance and mitigation.

For soil protection also, the concept of multi-functionality, implemented by integrated land use planning, has been recommended for policy action. This should include ecological adaptation of land-use management by using suitability/vulnerability assessments of soil, agro-forestry practices, adjusted stocking levels, rotation farming systems, and measures against forest fires. Results from the Swiss MAB-research programme confirm that the best soil protection in mountains is constant, ecologically adapted agriculture (Messerli, 1989).

3.3. In which direction is policy heading?

The most comprehensive changes for mountains can be expected from the appraisal of EU Regional development plans, the attention on rural development programmes as a new pillar in the CAP and the promotion of direct environmental benefits (European Commission, 1998). It has been announced that the Structural Funds budget will be increased to about one-third of the Community budget which will make the funds a powerful instrument (European Commission, 1997b).

It can be assumed that while new regional objectives will be added through the needs in the Accession Countries, this will require cuts in expenditure on present objectives. It is necessary to assess to what extent this will affect mountain areas in the EU.

In the ESDP further fields of work have been distinguished which significantly meet the need for better analysis of mountain areas in particular, such as the development of indicators, criteria and a typology of areas, which could complement the efforts of regional development in Agenda 2000.

New, economically based policy approaches for balancing the stewardship of mountain areas for lowlands have been proposed by the Mountain Agenda and include, for instance, fees for the entrance to parks and buffer zones, for hunting and fishing, for tour operating, for climbing peaks and for using roads and passes.

3.4. What could policy-makers require for evolving mountain policy?

First there is a general need to recognise mountains as a distinct area and to evolve objective criteria for area definition. This goes hand in hand with the identification of indicators for sustainable land use.

Furthermore better baseline information for decision-maker is necessary. This includes monitoring of mountain environmental conditions. Identification of mountain research needs the interaction of different disciplines and the integration of traditional, long-term experience of local people.

To sufficiently compensate the long-term conservation of natural resources, the goods and services offered by mountain regions and people need to be identified and evaluated. Methods are needed to calculate the costs of maintenance and protection and how to distribute the revenues. Once established periodic re-evaluations should be planned due to changing ecological and economic situations (Mountain Agenda, 1997).

Box 3.15.4 EU research programmes related to mountain issues

The EU has invested about 7.1% (852 M euro) of the 1994-1998 research budget for environment and climate under which the AMBIENTE programme deals with hazard prevention (Ruberti, 1994), the ECOMONT project with land-use impacts, and the ARTERI project with arctic-alpine ecosystems. Other mountain-related research is the MOLAR project on remote mountain lakes, on timberline (FOREST), effects of climate change on alpine and arctic streams (AASER), and desertification in Mediterranean mountains (MEDALUS, MEDIMONT). From other budgets such as the Cohesion Fund, forest-fire combat projects in Greece have been financed and about 105 M euro has been committed to desertification projects in southern Mediterranean countries. Implementation of such policies could be carried out by risk exposure plans (PER) as in the French 1985 mountain law or the risk zones in the Bavarian forest function plans. Erosion and natural hazards are investigated in the EROSLOPE, NEWTECH, FLOODAWARE, SAME projects.

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