Chapter Three

State of the Carpathians' Environment and Policy Measures

3.1 Species, Habitat and Landscape Diversity

Around the world, mountain regions are well known as centres of species diversity. Mountains' high levels of species richness and endemism were among the main reasons for their designation as biologically outstanding ecosystems in the Global 200 Initiative (Dinestein et al. 2000). The Carpathians were subsequently identified as one of the Global 200 terrestrial ecoregions that are critically endangered by the direct impacts of human activities.

The biodiversity of the Carpathians is difficult to estimate, due to imperfect and often fragmented knowledge on the exact number of species and each one's abundance, along with their precise distribution and range. As the Carpathian region encompasses broad foothill areas and river valleys, one needs to include in the list many species that represent lowland ecosystems, only marginally inhabiting montane areas. In addition, one should consider migratory and invasive species. It is estimated that the entire Carpathian region is home to more than 60,000 native species, excluding microorganisms.

Research on plant and animal diversity continues throughout Europe, with international groups investigating focal taxa and nominating areas where biodiversity is particularly high. One of the first study groups, BirdLife International, focused on European birds and produced a list of areas (Important Bird Areas, IBAs), considered significant for this taxon and later used as an important component of the EU list of Natura 2000 sites (Heat and Evans 2000, Sidło et al. 2004). Other groups, such as PlantLife International, are studying vascular plants and preparing a European list of Important Plant Areas (IPAs). Carpathian IPAs were identified and selected for the Czech Republic, Poland, Romania, Serbia and Slovakia (Anderson et al. 2005).

Carpathian Landscapes

Vertical Bio-climatic Zonation

Mountains are characterized by the vertical zonation of their flora and fauna, changing with elevation according to climatic conditions. Normally, for every 100-meter rise in elevation, the temperature drops 0.6 degree Celsius. The altitudinal variation of the climate and vegetation can be compared with longitudinal zonation between the poles and the Equator. In this regard, the Carpathians can be divided into five fairly distinct vertical zones of climate and vegetation types. In general, (1) the foothills correspond to a "mixed deciduous" zone; (2) the lower mountain (beech) forests correspond to a "temperate forest" zone; (3) the upper mountain (spruce) forests correspond to the "taiga" zone; (4) dwarf pine forests and alpine meadows correspond to the "tundra" zone; and (5) the sub-nival level to the "arctic" zone.

The **foothill zone (1)** extends up to 500-650 m above sea level in the northern Carpathians, and approximately 200-300m higher in the southern part of the range. In terms of forest types, foothills are dominated by mixed deciduous forests with pedunculate oak (*Quercus robur*), the small-leaf lime (*Tilia cordata*) and the hornbeam (*Carpinus betulus*), with an admixture of birch (*Betula pendula*) and Scots pine (*Pinus sylvestris*) in the north, and various oak species (*Quercus petraea, Q. cerris, Q. pubescens* and *Q. frainetto*) in the south. In the foothills of the Southern Carpathians in Romania, there is a forest steppe zone with oaks (*Quecus petraea* and *Q. pubescens*). However at present the foothill zone overall is dominated by agriculture, human settlements and artificial lakes.

The mountain forest zones – between 600 and 1450 m in the north, and 650 and 1750 m in the south – are dominated by European beech (*Fagus sylvatica*), Norway spruce (*Picea abies*) and silver fir (*Abies alba*). Pure beech forests dominate the mountain zone in some ranges of the Western Carpathians (Bile Karpatý, Male Karpatý, Tribeč), Eastern Carpathians (the Vihorlat, Bukovské, Bieszczady, Polonina Rowna, Polonina Krasna and the southern slopes of Swidowiec) and in some parts of the Southern Carpathians. Areas dominated by beech forests are slightly warmer and drier than other Carpathian areas. Beech species grow better in such conditions than do coniferous species.

The **lower mountain forest zone (2)** typically consists of almost pure beech forest stands and mixed forest ecosystems. Dominant species include beech (*Fagus silvatica*) and fir (*Abies alba*), with scarce occurrence of Norway spruce (*Picea abies*). On the southern slopes, one finds a mixture of oaks, maples and ash within beech forests.

However, in most of the Carpathians, beech is mixed with coniferous trees, namely with silver fir and Norway spruce (plantations of the latter have replaced many natural forests). In some places, the mountain zone is totally dominated by conifers, usually a mixture of silver fir and Norway spruce (Tatry, Moravske Beskydy and Oravska Magura in the Western Carpathians; Gorgany, Czarnohora and the Bistra Mountains in the Eastern Carpathians).

The **upper mountain forest zone (3)** is mainly constituted by spruce forests *Picea abies*, situated at 1,100-1,450 m in the Northwestern and Eastern Carpathians and at 1,300-1,750 m in the Southern Carpathians. Other main species are *Sorbus aucuparia* and stone pine *Pinus cembra*, silver fir *Abies alba* and *Alnus incana.* Grass cover is represented by *Oxalis acetosella, Soldanella Montana* and *Luzula sylvatica.*

On the highest Carpathian massifs, **alpine meadows and dwarf pine (***Pinus mugho***) forests (4)** are characteristic, but cover very limited areas. The alpine pastures consist of plant communities with grasses and sedges, including grass species such as *Carex curvula*, *Juncus trifidus*, *Agrostis rupestris* and *Festuca ovina*, *Vaccinium gault-*

heroides Ericaceae shrubs and dwarf willow *Salix herbaces*. In areas of intensive cattle and sheep grazing (e.g. in some parts of the Southern and Eastern Carpathians), there are grassy *Nardus stricta* pastures which may also be found at lower altitudes.

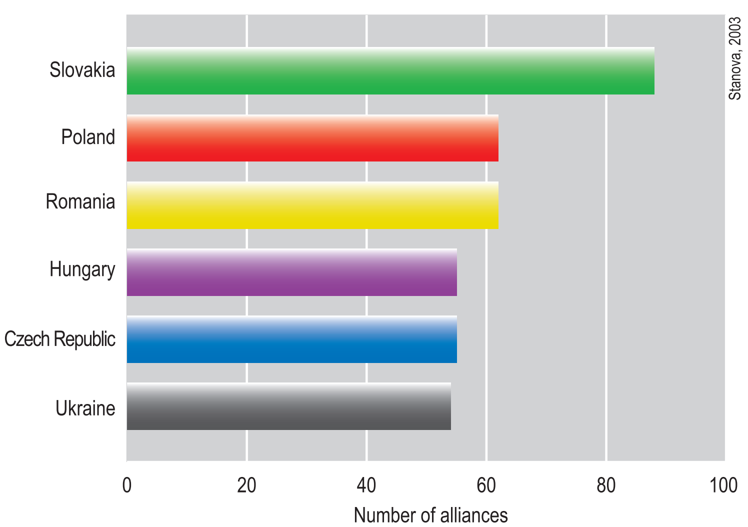
The stone pine (*Pinus cembra*) occurs on the alpine timberline in the highest mountain ranges of the Carpathians (Tatra, Gorgany, Czarnohora, Maramureş, Făgăraş, Retezat). In the timberline belt of the Tatra, one can find small areas of mixed *Pinus cembra-Larix decidua* forests similar to those growing in the central Alps. Above the timberline, which extends from 1400 m in the Northwestern Carpathians, about 1600 m in the Eastern Carpathians, and about 1900 m in the south, a distinct krummholz sub-zone is found. It consists of dense thickets of dwarf pine (*Pinus mugo*), at times with an admixture of dwarf juniper (*Juniperus communis subsp. nana*) and small groups of Norway spruce thickets.

Finally, the **subnival zone (5)** only occurs in the highest parts of the Tatra Mountains (above 2350 m). It is characterized by patches of permanent snow and a lack of glaciers (Mirek and Piękoś-Mirkowa 1992).

Flora and Vegetation

The richness of Carpathian vascular plants is well known. According to Tasenkevych (1998, 2003), the Carpathians are home to 3,988 native vascular plant species and archaeophytes (i.e. non-native plant species which were introduced in "ancient" times). Taking into account natural immigrants and invasive species introduced by humans, the total number of species in the Carpathians exceeds 4,000. This figure comprises approximately 30% of Europe's flora, while the proportion of the Carpathians' area to that of Europe is only 1:46 (Tasenkevych 2003).

Figure 3.1 The number and occurrence of plant alliances in the Carpathian countries (according to Stanova 2003)

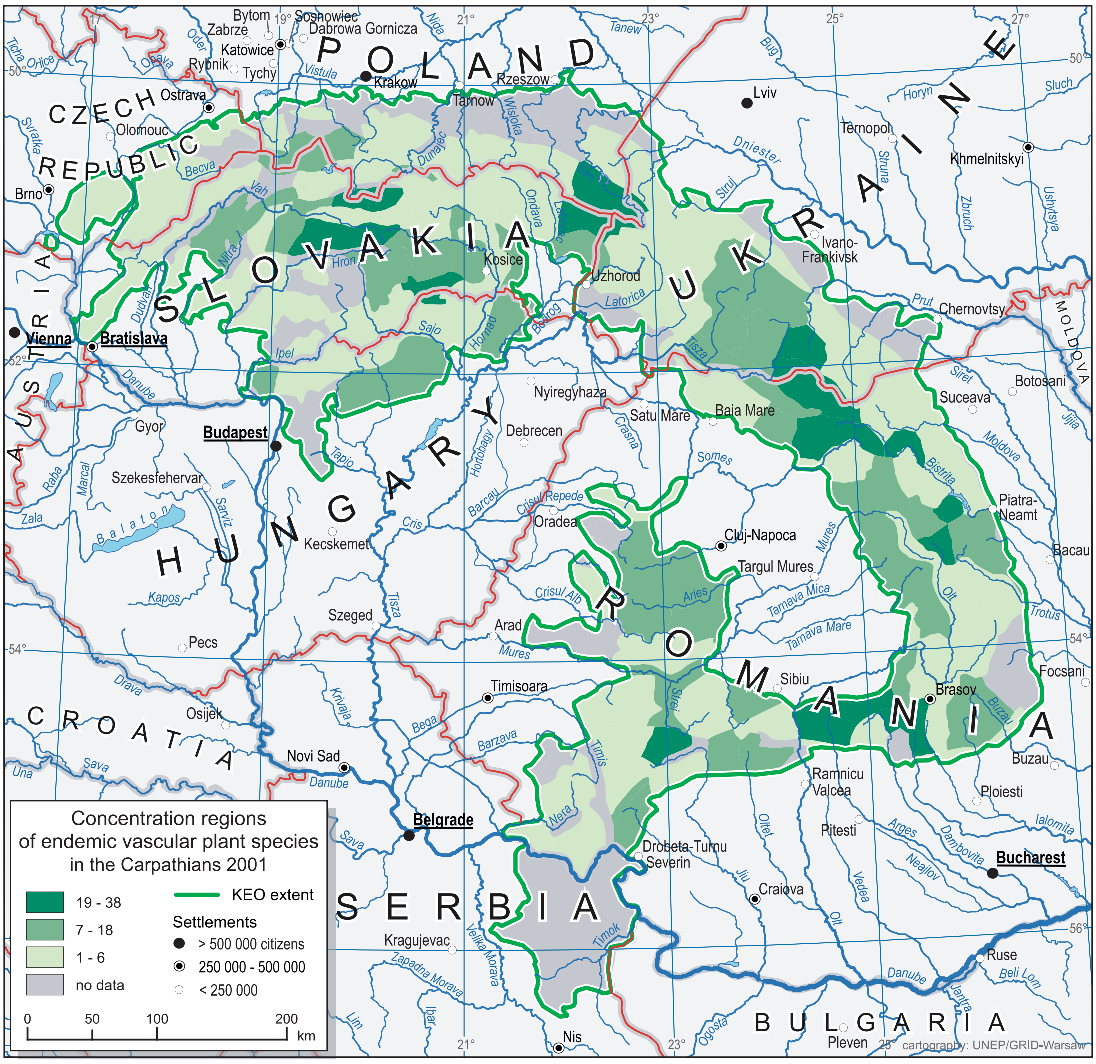


The flora of the Carpathians is relatively rich in endemic species. The current list of endemic plants includes 387 species and sub-species, and 99 'micro-species'[1] from the genera *Alchemilla*, *Rubus*, *Sorbus* and *Hieracium* (Stanova 2003). A similar number of endemic plant species has been reported in the Alps (Mirek, Piękoś-Mirkowa 1992), while in the Caucasus, more than 1,600 endemic species have been described (UNEP 2002).

In most cases, the distribution of Carpathian endemics is of 'island' type, with isolated centres in areas such as: the Tatra, Lower Tatra and Slovensky Kras in the North; the Bieszczady, Czarnohora, Maramuresului, Rodnei, Giumalau-Rarau, Ceahlau and Hasmas Mountains in the East; and Retezat, Fagaras, Bucegi and Piatra Craiului Mountains in the South (see Map 3.1). Some endemic species are broadly distributed in the Carpathians' area, such as the heart-leaf comfrey (*Symphytum cordatum*) and laserwort (*Laserpitium archangelica*) (Meusel et al. 1965, Parusel 2001).

[1] Species which reproduce asexually, with genetically identical specimens from one generation to the next.

Map 3.1 Concentration regions of endemic vascular plant species in the Carpathians (according to CERI 2001)

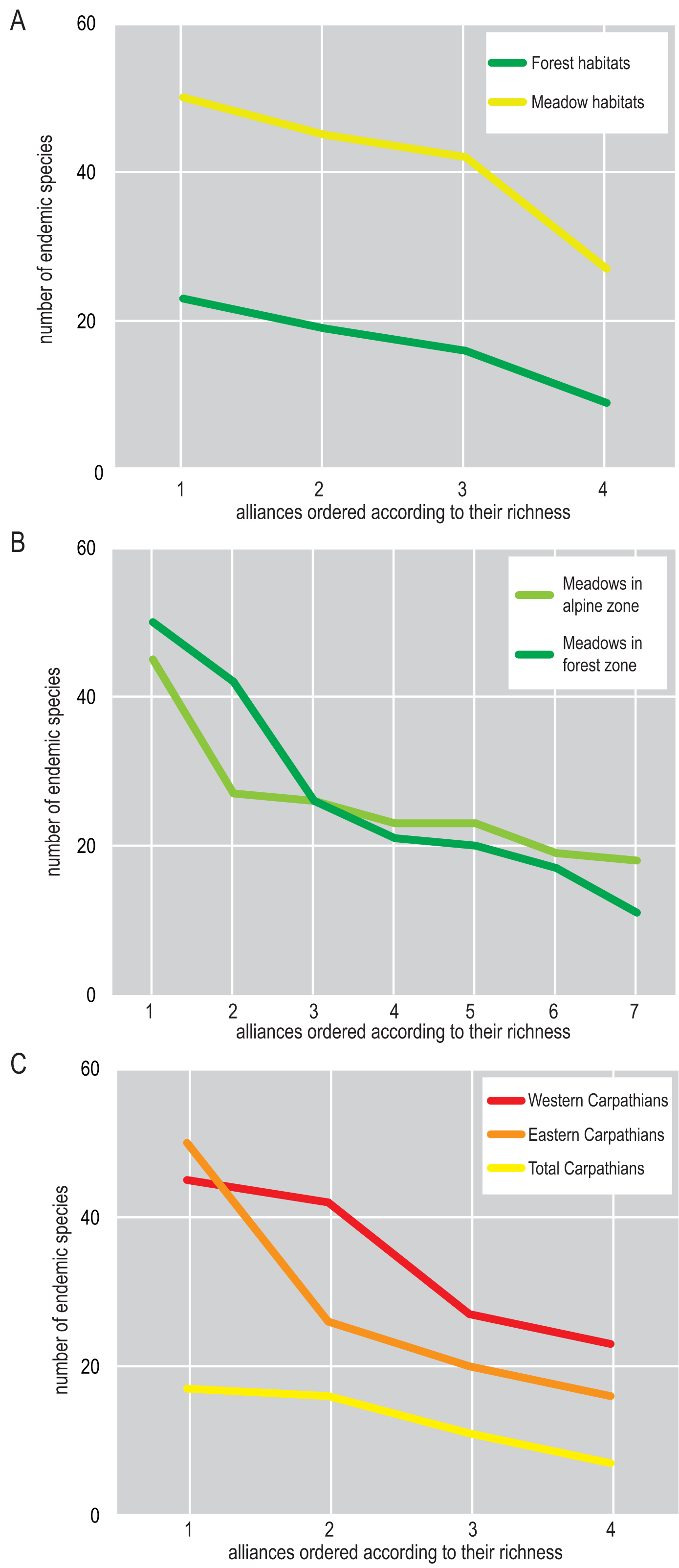


The most common and interesting endemics in the Carpathians are glacial relicts, species with an alpine-arctic distribution pattern. These include the alpine clubmoss (*Diphasium alpinum*) and Norway spruce (*Picea abies*). Other interesting groups include species living near the limit of their geographical range, such as the ox-eye daisy (*Dendranthema zawadzkii*), a post-glacial relict largely found in Asia, living in only three European sites – the Pieniny Mountains in the West Carpathians, and two Russian localities. Among commonly distributed 'archaeophytes', migrants that invaded the Carpathians following early human settlement and agriculture, are the wild oat (*Avena fatua*) and tiny veth (*Vicia hirsute*).

The richness and diversity of plant species are not evenly distributed throughout the Carpathian Mountains range. In general, the Western Carpathians are less rich in flora species than the eastern and southern parts. Low mountains and areas which are marginal to the mountain range also have less diverse flora than higher areas with an extensive alpine zone.

Stanova (2003) assessed the biodiversity value of habitats and ecosystems within the Carpathians by evaluating the proportion of endemic species in plant alliances. Results show a substantial richness of plant alliances in each region of the Carpathians (see Figure 3.1). The largest number of plant alliances exists in the Slovak Carpathians,

Figure 3.2 Comparison of top alliances ranked according to their proportion of endemic species (recalculated according to Stanova 2003)



A – open habitats vs. forest and shrub, B – alpine meadows vs. meadows and open habitats in the forest zone, C – the richest alliances in the Carpathians vs. Eastern and Western Carpathians. Axis X – alliances ordered according to their richness, axis Y – number of endemic species due to their extremely diverse geological background, exceptional mineral richness and their position between the Pannonian plane to the South and the Carpathian range to the North. The Eastern and Southern Carpathians remain less intensively surveyed, and thus the number of alliances and their floristic richness may actually be much greater than currently known.

Also according to Stanova (2003), endemic species are mainly concentrated in meadow-type alliances/habitats (see Figure 3.2a). Natural (alpine) meadows and meadows of human origin located in the forest zone show similar proportions of endemic species (Figure 3.2b). The highest proportion of plant endemism occurs in the most broadly distributed plant alliances known in the entire region. Lower proportions of endemism were identified within alliances located solely in the Eastern Carpathians, and the lowest endemism level was found in alliances located in the Western Carpathians (Figure 3.2c). According to Stanova's results, the most vulnerable and endangered plant alliances in the Carpathians are located in natural and semi-natural meadows and pastures.

Fauna

The Carpathian vertebrate fauna includes 90 species of mammals, 300 nesting birds, 17 amphibians, 12 reptiles and 82 species of fish and lampreys, including some alien, introduced species. Among small mammals, the distribution and geographical range of bats is perhaps best known. A total of 26 species of bats are described, the majority of them found in the entire Carpathian range (Wołoszyn and Bashta 2001).

Similarly to vascular plants, there are many endemic animal species in the Carpathians, most of them among invertebrate taxa. Only several vertebrate endemics can be found, such as the Tatra pine vole (*Microtus tatricus*), and the Carpathian newt (*Triturus montadoni*). Endemic fauna species may be found throughout the Carpathian range, or be restricted to only one of the numerous massifs of the Carpathians.

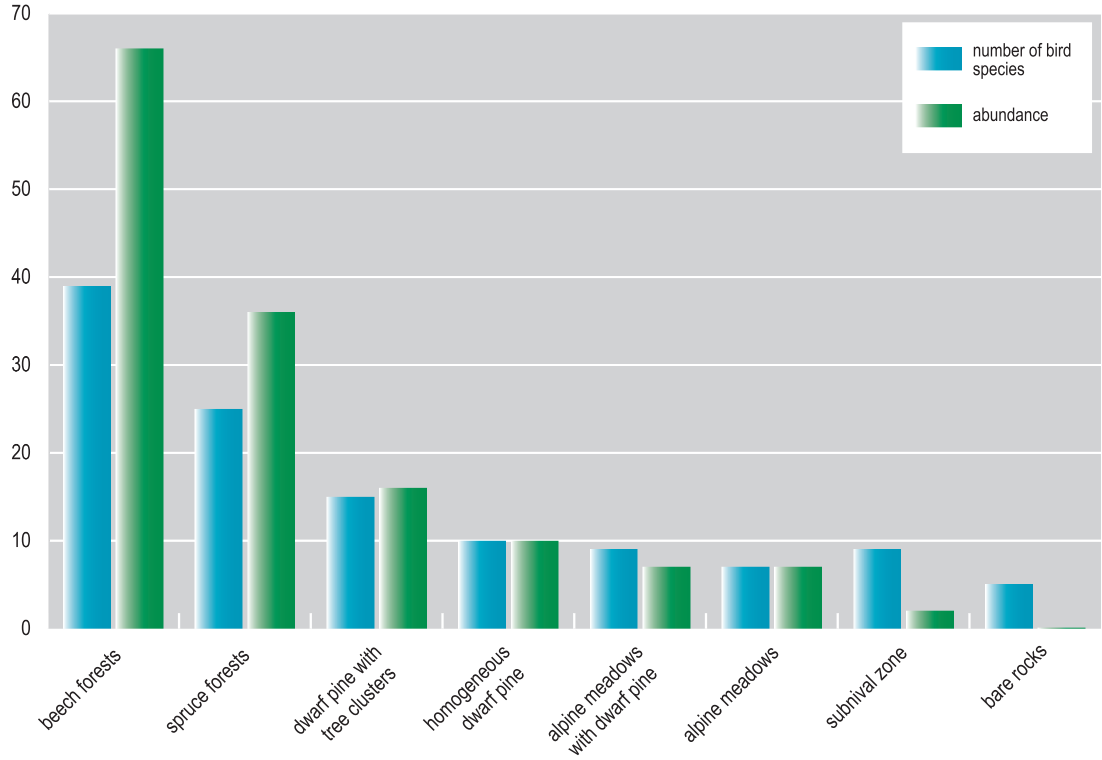
The number of endemic caddis flies (*Trichoptera*), a well-investigated water insect taxon, is extremely high in the Carpathians: at least 43 endemics have been described, nearly as many as in the Alps (47), where endemic invertebrate fauna in general is more numerous. Some of these can only be found locally, such as *Allogamus starmachi*, which occurs solely in small, high-altitude springs in the Tatra Mountains. Others, such as *Melampophylax polonicus* have a much broader distribution. Watercourses are also inhabited by endemic stonefly and mayfly species, which often occur throughout the region. While *Baetis beskidensis* is a good example of the latter, *Isoperla carpathica* is limited to the Eastern Carpathians. Beetles (*Coleoptera*) are also an important Carpathian endemic taxon, with *Carabus transsylvanicus*, for example, inhabiting alpine meadows.

Generally, the number of species and their population density decrease as altitude increases, such as observed in the bird fauna in the Tatra (Figure 3.3) (Głowaciński 1996). There are, however, exceptions to this rule, one of which is the *Tardigrada* group, invertebrates living in mosses and litter, whose number of species is highest between 1,700 to 1,800 m above sea level.

An enormous contribution to mountain diversity is made by 35,000 invertebrate species, mainly insects, soil mites and spiders. Except for some small, well-investigated areas such as national parks where invertebrate monitoring has been carefully done, current knowledge about the distribution, abundance and species composition of Carpathian invertebrates remains limited.

The Carpathians have the richest community of large carnivores in Europe, including all the large European predators. Their populations are

Figure 3.3 Number of species and abundance (no of specimen/10 ha) of birds in main habitats of the Tatra National Park (after Głowaciński 1996)



a – bare rocks (2100-2500 asl), b – subnival zone (1900-2200 asl), c – alpine meadows (1700-2000 asl), d – alpine meadows with dwarf pine (1600-1800 asl), e – homogeneous dwarf pine (1500-1700 asl), f – dwarf pine with tree clusters (1400-1600 asl), g – spruce forests (1300-1450 asl), h – beech forests (1000-1100 asl)

still vital and numerous. Official statistics indicate a population of more than 8,100 brown bears (*Ursus arctos*). Two main refuges with more than 1,000 individuals can be found in Romania and Slovakia. The density of bears in the Romanian part of the Carpathians slightly exceeds four individuals per 10 sq. km. Similar densities are observed in Slovakia, Ukraine and in the southeastern Polish Carpathians, where human population density is low.

Bear populations have shown a slightly upward trend, despite being a hunted species in Romania, Slovakia and Ukraine. According to official data, hunters annually kill approximately 350 bears in Romania and over 60 in Slovakia.

Wolf populations (*Canis lupus*) include approximately 4,500-5,500 individuals. The species is strictly protected only in those Carpathians countries where small or medium-size populations occur (the Czech Republic, Hungary and Poland). In other Carpathian countries, the wolf is a partially protected species or protected game species with hunting quotas established yearly. Only in Ukraine is the wolf neither protected nor managed as a game species. Strict protection has at times led to tensions between conservationists and farmers. In Romania, the annual loss of livestock due to wolves can surpass 2% of the herd (Mertens and Anghel 2000).

The lynx (*Lynx lynx*) represents the third distinctive large carnivore species of the Carpathians. Its population is currently estimated at 2,400-2,500 individuals, and decreasing in most Carpathian countries (Natura 2000 Newsletter 2007). The decline of the lynx during the last 20-30 years resembles the earlier decline of the wildcat (*Felis silvestris*), which disappeared from the Northwestern Carpathians during the first half of the 20th century. Vital populations still occur in southern Romania, Slovakia and Ukraine, while new inventories show its decline in Hungary (Heltai et al. 2006).

Species Richness in the Pieniny Park (Poland/Slovakia)

The Pieniny National Park in Poland (2,500 ha) and its counterpart in Slovakia have a great species richness compared to larger and better-investigated national parks in Poland (see table below). Extensive investigations carried out there covered vertebrate and invertebrate species, as well as plants and other taxa (Panigaj 2002, Razowski 2000, Voloscuk 1992, 1997, Zarzycki 1982).

Table 3.1 Numbers of known species in the best-surveyed Carpathian national parks in Poland by systematic group

Systematic group	Number of identified species			
	Babia Góra NP (3,392 ha)	Bieszczady NP (27,064 ha)	Pieniny Mts NP (2,500 ha)	Tatra NP (21,164 ha)
Vascular plants	626	780	~1100	~1000
Bryophyta and *Marchantiophyta*	380	361	327	650
Cyanophyta and *Algae*	118	Not known	184	1000
Lichenes	329	569	470	700
Fungi and *Myxomycetes*	1228	1030	1316	707
Protozoa	15	10	14	17
Molluscs	93	77	107	91
Arthropods	4116	6425	6770	5118
Other Invertebrates	51	118	144	385
Vertebrates	199	284	271	170
Total	**7155**	**9654**	**10703**	**9838**

One of the reasons for high biodiversity in the Pieninys is their location close to the biodiversity-rich Tatra Mountains. It has been shown that mountain species of flora and fauna in the Pieninys were supplemented from the Tatras by migrating species and accidentally by extraordinary events such as hurricane winds and floods. Secondly, the Pieniny Mountains have characteristic North-South perpendicular limestone structures. The majority of the mild slopes with a northern exposure maintain favourable habitats for mountain species, while much steeper slopes with a southern exposure preserve habitats more favourable for species which prefer warmer temperatures.

Furthermore, recent studies show that the Pieninys are one of the oldest places of human settlement in the Polish Carpathians. As a result, they were largely deforested for thousands of years. Small-scale traditional agriculture still dominates here. Small farms with mixed uses support a large diversity of landscapes and habitats, considered as main contributors to the enormous species richness in the Pieniny National Park.

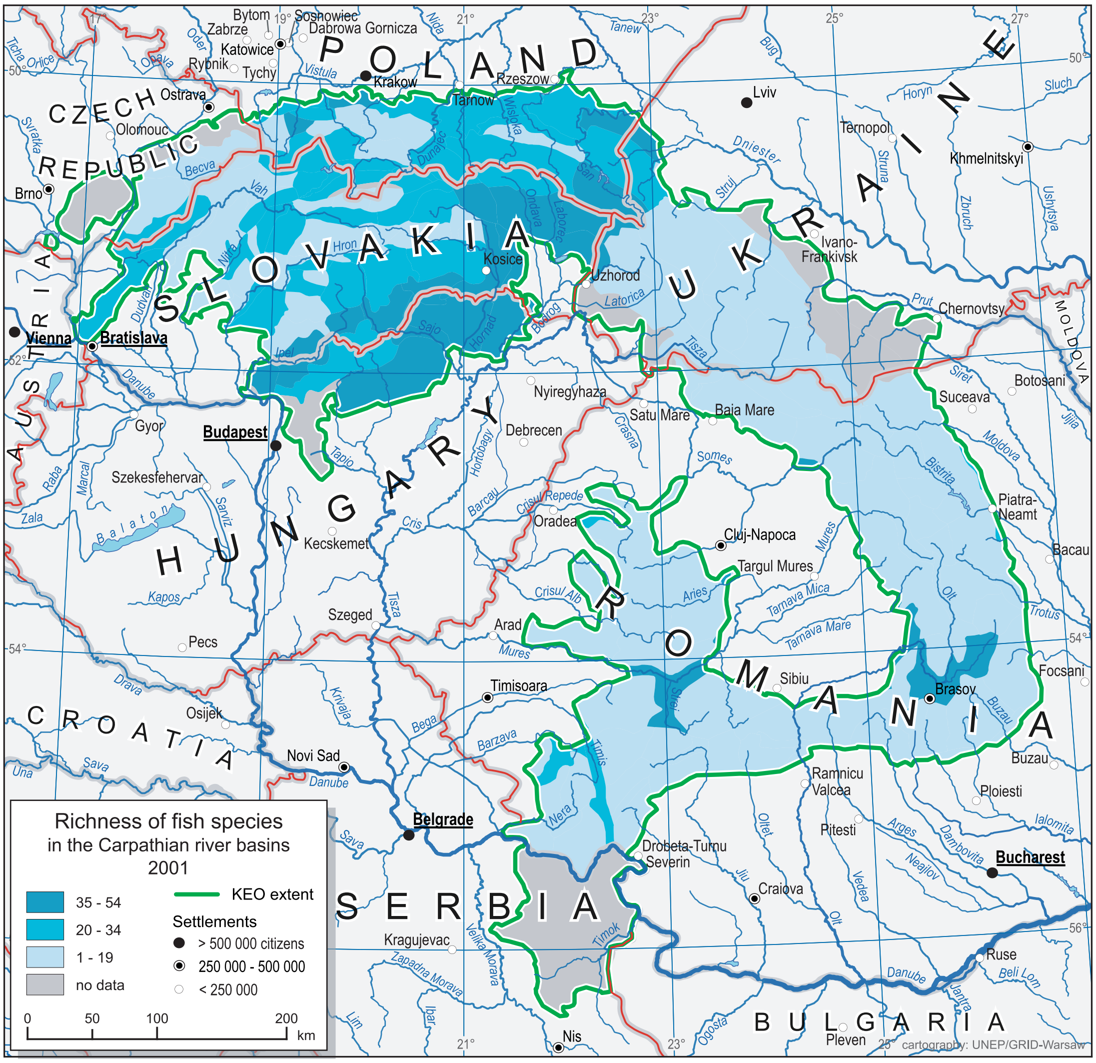
Carpathian game species include herbivores such as large populations of deer, roe deer and wild boar in the north, fallow deer in the south, and the European bison which was re-introduced in the Carpathians during the last century.

Among large bird species, the most characteristic are the imperial eagle (*Aquila heliaca*) and lesser-spotted eagle (*Aquilla pomarina*), both with at least 20 to 40% of their European populations living in the Carpathians. The wood grouse (*Tetrao urogallus*) and many other forest mammals and birds also find a major European refuge in the Carpathians.

The migratory elk (*Alces alces*), a large herbivore which lives in the vicinity of moors and large rivers, is one of the major representatives of the vertebrate fauna of wetlands and rivers. Another species maintaining vital populations in the region is the European beaver *Castor fiber*, successfully re-introduced in the Carpathians during the last three-four decades. The density of otter (*Lutra lutra*) populations is probably also one of the highest in Europe.

Fish species also represent a diversified and rich fauna taxon in the Carpathians (see Map 3.2). Some migratory fish species, such as the Atlantic sturgeon (*Accipenser sturio*) and Atlantic salmon

Map 3.2 Richness of fish species in the Carpathian river basins (CERI 2001)



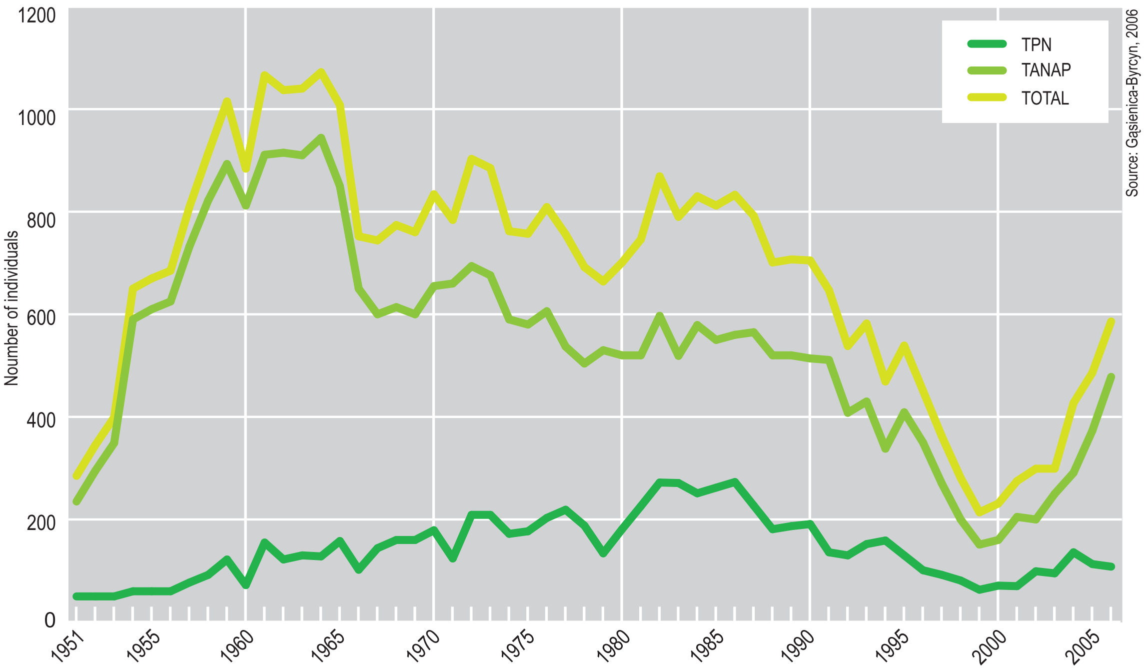
(*Salmo salar*), have become extinct in the Baltic-catchment rivers of the Carpathians due to dams and other waterworks.

The majority of fish species live in the Carpathian tributaries of the Danube. For example, the Kessler's gudgeon *Gobio kessleri* is a Ponto-Caspian element in the Danube and its Carpathian tributaries. During the last few decades, the species spread its geographical range to the alpine region, crossing the Vistula's tributaries and building abundant populations in the San River near the Polish-Ukrainian border. According to Hakai and Biroz (2007) both of these processes – broadening of the species' range and moving up to higher altitudes – are effects of climate change.

Alpine habitats and landscapes in the Carpathians are extremely limited in area, with less than 3% of the entire region having a high montane character. High montane vertebrate fauna in the Carpathians is not as rich as in the higher Alps or Caucasus. Two high mountain species can be found here, the chamois *Rupicapra rupicapra* and the marmot *Marmota marmota*.

Both of these species are liable to become extinct, as shown by a long-term monitoring study of Tatra chamois (Figure 3.4). The probability of extinction of high montane species in the Carpathians is likely to increase rapidly in the coming decades, since according to climate change predictions, mountain vegetation zones in the temperate climate zone would shift

Figure 3.4 Number of chamois in the Polish (TPN) and Slovak (TANAP) Tatra Mountains National Parks (Gąsienica-Byrcyn 2006)



upwards by nearly 200-300 m, resulting in the loss of some species and ecosystems.

In mountain areas, many species have small isolated populations. Long-term isolation leads to the development of 'divergent sub-species' – local ecotypes which differ from initial populations through specific anatomic and behavioural characters. Examples in the Carpathians include the chamois, represented by two sub-species: *Rupicapra rupicapra tatrica* in the Tatra Mountains and *Rupicapra rupicapra carpathica* in the Romanian Carpathians. Another strongly diversified species is the apollo butterfly *Parnassius Apollo*, comprising 20 sub-species in the Carpathians (Glassl 1993).

In addition two small rodents, the snow vole *Microtus nivalis* and Tatra pine vole *Microtus tatricus*, live in alpine habitats. High montane meadow bird species include the horned lark *Eremophila alpestris*, Alpine accentor *Prunella collaris* and water pipit *Anthus spinoletta*.

General Threats to Species

Among species at high risk in the Carpathians ("critically endangered" species), invertebrates form the grand majority, followed by plants and vertebrate species groups. Invertebrate species are less well documented in the Carpathians than other taxonomic groups. Witkowski et al. (2003) evaluated threats to three groups of invertebrates in the Carpathians; results are presented in Table 3.2.

In addition, 130 species of vertebrates are also listed as threatened in the Carpathians. Most of these are mammals, followed by fish and birds. About 25% of vertebrate fauna species are en-

Table 3.2 Threatened species of invertebrates in the Carpathians grouped according to their level of threat (Witkowski et al. 2003)

Category of threat	Number of species		
	Gastropods	Beetles	Butterflies and Moths
Extinct	0	0	0
Critically endangered	18	24	13
Endangered	13	25	34
Vulnerable	15	24	32
Total	46	73	79

Table 3.3 Endangered vertebrate species in the Carpathians grouped according to their level of threat (Witkowski et al. 2003).

Category of threat	Classes				
	Mammals	Birds	Reptiles	Amphibians	Fishes and Lampreys
Extinct	2	0	0	0	2
Critically endangered	2	7	1	0	3
Endangered	12	11	2	4	14

dangered. A comparison between taxonomic units shows that the most threatened categories are mammals and amphibians (60%). Nearly 40% of all reptilian species, 30% of fish species and lampreys and 10% of birds are also threatened (see Table 3.3).

Of 1500 vascular plant species listed in the national inventories of six Carpathian countries (i.e. other than Serbia), 307 species and 37 subspecies are classified as extinct or threatened (Tasenkevich 2003) (see Table 3.4).

Table 3.4 Threatened species of vascular plants in the Carpathians grouped according to their level of threat (Tasenkevich 2003)

Category of threat	Number of species and subspecies
Extinct	13
Critically Endangered	41
Endangered	135
Vulnerable	155
Total	344

Anthropogenic Impacts on Species and Habitats

Climate Change

Climate change is likely to result in changed habitats, a regression in the range of some species and expansion in the spatial distribution of others. Montane habitats are particularly vulnerable, as many endemic and relict plant and animal species have their only refuges in the mountains. Global warming is likely to result in the migration of vegetation zones towards higher altitudes. During this process, small, isolated populations of alpine species will become extinct from many sites in the Carpathians. Others will fall into a bottleneck trap; their populations will become too small to maintain their genetic viability and adaptability to a changing environment. An example of such climate change impacts in the Carpathians is the overall decline of Norway spruce. Foresters have observed a gradual increase of pests and pathogens, and a successive decline of the Norway spruce in the lower mountain forest zone.

Climate change is also likely to increase the spatial distribution of other species. For example, in the last two decades, newly established populations of the European mantis *Mantis religiosa* were discovered in the Beskid Niski and Bieszczady Mountains in Poland. Individuals crossed the crest of the Carpathians from south to north in places where the Carpathians' main ridge is relatively low.

Mass Tourism

The last decades have shown a rapid increase in tourism activities, particularly in protected areas. Large tourist centres, and particularly ski resorts, are being established. The Polish Tatras are an excellent example of these recent developments. In 1870, the area attracted no more that one hundred visitors. In 1938, about 60,000 tourists visited the area, and 150,000 in 1948. The "avalanche" in tourism began in the 1960s. In 1962, over one million visitors were recorded, in 1964 over two millions, and in 1976, 3.6 million tourists came for recreation in the Polish Tatras. Since then, the annual number of visitors has fluctuated around three million people (Mirek 1996).

The recent proposal to organise the Winter Olympic Games in Poprad, Slovakia, and Zakopane, Poland, could pose a major threat to biodiversity, as development plans imply large-scale damage to nature and landscape on both sides of the Tatra National Park (Janiga et al. 1992, Witkowski et al. 1998).

Mass tourism also favours the introduction of invasive species into native habitats. Even at high altitudes, in the alpine zone, the invasive annual grass *Poa annua* occurs alongside tourist trails. The nettle *Urtica dioica* also spreads in the vicinity of tourist camps and huts. Many activities aim at counterbalancing negative aspects of mass tourism in the Carpathians, within a sustainable tourism framework. The Carpathian Large Carnivore Project, aiming to develop and implement a comprehensive conservation programme for large carnivores in Romania, is one example. As part of the project, an eco-tourism programme "Wolves, Bears, and Lynx in Transylvania" was developed. Between 1997 and 2003, over 3,000 persons have visited the area through this programme.

Air and water pollution

Air pollution, mainly comprised by SO_2 and nitrogen oxide emissions, has affected the Carpathians for decades. The main pollution sources were steel works, power and heat stations, and coal mines concentrated in the Western and Northwestern Carpathians, in the Czech and Polish parts of the Silesia region. The most drastic effects have been observed in the upper montane forest zone, in the northwestern part of the Beskidy Mountains, and in the Western Carpathians. Annual growth rings in Norway spruce reveal a 30-50% growth reduction in the period 1960 to 1990 compared with the first half of the century (Orzeł 1993). The process of forest decline is still ongoing, because the natural recovery of habitats from acidification and deposition of heavy metals lasts for decades.

Hydro-electric investments: construction of large dams and reservoirs

Most of the large Carpathian tributaries of the Danube and Vistula River are now dammed. Additional constructions, such as the Czorsztyn-Sromowce artificial reservoirs on the Dunajec River threaten nature in the Pieniny National Park in Poland and Slovakia through changes of the natural river structure, water regime and microclimate (Rybacki 1995, Voloscuk 1997). The future impacts of hydroelectric constructions and artificial dams are likely to be even greater, as Carpathian tributaries of the Danube and Vistula contribute up to 30% to water resources in the countries surrounding the Carpathian region.

Planning and construction of trans-Carpathian highways and motorways

Trans-Carpathian highways and motorways will increase the isolation of the Carpathians natural environment from other mountain ranges and northern Europe. The highway Bratislava-Katowice and its branch to Ostrava on the Czech-Polish-Slovakian border divides the Moravian and Silesian Beskid into two separate parts, isolated from the other ranges of the Beskidy Mountains (Witkowski 1998). The planned highway joining Estonia and Greece along the eastern borders of the EU would cross the Carpathian crest at least twice. Highway construction involves such negative effects as high levels of dust and nitrate concentrations, noise and physical barriers to the natural movement of many organisms.

Changes in agriculture and forestry

Abandonment of traditional agriculture and forestry methods, such as pasturage or coppicing, is common in the Carpathians. As a consequence, many horse, sheep and cattle races are vanishing. The traditional fine-grained landscapes are disappearing and both species and landscape diversity are generally decreasing. The process is most advanced in the Western Carpathians where the high rate of forest fragmentation, changes to large-scale agriculture and urbanisation are now the main causes of species' extinctions (CERI 2001).

Hunting and poaching

These pressures affect nearly all taxa of fauna. In national parks, illegal hunting, poaching and anthropogenic destruction of habitats occur regularly. These illegal activities focus on rare and endangered species such as large carnivores, eagles, owls, chamois, marmots and many small invertebrates and plants. Small, isolated populations have become extinct or are unable to maintain long-term viability.

Invasive alien species

During the last century, many species have been introduced by humans, often unintentionally, into new areas across the globe. Invasive alien species often pose threats to native flora and fauna or natural ecosystems. In the Carpathians, they have entered natural and semi-natural ecosystems and become established in the region during the last decades.

Among plants, examples of invasive alien species include the Caucasian hogweed *Heracleum sosnowskyi*, introduced due to agriculture in the 1980s and now dispersed in many Carpathian river valleys. Invasive alien carnivores arriving in the Carpathians a few decades ago include the American mink *Mustela vison*. This new immigrant pushed its European relative *Mustela erminea* towards extinction in a relatively short period. Another carnivore from Asia, the raccoon dog (*Nyctereutes procyonoides*) was introduced in Europe from the former Soviet Union and spread quickly throughout the Carpathians, but fortunately is still a rare species.

Human impacts on Pilsko Mountain

As early as the 15th century, agricultural practices based on pastoral management of forest glades and clearings developed around Pilsko Mountain in Slovakia. These practices remained largely unchanged for 300 years, stabilizing the structure and composition of habitats. Forest areas fell to 46% of the total area of the massif, while ploughed areas covered 29% and mountain meadows and pastures 23%.

Several new plant associations emerged and became established on pasture glades, including *Gladiolo-Agrostietum*, *Hieracio-Nardetum*, *Rumicetum alpini*, as well as peat bogs. These were originally not found in the region, when the entire area was largely covered by forests. Meadows and pastures in the forest zone included many high-altitude plants such as the chive *Alium schoenoprasum* and felwort *Swertia perennis*, and animals such as the Tatra pine vole *Pitymys tatricus* and water pipit *Anthus spinoletta*. These species are now very dependent on the distribution of pastures and meadows (Kurzyński et al. 1996).

In the 1970s, a ski resort was developed at the top of Pilsko Mountain, essentially changing the structure of the local landscape. In earlier times, the landscape typically was 'coarsely grained', with extensive areas of forest dominating steep slopes, and pastures on flatter ones. The emerging ski industry led to a more 'finely-grained' structure, as forests were cut to facilitate access to steep slopes, whereas former pasture areas are now witnessing the initial phases of forest succession (Witkowski 1996). The remaining small patches of meadows and forests are now dominated by common species, as many specialized species were not able to survive.

The Pilsko Mountain case appears to be representative of many new ski resorts being developed in the Carpathians. Similar landscape effects were observed in newly-established ski resorts on Jaworzyna Krynicka Mountain and in the Tatras.

Policy Measures and Responses

In the last decade of the 20th century, the Carpathian countries made significant efforts to maintain their diverse native flora and fauna. Some basic conservation standards and measures were harmonized, including the categories of protected areas and lists of protected species. Moreover, significant international agreements devoted to nature conservation, such as the Ramsar Convention on Wetlands, Bern Convention on the Conservation of European Wildlife and Natural Habitats, and the Convention on Biological Diversity (CBD) were accepted and signed by all Carpathian countries.

These efforts resulted in a well-developed network of national parks and their cooperation within the Association of the Carpathian National Parks and Protected Areas (ACANAP). These include bi- and trilateral cooperation agreements between national parks and other protected territories. The first bilateral national park in Europe was established in 1932 in the Pieniny Mountains by Poland and former Czechoslovakia. Europe's first trilateral agreement protected border areas in the Bieszczady Mountains, including parts of Poland, Slovakia and Ukraine.

All of the Carpathian countries participate in the Pan-European Biological and Landscape Diversity Strategy (PEBLDS) and make efforts to implement the Kyiv Resolution on Biodiversity, endorsed at the 5th Ministerial Conference *Environment for Europe* in 2003, which has as its main objective to halt the loss of biodiversity in the pan-European region by 2010. The Carpathian countries are also members of the Ministerial Conference for the Protection of Forests in Europe, a high level political initiative working towards the protection and sustainable management of forests in the pan-European region.

Despite such local and regional achievements in the nature conservation field, local communities, ecologists and politicians became increasingly aware that bi- and trilateral cooperation agreements were insufficient for effective conservation of the entire unique Carpathian ecosystem. Partly to remedy this situation, a 'Carpathians Unite' parliamentary meeting was held in Warsaw in 1997 (Bloemhard et al. 1997), resulting in extensive cooperation between local and regional NGOs under the framework of the 'Carpathian Ecoregion Initiative' and WWF Danube-Carpathian Programme. This was followed by a political summit held in Bucharest in April 2001 (Webster et al. 2001). One final outcome of these political efforts was the Carpathian Framework Convention (CFC), signed in 2003 in Kiev, which UNEP played an essential role in brokering.

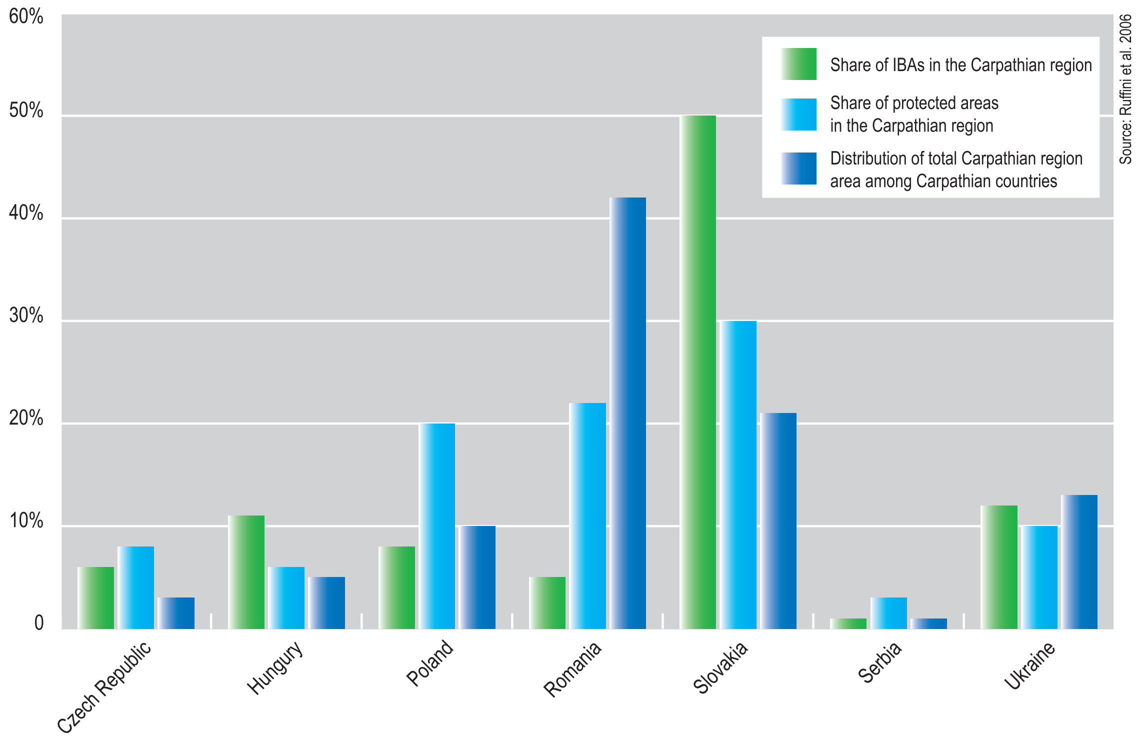
The Carpathian Framework Convention (CFC)

One of the main forces in nature conservation management in the entire Carpathian region is the CFC, providing a framework for integrated multi-sectoral policy coordination. The coordination activity of the Convention should solve some important questions related to nature conservation, including harmonization of legislation, particularly on hunting and fishing, unification of species status, closing time of hunting seasons, hunting methods and methods to calculate the percentage of populations being hunted. Another major issue for the Carpathians concerns landscape planning regulations and their consequences for nature conservation efforts. The development and harmonization of tourism should be pursued, with particular promotion of eco- and sustainable tourism activities. The most difficult and problematic issue is the maintenance of all regional aspects of culture, including traditional forest and agriculture practices, and their connection to sustainable use of natural resources. These also are among the most ambitious fields of local NGOs' activities. In general, the CFC seeks to assure an integrated and holistic vision of mountain development.

EU Directives

The majority of the Carpathian territory (approximately 90%) falls within EU member states since 1 January 2007. As a consequence, the

Fig. 3.5 The share of protected areas and Important Bird Areas (IBAs) in the Carpathian region



implementation of nature conservation measures and policies in the Carpathians is for the most part guided by the EU Bird and Habitat Directives and the Natura 2000 programme.

The implementation of Natura 2000 will result in at least 15% of the Carpathian territory being protected. Furthermore, the lists of protected habitats and species in the Carpathian countries will be better harmonized through the incorporation of lists of species and habitats for which special protection measures must be taken according to appendices of the Bird and Habitat Directives. Finally, the Directives require permanent monitoring of habitats and species, which will provide reliable and comparable data on the effectiveness of nature conservation measures in the Carpathians.

The EU Common Agricultural Policy (CAP) also influences biodiversity preservation measures in the Carpathians, with some financial resources dedicated to viable agro-environmental schemes. The introduction of GMO products may also constitute a threat to native species and ecosystems (Burdusel et al. 2006).

Protected Areas

The high value of the Carpathians natural environment is mainly preserved through two types of large-scale protected areas (greater than 1000 hectares): national parks and national nature parks (33 areas), as well as protected landscape areas or landscape parks (42 areas). These two categories of protected lands cover as much as 13% of the Carpathian area.

The EU legislation obliged new members and accession countries to prepare a new unified network of protected areas under the Natura 2000 program. To date, all seven Carpathian countries have finalised their proposals for Special Protection Areas (SPAs), which constitute the Natura 2000 component covering the needs for bird fauna conservation (Ruffini et al. 2006). Nevertheless, available data show that unequal efforts are being made in the nature conservation field in the Carpathian countries (see Figure 3.5).

The non-EU Carpathian countries preserve their natural landscapes through their national eco-

Table 3.5 Natura 2000 efforts in four EU countries sharing the Carpathian territory (IUCN 2005)

Country	Natura 2000 sites	Number	Area (ha)	% of country	Carpathians as % of country
Czech Republic	SPAs	41	~ 623 000	7,9	9
	pSCIs	864	~ 718 000	9,1	
	Total	**905**	**~ 1 065 000**	**13,5**	
Hungary	SPAs	45	1 191 784	12,8	8
	pSCIs	457	1 237 785	13,3	
	SPAs & pSCIs	10	159 572	1,7	
	Total	**512**	**1 975 159**	**21,2**	
Poland	SPAs	72	3 312 800	7,8	6
	pSCIs	184	1 171 600	3,6	
	Total	**248**	**?**	**~ 10,3**	
Slovakia	SPAs	38	1 220 563	25,2	72
	pSCIs	382	571 191	11,72	
	Total	**?**	**~ 1 426 102**	**28,9**	

logical networks, by implementing international agreements such as the Bern Convention (which includes participation in the Emerald Network), and by contributing to the Pan-European Ecological Network (PEEN). For example, Ukraine has established more protected areas in forms of national parks and strengthened incentive measures in recent years under its National EcoNetwork Formation Programme (CBD 2007).

IUCN (2005) has also shown that there are differences in implementing Natura 2000 guidelines in four (of five) EU Carpathian countries (see Table 3.5). In Slovakia, where the Carpathians cover as much as 72% of its territory, nearly 29% of the country's area is included in Natura 2000. As for Romania, the country's proposal for the Natura 2000 network is now in the final phase of preparation.

Table 3.6 Establishment of protected areas in non-EU Carpathian countries (CBD 2007)

Country	Number	Area (ha)	% of country	Carpathians in % of country
Ukraine	7243	~2 916 158	4,8	~5
Serbia	178	N/A	N/A	N/A

Conclusions

Many landscapes, habitats, and flora and fauna species show characteristic and unique features occurring solely or mainly in the Carpathian region, as results of long-term evolution, migration and adaptation processes that existed well before humans settled in the Carpathians.

Human penetration in the Carpathians was a slow process. In the beginning, human influence was relatively beneficial to the landscape, habitat and species diversity. Traditional methods of woodland management, such as the coppicing of forests and establishment of meadows and pastures created new ecosystems that enriched Carpathian landscapes and biodiversity. This situation changed with industrialization and increased human settlement. These processes caused major changes to forests, simplified the local diversity of agro-ecosystems and resulted in a decline of native flora and fauna. Later in the 20th century, new biodiversity threats emerged in the region, including air and water pollution, climate change, large-scale investments such as highways and artificial lakes, illegal collection and poaching and a major increase in tourism and recreation activities.

To counterbalance these activities, some countries began to introduce their own protective mechanisms and measures such as establishing protected area networks, species protection decrees and inventories for monitoring the decline of habitats and species. Carpathian countries have also signed bilateral/multilateral cooperation agreements, culminating in the adoption of the Carpathian Convention, a regional framework within which new sustainable development and biodiversity conservation measures and policies will be implemented.

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3.2 Forest Resources

The existence of virgin primeval forests throughout the Carpathian region lasted until one to two millennia ago in the lower mountains. Human influence in the region dates back to ancient times in the foothills of the Southern Carpathians, while in the North, human settlement began in late medieval times.

At the end of the 16th century, the Wallachian people, many of them shepherds, began their in-migration from the Balkans to settle in the Carpathian region's higher altitudes. They were the first people to inhabit more remote areas within the mountains. By cutting and burning forests along the mountain ridges, they created numerous glades and meadows, which have since become a distinguishing feature of the Carpathian landscape.

From the 18th to 20th centuries, Carpathian forests were in many places much reduced through the rapid development of industry, including sawmills, glass and smelting works and metal ore mines. Forest cover decreased and changed rapidly. The majority of native beech and fir forests were replaced, often through clear-cuts, by monocultural Norway spruce plantations. The impact of industrial activity was much stronger in the Western Carpathians than in the Romanian and Ukrainian parts of the range.

Until the second half of the 19th century, the main function of forests was wood production and its economic values and benefits, measured as the quantity and quality of wood produced. Other functions, including areas for hunting and recreation and environmental and social values, were of secondary importance. In the late 19th century, tourism and recreation became increasingly important services provided by forests. In the second half of the 20th century, during the period of communism, timber production was one of the most important sources of foreign currency, and large-scale and wasteful clear-cut areas were commonly found on the mountain slopes.

However, by the 1990s, the attitude of scientists, foresters and communities towards forests had changed, with the ecological and social functions of forests matching their economic function nearly everywhere in the Western Carpathians. While in Ukraine forest practices continued to focus on economic uses, timber exploitation in the other Carpathian countries became only one amongst many forest functions. Today, forests continue to be a major economic resource.

The logging and wood-processing industry still represents the main source of income in many areas. Nonetheless, the importance of other forest functions has grown, as they are no longer perceived from a purely economic perspective and as a source of timber. Their recognized ecological services now include stabilization of soils, regulation of water output from mountain watersheds, carbon sequestration and air purification. Social functions include providing jobs for local people and enhancing recreation and tourism. Their provision of non-wood products, such as wild animals, mushrooms, berries, flowers and honey, is also important to inhabitants.

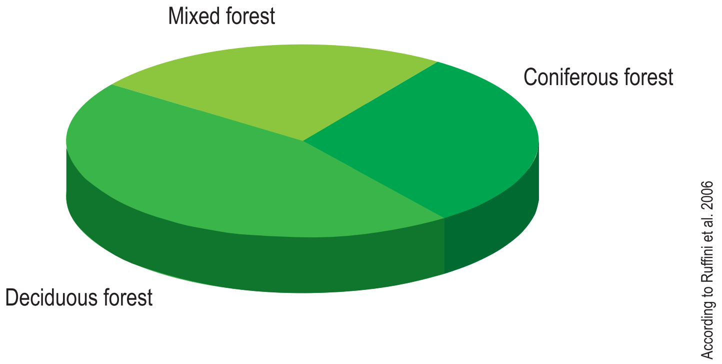
Carpathian forests are increasingly valued for both nature conservation and biodiversity maintenance, given the high utility assigned to their diversity of plant and animal species. The forests are a reservoir and prime habitat for one of the richest continental stocks of large animals, and icons of the primeval forest. They are a crucial sanctuary for large carnivores, where bears, wolves and lynxes are estimated in the thousands, as well as for many large bird species in Europe (see section 3.1). For vital populations to survive, these species need extensive areas of forest and large patches of pastures and meadows.

A key positive result of this recognition of forests' multiple roles has been new forest policies and laws, improved forest management and an increase in protected forest areas.

Current Forest Cover and Composition

Much of the Carpathian range is covered by vast areas of forests. On average, forest cover is nearly 60% but the percentage varies significantly among countries and areas. The largest forest complexes are in the Eastern Carpathians. In the Western and Southern Carpathians, substantial areas were deforested and converted to other landuses. Past deforestation and fragmentation increases from the region's main ridge to its peripheries. In the foothill areas, forests are small and scattered and the landscape is dominated by other land uses (see Map 3.5).

Figure 3.6 Main types of forest formation in the Carpathians (according to Ruffini et al. 2006)



The Carpathians are famous for their relatively large share of natural and semi-natural forests, occurring either at high elevations or in areas of rugged topography with limited access. While their total area is not precisely determined, an estimate is 3,000 sq km (see Map 3.3). Lower plants, lichens and fungi associated with these old-growth forests and their ecosystems, especially dead wood, are still poorly known. However, it is expected that these ecosystems provide shelter to a rich variety of rare species, now extinct elsewhere due to intense forms of forest management.

The forests of the Carpathians are a patchwork of coniferous, deciduous and mixed stands (see Figure 3.6). Like other vegetation types, forests display a distinct vertical zonation. The four main levels are the foothill zone, lower mountain forest zone, upper mountain forest zone and dwarf pine zone (see section 3.1).

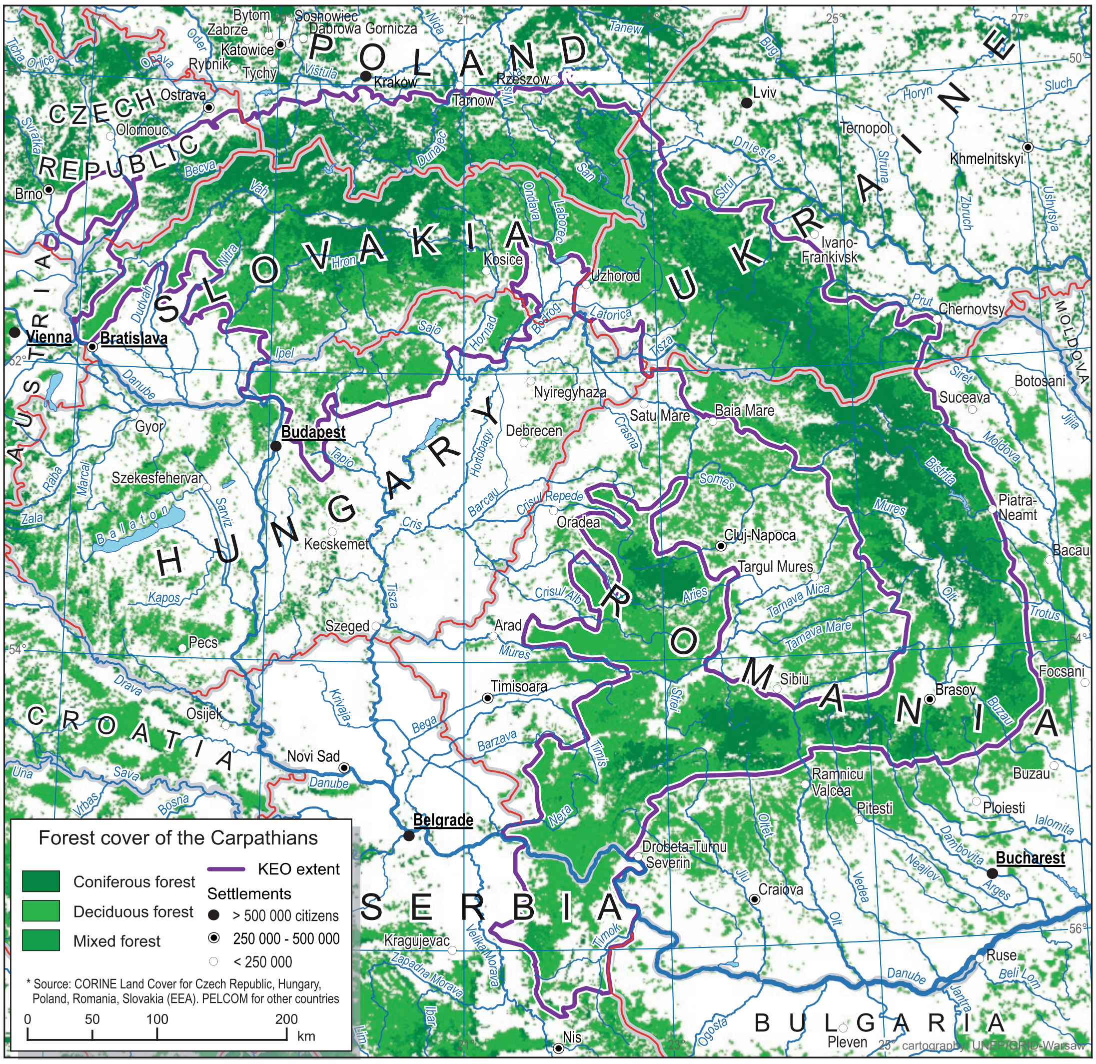
In most areas of the Carpathians, beech is mixed with coniferous trees, namely silver fir and

Norway spruce. In the lower parts of the montane zone, especially on south-facing slopes, a mixture of oaks, maples and ash may be found in beech forests. In some places, the montane zone is totally dominated by conifers, usually a mixture of silver fir and Norway spruce (e.g. the Tatra, Moravske Beskydy, Oravska Magura in the Western Carpathians, and the Gorgany, Czarnohora, and Muntii Bistrei in the Eastern Carpathians).

Natural Virgin Forests

Characteristic features of natural Carpathian forests include their age, the existence of large carnivores and raptors and the volume of dead wood. Natural forest floors maintain over 100 cubic meters of dead wood per hectare, while in managed forests dead wood occupies less than 10 cubic meters over the same area. A lack of dead wood implies a significant lack of biodiversity (e.g. plants, fungi and invertebrates that depend on this particular substrate for their survival). For

Map 3.3 Forest cover of the Carpathians (CORINE Land Cover/PELCOM)



example, in the Carpathians, two rare beetle species – *Osmoderma eremita* and the Longhorn beetle *Rosalia alpina* – are of European importance for the EU's Natura 2000 network. Many rare species of fungal symbionts[2], lichens and lower plants also depend on dead wood. Furthermore, dead wood has many environmental values, the most important being carbon sequestration, particularly in higher altitudes where the process of tree decay can be as long as one century, much longer than in the lowlands. Recently, the EU proposed a new agro-environmental scheme of financial support during the period of 2007 to 2013 that would provide opportunities for increasing the area of old wood refuges and protected primeval forests which are in private ownership.

[2] Organisms that live in association with individuals of different species.

Nearly all the remnants of natural and semi-natural forests in the Western Carpathians are now protected in nature reserves and national parks in the Czech Republic, Hungary, Poland and Slovakia, including their valuable, rare and threatened forest ecosystems. Much larger areas of natural and primeval Carpathian forest still exist in the Eastern, Southeastern and Southern Carpathians in Ukraine and Romania. Not all of these areas are protected by law, but large-scale clear-cuts have nevertheless been abolished and forest management is mainly conducted by establishing protected areas of various kinds, employing selective cutting systems and limiting forest exploitation. Forest regeneration is mostly natural, while the planting of tree seedlings is widely used as a way to convert secondary Norway spruce stands (plantations) into more diverse forest stands.

Current Threats

Deforestation

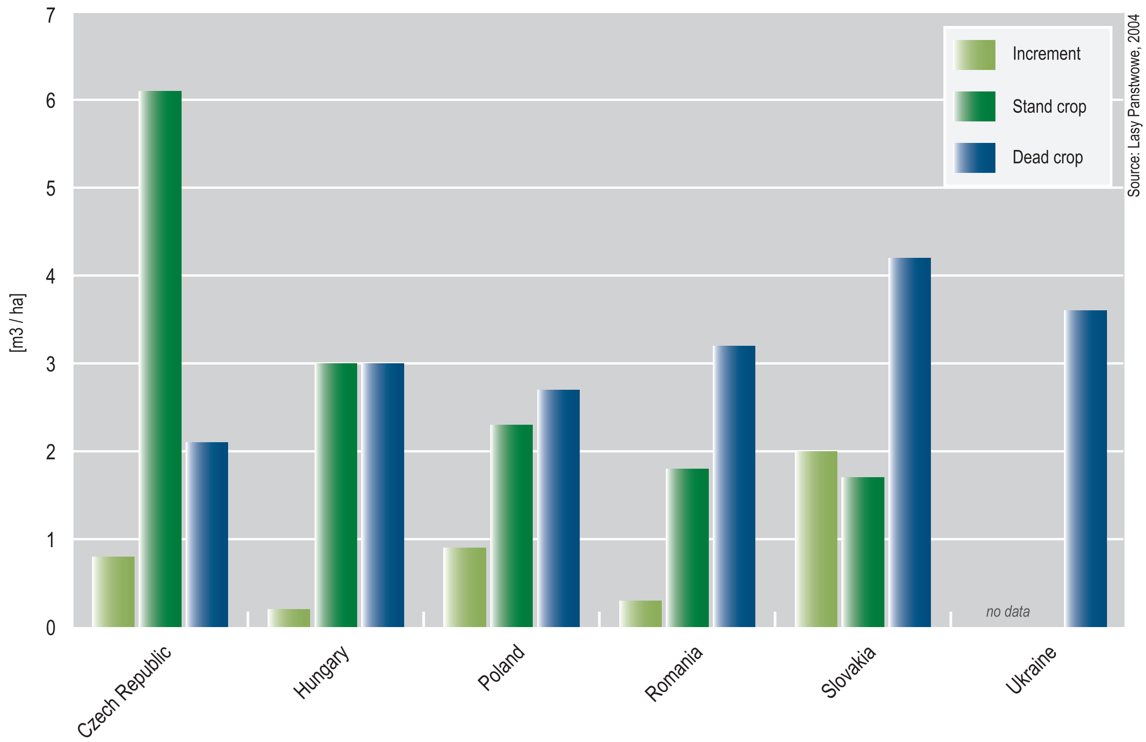
The current status of Carpathian forestry is complex, and a lack of precise data renders a detailed assessment even more difficult. On the one hand there are processes of reforestation. On the other, timber production in some countries equals or exceeds the annual increment of tree stands, resulting not only in deforestation, but also a thinning of the stands.

Data presented by the Temperate and Boreal Forest Resource Assessment (Lasy Państwowe 2004) suggest that forest timber yield (calculated as the stand crop plus the dead crop) may sometimes exceed the annual increment of forests in some Carpathian countries (see Figure 3.7). However, this figure is calculated for entire countries and not according to particular country areas in the Carpathians. According to the same source, Carpathian forests are healthier and less exploited than those in lowland areas (many of which are plantations), since access to many mountain forest stands remains limited due to topography.

In general, as in most European countries, overall annual timber cutting in the Carpathians is lower than the gross annual increment of wood volume (Figure 3.7). Nevertheless, deforestation processes are still occurring in the region, and can be observed in Ukraine and to a lesser extent in Romania (see Figure 3.10). Local, small-scale deforestation was monitored and documented in the western part of the Beskidy Mountains in the Czech Republic, Poland and Slovakia (Fabijanowski and Jaworski 1996). These processes resulted from synergetic effects of several factors, such as increases in soil pollution and acidification due to the long-term effects of acid rain. Similar effects were also reported near ski trails where the opening of forest margins altered the microclimate and gave rise to bark-beetle outbreaks.

Pure Norway spruce stands, planted using varieties outside of their natural range and habitat in the Carpathian foothills and lower montane forests zone, are prone to diseases and bark-beetle outbreaks. Furthermore, illegal clear-cutting, poaching and the over-exploitation of other forest products such as mushrooms, berries

Figure 3.7 Forest yearly increment and standing crop divided into stand and dead crop (in cubic meter/ha) (Lasy Państwowe 2004)



and rare plants and animals are alarming phenomena that are on the upswing.

Afforestation

After centuries of deforestation, the forest area expanded substantially over the last few decades, especially in the Western Carpathians. Forest recovery is crucial for the conservation of rich habitats in the Carpathians and maintenance of its biodiversity, especially for large carnivores. The afforestation process predominates in the Czech Republic, Hungary, Poland and Slovakia (see Figure 3.10). This was mainly a result of tree planting in former arable fields and natural processes of secondary forest succession in areas abandoned by agriculture. The Millennium Ecosystem Assessment (Hassan et al. 2005) shows that the process of deforestation is being reversed in Europe, and some of the first signs of this turn-around are observable in the Carpathians.

Forest ownership changes

The structure of forest ownership in the Carpathians has changed rapidly over the last decade. In the 1990s, the majority of forests were state-owned, nearly 100% in Ukraine, over 90% in Romania, and more than 80% in Hungary and Poland. The subsequent re-privatisation and restitution of forest properties to private owners (those who owned forests prior to 1945) were most advanced in the Czech Republic and Slovakia, with nearly 40% of forests returned to private hands after 1999.

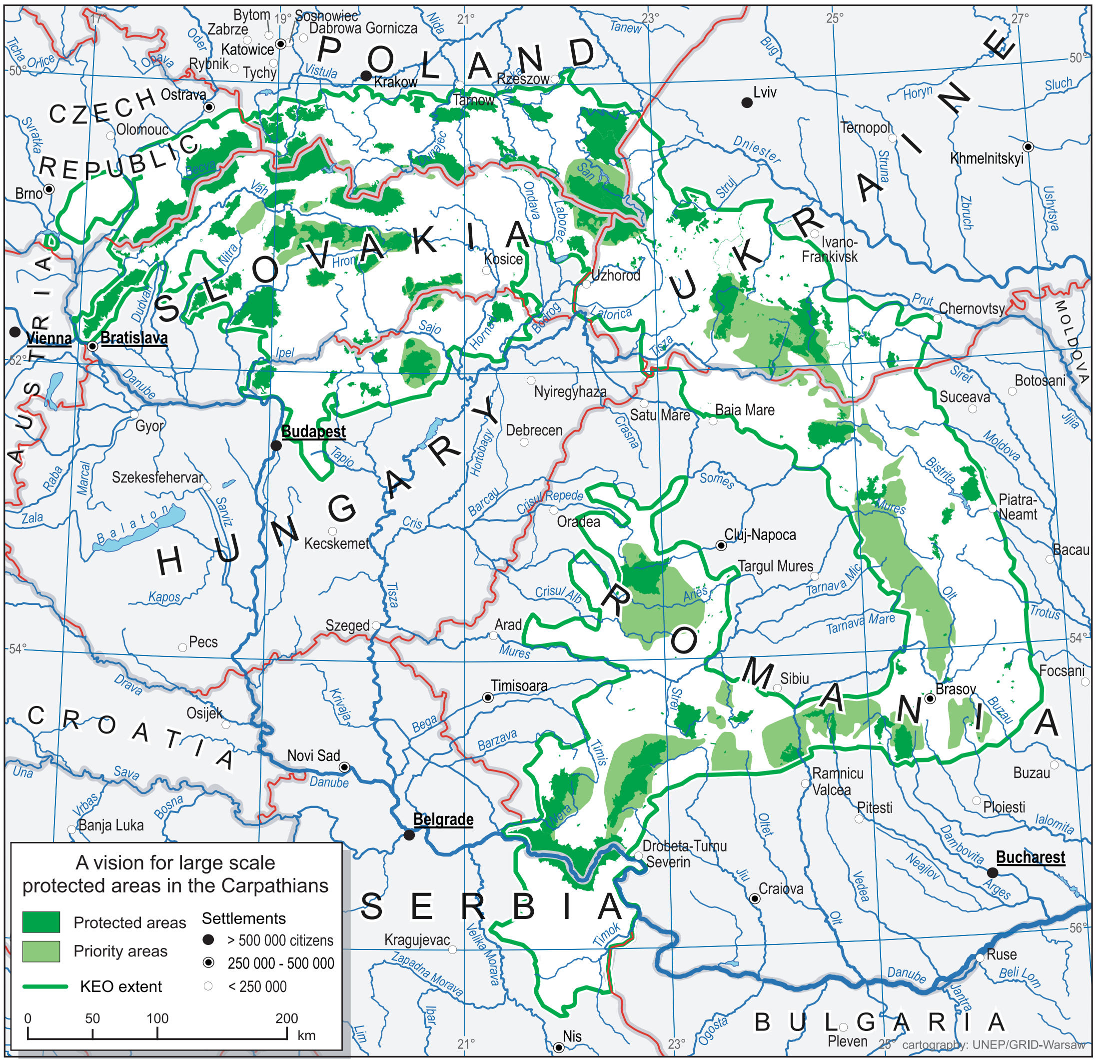
Private ownership often results in a disintegration of forest management and fragmentation of stands. A good example may be found in Poland, where the number of private forest owners is estimated at 900,000. Regular censuses of forest resources show that private forests are now younger and thinner than state-owned forests, and often inappropriately managed. Forest privatisation also tends to place more value on economic benefits rather than on ecological and/or social values of forest ecosystems, as new forest owners often do not recognize their social and environmental responsibilities (Lasy Państwowe 2004). A recent positive sign is EU support for the development of cooperative owner groups, which are economically stronger and better suited to improved cooperation and management.

Protected Areas

The efforts to protect Carpathian forests have been growing from decade to decade. The increase in the protected area in the Polish Carpathians serves as an example of this positive trend. In 1980, less than 10% of forests were protected. By 2003, protected areas of various types (biodiversity and landscape protection) covered nearly 40% of all forests. The same process can be seen in other regions of the Carpathians, especially in those countries which became new members of the EU.

Large-scale protection of Carpathian habitats is still far from optimal. The Carpathian Ecoregion Initiative (CERI 2001) developed the first large-scale analysis of the Carpathians with an assessment of the conservation needs of key species and habitats (see Map 3.4). It was found that in the Western Carpathians the CERI conservation proposal mostly coincides with the existing protected areas. However, in the Eastern and Southern Carpathians, data show that much work is still needed to build and implement a conservation network.

Map 3.4 A vision for large scale protected areas in the Carpathians (CERI 2001)



Conclusions

Centuries of evolution and human impact changed the initial natural species composition, forest stand structure, size scale and character of the Carpathian forests. However forests are still vital. Many virgin stands rich in species remain of high social, environmental and economic value for the local people and visitors to the region.

Timber production remains a major source of income in the Carpathian region. However, in some areas, small sawmills and other wood processing industries have a more social than economic character (e.g. preventing local unemployment). A growing source of income from forests is tourism and recreation. Forest tourism trails, hunting areas and guest rooms in mountain villages are all successful economic activities competing with simple wood processing in the Carpathians.

Three key changes have recently been observed as having positive effects on the situation: the attitude of local people towards forest use, privatisation, and conservation status of forests. The attitudes of local people towards forests have become increasingly "sustainable". Even if the majority of forests remain in public hands, private owners are now an important segment of the market for timber production and other economic forest uses. The new EU proposal of financial support for forest protection through an agro-environmental scheme for the period 2007 to 2013 gives an opportunity to private owners to increase the area of old wood refuges and protected primeval forests.

Forest conservation in the Carpathians is primarily supported by a wealthier segment of the population. Economically disadvantaged communities throughout the Carpathians currently have little interest in conservation issues as such. Along with increased environmental education, the most important goal for decision-makers should be to give local communities a chance for a better quality of life, including improved incomes from sustainable forest usage.

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3.3 Land Resources

Most of the area of the Carpathian Mountains is covered by forests (59.2%). The second largest form of land cover is agriculture (27.5%). Other land uses, mainly urbanized and industrial areas, cover 13.4%. Much of the land-use pattern in the Carpathians has been modified by the human presence over centuries of time. A characteristic feature of the Carpathians' landscape is the typically small scale of land use patches. Except for large patches of forests, areas used for other purposes such as grasslands, pastures, agricultural lands and urban settlements are small, with the latter distributed throughout the region except in forest areas. Together, these patches form a unique landscape 'grain pattern' with 'coarse' forest areas and 'fine' areas for other uses (see Map 3.5).

State and Trends: Soils

Origin of soils in the Carpathians

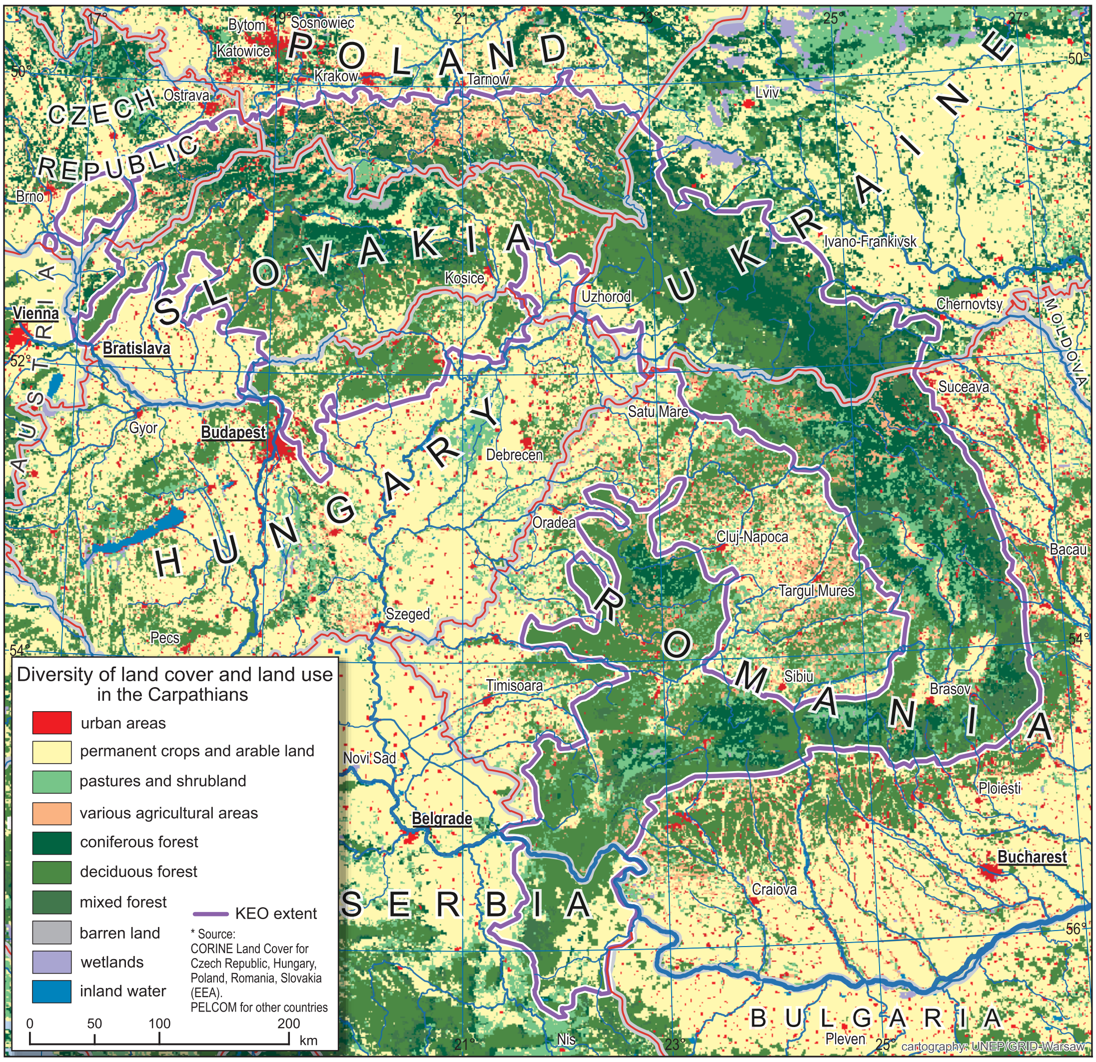
Several characteristic features differentiate Carpathian soils from lowland soils. Their origin is directly connected to slow weathering processes that produced regolith (the layer of weathering bedrock), and intense morpho-genetic processes (e.g. rock falls, rock slides, debris and grain flows, solifluction) that determined the fragmentary character of the soil cover. As a result, the shallow soil profile and large amount of rock pebbles in the soil mass are characteristic features Carpathian soils.

Different variants of soil occur at high altitudes (Skiba 2006). Examples include those of the Tatra Mountains, rock walls in the Bucegi Mountains, Western and Eastern Beskidy Mountain ridge, rock outcrops and rock rubbles in the Gorgany Mountains.

The mountain relief and regolith[3] are also connected with specific hydrological conditions. The lateral movement of soil solutions (liquid

[3] Material covering solid rocks, comprising the soil, alluvium and bedrock.

Map 3.5 Diversity of land cover and land use in the Carpathians (according to CORINE Land Cover)



component of the soil) produces exudations which occur in the form of slow and steady water discharges, as well as moist areas and in-slope water sources. These waters are characteristic of mountain soils, and also influence the formation of specific soil variants. Examples include patches of eutric regosols enriched with alkaline elements, as well as Carpathian mollic gleysols occurring in the Outer Carpathians.

An interesting characteristic of Carpathian mountain soils is the large amount of weakly decomposed and peat-like organic matter, as well as the increase in organic layer depth with increased altitude. The mountains' cool and humid conditions, as well as the adjacent plant communities (together with soil organisms), lead to low rates of decomposition of plant material (Skiba et al. 1997, Drewmik 2006). Soils with organic horizons of more than 10-20 cm occur at high altitudes, under blueberry (*Vaccinietum*) and dwarf pine communities, forming tangel rankers or tangel rendzinas soil types. This shows the important role of both the local climate and vegetation in the genesis of the mountain soils.

The acid reaction of the surface soil in the mountain regions derives from soil genesis processes that are characteristic for the humid climatic conditions of the Carpathian Mountains. Low pH levels are not always affected by acid rains (Skiba 2006); however, some extremely acidic soils in the Western Carpathians can be further overloaded by acid deposition.

Soil division in the Carpathians

The Carpathian region includes the Carpathian foothills, Outer Carpathians and Inner or Central Carpathians (see Chapter 1). Nearly 90% of the foothills area is covered by silt formations deposited on flysch formations, known as Carpathian loess, up to 25-30 meters deep. Concomitant soil formations (e.g. gley and fluvi-eutric soils) cover significantly smaller areas. Similar soils are found in the Transylvanian Plateau in Romania.

The Outer Carpathians include the Beskidy Mountains, whose ridges are situated within nappe-fold flysch formations that belong to different structural units (nappes), built of complexes of sedimentary rock beds. The mantle rock of these formations is usually loamy and remodelled by morpho-genetic processes that form the slope cover. In the Outer Carpathians, mainly dystric cambisols developed on decalcified clay slopes. Shallow cambic rankers and eutric cambisols cover smaller areas, usually on carbonate flysch weathering formations. They are also found in areas enriched in alkaline elements.

The Inner Carpathians have a very differentiated geological substratum, similar to that of the Southern Carpathians. The geological base is formed of crystallic, volcanic and metamorphic rocks and Mesozoic limestone and dolomites. The soil cover corresponds to the varied geological and orographic conditions. On non-carbonate rocks (e.g. granites, shales), acidic soils (mainly haplic podzols) were formed. On steep slopes, podzolic rankers and raw-humus forms of alpine rankers developed. Within the sub-alpine and alpine belts, initial soils and regosols prevail.

On carbonate rocks, various sub-types of rendzinas (such as rendzic leptosols) prevail, including specific alpine variants of raw-humus rendzinas. On volcanic rocks, andi-lithic leptosols may be found.

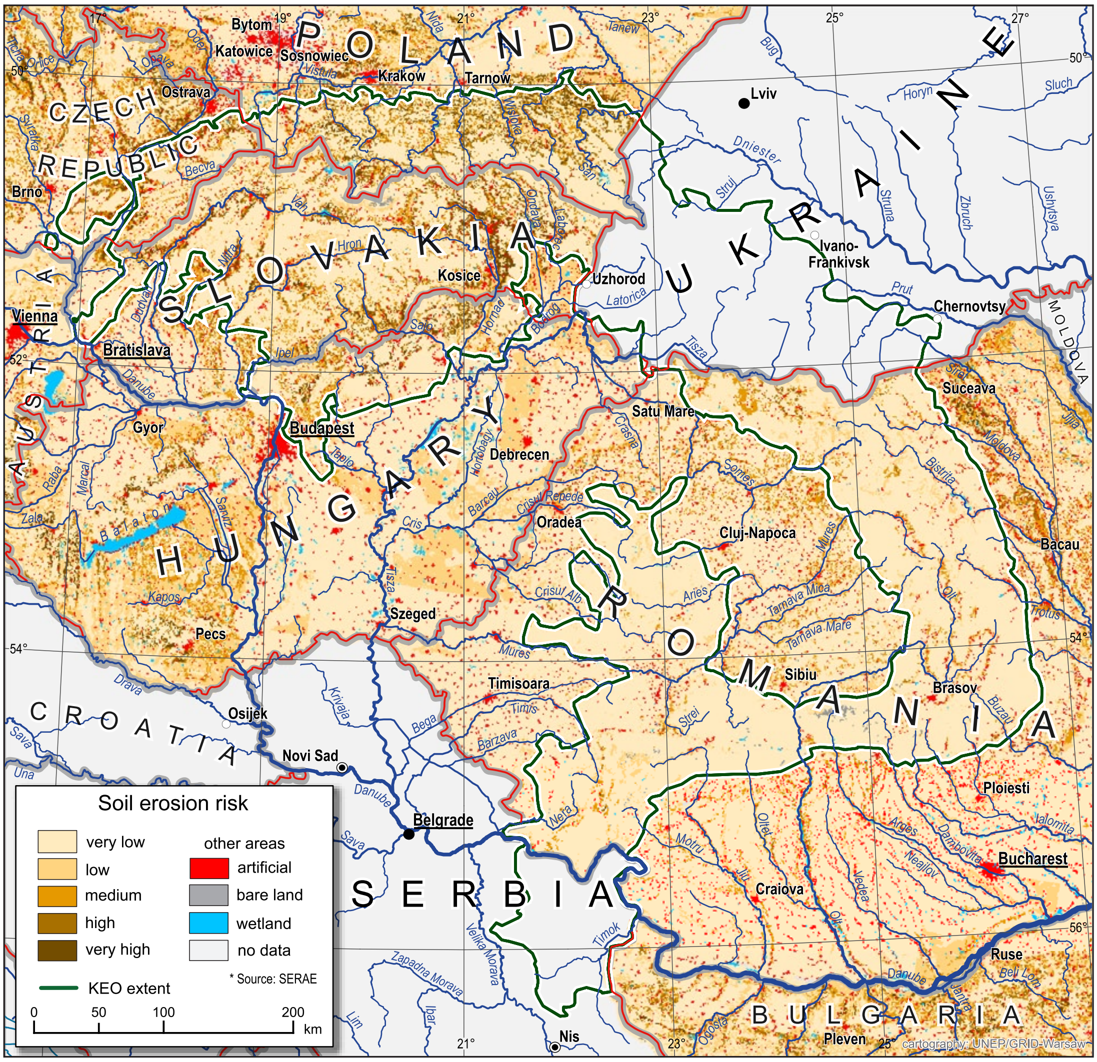
Erosion

Threats to soil cover in the Carpathians include natural processes, such as soil erosion and landslides, and processes stemming from human activities and land uses, such as forest management, pasturing, tourism and recreation. Natural threats mainly affect areas above the forest zone, where geomorphologic processes are most intense (e.g. debris flows, rockfalls, gravitational movement of detached material) (Kotarba et al 2002).

One of the most important consequences of inappropriate agriculture and forest management (e.g. large clear-cuts) in mountain areas is soil erosion (see Map 3.6). Examples include the maintenance of ploughed fields on steep slopes and excessive concentrations of cattle or sheep in mountain pastures. Deforestation is the main anthropogenic activity increasing the instability of slopes, and also triggering gully erosion. Afforested sectors have very stable slopes, being affected by mass movements only to a small degree (10-15%). Deforestation is accompanied by rapid expansion of degraded lands. Low-stability slopes are entirely deforested in some sectors and more than 70% are susceptible to landslides. The vulnerability of mountainous systems to landslide and erosion also increases when agricultural uses are intensified or reduced. Traditional land use composition and structure as organised by Wallachian shepherds were strongly dependent on the slope exposure and topography. Their main pastures and hay meadows were located on low-angle slopes near the mountain ridges.

The degree of erosion depends on several factors such as the steepness of the slope, soil character and land management scheme. The soil outflow is calculated as less than 0.00001 mm/year from forested slopes, 0.0002 mm/year from pastures and grasslands with similar slopes and soils,

Map 3.6 Soil erosion risk in the Carpathians



while in potato fields it reaches more than 1 mm per year (Starkel 1972).

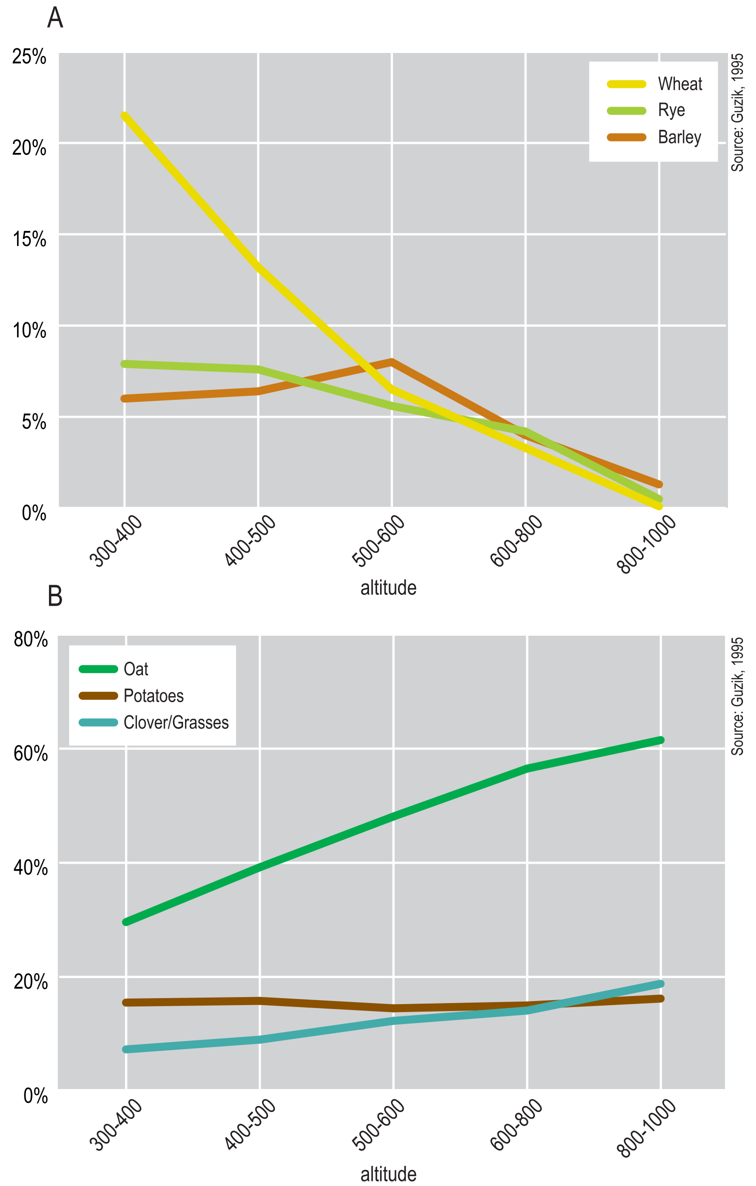
In addition, soil water retention decreases as soil cover is degraded through timber extraction, forest thinning and chemical changes in pasture glades. The catastrophic floods in the Ukrainian Carpathians (Tisza Valley) in the last decade are an example of this impact.

The occurrence of extreme phenomena affects the evolution of valley floors and slopes. The intensification of vertical erosion is also connected with the increased frequency of heavy rainfalls and higher river energy. The tendency of valleys to deepen, correlated with higher water movement on slopes, brings about greater instability on colluvial slopes and the expansion of landslide-prone areas.

State and Trends: Agriculture

Historically, the main factor of land and habitat stabilization in the Carpathians and surrounding hilly areas was agriculture. Carpathian countries have mainly produced grain crops, corn, vegetables and potatoes, as well as fruits (Hungary, Romania and Ukraine), grapes (Romania) and hops (Slovakia).

Figure 3.8 Percentage presence of wheat, rye and barley (A) and oat, potatoes and grasses/clover (B) in relation to altitude (Guzik 1995).



Traditionally, the main agricultural crops in the Carpathians were strongly dependent on altitude. At higher elevations, on steeper slopes and poor soils, productive crops such as wheat, rye and barley were replaced by cold-resistant crops such as oats and potatoes, as well as grasslands, clover fields and pastures (see Figure 3.8). Such a traditional crop division is still maintained in some marginal agricultural areas of Poland, Romania and Ukraine (Guzik 1995).

Animal breeding density was also dependent on altitude (Guzik 1995). Livestock species were found in higher numbers in the Carpathian foothills. In mountain farmlands, the density of sheep reached their local peak, with the montane race of sheep predominating in the higher regions of Polish, Romanian and Slovakian Carpathians (see Figure 3.9).

Traditional small farming was particularly difficult and unprofitable in mountain locations, due to severe climate, shallow soils and infertile habitats. Mountain farmers needed additional land for food production, and thus any suitable land was converted to farmland, meadows or pastures. Forests areas were subsequently reduced and large carnivore species and raptors became gradually extinct. Nevertheless, the regionalisation of crop varieties and animal breeding led to an increase of habitat, landscape and species diversity. Changes in landscape and habitat structures were beneficial for open habitat species, such as pollinating insects and butterflies, warm climate snakes and other land reptiles, as well as many bird species such as the corncrake *Crex crex*, partridge *Perdix perdix*, quail *Coturnix coturnix* and skylark *Alauda arvensis*.

After World War II, traditional agricultural practices including the ownership structure changed rapidly, as forced collectivisation was introduced. As a result, state-farm agriculture replaced small-scale private farms. In some Carpathian countries such as Poland and Romania,

Wallachians and the mosaic of land cover in the Carpathians

Wallachian shepherding, agriculture and forestry were nature-friendly. Traditional agricultural and forestry practices changed the landscape, habitats and species composition. The effects of these human activities are still visible, including large patches of meadows and pastures, as well as ploughed lands at high altitudes, that have been preserved for centuries. Beautiful landscapes abound, with a balanced composition of forest areas covering slopes, meadows and pastures around mountain ridges, and sparse settlements and intensive agriculture areas in the valleys.

Mountain biodiversity was influenced in a positive manner by this mosaic structure. For example, new meadow plant communities have developed on mountain glades, including *Gladiolo-Agrostietum*, *Rumicetum alpine*, *Hieracio-Nardetum* and various mountain peat bogs. At higher elevations, new communities of alpine plant species, such as the alpine lovage *Ligusticum mutellina*, gul potentil *Potentilla aurea* and alpine bog swertia *Swertia perennis alpestris*, spread and have remained. High montane meadows and pastures were also successfully colonized by montane endemic fauna such as the rodent *Pitymys tatricus*, newt *Triturus montadoni* and high alpine species such as the water pipit *Anthus spinoletta* and bumblebee *Bombus pyrenaeus*. Meadows and pastures in the mountains include nearly as many endemic plants as alpine meadows above the tree line, including over 60% of the Carpathians' total biodiversity (Burdusel et al. 2005).

This rich biodiversity and characteristic pattern of the mountain landscape are currently disappearing throughout the Carpathians. Mountain meadows and pastures have lost their economic importance, and many highland dwellers are now more interested in revenues from tourism and recreation, or leaving the land altogether.

forced collectivisation in mountain regions was less extensive than in the hills and plains. The fine-grained mosaic of small-scale fields, grasslands and wetlands was transformed into vast uniform fields covering hundreds of hectares. By simplifying the landscape structure, species and habitat diversity were substantially reduced. Many common mountain species became rare, including the corncrake, quail and numerous hay meadow plant and insect species.

This trend was reversed in the 1990s with the recovery of private property. Between 1992 and 1994 in Hungary, privatisation created some 350,000 new landowners, who regained 1.5 million hectares of land (Csorba 1996). As a result, private producers now own 47% of the arable land. The process altered and diversified the land use structure, as small parcels now adjoin large traditional farms, pastures and abandoned lands.

Poland was the only Carpathian country where the collectivisation of agriculture was limited and land remained in private hands. The land ownership structure in the 1990s had hardly changed from the beginning of the 20th century. In the Polish Carpathians, the mean size of farms (including forests) is now approximately three to five hectares, and the land ownership and land use patterns are quite complex. In other Carpathian countries the mean size of farms and private forest units is still much larger.

In the Eastern, and to some extent in the Southern Carpathians, industrial unemployment and slow economic growth have added new pressures by increasing the share of agriculture lands at the expense of forest cover (see Figure 3.10). The process is dynamic and difficult to analyse

Figure 3.9 Percentage presence of livestock, hogs and sheep according to altitude (Guzik 1995). Altitude classes: 1: 300-400 m, 2: 400-500 m, 3: 500-600 m, 4: 600-800 m and 5: 800-1000 m.

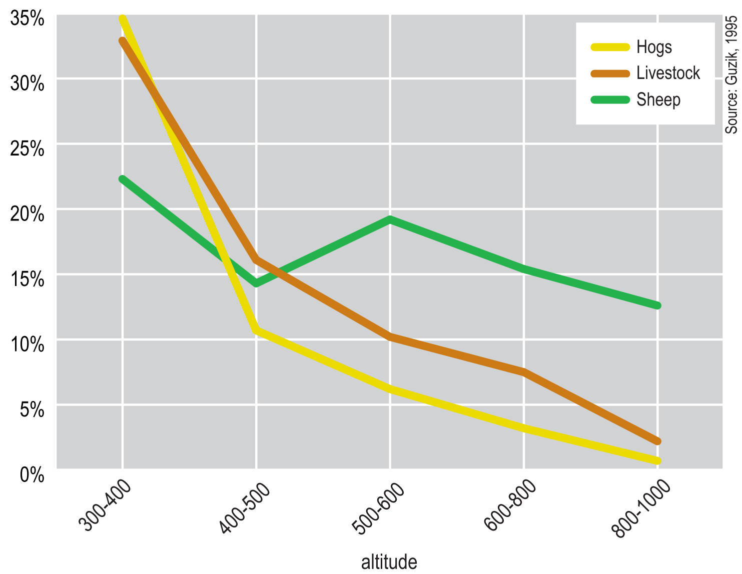
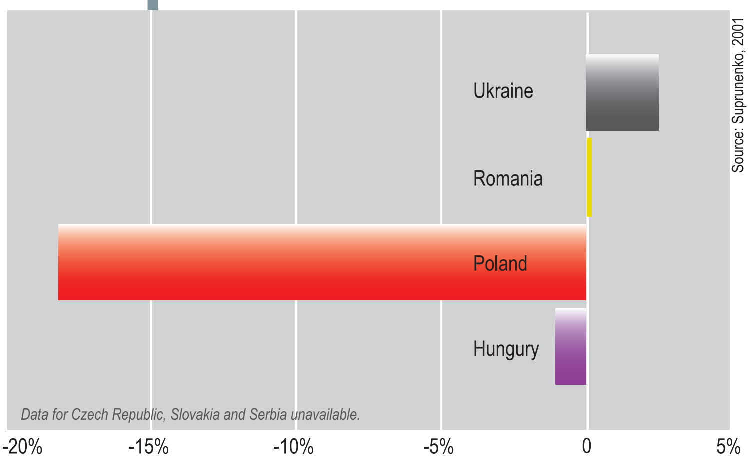


Figure 3.10 Increase/decrease in agricultural land in some Carpathian countries in the second half of the 1990s (data for Czech Republic, Slovakia and Serbia unavailable). (Suprunenko 2001)



quantitatively. Forest cover changes from 1987 to 2000 on the border between Poland and Slovakia confirmed that there was a net increase of the forest area over the last few decades in the Western Carpathians (Kozak et al. 2007). It has also been shown that the dynamics of land use change are dependent on elevation. Afforestation and deforestation processes were more rapid at lower elevations (up to 800 m above sea level) than at higher altitudes.

Today, the main factor governing land use in the mountain region is economics. Only in some areas, particularly the foothills, is agriculture a profitable activity. According to Delbaere and Nieto-Seradilla (2004), economic decisions are leading to an intensification of agriculture (see Figure 3.11). Economic gain forces farmers to intensify their activities and adopt practices resulting in large-scale production and specialization in one crop or animal product. Modern agricultural practices include mechanization, fertilization, excessive use of pesticides, herbicides and biotechnology, without assessing their negative consequences for landscapes, habitats and the species living on or near conventional agricultural areas (Suprunenko 2001).

Many examples of such farming practices can be observed across the Carpathians: excessive fertilization of ploughed fields in Poland with negative consequences on adjacent streams and rivers, large-scale farming in Slovakia and consequent increased deforestation, high density of stock farming in the Ukrainian Carpathians with negative impacts on soil erosion processes, and use of biotechnology and GMO crop production in the Romanian Carpathians (Burdusel et al. 2005).

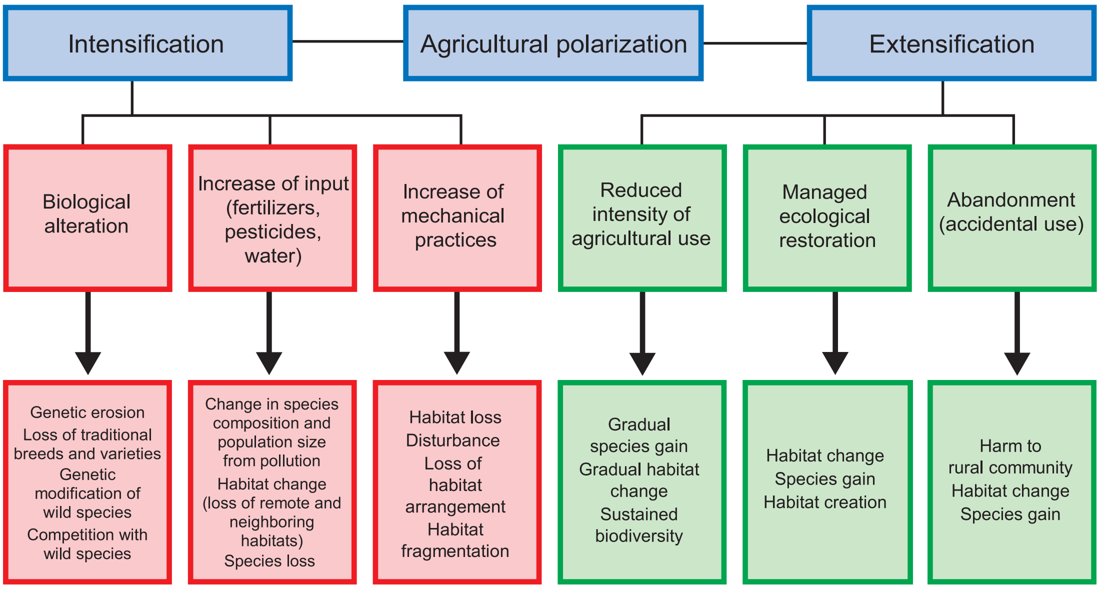
On the other hand, the "extensification" of land use (and land abandonment) is an opposite phenomenon, also driven by market forces (Figure 3.11). In recent years, many farmlands have been abandoned and become fallow in the Carpathians. The land may also be kept by the owner in a semi-abandoned state, neither formally abandoned nor cultivated, but simply kept available for future alternative use. This phenomenon can be observed on the Polish-Slovakian border and in the Romanian Carpathians, where lands are being set aside for tourism purposes (CERI 2001).

The abandonment of pasturage has particularly negative consequences for the environment. In some traditional grazing areas, cattle and sheep stocks are falling below the level required to maintain biodiversity-rich pastures and hay grasslands. Only in the Ukrainian Carpathians is the process of land abandonment limited, with farming being one of the most important responses to unemployment. Traditional agriculture and cattle breeding remain basic sources of food and fuel for local communities there.

Conversely, land abandonment had positive consequences on meadow-forest ecotone habitats, where the density and number of species increase due to the slow process of forest succession in open habitats. Following this process, forest species of high shade tolerance penetrate the ecosystem, slowly eliminating open habitat species. Such processes were observed in the Carpathians after the Second World War, when many Carpathian regions were abandoned.

Despite such tendencies, contemporary data suggest that both the processes of intensification and extensification of agriculture have overall negative impacts on the environment. In the Czech Republic, they have changed the landscape pattern and led to a decrease in landscape diversity (Lipsky 1996).

Figure 3.11 Some generalizations on the impact of agriculture on biodiversity (simplified scheme of Delbaere and Nieto-Serradilla 2004)



Traditional, extensive multi-functional small farm management is beneficial for biodiversity. Small farms and traditional farming practices are accompanied by more diverse landscapes, less intensive use of fertilizers, use of permanent meadows for hay and pasture, coppicing of trees for fuel wood, and afforestation of areas improper for agriculture (e.g. those with poor soils or steep slopes). Some traditional small farms have been converted into organic farms, particularly in the Czech Republic and Hungary. This process is supported by the EU's Common Agricultural Policy (CAP), with financial aid directed to less favourable areas and agro-environmental schemes aimed at preserving biodiversity (see Policy Measures and Responses below).

Threats and Impacts

Tourism and recreation

One major change observed in the Carpathian Mountains is the development of residential property in the countryside by urban dwellers. Such developments now occupy many scenic slopes and valleys in the Carpathians, particularly where landscape planning is weak.

New investments in tourism and recreation are currently being made in many attractive areas in the Western Carpathians. Some of these facilities are nature-friendly, such as hiking and horseback riding, while many adverse effects of mass tourism are due to motorised recreation (e.g. quad bikes) in the mountains. Overcrowded recreation areas may be found around the Tatra Mountains, Slovensky Kras or Pieniny Mountains in the Western Carpathians, as well as Retezat and Poiana Brasov in the Southern Carpathians.

Tourism attractions lead to increases in local resident populations and higher administrative status. For example, Slovak regions around the Tatra Mountains are now merged into one administrative town unit. On the Polish side of the Tatras, the small town of Zakopane has experienced a significant rise in the number of inhabitants, becoming a regional administrative centre. A similar trend of concentration of human settlements is observed in other attractive mountain areas in the Hungarian, Polish, Romanian and Slovak Carpathians.

Other pressures

In the second half of the 20th century, and particularly in the 1970s, large-scale pollution influenced habitats and species in the Western Carpathians. Heavy metal accumulation in soils and soil acidification were observed in many places. These processes influenced tree stands in large areas. A decrease in the annual increment of wood was recorded (Muzika et al. 2004), along with outbreaks of cambiophagous (wood-eating) and phyllophagous (leaf-eating) insects (Witkowski et al. 1987).

Furthermore, the development of waterworks, particularly the Czorsztyn-Sromowce Niżne hydropower station, in one of the most scenic Carpathian historical landscapes near to the Polish-Slovakian border, induced ecological effects that are still being investigated and are contested in both countries.

New highway construction through the Carpathians is also proposed. Following Romania's EU accession, EU planners suggest implementing a new trans-national highway running from Estonia through Carpathian countries to Greece (see section 3.1 for more details), which would cross the Carpathians at least twice.

Policy Measures and Responses

The Carpathians' high-quality landscapes and rich biodiversity evolved during a centuries-long process of gradual modification due to interaction between humans and nature. The resulting historical and biological heritage is one of the most vital in Europe. Carpathian peoples used their fields, meadows, pastures and forests in a sustainable way, maintaining high levels of landscape and species diversity. Their future prosperity and the preservation of mountain landscapes, habitats and species depend on the level of awareness and will to act of local communities, and the effective use of a number of available instruments.

EU directives are among existing instruments to achieve sustainable development in the region. Today, nearly 90% of the Carpathian area belongs to the EU. The EU's CAP is important for an emerging more environmentally-friendly agriculture. A crucial element of environmental policy within the CAP is Regulation No 1257/1999 including its later amendments. Within the first pillar of the CAP, which comprises traditional market support measures and new decoupled direct payments to farmers, the Agenda 2000 Reform of the CAP requires member states to take appropriate environmental measures for agricultural production. Three policy instruments are available in this context: Codes of Good Farming Practice, Environmental Cross-Compliance and Agro-Environmental Schemes (European Environment Agency 2004).

Good Farming Practices will be a precondition for implementing agro-environmental schemes and for payments to Less Favoured Areas (LFAs). The cross-compliance scheme will be optional for new EU members. The third instrument – agro-environmental schemes – is among the most promising, particularly within LFAs and Natura 2000 areas. New forms of environment-friendly production schemes, including forest cultivation schemes and maintenance of rare and vanishing species (by farmers) will be considered in the future.

These funds supporting bio- and landscape diversity are administrated by Ministries of Agriculture, while environmental management duties are under the competency of Ministries of Environment. Therefore, the proper use of funds for agro-environmental schemes supporting Natura 2000 sites, habitats and species requires close cooperation between two key ministries, along with preparation of precise management plans.

Another factor to take account of is national regulations which may support (or to the contrary neglect) mountain regions. Among the Carpathian countries, only Romania and Slovakia have specific mountain laws, geared to supporting mountain residents, their economies and environments.

The Carpathian Framework Convention is another major instrument that is devoted to the conservation and sustainable development of the Carpathian Mountains. The Convention has a particular value for Serbia and Ukraine, the only two Carpathian countries which are not EU members, as it facilitates their conducting close economic, social and environmental interactions with the Carpathian EU members.

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3.4 Mineral Resources

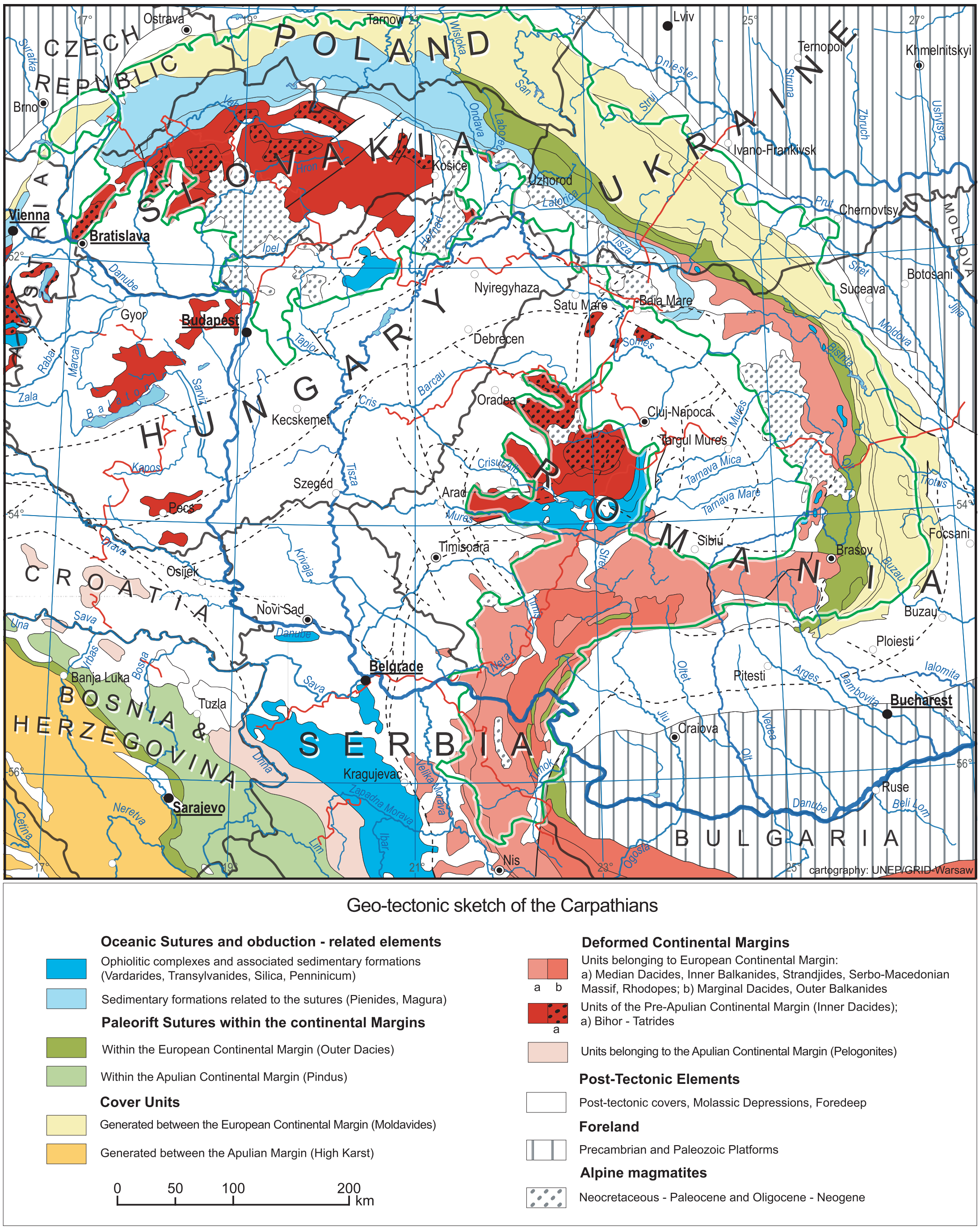
Knowledge of the origins of mineral deposits, their history and methods of exploitation help to understand how mining activities affect the environment, and impact upon local and regional ecosystems. The effects of environmental pollution have become increasingly evident as extraction techniques, transport of and manufacturing from larger volumes of ore have been developed, while waste, tailings and slag dumps produced by these activities cover substantial areas, reducing productive land and spoiling the landscape.

The first effects caused by mining sites date to antiquity, and have progressively expanded since feudal times. In the 19th century, the exploitation of industrial minerals, coal and hydrocarbons became very common, and such activities have continued to expand, but at a slower rate up to the present day. They affect nearly all of the abandoned mining areas called 'remnant pollution zones'. Under communist systems based on centrally planned economies (1950-2000), intensive, brute-force exploitation methods were used in the Carpathian region, even on deposits without economic value. As the number of processing plants and metallurgical centres increased, so did the waste, plant-released tailings and slag dumps. In the meantime, the exploration and exploitation of old, abandoned deposits situated in traditional regions was resumed, and new sites were identified in other areas, increasing overall mining activity in the region and inducing greater pollution.

After 2000, strong environmental protection measures in line with European norms were put in place. Physical changes (modifications of the land morphology and landscape) and chemical ones (soil, water and air pollution and contamination by noxious elements) have led to degraded biological conditions, sometimes inducing labour out-migration, or even abandonment of settlements. Such cumulative negative effects engendered so-called "critical environments" – habitats already modified beyond their rehabilitation capacity, or on their way to being gravely or irreversibly modified by human activity.

Mining activities seriously modify the environment, which may then no longer sustain current levels of resource exploitation; hence, human health and even lives can be jeopardized (Kasperson et al. 1995). In the last period of intensive/excessive and selective mineral exploitation, the habitats of several zones in the Carpathian region

Map 3.7 Geo-tectonic sketch of the Carpathians



were critically degraded. In time, some of the toxicity was reduced and these areas were assimilated to remnant pollution zones, where poisonous materials remained two or three times above permissible standard values. Currently, when the richest parts of ore deposits are exhausted, future exploitation projects mainly target ore deposits with low contents, exploitable in open pits. In this situation, disputes between opposing interests – mining companies versus governmental agencies and non-governmental organisations for environmental protection – may become more serious.

The Carpathian fold belt (Map 3.7) originates in Cretaceous (135-65 million years ago) and Tertiary (65-1 million years ago) tectogenetic events. Within this belt, Precambrian and Palaeozoic metamorphic and magmatic rocks, as well as Upper Palaeozoic, Mesozoic and Tertiary sedimentary rocks resulted from several crustal deformations. Magmatic activities – intrusions and extrusions – occurred in different areas during the entire Carboniferous-Neocene time span. Above the Cretaceous-folded Inner Carpathian units, two important Tertiary post-tectonic basins were formed: the Pannonian Basin and the Transylvanian Basin, which overlap the so-called 'Inner Carpathian' structures.

Within the Carpathian region, Precambrian, Palaeozoic, Mesozoic and Tertiary (including Quaternary) formations contain a large variety of mineral resources: metalliferous, radioactive and industrial mineral ores, coal and hydrocarbon deposits. The genesis of these deposits is mostly magmatic and sedimentary, but metamorphic processes are also involved. The spatial and temporal distribution of the mineral deposits is strictly connected with their origin, size and morphology (see the box below).

Typology of mineral resource occurrences in the Carpathians

Taking into account the nature and origin of mineral deposits in the Carpathian area, the following chronostratigraphical classification can be used:

Precambrian metamorphic and magmatic formations:
- metalliferous ore deposits: ferrous, base metals and gold-bearing ores: iron (Fe), manganese (Mn), copper (i+Cu), cobalt (Co), lead-zinc (Pb-Zn), gold-silver (Au-Ag);
- radioactive ore deposits: radon-thorium (Rn-Th); and
- industrial mineral deposits: graphite, cyanite, andalusite and garnet.

Palaeozoic metamorphic, magmatic and sedimentary formations
- metalliferous ore deposits: ferrous (iron – Fe, manganese – Mn, chromium – Cr, nickel – Ni, cobalt – Co), copper (Cu±Mo; Py-Cu), base metals (Cu, Pb, Zn±Py±Au-Ag±Sn) and antimony (Sb) ores;
- radioactive ore deposits: uranium (U, U-TR);
- industrial mineral deposits: feldspar, mica, quartz, pure quartz, beryl, spodumene, magnesite, talc, asbestos, barite, aragonite; and
- coal deposits: black coals.

Mesozoic magmatic and sedimentary formations
- metalliferous ore deposits: ferrous (Fe, Mn, Cr), copper (Cu+Fe, Cu+Mo) and tungsten-molybdenum (W-Mo) ores, basic metal ores (Cu, Pb, Zn) and gold-bearing ores (Au-Ag);
- radioactive ore deposits: U, U-TR;
- industrial mineral deposits: bauxite, bentonite, aragonite, glauconite, phosphates, flint clay, and prophilite; and
- coal deposits: black coals.

Tertiary magmatic and sedimentary formations
- metalliferous ore deposits: gold-bearing ores (Au-Ag; Py-Au; Pb-Zn±Au-Ag), copper-gold-bearing ores (Cu±Au-Ag±Mo), base metal ores (Cu, Pb, Zn), mercury, stibium ores (Hg±As-Py), ferrous ores (Fe, Mn) and titanium-zirconium (Ti-Zr) accumulations;
- radioactive ore deposits: U-Cu;
- industrial mineral deposits: rock salt, potash salt, anhydrite, kaolin, bentonite, diatomite, phosphates, glauconite, flint clay, alabaster and celestite;
- coal deposits: black coals, brown coal and lignite; and
- hydrocarbon-bearing rocks: bituminous clays and bituminous silicolites, clay and marls.

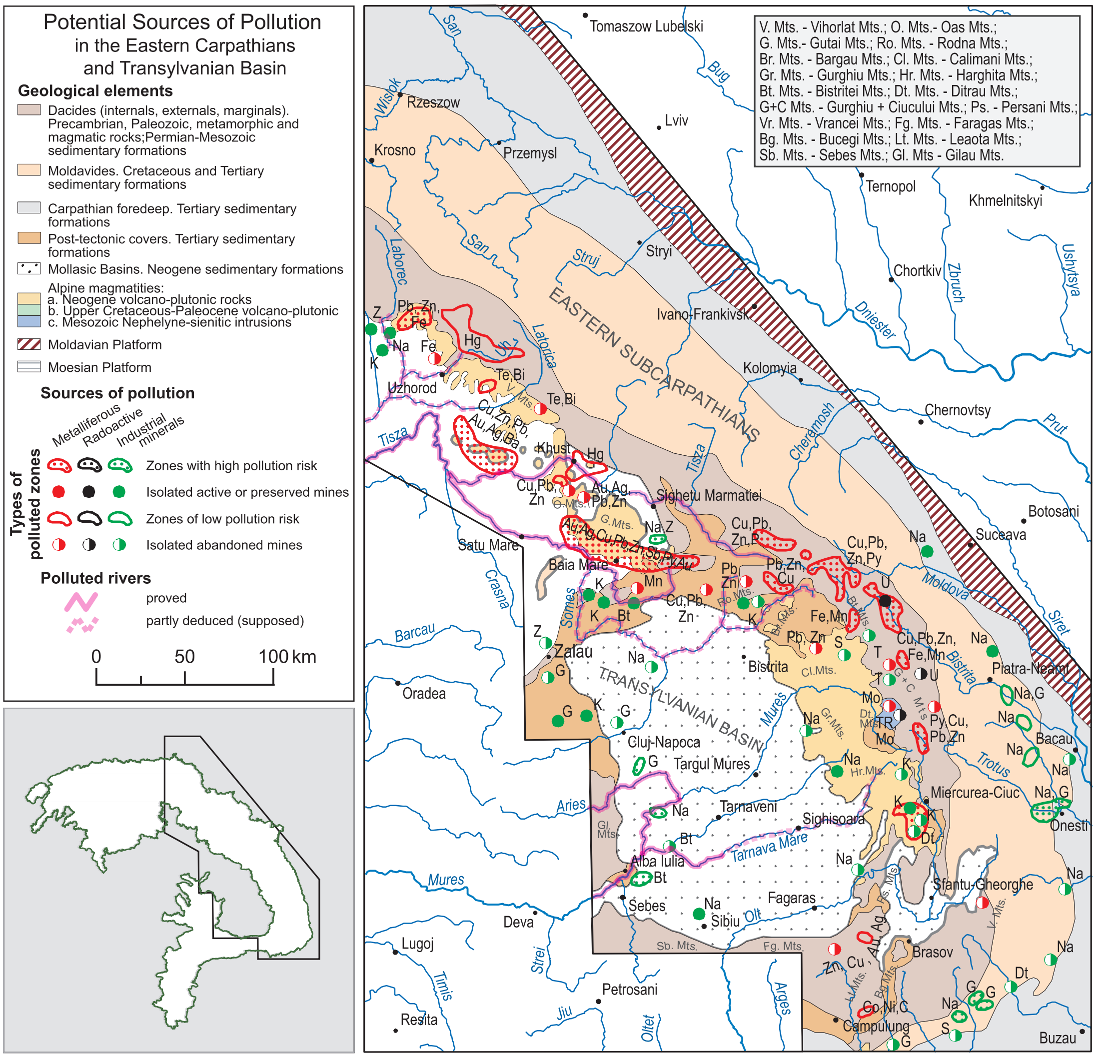
Quaternary to actual
- alluvial formations, thermal-mineral springs; and
- metalliferous ore deposits and industrial mineral deposits: gold (Au), iron (Fe), titanium (Ti), Zr±Fe, sulphur (S), boron (B), phosphorus (P), and garnet.

Some of these deposits may be identified within the major Carpathian geological units, cropping out or covered by younger formations (mine fields, districts or zones, coal basins or hydrocarbon fields). Usually, such areas show a dense agglomeration of different stages of exploration and/or exploitation. In many situations the ores have been intensely mined in their rich segments, and even depleted.

Metalliferous Ore Deposits

High pollution risk regions showing the greatest density and diversity of active pollution sources, as well as latent pollution regions, are located in the central and northwestern part of the Eastern Carpathians, western and south-central part of the Apuseni Mountains, Western Carpathians and western and southwestern parts of the Southern Carpathians. The Pannonian Basin and the Transylvanian Basin are only polluted in marginal areas. Advanced pollution may be found in regions where there is a great diversity of mineral resources, further enhanced by the activity of associated plants and particularly by the toxic effect of the resulting waste. Although after 2000

Map 3.8 Potential Sources of Pollution in the Eastern Carpathians and Transylvanian Basin

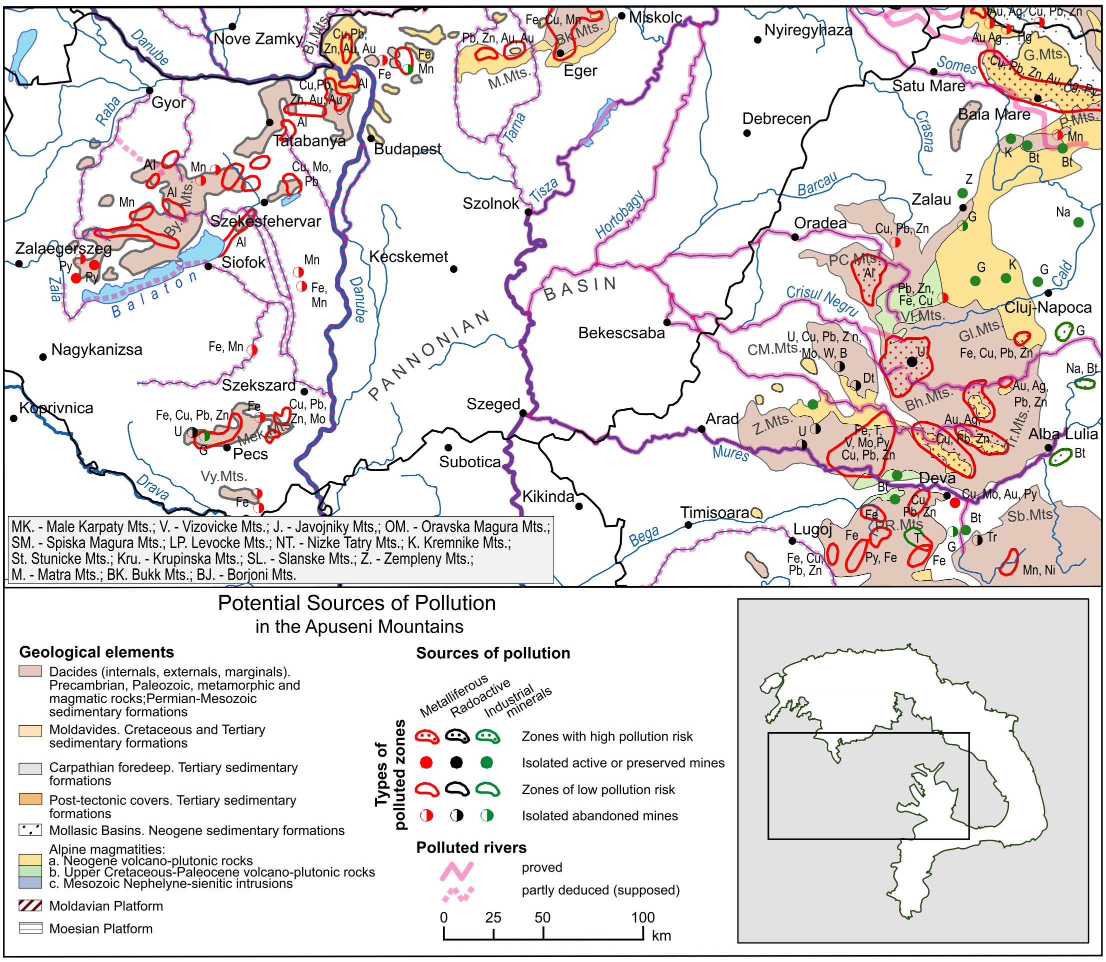


the majority of such mining sites were closed down or subject to conservation regimes, the pollution process persists, sometimes actively, because of large mining and industrial waste deposits drained by waters or carried by the wind.

Normally, evacuated acid mine waters contain micronic and sub-micronic elements, as well as metal ions (chromium, copper, manganese, nickel, zinc, uranium), calcium, barium, chlorides and sulphates in various proportions, depending on sources. Degraded wastewaters from ore dressing activities contain similar impurities – cyanides, phenols, xanthates, reagents, frothers, oil, etc. Large volumes of contaminated acid mine waters and degraded wastewaters are evacuated in streams, spreading within the respective drainage basins and having harmful consequences for the natural environment. The air surrounding the exploitations and the ore dressing and metallurgical plants is impure, with particle emissions (rock particles from extraction and ore preparation activities) and gaseous emissions produced by explosions in mining extraction works and vapours containing metal oxides from metallurgical plants. In periods of maximum activity, estimated losses were of 50-60 kg/t of lead, about 75kg/t of zinc, 60 kg/t of copper, accompanied by significant amounts of tellurium, phosphorus, mercury, cadmium and hydrogen sulphide H_2S.

The soil constitutes the main receptor of mining contamination by the infiltration of mine waters and degraded industrial wastewaters, as well as sedimentation of particles from the air, in the

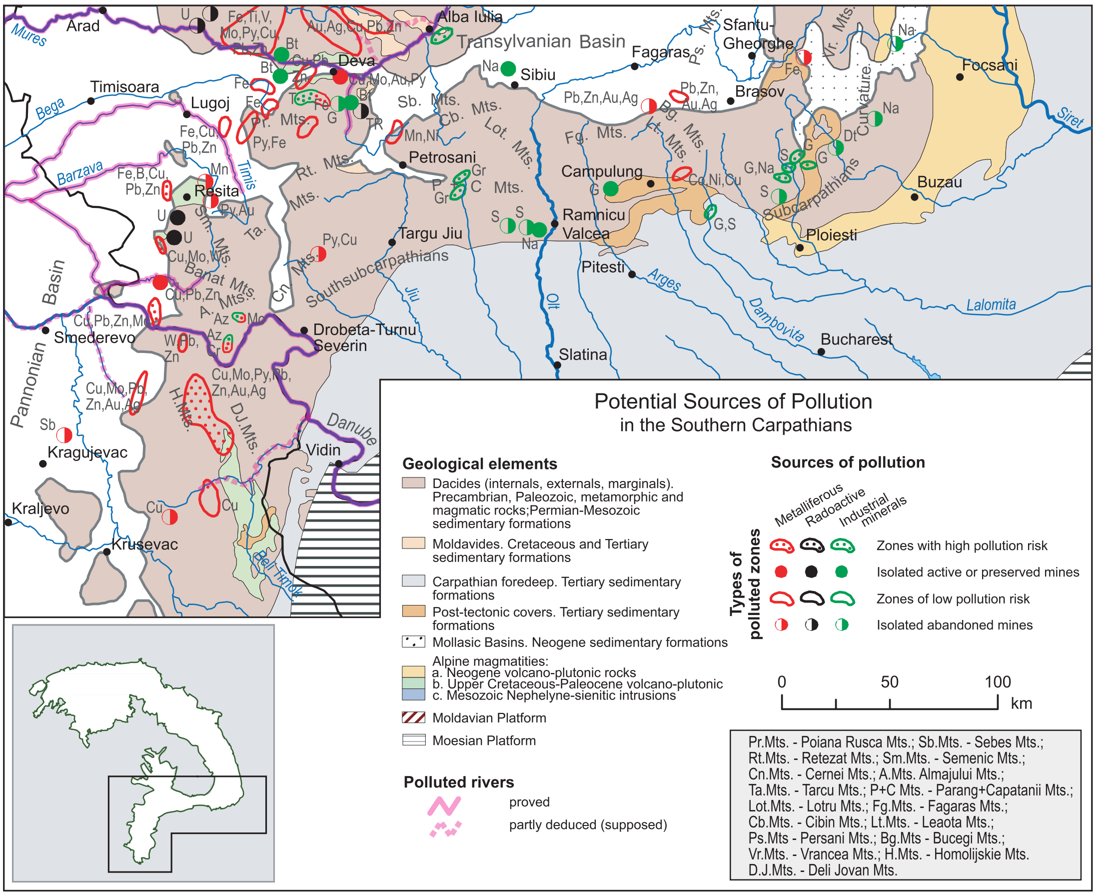
Map 3.9 Potential Sources of Pollution in the Apuseni Mountains and Pannonian Basin



form of aeolian deposits on soil, water and vegetation. These deposits increase the soil's content of highly toxic chemicals (Pb, Cu, Zn, Mn, Hg, Cr, Cd, B), especially in close proximity to manufacturing sources. Their negative effects are propagated in the associated biotope, and sometimes even in the upper levels of underground waters. Among pollutants, residual water has proven to be the most polluting agent, with the greatest transport and contamination capacity through the extended river network. The Danube River, recipient of most watercourses coming from the Carpathians, contains approximately 2-5 parts per billion (ppb) cadmium, 20 ppb copper, up to 100 ppb zinc, 50 ppb manganese, 20-51 ppb lead and 50 ppb nickel before reaching the Black Sea. These values correspond to class II-IV waters (see section 3.5 for more details).

In the Eastern Carpathians (Map 3.8), pollution is largely due to poisonous substances released by mining and industrial waste deposits that derive from predominantly poly-metallic and ferrous ores (resources in the Rodna Massif, Maramureş, Bistriţa and Giurgeu-Hăşmaş Mountains), as well as gold-bearing and poly-metallic ores from resources in the Vihorlat Mountains, Vyshcovo-Beregovo trans-Carpathian zone (where before 2002 allowed air pollution limits were often surpassed by 16 times for lead and 10 times for cadmium) and the Oaş-Gutâi Mountains. High levels of polluting substances released by mining exploitations and industrial preparation activities (such as copper, lead, zinc and cadmium) contaminate Carpathian environments. After 2002 and until the present day, the situation has slowly improved: the concentration of toxic elements (Cu, Pb, Zn, Cd, Mn, Cl and cyanides) in the Tisza's tributaries (Mureş, Someş, Tur, Latoriţa etc.) from the source area up to Miskolc rarely exceeds imposed limits (or does so only in the areas near to sources). The

Map 3.10 Potential Sources of Pollution in the Southern Carpathians

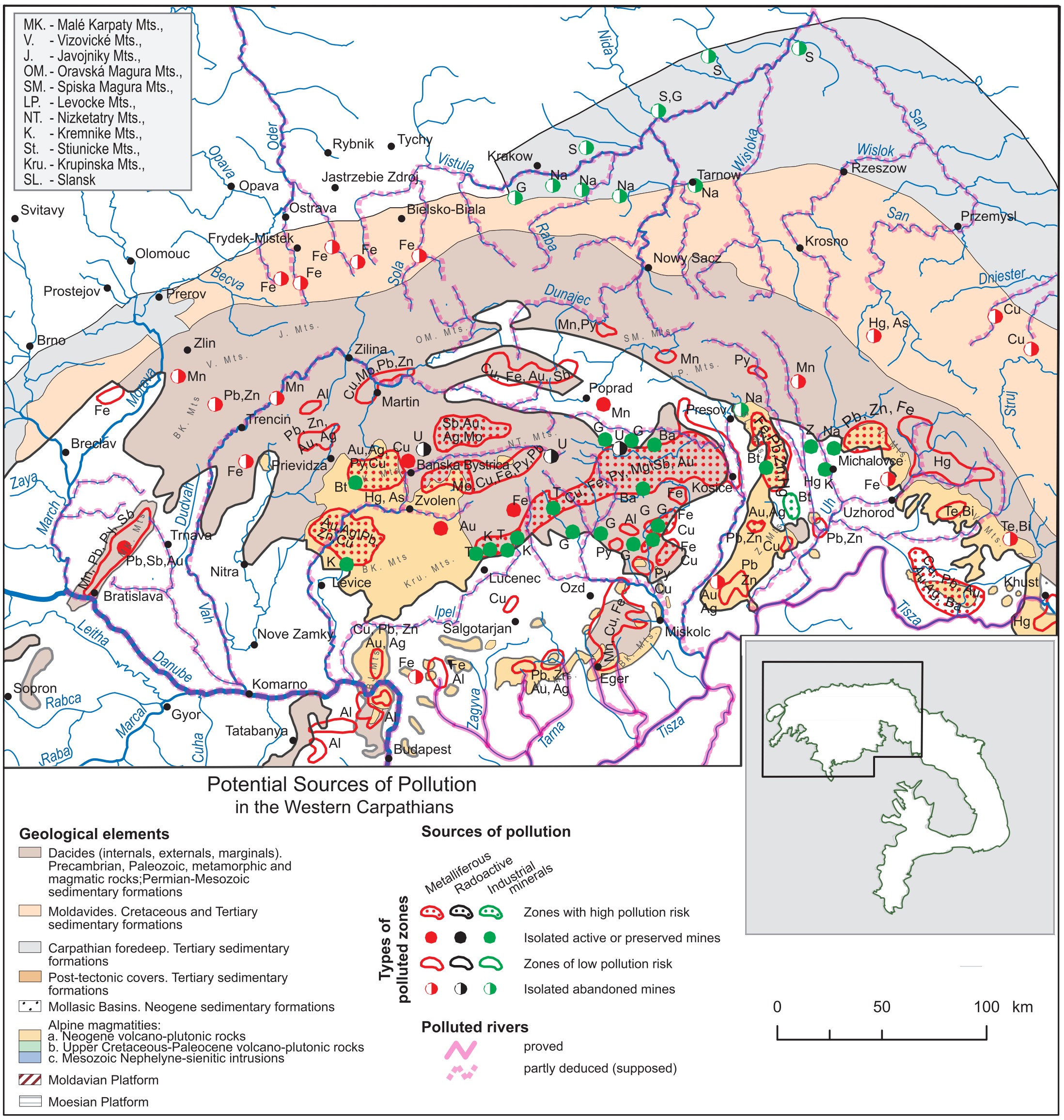


same level of pollution risk exists in the air and soil, where preparation and metallurgical plants are being operated, as in Baia Mare or Vyshcovo-Beregovo areas.

In the Apuseni Mountains (Map 3.9), the degree of pollution and its environmental effects are comparable to the ones mentioned in the Eastern Carpathians. Highly polluted regions are the gold-bearing mining districts with poly-metallic gold and copper sulphide ores in the Metaliferi Mountains and poly-metallic and uranium ores in the Bihor Massif. These areas have experienced severe environmental pressures until 2000, with lower pollution intensity nowadays. The drainage basins corresponding to the Crişul Repede, Crişul Negru, Crişul Alb and Mureş rivers show pollutant values that fluctuate within permitted limits, but appreciably higher (over twice the limit) in the vicinity of pollution sources (e.g. Zlatna was under the influence of extreme pollution levels until 2002). The Roşia Montană project of gold-bearing pyrite exploitations may represent an unprecedented risk in the mining history of the Carpathian space. There, the destructive effects of environmental degradation (morphological and landscape changes, contamination of soil, biotopes and surface and ground waters), accompanied by predictable long-term severe socio-economic consequences, are currently and in the future will be very difficult to deal with.

In general, the Southern Carpathians are less impacted by mining pollution (Map 3.10). The most polluted areas are only located in the surroundings of the Bor settlement. The main contamination sources are the mining of copper-bearing and poly-metallic ores, their industrial preparation and metallurgy, as well as resulting waste deposits. Copper-bearing exploitations of Banat, and the poly-metallic and ferrous mines at Poiana Ruscă, though nearly closed down, pollute through mining activities and industrial waste deposits; the main pollutants identified in water and soil in these areas are heavy metals,

Map 3.11 Potential Sources of Pollution in the Western Carpathians



with concentration values slightly exceeding permissible limits, and somewhat higher in the Moldova Nouă-Ciclova-Oravița zone.

The Western Carpathians (Map 3.11) represent the largest Carpathian mining region. As a consequence, numerous and vast mining and industrial waste deposits are found in the region. The type and quantitative distribution of pollution agents vary regionally. The central zone (Slovenske Metalliferous Mountains) is dominated by copper-bearing, ferrous and poly-metallic ores, along with gold, silver and antimony deposits; the eastern marginal zones (Slanske Mountains and Zemplény Mountains), and western (Krupinska Mountains, Ştiavnicke Mountains, and Kremnicke Mountains) and southern zones (Borjoni and Mátra Mountains) are characterized by the presence of gold-bearing poly-metallic deposits and gold-silver deposits. Many of these areas experienced extreme pollution levels in the 1945-2000 period. Unlike other parts of the Carpathians, this region is characterized by much larger-scale mining, along with corresponding industrial activities and significant pollution levels.

In the Pannonian Basin (Map 3.9), the Danube and Tisza Rivers, together with their tributaries (the Sarvis, Tarna, Eger, Sajó, Someş, Crişul

Repede, Crişul Negru, Mureş and Timiş) form water corridors polluted by heavy metals, cyanides and various other substances with variable contents, usually small but still beyond permissible levels. Pollution may also be significantly increased through human errors and natural events, as demonstrated by past events (e.g. the cyanide spill at Baia Mare in January 2000).

Only in some marginal mining areas and areas with industrial waste deposits resulting from bauxite preparation and metallurgy, fluoride gases and saline emissions (sulphur dioxide, tar and other detrimental powders) may exceed permissible limits and greatly affect the ecosystem. The same situation is seen on the eastern boundary of the Crişul Repede River, close to the city of Oradea, where pollution is mainly due to ore dressing waste coming from the preparation of bauxites extracted in the Pădurea Craiului Mountains (Apuseni range).

The Transylvanian Basin (Map 3.8) presents a single active pollution source, the lead/zinc metallurgy plant at Copşa Mică, with large negative impacts on the area due to important metal ion emissions. The emissions are two or three times higher than permissible limits, with noxious elements dispersing into the land, soil and water, especially the Târnava Mare River.

Radioactive Ore Deposits

The extraction and processing of uranium ores represent increased environmental pollution hazards. Air and water are vectors for rapid dissemination of radioactive elements, with a significant impact on the areas surrounding the extraction and processing works. The environment can easily be contaminated with nearly all the elements of the uranium family. In the Carpathian region, the main uranium deposits are found in the Apuseni Mountains (Bihor and Drocea massifs), Southern Carpathians (Banat Mountains) and Eastern Carpathians (Bistrița Mountains). The degree of natural uranium, radium226, radium222, radon and thorium pollution may be two or three times higher than permissible limits. Current pollution sources are primarily massive wastes dumped from old extractions, rather than current exploitations of ores and radioactive metals. According to estimations, a volume of some 5 million cubic meters of uranium material covered up to 140 hectares during 2000-2001. The contamination is perpetuated by radioactive polluted mine waters and liquid and solid radioactive wastes, as well as gas emissions with powders and aerosols released by the Feldioara preparation station. These elements represent a major source of radioactive contamination in this area, requiring permanent surveillance and mitigation/recovery activities and measures.

Industrial Mineral Deposits

With the exception of salt deposits and related preparation installations, the impact of these sources is less intense, affecting areas situated in close proximity to mining extraction and preparation sites. The exploitation of industrial mineral deposits (gypsum, bentonite, zeolite, barite, sulphur, kaolin, talc, etc.), dispersed unevenly in many parts of the Carpathian Mountains (see Maps 3.8 to 3.11), has mainly led to changes in terrain morphology due to numerous excavations, and deposits of sterile waste and removed surface material. In most cases, pollution occurs due to raw material preparation processes and complex physical and chemical methods of purification. These effects result in the accumulation of large volumes of industrial waste, with moderate impacts on soil (through waste dumps and discharges), air (with small colloidal dispersions) and water (with tailings and floating reagents). The exploitation of salt deposits can have severe consequences. The underground voids cause irregularities of the surface, sometimes associated with brine outflows that have a serious impact in the vicinity of, or within neighbouring localities. At the same time, the exploitation of salt also modifies the chemistry of groundwaters – the fluorine content of phreatic waters being up to three times higher than permissible values. Environmental pollution caused by preparation activities related to major deposits only exceeds established limits when/where accidents occur. Such situations are characteristic of salt deposits in the eastern and southern sub-Carpathian areas of the Eastern Carpathians and the peripheral zone of the Transylvanian Basin, the only regions where Carpathian salt is exploited.

Coal Deposits

Regional coal deposits are found in Upper Carboniferous formations (in the Southern Carpathians), Lower Jurassic formations (Southern Carpathians – Banat, Pannonian Basin, Apuseni Mountains), Oligocene deposits (Petroşani Graben in the Southern Carpathians, as well as in the northeastern part of the Transylvanian Basin and northern Pannonian Basin), and Neocene deposits (Southern and Eastern sub-Carpathians, as well as the Transylvanian and Pannonian basins) (see Map 3.12). The Palaeozoic, Jurassic and Palaeocene coal deposits are in some cases (e.g. in the Southern Carpathians) anthracite coal formations of small importance.

Pollution related to coal mining processes may be summarized as follows:

- important wind transport of dust generated by open quarries;
- pollution of the aquiferous levels generated in operational or closed mines;
- pollution of surface waters which may be contaminated by rain, mostly in open quarries, but also by dumps of active or closed mines;
- important changes of the landscape and relief in areas of open quarries; and
- large disturbances of roads in areas where coal transport takes place.

Hydrocarbon Fields

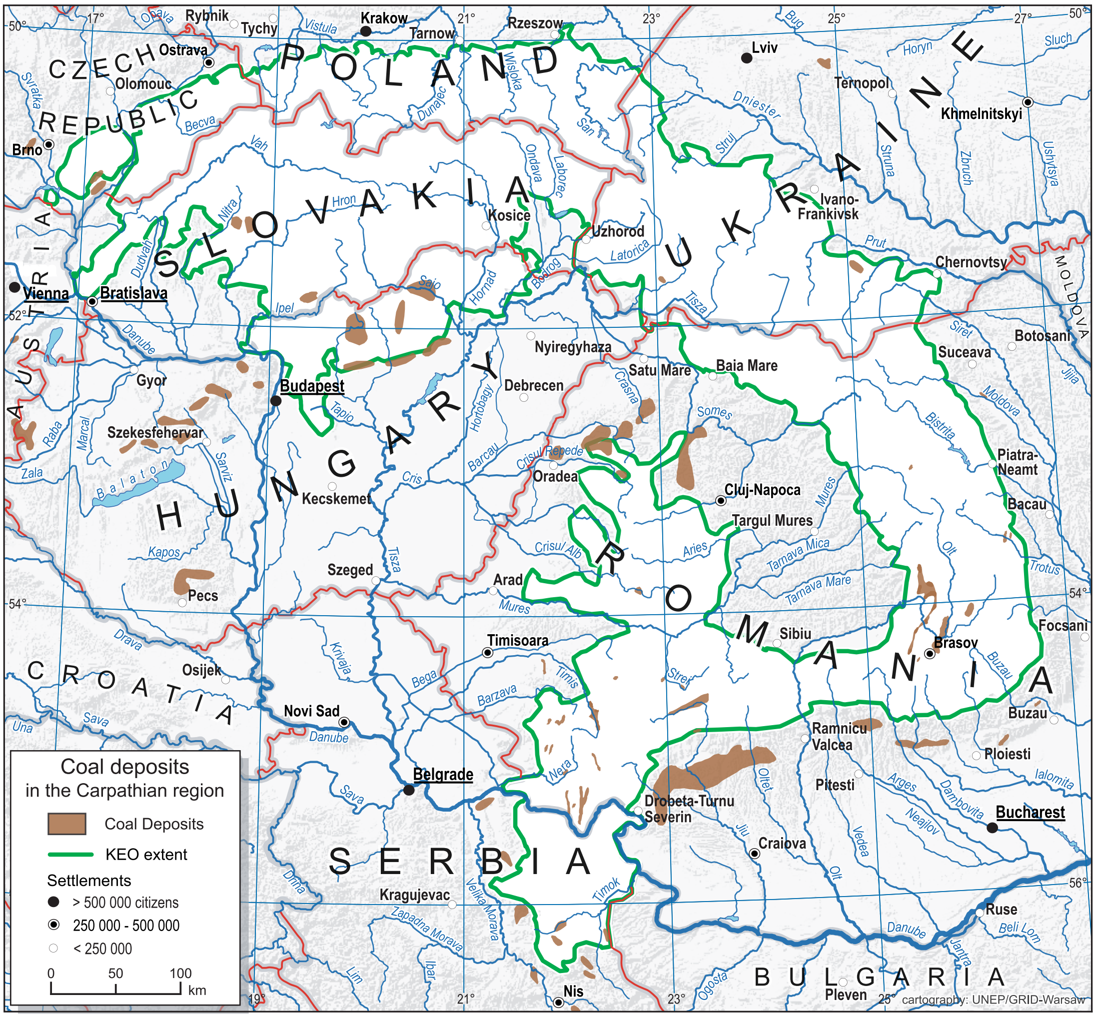
Hydrocarbon deposits are found in the Carpathian and sub-Carpathian areas in Palaeocene and Neocene formations of the Outer Eastern and Western Carpathians, Eastern and Southern sub-Carpathians, as well as in the Transylvanian Basin and the eastern part of the Pannonian Basin (see Map 3.13).

The Outer Eastern Carpathians (Moineşti area) and the Eastern (Buzău-Moreni area) and Southern (Piteşti-Târgu Jiu area) sub-Carpathians have the largest share of oil and gas fields in the Carpathians. Less important oil and gas fields are also found in the Outer Western Carpathians (Vienna Basin, Eastern Polish and Ukrainian Outer Carpathians), as well as the Eastern Pannonian Basin (in the western part of the Apuseni Mountains). The most important gas fields are in the central part of the Transylvanian Basin.

Pollution connected to the hydrocarbon deposits relates to:

- prospecting and operational drillings, in the case of technical errors;

Map 3.12 Coal Deposits in the Carpathian region

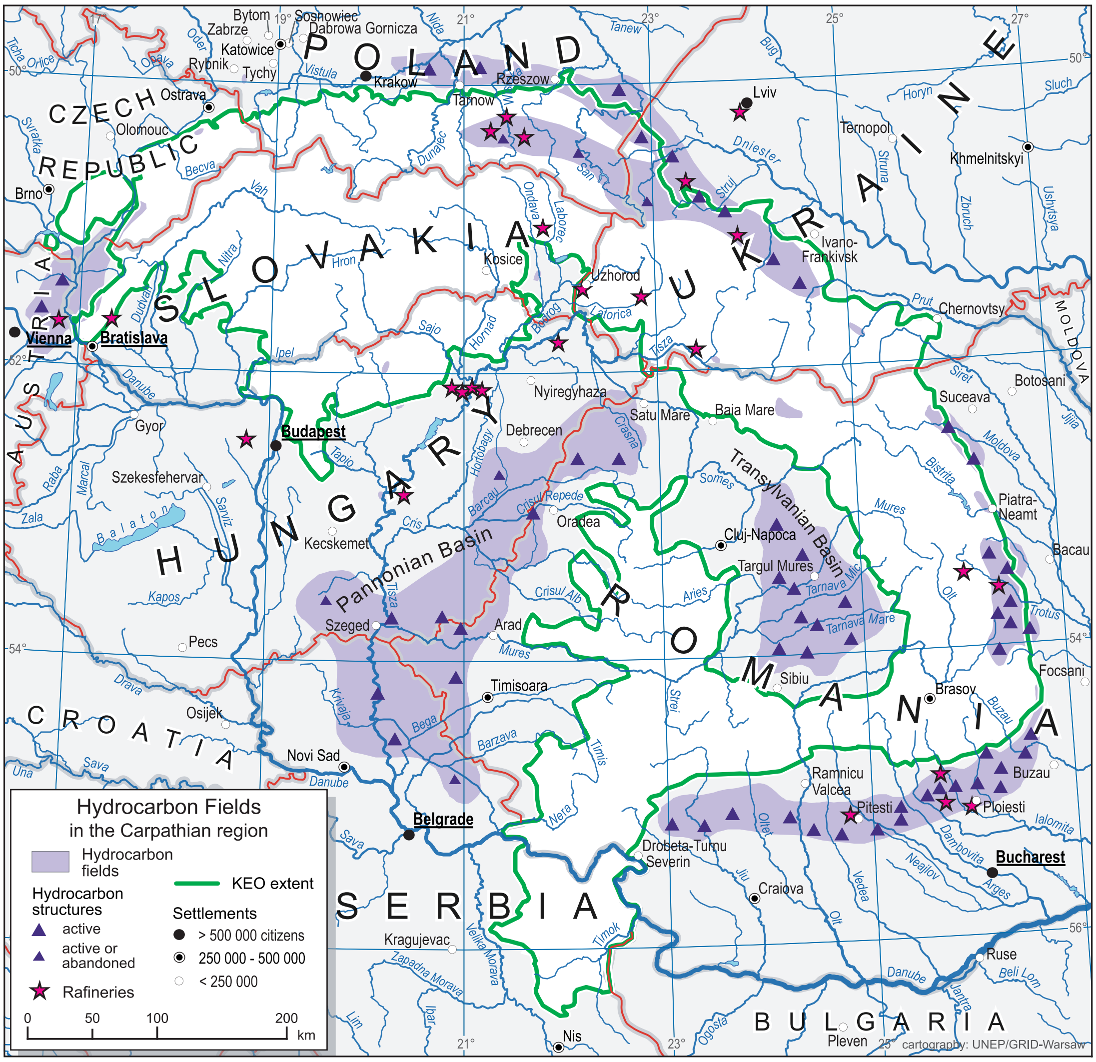


- oil processing, with the largest impact on the environment (air, soil and water);
- oil storage, which may also accidentally damage the environment;
- accidents that occur during drilling and may cause great damage to the environment (mud-slides, fires, destruction of agricultural crops and/or forests) in the case of errors; and
- accidents occurring during the transport through pipelines due to technical or human errors.

Policy Measures

The pollution of the Danube, Tisza and other rivers caused by the cyanide spill following a dam break at a tailings pond in Baia Mare, Romania, has increased public awareness of the environmental and safety hazards of mining activities. The Baia Mare accident showed that the level of public knowledge and understanding of risks inherent in mining and related industrial processes was very low in the region. It also showed that there was insufficient communication between the various levels of officialdom and between these authorities, non-governmental

Map 3.13 Hydrocarbon Fields in the Carpathian region



organisations (NGOs) and the public concerning emergency preparedness, emergency response and damage prevention options and possibilities (EC 2000).

Within the Carpathian EU member states, there are a number of existing EC legal instruments which address the environmental aspects of mining activities intended to prevent such disasters:

- Council Directive 85/337/EEC (as amended by Council Directive 97/11/EC) on the assessment of the effects of certain public and private projects on the environment requires an environmental impact assessment of a large number of economic activities, including mining activities and dams, in the case such activities are likely to have significant impacts on the environment.
- Council Directive 96/82/EC on the control of major-accident hazards involving dangerous substances (Seveso II Directive) aims at the prevention of major accidents which involve dangerous substances and the limitation of their consequences for humans and the environment.
- Directive 99/31/EC on the landfilling of waste contains a number of requirements which are relevant to waste management in connection with mining activities:
  - The location of the landfill must take into consideration the distance from groundwater or superficial water and the risk of flooding, subsidence, landslides or avalanches.
  - Appropriate measures must be taken to

control water from precipitation and prevent it from entering into the landfill body.

– The emplacement of waste on the site must be done in such a way to ensure the stability of the waste and the associated structures, particularly to avoid slippages.

- Council Directive 96/61/EC concerning integrated pollution prevention and control (IPPC Directive) covers the overall environmental impact of the production process; i.e. air, water and soil pollution, generation of process residues, etc.

Further to recent mining accidents, including the cyanide spill at Baia Mare, the Directive 2006/21/EC on the management of waste from extractive industries was adopted to prevent adverse effects on the environment, in particular water, air, soil, fauna and flora and landscapes, and any resultant risks to human health brought about as a result of the management of waste from mining activities, and to minimise the risk of accidents.

Conclusions

Qualitative and quantitative analyses of environmental pollution due to mining activities in the Carpathians show that the region faces serious problems and potential dangers, primarily due to the toxic action of mine wastes from old and currently active mines, mine tailing dam failures, dumps and tailing dams and ponds, slag dumps from metal smelting plants and tailings from oil and gas refining. Industrial activities related to the extraction and preparation of mineral resources produce large volumes of pollutants of various types, susceptible to rapid dispersion across the region, and dissemination in watercourses, air and soil. Natural disasters and technological accidents may also trigger unprecedented consequences for the environment.

The mining sector is an important contributor to local and national economies in the Carpathian countries, but is often characterised by inappropriate planning, and operational and post-operational practices taking place within inadequate regulatory frameworks. A set of key measures could be developed and applied under a programme convened and monitored by a common body for the entire Carpathian region. Such a regional-scale programme could involve the following steps:

- Preparation of a cadastral inventory, periodically updated, of all the mentioned storage site failures, supplying information on the location, size, volume, composition, stability and risks posed by these deposits.
- Periodic preparation and publication of special maps (scale 1: 1000000), mandatory for all Carpathian countries, marking the types of mineral resource accumulations (with operational activity stages), as well as mining and plant failures.
- Stimulation of scientific and technological research in order to neutralise pollution sources and rehabilitate environmental factors through:
  - Increasing the stability and compactness of dumps and tailings by physical and chemical procedures, by vegetation or other methods;
  - Processing of dumps and tailing failures with a view to recovering useful elements and substances (copper, lead, zinc, iron, titanium, tungsten, chromium, nickel, gold, silver, mercury, arsenic etc.), along with minor elements (cadmium, indium, gallium, germanium) and industrial minerals (feldspar, quartz, garnets, boron, etc.);
  - Decontamination of residual mine waters;
  - Reduction of pollution from ore metallurgy.
- Promotion of environmental rehabilitation through:
  - Converting abandoned waste deposits and quarries into useful land uses (for agriculture, forestry, fisheries, septic pockets, industrial and residential areas, cultural and recreational areas and even tourist attractions).
- Prevention of mining pollution through:
  - Review and improvement of environmental protection laws and their implementation in the Carpathian countries;
  - Involvement of specialized institutions and

research centres as consultants in technical-scientific decision-making;

o Adoption of special protection measures for subterranean aquifers, with a view to present and potential climatic conditions and future length of drought episodes; and

o Organisation of a monitoring network (similar to the meteorological one) for high-pollution risk zones, with surveillance points to periodically check water, soil and air pollution levels and/or in cases of natural disasters.

3.5 Water Resources

In the Carpathians, water resources are a key factor for development, in particular for agriculture, fisheries, industry and power generation, tourism and direct human consumption. Favourable climatic and hydro-geological conditions offer plentiful fresh water resources supporting fundamental needs of human well-being and natural life in the Carpathian region, as well as in adjacent areas.

This section deals with qualitative and quantitative water resource availability and use, although for the latter very limited data exist, particularly on the Carpathian region alone.

Herein, the method used to establish overall water balance is based on long-term measurements of rainfall and evapotranspiration values and on the assessment of surface and groundwater runoff. Surface water resources are usually computed by measuring or assessing the total annual river flow of a country. The groundwater part of the water balance has been quantified on the basis of hydrographic separation, lysimeter measurements and river runoff analysis. There is an overlap in the volume of water resources common to both surface and groundwater. Two types of exchanges produce this overlap: the contribution of aquifers to surface flow and the recharge of aquifers by surface runoff (see Table 3.7).

Main Quantitative Data on Surface Waters

Due to the difficulty to divide the groundwater component of each geographical sub-unit (mountains, hills and plains), national water balances for the seven Carpathian countries are synthesized in Table 3.7. For evaluating Carpathians' river resources (row 3 in Table 3.7), the mountainous area (km^2) of each country was multiplied by the surface runoff modulus (specific water renewal yield; liter per second (l/s) × km^2).

Table 3.7 Main quantitative data on water resources in the Carpathian countries (average annual values 1977-2001)

Characteristics	Czech Republic	Poland	Slovakia	Hungary	Ukraine	Romania	Serbia
Internal renewable resources, m^3/year	13	66	15	12	70	50	45
Surface water produced internally, km^3/year	13	53	13	6	50	42	42
Surface resource in the Carpathians, cubic km/year	1.5	5.0	12.2	1.8	5.7	23.3	2.1
Groundwater recharge, cubic km/year	1	13	2	6	20	8	3
Overlap, cubic km/year	1	12	2	6	17	8	1
Total internal renewable resources (TIRR) cubic km/year	13	54	13	6	53	42	44
TIRR per capita[1], cubic meters	1,283	1,391	2,330	608	1,091	1, 894	4,182
Natural renewable resources (NRWR), cubic km/year	13	62	50	104	140	212	209
NRWR per capita[2], cubic meters	1,283	1,598	9,265	10, 541	2,868	9,486	19,815
Total water withdrawals, cubic km	2.7	12.3	1.8	6.8	26.0	26.0	13.0
Withdrawals (%) of actual resources	20,7	20.1	3.6	6.3	17.4	12.0	6.2

Source: earthtrends.wri.org/pdf library/country profiles
1. At the level of 2001. 2. Using national population data for 2002.

Surface water resources in the Carpathians total 51.6 cubic km/year, the national breakdown of which is 1.5 in the Czech Republic, 1.8 in Hungary, 5.0 in Poland, 23.3 in Romania, 2.1 in Serbia, 12.2 in Slovakia and 5.7 in Ukraine).

Main Surface Rivers and Reservoirs

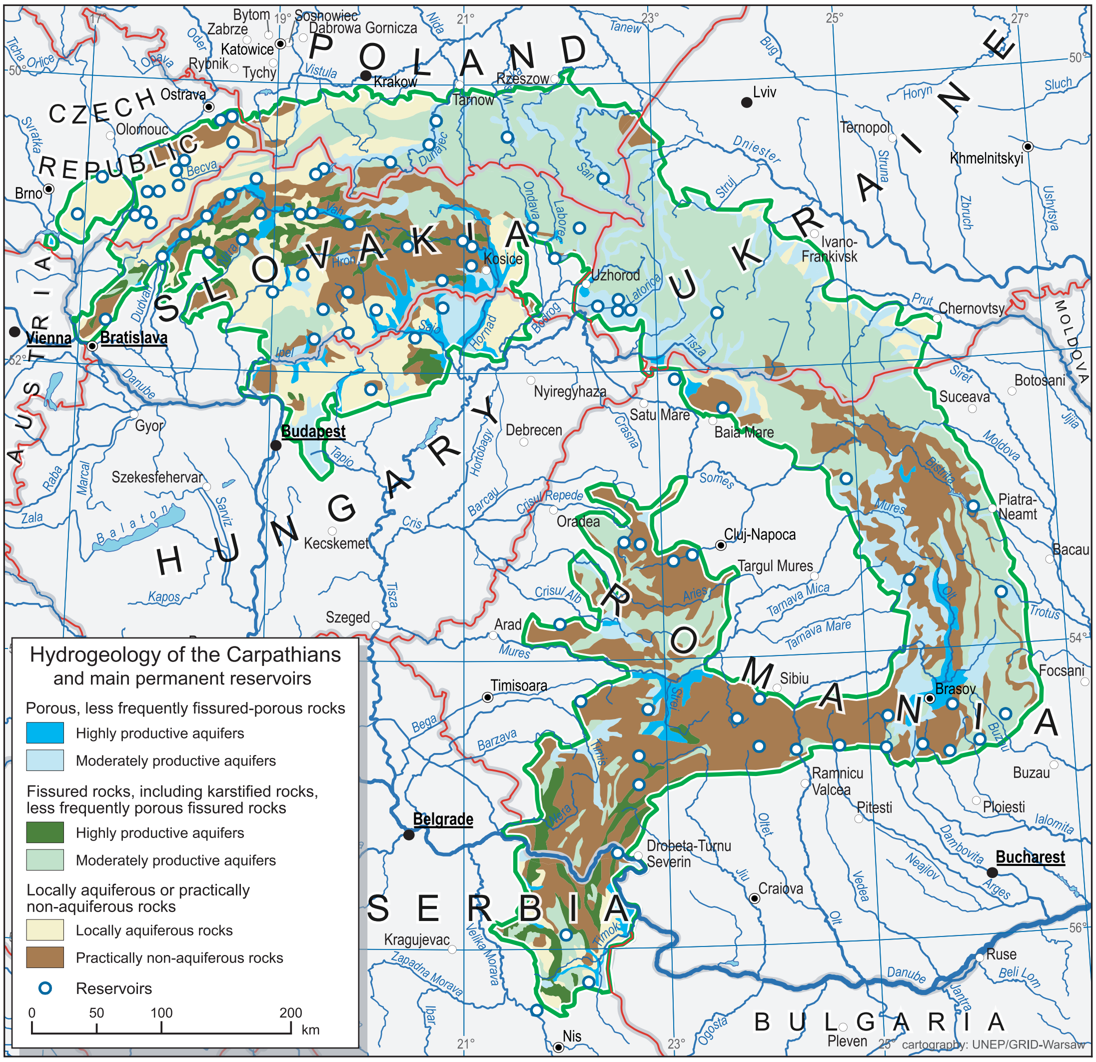
The major Carpathian tributaries of the Upper Danube Basin are the Morava River with the Dyje River on its right-hand side (Pasoi 2004). The total volume of nine permanent reservoirs in the Czech Republic is 0.045 km^3 (see Map 3.14).

The major Carpathian tributaries of the Middle Danube Basin are the Váh, Hron, Ipel' and Tisza (the largest tributary of all) and Južna Morava (on Serbian territory). The total amount of 33 permanent reservoirs pertaining to Slovakia is 1.84 km^3. In Hungary's Carpathian sector, there are only three permanent reservoirs (0.02 km^3). Ukraine has five reservoirs on the right-hand side tributaries of the Tisza (0.052 km^3).

The Lower Danube Basin contains the following Carpathian rivers: the Timok, Jiu, Olt, Argeş, Ialomiţa and, most importantly, the Siret and the Prut. Portile de Fier I – Iron Gate I and Portile de Fier II- Iron Gate II reservoirs (on the Danube River, shared by Romania and Serbia) have a total volume of 2.9 km^3 and 1 km^3 respectively, and were built mainly for energy production and navigation purposes.

In the Carpathian sector, Serbia has only three permanent reservoirs, Bovan, Grlište and Borsko Jezero, totalling a volume of 0.73 km^3 water. In Romania's Carpathian territory, 30 permanent reservoirs add up to 4 km^3 water. Situated in the

Map 3.14 Hydrogeology of the Carpathians and main permanent reservoirs (simplified map)



hilly and mountainous part of the Carpathian chain, the mean multi-annual discharge of the Danube's tributaries in Slovakia ranges from 21 to 170 m^3/s. In Hungary, situated in the lowest part of the Carpathian Basin, mostly lowland plains prevail. Rivers enter the country from the west, north and east and drain towards the south. Given this abundance and thanks to the state's efforts, the level of public drinking water supply has reached the highest feasible rate; 98% of the population receives piped drinking water. In Romania, about 4,100 inland rivers are classified in the Water Cadastre. The major source areas for groundwater recharge are found in the higher parts of the inner-basin mountain range, richer in precipitation than the adjacent units. The estimated surface water resources are of ca 656 m^3/s (207 billion m^3/year), of which only 37 billion m^3/year come from internal rivers; the difference is attributed to the Danube River (170 billion m^3/year). Of all the registered waterways, only some 1,200 rivers include reservoirs. The 70 largest reservoirs (each having more than 5-10 million m^3) have a total volume of approximately 11 billion m^3.

Main quantitative data on groundwater resources

The age of rocks and tectonic activities control the degree of diagenesis[4] and the relationship between inter-granular and fissure porosity of rocks, determining transmissivity rate, from more than 1,000 m²/day to less than 0.1 m²/day (Krásný 2002). According to permeability and dominant flow characteristics, the natural associations of rocks were classified into three different hydrogeological units, refined in six classes on the basis of their productivity (in l/s/m).

For a semi-quantitative outline of the Carpathian groundwater resources (see Map 3.14), the information supplied by the "Warsaw", "Budapest" and "Bucharest" Hydrogeological Sheets, scale 1:1 500 000, was processed using the Gilbrich et al. (2000) criteria. Using the Guide of the International Association of Hydrogeologists (Struckmeier and Margat 1994) for the mapping of underlying rocks according to their capacity to transmit and/or store water, six classes of formations were separated (Table 3.8).

1. The first class of "porous rocks having highly productive aquifers" represents some 44% of the total area in Slovakia (along the Uh, Ondava, Latorica, Hornad, Nitra and Vah floodplains) and only 27.85% in Romania (due to multi-aquifer systems of intra-mountainous Ciuc, Braşov, Petroşani Basins infill).

2. The second class of "porous rocks having moderately productive aquifers" are preponderant in Ukraine (26.38%) and Romania (38.64%). In Hungary, Romania, Slovakia and Ukraine

[4] Diagenesis is the physical, chemical or biological alteration of sediments into sedimentary rock at relatively low temperatures and pressures that can result in changes to the rock's original mineralogy and texture.

[5] Data were computed as follows: simplification of the Hydrogeological Map and conversion of the rock-water features into six hydro-lithological units (according to Struckmeier and Margat 1995); computation of the areas (km²) of each unit/class for each country and total Carpathian surface occupied by each unit.

Table 3.8 Surfaces (km²) and percentages for the six main types of aquifer formations[5]

Country	I. Porous, less frequently fissured-porous rocks		II. Fissured rocks, including karstfied rocks,		III. Locally aquiferous or practically non-aquiferous rocks	
	Highly productive aquifers	Moderate productive aquifers	Highly productive aquifers	Moderate productive aquifers	Locally aquifers	Practically non-aquifers
Czech Rep.	130	202	0	0	5,277	1,195
%	1.32	0.91	0	0	19.49	2.14
Poland	0	3,006	0	11,643	3,055	1,202
%	0	13.57	0	19.15	11.28	2.16
Ukraine	323	5,838	0	17,882	1,364	624
%	3.28	26.38	0	29.43	5.04	1.13
Slovakia	4,330	1,463	3,220	7,952	9,926	11,677
%	43.97	6.61	41.71	13.08	36.67	20.94
Hungary	1,474	2,678	366	21	4,481	863
%	14.97	12.09	4.74	0.03	16.56	1.54
Romania	2,742	8,554	1,938	21,022	1,204	38,317
%	27.85	38.64	25.11	36.08	4.45	68.73
Serbia	847	397	2,195	1,335	1,763	1,876
%	8.61	1.79	28.43	2.19	6.51	3.36
Total km²	9,846 km²	22,138	7,719 km²	59,855	27,070	55,754
Weighted	5.39%	12.14%	4.24%	32.82%	14.84%	30.57%

these aquifers are hosted in volcano-sedimentary formations.

3. "Fissured rocks, including karstified rocks, having highly productive aquifers" are frequently found in Slovakia (41.71%), Serbia (28.43%) and Romania (25.11%).

4. The class of "fissured rocks, including karstified rocks, having moderately productive aquifers" are found in flysch formations largely developed in Romania (36.08%), Ukraine (29.43%) and Poland (19.15%). Some of the main springs are bottled as curative/medicinal waters (Slănic Moldova, Poiana etc) or used as carbonate-sparkling waters for spa cures.

5. The class of "locally aquiferous, porous or fissured rocks" representing 36.67% of the total area in Slovakia, and 19.49% in the Czech Republic, corresponds mainly to areas with pyroclastic rocks.

6. As column 6 of Table 3.8 indicates, "practically non-aquiferous rocks" are found in over 30.57% of the Carpathian region. In fact, one-third of the Carpathian area is occupied by crystalline and magmatic rocks. Their permeability typically decreases with depth. These formations are extensively developed in the Eastern and Southern Carpathians, and are mainly found in Romania (68.73%).

Table 3.9 Weighted (%) main types of formations compared with the total surface area (km^2) of each country (data derived from Table 3.8)

Country	I. Porous, less frequently fissured-porous rocks		II. Fissured rocks, including karstfied rocks,		III. Locally aquiferous or practically non-aquiferous	
	Highly productive aquifers	Moderately productive aquifers	Highly productive aquifers	Moderately productive aquifers	Locally aquifers	Practically non-aquifers
Czech Rep.	130	202	0	0	5,277	1,195
%	1.89	2.97	0	0	77.57	17.57
Poland	0	3,006	0	11,643	3,055	1,202
%	0	15.90	0	61.58	16.17	6.35
Ukraine	323	5,838	0	17,882	1,364	624
%	1.24	22.43	0	68.70	5.23	2.40
Slovakia	4,330	1,463	3,220	7,952	9,926	11,677
%	11.22	3.81	8.35	20.62	25.73	30.27
Hungary	1,474	2,678	366	21	4,481	863
%	14.92	27.09	3.71	0.22	45.33	8.73
Romania	2,742	8,554	1,938	21,022	1,204	38,317
%	3.71	11.59	2.62	28.49	1.64	51.93
Serbia	847	397	2,195	1,335	1,763	1,876
%	10.07	4.72	26.08	15.86	20.95	22.30

Water Availability and Use

The difference between Total Internal Renewable Resources (row 6 of Table 3.7) and Total Water Withdrawals (row 10) was analysed and weighted for each Carpathian country. Results show that only 3.6% (Slovakia), 6.2% (Serbia), 6.3% (Hungary), 12.0% (Romania), 17.4% (Ukraine) and 20.1% (Poland) of the water resources available are currently being used. Freshwater is thus abundantly available, particularly in the mountain areas.

Table 3.10 Relationship between climatic and hypsometric conditions and groundwater runoff (according to Krásný, 2002)

Morphological (hypsometric) unit	Approximate elevation (m asl)	Mean annual precipitation (mm)	Mean annual evapotranspiration (estimation, mm)	Groundwater resources (l/s/km^2)
Mountains	1,200-1,600	1,000-1,200	450	10-15
Lower mountains	800-1,200	800-1,000		7-10
Piedmont areas	300-800	600-800		3-7
Flat areas	< 300	500-600	650	1-3

In the Carpathian region, climatic and hydrogeological conditions favour an adequate replenishment potential. Groundwater in the Carpathian region is extracted mostly from porous (intergranular) and karstic aquifers. Over 80% of human water consumption in the Carpathians is supplied by groundwater. In some catchments, and in the vicinity of mountain peaks, the long-term specific groundwater runoff from hard rock areas reaches values of 15 l/s/km^2. With decreasing elevation (see Table 3.10), and mostly due to decreasing precipitation, the rate of groundwater runoff generally diminishes to 1-2 l/s/km^2.

There are four main types of water supply: groundwater tapping from Quaternary sediments (mostly alluvium), karstic spring water tapping, surface water use from reservoirs or directly from stream water, and combined systems.

Using the general water balance formula (considering mean yearly rainfall, volume of river runoff, evapotranspiration and intakes values), Romania has approximately 385 m^3/s of groundwater resources. Exploitable resources, determined on the basis of quality, and technical and economic criteria, add up to a total of 304.9 m^3/s (Bretotean 2002), of which some 149.4 m^3/s (4.7 billion m^3/year) pertain to phreatic waters and 155.5 m^3/s (4.9 billion m^3/year) to confined waters. Groundwater tapping consists of over 800 intakes, where supply is about 90 m^3/s through over 1000 wells, 55 catchment lines and 70 spring sources (Cineti 1992). In Slovakia, due to different natural conditions and constraints, the reservoirs built on 21 streams are important drinking and industrial water suppliers. Their total mean discharge is about 3,037 m^3/s (Pasoi 2004). On Ukrainian territory, total available renewable water resources total 53 km^3/year (2.610 l/day/capita) with the following structure: 62% incoming waters; 14% groundwater recharge and 36% surface water produced internally (FAO Aquastat).

Unfortunately, only limited data exist on sectoral water use within the Carpathian region. FAO Aquastat provides data on sectoral water consumption for only five Carpathian countries (the Czech Republic, Hungary, Poland, Romania and Ukraine). In 2000, the highest water consumption level was reported for industry and power generation, ranging between 34 and 57% of total water withdrawals, households consumed 9-41% and agriculture 2-57%.

Natural mineral water is an ecologically pure product inducing beneficial health effects due to its composition. According to the EC Directive 80/777, the main criteria used for defining natural mineral water refer to its original purity and adequate protection against any pollution hazard. In the Carpathians, mineral water consumption is an old tradition. The geological setting and the existence of unpolluted areas favoured the development of mineral water sources of an outstanding quality, many of which also include carbon dioxide in a natural state.

Surface and Groundwater Quality: Eutrophication

Surface water quality

The main physical and chemical indicators determining the chemistry of surface waters are the following: transparency, temperature, pH, dissolved oxygen, organic substances, biochemical consumption of oxygen, total suspensions, sodium, calcium, magnesium and steady residuum. In addition, heavy metals are also included in monitoring programmes. The common sources of water pollution are industrial wastewater, solid waste dumps and residues from the processing of mining ore and smelting operations. For instance, in the Northern Carpathians (Spišsa Novovesko, Smolnik and Banská Štiavnica mining areas), river waters have pH values of 2-3 and concentrations of 15 – 50 gl^{-1} dissolved salt (Hudacek 1999, Šotnik et al. 2002).

In the southernmost portion of Carpathians (Bor – Serbia), after the destruction of the Bor base ores processing plant in 1999, the "Joint Danube Survey Initiative" identified very high concentrations of copper, zinc and lead, as well as excessive cadmium values along the Timok River (Dobre, 2005). Most of the main rivers are polluted downstream of urban centres, mainly by organic slumps and heavy metals. But the main form of contamination is diffuse pollution from agriculture.

After 1991, as a result of pollution reduction measures, the percentage of "good-quality" rivers increased significantly in the Carpathians (for example from 40.5 to 65% in the Romanian Carpathians). Seepages from agricultural terrains are responsible for most of the polluting elements identified in lakes and rivers: 60-70% nitrogen, 40-50% phosphorus (Ackermann 1994). By excessive enrichment of soils with nitrogen, phosphorus and ammonia, the eutrophication process is favoured.

At its entry point to Romania, the Danube's water is of quality class II in terms of nitrate and phosphate content (see Table 3.11). In comparison with current agricultural schemes in Romania, the upstream Danubian countries administer much higher concentrations of fertilizers per hectare. At the entrance point (Bazias), approximately 80% of nitrogen substances and 70% of phosphates come from upstream sources. In the 1989-1990 interval alone, the Danube carried 40 kilotons of phosphates and 500 kilotons of nitrogen to the Black Sea (ten times more than in 1960; Tomescu 1999). Every year the Danube carries to the Black Sea approximately 1,000 t of chromium, 900 t of copper, 60 t of mercury, 4500 t of lead, 600 t of zinc and over 50,000 t of oil products (Jelev 1999).

Table 3.11 River Water Quality – main classes (Serban and Galie 2006)

Rank Quality mark Country, year	I Good %	II Moderate %	III Satisfactory %	IV Degraded %
Poland, 1990	10	33	29	28
Czech Rep., 1990	12	33	27	28
Romania, 1990	40	28	11	21
Romania, 2003	65	23	6	6

The overall length of river courses with a minimal ecological water discharge level is 120,000 km. Because only 48% of the waters being used by the population are treated, many rivers are polluted by urban refuse. Using as a reference the monitoring of the 20,500 km of water courses in Romania, only 55% are class I rivers, and therefore available for water supply if purified. Unfortunately, these river sections occur in mountainous areas, far away from the main demand. Class II rivers represent 26% and are used only for fisheries with species less sensitive than the salmon. Class III rivers (8%) are used for irrigation, industrial cooling installations, car washing and hydropower plants and class IV (11%) are extremely polluted waters without fauna (Document of Common Strategy, European Union and Romanian Government for Environment Protection 2005). The main polluted rivers in Romania are the Siret (80% of its length), Ialomita (58%), Olt (24%) and Someş (24%).

Groundwater quality

Generally, the Carpathians are situated in recharge areas, having potable waters of bicarbonate, calcium and/or magnesium types. The main chemical processes are the decomposition of silicates and dissolution of carbonates, sulphides, sulphates, iron and manganese oxides among others. However, some cases of nitrate pollution have been identified within the intra-mountainous basins (Radescu & Dragusin 2004). Additionally, due to the decomposition of boron nitrate from phreatic aquifers, natural pollution in the Eastern Carpathians moffete aureole exceeds the screening value of the EU Directive 80/777 for boron (32%) and ammonia (17,5%) (Lupescu 2004). Special studies must be undertaken for arsenium-rich pirites (Hunedoara, Arad and Suceava counties) and low-pH rivers which are favourable to enrichment with radioactive substances crossing granite massifs.

The Programme for Action for Environment Protection in Central and Eastern Europe 1994 shows that the aluminium content of the first meter of phreatic groundwater is as high as 0.2-2.0 mg/l in some places of the Carpathian chain. An increasing number of negative ecological impacts and hydrological disasters (major reductions in groundwater levels associated with mining subsidence, serious deterioration of groundwater quality among other reasons) indicate the urgency for protection of water resources.

Policy Measures and Responses

The Carpathian countries have full rights and duties within the EEA's European Environment Information and Observation Network (EIONET). One of the main EIONET components is EUROWATERNET, which provides qualitative and quantitative data on surface and ground waters. The following Environmental Quality Standards are applied within Carpathian EU member states: 75/440/EEC – Surface Water for Potabilisation, 76/160/EEC – Quality Water for Bathing, 78/659/EEC – Water Quality Protection and Improvement for Fish, 79/923/EEC – Water Quality for Molluscs, and 98/83/EEC Directive – Water Quality for Human Consumption (Şerban and Gălie 2006). Furthermore, the Directive 2000/60/EC establishing a framework for Community action in the field of water policy lays down the basic principles of sustainable water policy in the EU. The Water Framework Directive also provides incentives for integrating the protection and sustainable management of water into other policy areas such as energy, transport, agriculture, fisheries, regional policy and tourism.

At the regional level, a "Central and Eastern European Network of Basin Organizations" was founded following a Romanian proposal in February 2002. It promotes the integrated management of water resources in each hydrographic basin as an essential tool of sustainable development. An ecological approach to the environment, protection of water resources, determination of usage constraints and environment-friendly uses are the main points for future action. It is necessary to establish a hydro-ecological database in the form of an environmental information system, focusing on the present state of available water resources, their exploitation and the ecological situation of specific regions.

In all Carpathian countries, water management will face great challenges due to economic transition and privatisation of the public sector, as well as current socio-economic developments and human lifestyle tendencies in the Carpathians. Currently, the consumption of drinking water tends to decline in many countries of the region as a result of the transition in the industrial sector, measures to maintain the water infrastructure, and improved public awareness through education and advertisement of the necessity to rationalize consumption.

The adequate management of water resources and the corresponding policy should be based on ensuring safe drinking water supply; preventing the further deterioration of water sources; protecting freshwater ecosystems; and using both ground and surface waters, artificially regulated in a sustainable manner.

Global climate change will profoundly affect hydrological systems. The management of surface- and groundwater will thus face new challenges in fulfilling not only the common objectives of securing water supplies, but also improving and protecting ecological health, while having to cope with greater climatic fluctuations and population pressures.

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3.6 Atmospheric Processes

This section provides a general view of climatic changes in the Carpathian region over the second half of the 20th century, focusing on a quantitative assessment of the main climate parameters (temperature, precipitation and snow cover) over the period 1990-2005. An outlook of future climate change in the Carpathian region is also presented here, along with the impact of anthropogenic drivers on air quality, and policy measures and responses.

The "Summary for Policymakers of Working Group I Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change" (IPCC) (here after WGI-AR4 SPM 2007), approved in February 2007, summarized new research findings on human and natural drivers of climate change, observed climate change and estimates of future scenarios. Based on new data, more sophisticated methods of data analysis and improved simulation models, this report concluded that the warming of the climate system is unequivocal, as it is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea levels.

This warming phenomenon was more pronounced in the second half of the 20th century as a consequence of increasing greenhouse gas concentrations in the atmosphere due to human activities. The observed pattern of tropospheric warming and stratospheric cooling is very likely[6] due to the combined influences of greenhouse gas increases and stratospheric ozone depletion. Climate model simulations have shown that the anthropogenic influence on climate overlaps with natural influences such as solar radiation and regional distribution of land and water, leading to specific regional patterns of climate variability and change.

Difficulties remain, however, in simulating and attributing observed temperature changes at smaller scales. On these scales, natural climate variability is relatively larger, making it harder to distinguish between natural changes and those produced by external anthropogenic influences. Uncertainties related to local influences and feedback also make it difficult to estimate the contribution of global greenhouse

[6] Virtually certain > 99% probability of occurrence, Extremely likely > 95%, Very likely > 90%, Likely > 66%, More likely than not > 50%, Very unlikely < 10%, Extremely unlikely < 5% (IPCC 2007).

gas increases to observed small-scale temperature changes.

Among natural factors, orography plays a key role in determining regional climate characteristics by modulating the influences of large-scale processes. Europe is characterised by a very complex orography that regulates the effects of global climate warming on a regional scale. The Carpathian chain is one of the largest mountain systems in Europe, a fact which leads to various specific effects in the regional climate variability (see Chapter 1 and below).

Climate Change

General overview of climate changes in the Carpathian region over the second half of the 20th century

A comprehensive overview of global warming over the period 1976 to 2000 is given by the IPCC Third Assessment Report (TAR) (2001). 1976 is widely acknowledged as the "climate shift" year (e.g. Trenberth 1990), when global mean temperatures marked a pronounced upward trend at least partially attributed to increases in greenhouse gas concentrations in the atmosphere (see the TAR, IPCC 2001). The Report includes Europe among the regions with the largest increase in annual mean temperature (between 0.8-1.0°C/decade).

Various detailed studies of the Carpathian region have shown different regional and local climate change features. For example, in the Southern and Southwestern Carpathians, Boroneant and Ionita (2005) found different ranges of warming in the annual temperature variability over the period 1962 to 2000: 0.3°C -0.5°C in the Bucegi Mountains (Vf. Omu), 0.5°C -0.7°C in the Semenic Mountains and 0.8°C -0.9°C in the Eastern part of the Southern Carpathian (Poiana Stampei) and Apuseni Mountains (Baisoara).

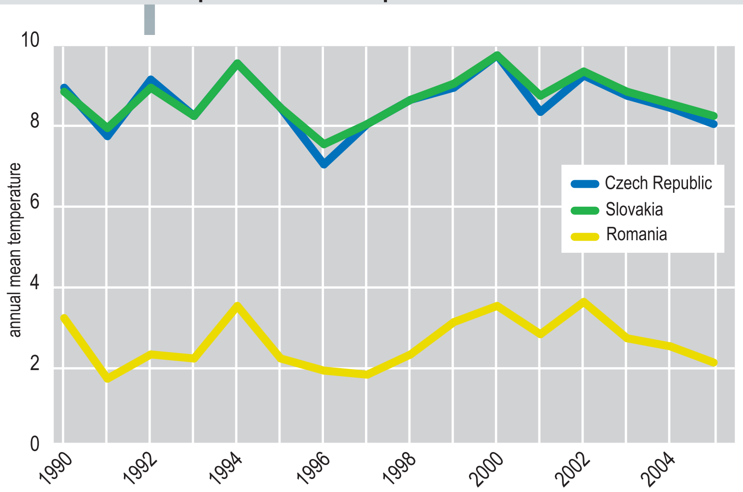
The temporal behaviour of some climate extremes in the Carpathians (e.g. dry/wet spells, tropical days, frost days) were analysed by Baciu et al. (2004), Cheval et al. (2005) and Dragne et al. (2005). Baciu et al. (2004) found that the annual frequency of rime days has significantly increased in the Bucegi Mountains (Southern Carpathians), while in the Southwestern Carpathians, significant decreases were noted, this last feature being in contrast with all surrounding areas in Romania. These increases were associated with the shift of the last rime day to late spring, causing problems for agriculture. Cheval et al. (2005) found increasing trends in the heat wave duration index and annual number of days with minimum temperatures below 0°C in the Romanian Carpathians.

On the other hand, precipitation extremes follow different tendencies. While an increasing number of consecutive dry days was noted, one can also observe a decrease in the number of cases with precipitation events above certain amounts (10, 20, 30, and 50 mm). A decreasing trend in annual precipitation was noted in the Southern and Southwestern Carpathians, more pronounced in the South (Boroneant and Ionita 2005).

The physical mechanisms responsible for climate variability in the Carpathian region (e.g. atmospheric circulation), including the Carpathian influence on regional climate, have also been assessed by several authors. According to Busuioc and von Storch (1996) and Busuioc (2001), the Southern and Southwestern Carpathians act as a barrier for southwestern circulations, transporting moist Mediterranean air masses, and leading to higher precipitation amounts in southwestern Romania (including the southern part of the Southwestern Carpathians). In addition, the northern part of the Southwestern Carpathians (Apuseni Mountains) blocks northwestern atmospheric circulations transporting moist North Atlantic air masses, leading to higher precipitation amounts over northwestern Romania (including the Apuseni Mountains) and less precipitation over the Transylvanian plateau.

Changes in the frequency and intensity of these air circulations lead to changes in the precipitation regime over the areas under influence. For example, Busuioc and von Storch (1996) found that after 1970 the winter southwestern circulations became less frequent, leading to a decreasing trend in winter precipitation over Romania, more pronounced in the southwestern part. Boroneant and Ionita (2005) also identified a pronounced decreasing trend in the mountain area (e.g., 45 mm/decade at Vf. Omu station in the Bucegi Mountains), especially in the Southern Carpathians, which are more affected by southwestern circulations. Kaszewski and Filipiuk (2003) have reported a connection between decreases in precipitation in the Polish Carpathians and changes in the atmospheric circulation over Central Europe.

Figure 3.12 Spatial averages (country level) of annual mean temperature over the period 1990 to 2005



The number of stations used in computing each spatial average is noted: 17 for Romania, 19 for Czech Republic and 62 for Slovakia.

These changes in atmospheric circulation on a regional scale are consequences of changes in larger-scale circulation patterns, such as the North-Atlantic Oscillation (NAO), the dominant variability mode over the Atlantic-European area. Various studies have documented that the strongest warming during the winter season, and associated downward trends in snow depth observed in mid-late winter (January to March), occurred over the last half of the 20th century and appear to be associated with NAO variability (e.g. Hurrell 1996). Bojariu and Dinu (2007) show that diminishing snow depth over the Romanian territory, which is only significant in some areas including small mountain areas in the Eastern and Southwestern Carpathians, is related to the overall tendency toward the positive phase of the NAO. Nevertheless, local and regional factors have more influence on snowpack variability in the Carpathians than in the Alps, where large-scale influences play a dominant role in controlling the timing and amount of snow (Beniston 1997).

Climate trends from 1990 to 2005

Temperature

Figure 3.12 presents a comparison of the average annual mean temperature in three Carpathian countries. The temporal evolution of the time series generally shows similar features, and some differences in the magnitude of values between the Northwestern and Eastern-Southern/Southwestern Carpathians. The temperature variability over the Northwestern Carpathian region is very similar with respect to the temporal evolution as well as the magnitude of values (spatial average between 7.0°C-9.7°C). Different results obtained in the Southern/Southwestern Carpathians (spatial average between 1.7°C -3.6°C) can only be explained by the lack of data homogeneity.

In the Northwestern Carpathians, 1996 was the coldest year and 2000 the warmest. In the Southern/Southwestern Carpathians, 1991 was the coldest year and 2002 the warmest. No significant linear trend was noted, the inter-annual variability being the dominant feature of temperature variability over the period under analysis. This result shows that large-scale mechanisms (e.g. atmospheric circulation) could be the main drivers of this behaviour. For example, 2000 was for a long period under the influence of anticyclonic weather in Central and Southeastern Europe. The time period analysed is, however, too short to draw a clear conclusion about the causes that determined this behaviour, namely if they are of natural or anthropogenic nature, or a combination of both. Most probably, both factors had an influence. The most recent IPCC report (WGI-AR4 SPM, 2007) reached a similar conclusion, namely that the characteristics of global climate variability over the 20th century can be explained by a combination of natural and anthropogenic factors.

Precipitation

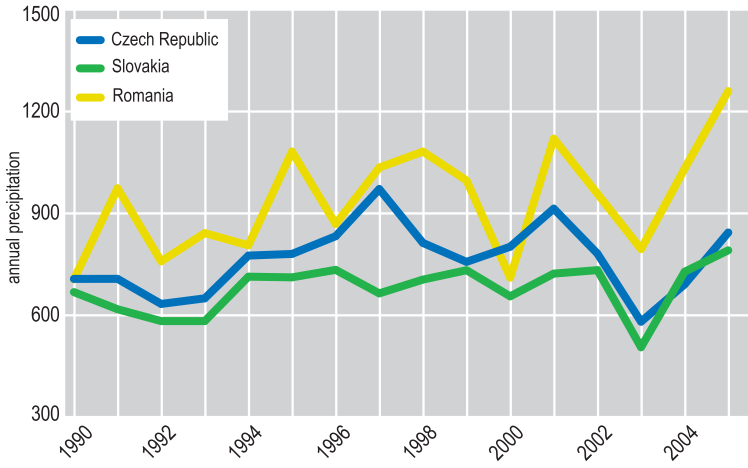
A slightly increasing trend in the average annual precipitation was identified in the Romanian and Czech Carpathians over the period 1990 to 2005, along with high inter-annual variability (see Figure 3.13). The largest annual precipitation amount was recorded in 2005 in the Southern Carpathians (1260 mm/year) and in the western part of the Northwestern Carpathians (791 mm/year). In the eastern part of the Northwestern Carpathians, the largest annual precipitation amount was identified in 1997 (971 mm/year). The year 2003 was the driest one in the Western Carpathians (506-581mmm/year), associated with a very hot summer over Central Europe. In the Romanian Carpathians, 1990 and 2000 were the driest years (706 mm/year and 711 mm/year, respectively).

On a local scale, only a few stations exhibited a significantly increasing trend in the precipitation pattern (six stations in the Romanian Carpathians and eight stations in the Slovak Carpathians), but are not necessarily part of a long-term precipitation trend. It is difficult to conclude that the characteristics of precipitation variability in the analysed regions belong to the natural decadal and/or interdecadal variability that is a characteristic of precipitation variability (see WG1 AR4 SPM, 2007). Future global warming may nevertheless induce more frequent and severe climate events, both "positive" (extreme precipitation and floods) and negative (such as droughts).

Snow cover

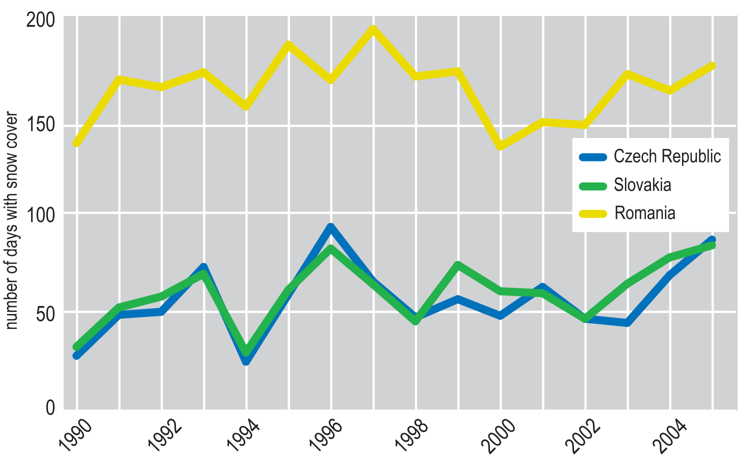
The annual number of days with snow cover exhibits significant spatial and temporal variability. These characteristics are in agreement with the temperature and precipitation variability patterns presented above. Firstly, there are large differences between the Western Carpathians (56-60 annual average number of days) and the Southern/Southwestern Carpathians (163 annual average number of days), as shown in Figure 3.14. This may also be due to a lack of data homogeneity. Secondly, a slight increasing trend was noted over the Northwestern Carpathians (nine stations in Czech Carpathians and 20 stations in the Slovak Carpathians) and a slight downward shift for some stations in the Romanian Carpathians (Calimani, Ceahlau-Toaca and Vladeasa). These spatial details are represented in Map 3.15.

Figure 3.13 Spatial averages (country level) of annual precipitation over the period 1990 to 2005.



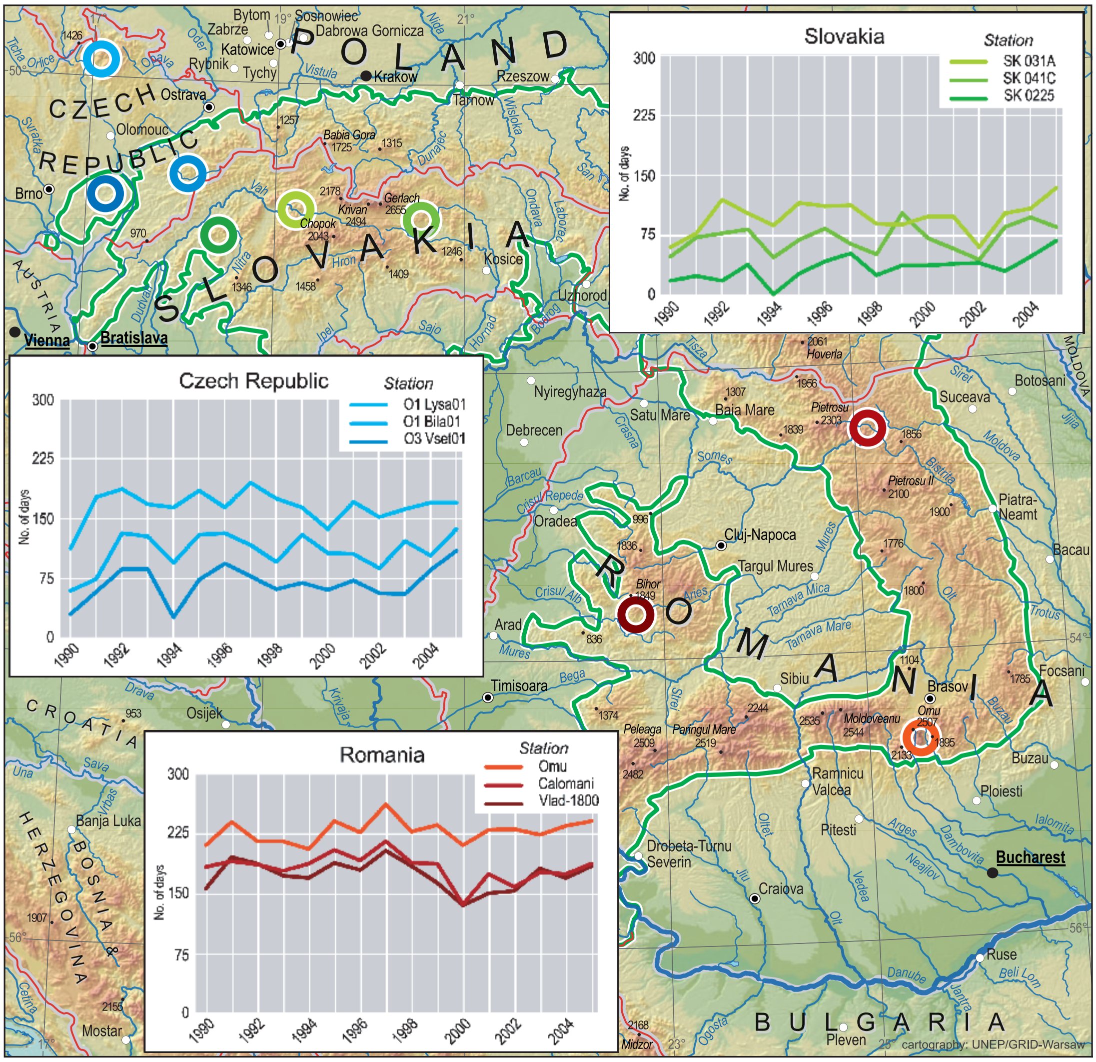
The number of stations used in each spatial average is noted: 17 for Romania, 86 for Czech Republic and 62 for Slovakia.

Figure 3.14 Spatial averages (country level) of the annual number of days with snow cover over the period 1990 to 2005



The number of stations used in each spatial average is noted: 17 for Romania, 86 for Czech Republic and 62 for Slovakia

Map 3.15 Annual number of snow cover days in the Carpathian region. Local details are presented for the Slovak, Czech and Romanian Carpathian areas



Outlook on future climate change

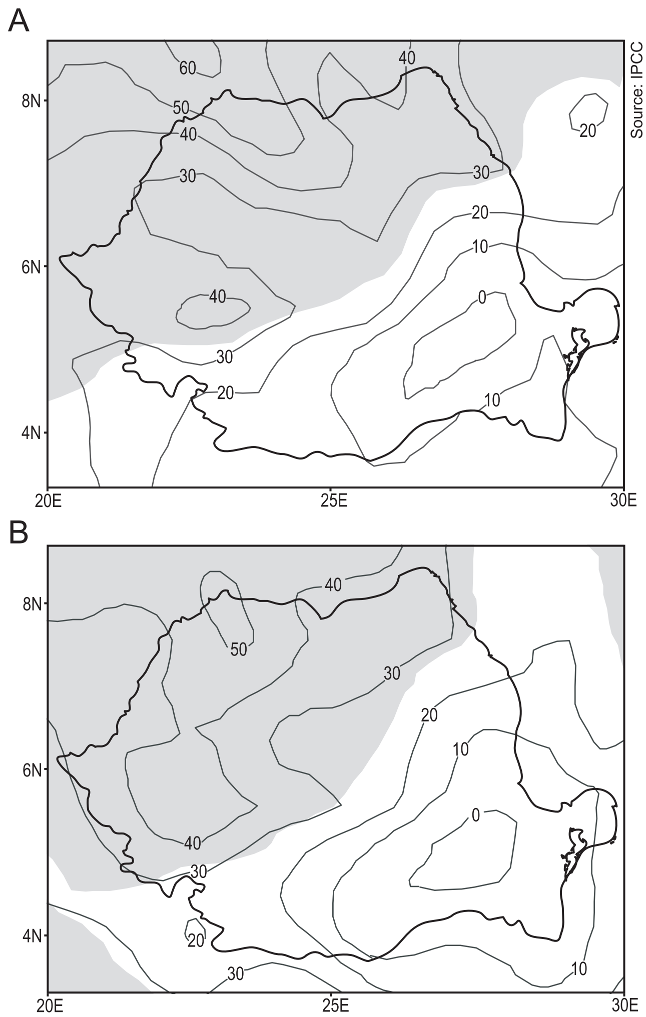
In February 2007, the IPCC approved a "Summary for Policy Makers" (WG1 AR4 SPM) as the first of a series of publications associated with the panel's Fourth Assessment Report. It summarized the main results of research on climate change projections for the 21st century, using various global and regional climate models of increasing complexity and realism under various emission scenarios. Model simulations cover a range of possible futures including idealised emissions or greenhouse gas (GHG) concentration assumptions, according to the IPCC Special Report on Emission Scenarios (SRES).

Model experiments show that even if all climate forcing agents are held constant at their 2000 levels, a further warming trend would occur in the next two decades at a rate of approximately 0.1°C per decade, mainly due to slow ocean feedback. Globally, snow cover is projected to decrease, and widespread increases in thaw depth are projected over most permafrost regions. On the European scale, including the Carpathian region, almost all models and SRES scenarios show a warming between 1.0°C and 1.5°C for the period 2020 to 2029 compared to the baseline period 1980 to 1990 (WG1 AR4 SPM, 2007).

Details on mountain regions (including the Carpathians) cannot be found in global climate change scenarios. Such details can only be obtained by using downscaling techniques to infer regional climate information on a finer scale: dynamic approaches given by regional climate models (RCMs) (Giorgi et al. 2001) and statistical downscaling models (SDMs) (e.g. Busuioc et al. 1999, Huth 2001). When both approaches show similar climate change signals, confidence in the results obtained increases. SDMs have the advantage to obtain climate change information on a station scale. Unfortunately, only a few studies have systematically compared the two downscaling techniques.

For example, Busuioc et al. (2006a,b) compared the ICTP RegCM regional climate model and SDM simulations generating winter precipitation scenarios for Romania (under IPCC A2 and B2 scenarios for the period 2070 to 2099), and found similar signals in the Southwestern and Northeastern parts of the Romanian Carpathians (see Figure 3.15). RCM simulations show that winter precipitation is projected to increase by 40-50 mm under both scenarios, when SDM simulations produce lower rates of increase. The results obtained for the Romanian Carpathians are in agreement with those noted in AR4 SPM. For extreme temperatures, Busuioc et al. (2005) found similar RCM-SDM signals, especially for winter minimum temperatures (under the A2 scenario), with greater warming in the eastern part of the Romanian Carpathians (above 5°C) compared to the Southern/Southwestern Carpathians (4.5°C-5°C).

Figure 3.15 Changes in winter precipitation over Romania derived from RegCM simulations under IPCC A2 (a) and B2 (b) scenarios. Units are mm/season. Grey areas indicate statistical significance at the 5% level



Overview of climate change impacts

Based on observational evidence, the last WGII IPCC Report (IPCC WGII SPM 2007) concluded that recent warming is strongly affecting hydrological and terrestrial biological systems in mountain regions through increased runoff and earlier spring peak discharge in many glacier- and snow-fed rivers, warming of lakes and rivers with effects on the thermal structure and water quality, earlier timing of spring events, such as leaf-unfolding, bird migration and egg-laying.

Nearly all European regions are anticipated to be negatively affected by future climate change impacts, particularly the increased risk of inland flash floods and erosion, which will pose challenges to human lives and livelihoods, and for many economic activities. The great majority of montane organisms and ecosystems will have difficulties in adapting to climate change. Mountainous areas will face reduced snow cover and extensive species loss (up to 60% by 2080 in some areas, under high emission scenarios). Forest productivity is expected to decline and the frequency of peatland fires will increase. In addition, some specific regional features of climate change impacts in the Carpathians are noted below.

Impact of climate change on agriculture

During the last 10-15 years, agricultural production, including crop production and animal husbandry, decreased in the Carpathians, and large areas became fallow land (see section 3.3).

Climate change impacts on agriculture were mostly detailed in the Slovak Carpathians (MoE of the Slovak Republic 2005). It was found that increased temperatures induce an acceleration of plants' physiological processes and an early start of physiological development and vegetation periods. The extension of the vegetation period is forecast to reach up to 84 days in the Slovak Carpathians by 2075. It is estimated that there will be an increase of 126 mm in the evaporation deficit in southern Slovakia, and as much as seven times the current value in the northern part. Gradual changes to the water balance would be caused by reductions in the snow stock, increased mean temperature in early spring and increased evapotranspiration in winter months. By 2075, the biomass production potential is projected to increase by 25% in the northern mountainous part of Slovakia, and corn farming could expand from the present limit of 100-400 m altitude up to 800 m.

Impact of climate change on forests

Generally, environmental degradation in mountain regions can be driven by numerous factors, including deforestation, over-grazing and cultivation of marginal soils. Mountain ecosystems are highly susceptible to soil erosion, landslides and the rapid loss of habitat and genetic diversity (Beniston 2003). Changes in climate conditions will also have an impact on forest ecosystems. As case studies for climate change impacts on forests, the Western Carpathians (Slovakia) and Southwestern Carpathians (Romania) are presented here.

In the Western Carpathians, it was found that climate change would increase the water deficit during the vegetation period. Increasing air temperatures and decreasing precipitation in warm periods will lead to a decrease of relative air humidity. This will result in less favourable conditions for high forests and the expansion of xerothermic shrub vegetation and steppe vegetation.

Climate change will also result in changes to biodiversity. The dendroclimatic model for the region of upper Orava showed that 11.5% of individual trees will be negatively impacted by climate change, 34.6% will be unaffected and 53.9% will react positively. The research also showed that climate change would mostly affect forest cover at higher altitudes (Lapin et al. 1996, 2000). Jankovsky and Cudlín (2002) showed that high mountain forests would be impacted by a precipitation deficit that will result in weakened spruce and mountain pine communities, making them vulnerable to windstorms and intensive rains. Table 3.12 presents the forest areas in Slovakia endangered by climate change, under present climate conditions and projected future conditions. Nearly half of the forest area is projected to be at risk by 2075.

Furthermore, climate change would induce the migration of species and current life zones towards higher altitudes. The present sub-polar tundra zone (according to the Holdridge classification) is projected to disappear from the Romanian Carpathians, while other zones typical for the current plain and hill climate (e.g. cool temperate steppe and cool temperate moist forest), are projected to expand in higher mountain areas (Alexandrescu et al. 2003).

Impact of climate change on health

Climate change will also impact human health, either directly through the physiological effects of heat and cold, or indirectly, through the spread of vector-borne pathogens. An increase in such impacts has already been observed during recent decades. Direct impacts on human health are mainly associated with heat waves and floods. Extreme hot or cold conditions can be detrimental to many human body functions and may have an important effect on daily mortality (EEA 2005).

As an example, studies on the Slovak Carpathians found that extreme positive temperatures during wintertime can provoke increased occurrence of influenza. During the last decade, one to two million people were affected every year by influenza or influenza-like infections. The highest age-specific morbidity is reported for the pre-school age category (children up to five

Table 3.12 Forest ecosystems in Slovakia endangered by climate change

Endangered forest ecosystems	Area (ha)	% of total forest area
Acute endangered forest ecosystems (endangered at present)	29 000	1.5
Directly endangered forest ecosystems (endangered up to 2030)	260 000	13.0
Potentially endangered forest ecosystems (endangered up to 2050-2075)	964 000	48.3

Source: MoE of the Slovak Republic 1997

years) and for school-age children (6 to 14 years). There were occasional reports of deaths from influenza, most of them occurring during the 2002 and 2003 winter seasons (MoH of the Slovak Republic 2005, PHA of the Slovak Republic 2005).

The incidence of water and food-borne diseases may also increase with climate change, particularly when water availability decreases and high temperatures affect the quality of food (EEA 2005). The projected rise in temperature is likely to increase the geographical extent of ticks and lead to infestations in areas that are currently tick-free.

Lastly, the increasing intensity of heavy rainfall, as projected along with future climate change, is likely to result in more extreme floods. The number of deaths can be particularly high during sudden flash floods. In 2005 in Slovakia, floods in 237 villages and towns affected nearly 1,800 homes. The largest loss of human life occurred during floods in July 1998 in Eastern Slovakia, with 46 victims and four missing persons (MoE of the Slovak Republic 2005).

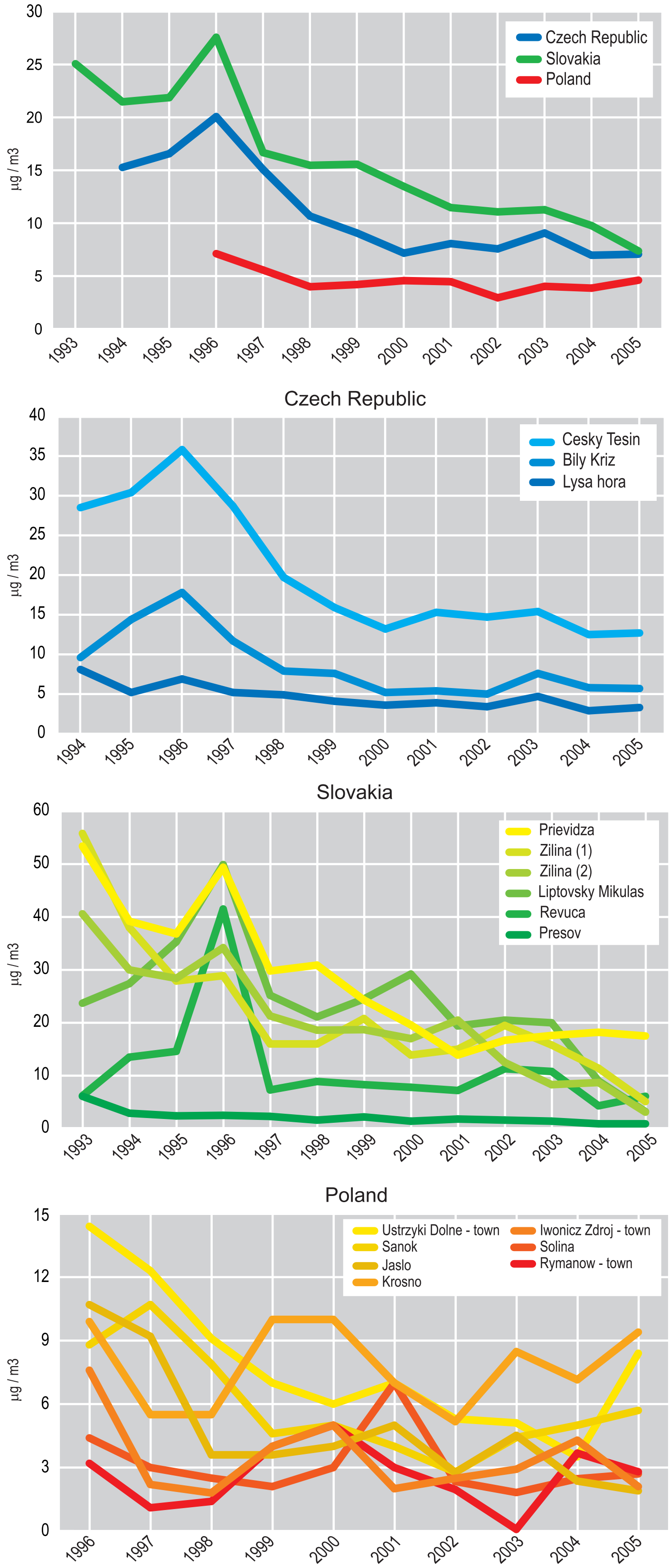
Anthropogenic impacts on air quality

The main sources contributing to air pollution are incineration processes, industry, transport and agriculture. Carbon dioxide also enters the atmosphere via the conversion of grasslands and forest areas into agricultural land and via forest fires. The major sources of methane are agriculture, large-scale beef cattle and pig breeding, leaking of natural gas from distribution networks, brown coal mining and biomass burning. In comparison with other greenhouse gases, the assessment of nitrous oxide (N_2O) emissions and sinks involving the nitrogen cycle in the atmosphere is rather difficult. The primary sources of N_2O are agriculture, waste treatment and fuel combustion (e.g. energy and transport).

Expressed as CO_2 equivalent, total emissions in Slovakia consisted of 80% carbon dioxide emissions, approximately 10% CH_4 emissions, 7% N_2O emissions and less than 1% fluorinated gases (SHI 2006). In the Northwestern and Northeastern Carpathians, the time series analysis of NOx, SO_2, lead and other air pollutants illustrates that annual average emissions generally decreased under the influence of economic decline in most Carpathian countries. According to Romania's National Communication on Climate Change (2005), similar trends were noted in the Southern and Southwestern Carpathians.

In Slovakia, a reduction of 81.6% in SO_2 emissions was reported between 2000 and 2004, as a consequence of a reduction in energy production and consumption, and changes to better quality and more purified fuels. Over the same period, a 56% decrease in NOx emissions was mainly due to technical and technological improvements of the incineration process and denitrification. Ammonia (NH_3) emissions dropped by 59% due to changes in agriculture, where livestock numbers were reduced. Organic and

Figure 3.16 SO_2 concentrations – annual spatial averages in the Czech Republic (three stations), Slovakia (13 stations) and Poland (10 stations). Local details are also presented



industrial fertiliser volumes on agricultural land were also reduced.

Figure 3.16 shows atmospheric SO_2 concentrations in several Carpathian countries, including country averages and local details at the district/station level. While similar decreasing trends are noted for all countries, some differences may be observed at the local scale with respect to the magnitude of concentrations and their temporal evolution.

As in other Carpathian countries, heavy metal emissions (lead, cadmium and mercury) have shown a significant decreasing trend in Slovakia between 1990 and 2002, followed by a slight increase. This was mainly due to closing down many inefficient production processes, extensive reconstruction of separation equipment, changes to raw materials used and, most of all, the transition to using unleaded petrol. Emissions of particulate matter have also diminished, due to using more purified fuels of better quality, and reductions in energy production and consumption (MoE of the Slovak Republic 2003).

The same trend was identified for non-methane volatile organic compounds (NM VOC). Emission abatement resulted from lower use of coating compounds and gradual introduction of low-solvent coating types. The introduction of gas technologies in incineration processes and of automobiles equipped with catalytic converters also generated NM VOC emission reductions (SHI 2005).

As a result of atmospheric pollution, acid precipitation is an important issue in the Carpathians, with nitrates contributing less to the acidity of precipitation than sulphates. Acid rain may have detrimental consequences for wildlife, forests, soils, freshwater and buildings. Incineration processes, industry and transport are main contributors to the formation of acid rain. A slightly diminishing trend was nevertheless observed in the acidity of atmospheric precipitation from 1993 to 2003.

Stratospheric Ozone Depletion

Stratospheric ozone depletion, observed since the 1970s, is primarily caused by higher atmospheric concentrations of reactive chlorine and bromine compounds that are produced through the degradation of Ozone Depleting Substances (ODS), including halons, CFCs, HCFCs, methyl chloroform (CH3CCl3), carbon tetrachloride (CCl4) and methyl bromide (CH3Br). Each type of gas has different ozone depletion effects depending on historical emissions, lifetime and amount of chlorine and/or bromine existing in each molecule. Recent observations and model calculations suggest that global average ozone depletion has now stabilised.

Ozone depletion produces a negative radiative forcing (cooling) of the climate, which is related to the indirect effect of ODS. Reduced ozone causes the stratosphere to absorb less solar radiation, thus cooling the stratosphere. On the other hand, ODS are greenhouse gases with a direct warming effect. The warming due to ODS, and cooling associated with ozone depletion, are two distinct mechanisms influencing the climate that do not offset one another.

As for tropospheric ozone, time series analyses of the ozone concentration in the Carpathian countries did not identify significant trends. As a common feature, during the heat wave of the summer of 2003, record-breaking levels of tropospheric ozone pollution were registered everywhere in the Carpathian countries. For example, in Slovakia increased values of ground-level ozone were detected at all monitoring stations (MoE of the Slovak Republic 2003). Compared to previous years, 2003 registered O_3 amounts exceeding threshold limit values for public information (180 $\mu g/m^3$). Furthermore, during 2001-2003, this target value was largely exceeded at most monitoring sites, with the exception of several urban stations.

Policy Measures and Responses

Climate change

The United Nations Framework Convention on Climate Change (UNFCCC) "acknowledges that changes in the Earth's climate and its adverse effects are a common concern of humankind." The ultimate objective of the Convention is to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." The Carpathian countries participate in UNFCCC and Kyoto mechanisms designed to limit their emissions and adapt to climate change. According to the Protocol, the countries included in Annex B of the protocol agreed to reduce their aggregate emissions of all greenhouse gases (i.e. CO_2, CH_4, N_2O, HFCs, PFCs and SF_6) on average by 5.2% compared to 1990 levels during the first commitment period of 2008 to 2012. The EU, including five Carpathian countries, accepted a target of -8%.

The emission reductions registered in the Carpathian countries since 1990 are the result of a number of processes linked with the transformation of their economies during the transition period. These include a gradual decrease in energy intensity, higher share of services in GDP generation, higher share of gas fuels (as opposed to oil and coal), structural changes in industry, decrease of energy consumption in energy-intensive sectors (with the exception of metallurgy), less energy-intensive industries, and the impact of legislative measures influencing directly or indirectly GHG emissions (SHI 2006).

According to predictions of the future dynamics of GDP growth in the Carpathian countries, there is a legitimate assumption that GHG emissions will increase in the near future. It therefore seems necessary to prepare investment strategies and programmes to achieve GDP growth, while simultaneously maintaining emissions at levels that meet the requirements of the Kyoto Protocol.

One option to reduce CO_2 concentrations in the atmosphere is to apply Carbon Capture and Storage (CCS) technologies, as mentioned in the

"IPCC Special Report on Carbon Dioxide Capture and Storage" (IPCC 2005b). CCS is a process that entails the separation of CO_2 from industrial and energy-related sources, transport to storage locations and long-term isolation from the atmosphere. Furthermore, CCS is recognised by the UNFCCC as a "mitigation of emissions at source", and thus represents an eligible mitigation action under emissions trading schemes and the Clean Development Mechanism (CDM).

Other mitigation options include energy efficiency improvements, switching to less carbon-intensive fuels and nuclear power, using renewable energy sources to a larger extent, enhancing biological sinks and reducing non-CO_2 GHG emissions (such as methane and nitrous oxide).

In addition, the importance of using biofuels for transport has also been stressed in strategy and action plans of the European Union (EC 1996, 1997). There is also an EU Directive on the promotion of biofuels and other renewable fuels for transport, that obliges member states to sell a certain amount of biofuels on their national markets for transport fuels in the period 2005 – 2010 (Directive 2003/30/EC). The opportunities for energy crop production are also acknowledged in the Common Agricultural Policy (CAP). Conversion of excess cropland to profitable energy crop production is regarded as one option for addressing several key challenges in the agricultural sector, such as the abandonment of cropland, increased unemployment and depopulation in rural areas.

At present there is a modest use of bioenergy in the EU; about 6% of the primary energy supply is biomass-based (EC 2003). Carpathian EU members have a substantial biomass production potential, and production costs are much lower than in Western European countries. If this potential would be realized, these countries could contribute to EU targets on bioenergy and renewable energy sources (Berndes and Hansson 2007).

Finally, according to REC/EURAC (2005), all Carpathian countries have National Environmental Programmes and other related programmes focusing on specific environmental issues. Only Romania reported a "Sustainable Development Strategy on the Mountain Region", which was approved in 2004. A National Strategy on Climate Change for the period 2005 to 2007, and a National Action Plan on Climate Change for the same period have also been prepared. Also, Slovakia began a National Climate Programme in 1993.

Ozone

Options related to safeguarding the ozone layer have been presented by the IPCC Special Report "Safeguarding the Ozone Layer and the Global Climate System: Issues Related to Hydrofluorocarbons and Perfluorocarbons" (IPCC 2005a). The report notes that some options for protecting the ozone layer could influence climate change, while climate change may in return influence the ozone layer. According to this report, direct GHG emissions from refrigeration appliances can be reduced by 10% to 30%.

A variety of policies, measures and instruments have been implemented to reduce the use of ODS. Their consumption and production is controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer, and they are being phased out according to a rigid timetable. Among existing mechanisms, there are regulations, economic instruments, voluntary agreements and international cooperation. Furthermore, energy and/or climate policies also encourage ODS' regulation, their substitutes or "not-in-kind" alternatives (i.e. non-fluorocarbon options). It should be noted that policy considerations are dependent on specific applications, national circumstances and other factors. As an example, the requirements contained in EU regulations are more stringent than phase-out targets of the Montreal Protocol.

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3.7 Waste and Hazardous Chemicals

A current evaluation of waste and hazardous chemicals in the Carpathian region (e.g. industrial and agricultural waste production, number of illegal waste deposits) provides a mainly positive picture as, in general, the situation has improved since 1989. The amount of waste generated, including industrial and hazardous waste, decreased from 1990 to 1996 mainly due to the economic recession and general decline of mining and heavy industry. Improvements related to toxic and hazardous waste sites are particularly significant. The region also has new, progressive waste legislation and newly-established related institutions.

Despite progress, several problems remain and some negative tendencies have emerged. The amount of waste is increasing again, accentuating environmental damage such as soil and water pollution and spoiling landscapes and aesthetic values. In many places, waste dumping is on the rise, sometimes dramatically, as old refuse dumps are full and there is a lack of acceptance of new sites being placed in local communities. Key issues related to waste management in the Carpathian countries are the predominance of landfilling as a waste management option, and the problem of low recycling rates.

The greatest problem appears to be municipal waste, where waste generation is worse than 17 years ago. The existence of obsolete hazardous chemicals remains a major issue. One emerging problem concerns new types of hazardous chemicals and the recent 'hazardous waste market'. A special category of problems is represented by brownfields and the numerous sites which have been ruined by a variety of waste-related problems.

Moreover, major new construction projects (e.g. large dams, highways, factories, harmful mining technologies, mountain winter sport resorts) have led to severe negative impacts on nature and landscapes, as well as producing additional wastes.

The import and mass utilization of non-recyclable materials have increased problems associated with waste management, especially at the local level, including a significant rise in the total amount of municipal waste. Finally, legislative, conceptual, organizational and technical ignorance of the scope of problems such as communal waste has caused the proliferation of thousands of small local waste sites, both informal and illegal.

Municipal Waste

During the communist period, municipal waste management received little attention or funding. In the majority of the Carpathian countries, both relevant legislation and institutions did not exist. For example in 1989, Poland did not have an efficient system for collecting or recycling municipal waste. Every year, 40 to 46 million cubic meters of waste were dumped at disposal sites, with over 500 refuse dumps located in towns and 1,300 in rural areas. Simultaneously, there were over 10,000 illegal deposit sites located in forests or along country roads (Nowicki 1997). However a system did exist for collecting old paper and glass bottles.

Since the demise of communism, especially in the first period after 1989, the municipal waste situation worsened, in part because of the collapse of the system for collecting old paper and glass. Other causes were the increased use of non-reusable packages and lack of municipal waste recycling. With more processed food products, and the spread of hypermarkets and other large chain stores, increased human consumption has resulted in greater waste production. Overall, municipal waste production in all Carpathian countries has grown significantly in the last decade by about 2 to 5% annually (Třebický et al 2002).

At the same time, total municipal waste production in the Carpathian countries remains below the EU and OECD averages. Hungary is the only exception, where the estimated per capita quantity of municipal waste corresponds to the average of the European OECD countries and is much higher than in other Visegrad countries. Hungary has the highest relative production of municipal waste among all OECD countries per unit of consumption. At the end of 1990s, Poland was fourth, Slovakia fifth and the Czech Republic tenth in relative terms (OECD 2001). With waste production in the Carpathian region now rising at a faster pace, the difference between the Carpathian and OECD countries is diminishing.

Despite general improvements since 1989, most communities next to rivers lack proper garbage sites and refuse is dumped on river banks. Furthermore, some polluting industries are still operational. The great majority of water purification stations are inadequately operated and/or their operational capacity is relatively low. Groundwaters are degraded by organic substances and other pollutants spilled by the chemical industries of large urban agglomerations, and by other sources such as oil and salt water.

The waste situation in Hungary

In Hungary between 1985 and 1994, the quantity of waste generated dropped by approximately 20% due to reductions in economic output and consumption.

About 82% of municipal waste was collected at the end of the 1990s, of which most was disposed in waste disposal sites and 15% was incinerated. While the capacity of existing waste disposal sites is sufficient for several years, not all meet environmental standards. Moreover, numerous illegal dump sites and waste disposal sites near villages and towns also fail to meet environmental standards. Only about one-half of all production waste is re-used, representing 3% of total material use.

Various waste management projects, especially for waste minimization (e.g. re-use and recycling, methods, technologies, systems and investments) and waste disposal investments (under new rigid regulations) are launched and at least partially financed from the 'Central Environmental Protection Fund' and/or co-financed from international financial sources.

The state of sewerage and sewage treatment is unsatisfactory. In order to improve this situation, new programmes and financial means were introduced particularly from the mid-1990s to meet the requirements of EU accession (see more in Geller 2002).

Hazardous Waste

Hazardous wastes and their management are a substantial problem in a majority of the Carpathian countries. The number of sources generating hazardous waste is fairly stable. Approximately 65% of the total amount of hazardous waste comes from manufacturing. The share from the processing industry is only about 27-29%, indicating large volumes of hazardous waste generation at individual sources. This may suggest that new, smaller industrial sources do not report waste in order to avoid fines. The agriculture and service sectors also generate small volumes individually, including pesticides.

The current status of hazardous waste production is less clear in other economic sectors such as mining and quarrying, construction, electricity, gas and water supply, wholesale and retail trade, repair of motor vehicles, health and social work, as well as other community, social and personal service activities.

In Poland, hazardous wastes are and will continue in future to be a serious problem (Nowicki 1997). The annual production reached about 4.5 million tonnes in the year 2000, of which only 27% was recycled with the remainder dumped at more than 800 deposit sites. To date, over 400 million tonnes of hazardous waste, mainly from chemical and pharmaceutical industries, have been deposited in dumps.

In Hungary, a programme to build a network of regional hazardous waste landfills and incinerator plants was elaborated in the mid-1980s, but has not been fully completed due to limited financial resources.

Foreign waste import to Ukraine

In the EU, hazardous waste export has a fairly extensive history and remains to this day a relatively inexpensive option. For example, before 1989, some 675,000 tons of toxic waste were transported annually from the former Federal Republic of Germany to the former German Democratic Republic. Today, much waste from EU countries continues to be transported to the East.

Bakta village, in Beregivschyna in the trans-Carpathians close to the Hungarian border, is a typical example of the new toxic import business. German journalist Ralf Arens published a story about Bakta and how it represents Ukraine being used as a frequent destination for hazardous wastes.

The story begins with Oksana Stankevytch, an environmentalist from the local environmental NGO Ecosphere, and villagers examining bags on the territory of the State Institute of Agriculture in Bakta in the winter. Then, the chemical smell is hardly noticeable. In the summer, however, "there is a smell in the air, and the headache comes along in five minutes," she says.

The bags are labelled with "Premix" and contain red-brown powder of unknown origin. According to official information, from 1999 to 2005 the Hungarian company Eltex from Debrecen sold 1,500 tons of Premix to the trans-Carpathian company "Ozone" as raw material for manufacturing brake blocks. However, never reaching Ozone, the bags were left in different trans-Carpathian locations, four of which have been revealed. One is located in Shom village in a school courtyard. In early 2005, local engineer Sofroniy Gumeliuk sent the powder for chemical testing, after which one laboratory worker exclaimed: "After several more years, there will not be a single human left in Bakta!"

Shocked villagers informed newspapers and TV stations. In response, the Prosecutor General's office in Kyiv interfered and ordered the State research institutes to carry out further detailed analyses. Results confirmed that Premix contained high levels of poisonous heavy metals such as lead, chrome, copper and nickel. Although Ukrainian law requires compounds such as Premix to undergo special treatment, nothing was done to address the problem.

A Bureau of Environmental Investigation representative Dmytro Skrylnikov remarked that: "Since 2003, we have been applying to the Council of National Defence and Protection, the General Prosecutor and other competent authorities with the notification that Ukraine is becoming the polygon for European wastes of different types and hazard classes." He added that investigations of all cases should be immediate, that there is a need to introduce a moratorium on the import of wastes, and to develop and introduce effective legal mechanisms to prevent and control hazardous waste imports.

An important emerging problem is the illegal or "semi-illegal" import of hazardous waste and toxic chemicals from one Carpathian country to another. For example, from 2003 to 2006, different types of hazardous waste were illegally imported from Hungary into Ukraine's Lviv region. These included 3,044 tons of maleic anhydride residues and 2,996 tons of acid tar. The acid tars were brought to the Dobrotvir Thermal Power Station for incineration, and the maleic anhydride residues to Drogobych City. Several new locations for waste disposal have been discovered, including one at a school in Shom village (see box above).

In June 2005, Itar-Tass reported that Ukrainian law enforcement agencies had begun searching for 3,500 tonnes of highly dangerous chemical waste imported from Hungary to Ukraine over the last five years. The first 500 tonnes of toxic chemicals were found in ordinary sacks stored in the open air at enterprises in the Beregovsky district of trans-Carpathia. In response, Ukraine's President requested that the Ministry of Environmental Protection and the Ministry of Health begin a review of contaminated facilities.

Industrial Waste

At the end of the 1980s, industrial plants in Poland generated about 170 million tonnes of waste, 43% of which was dumped into disposal sites. Industrial waste production declined with the fall in heavy industrial production following the end of communism. However, the decline was reversed during a renewed period of industrial growth. Nearly 50% of industrial waste is now dumped at deposit sites. The same rate applies to waste from coal mines and fly ash from power plants. The situation is even worse for zinc and copper mining, where only one-third of the waste is recycled, in comparison to Western countries where 70-80% of industrial waste finds many other economic applications (Nowicki 1997).

A similar trend was noticed in Hungary. Here, the assertion that the economic recession in the first part of the 1990s was the most important factor behind a declining trend is supported by the observation that, where the power sector's output is slightly increasing, waste generation also increases (i.e. waste production is linked to economic production; see more in Lehoczki and Balogh 1997).

The share of industrial waste in the total waste production of Czech Carpathian districts is about 22.6%, with less than 1% recycled. In Slovakia, 79% of agricultural waste and 60% of the waste from hotels and restaurants is being recovered. The percentage of recovered waste from industry in Slovakia is also relatively high (29%).

The main groundwater pollution sources are communal sewage, mostly in rural areas, and the agricultural sector. The main pollutants from agriculture are phosphates and nitrates. One can generalize that the use of industrial fertilizers and pesticides has been high, with serious impacts on soils, underground waters and the entire biosphere, including human health.

Waste Management

Waste management is a key response, but in general remains poorly developed in the Carpathians, in comparison to the substantial progress that has been made in air and water protection. The creation of modern, large disposal sites and waste incineration plants often faces heavy protests from local authorities or municipalities.

However, an increase in proper waste management techniques may be seen among private and public companies and local governments, as evidenced by an increasing number of new municipal waste management investment projects and waste processing plants. New legal and economic measures favour and sometimes enforce these trends.

For example, the Act on Waste Management, in force in Hungary since January 2001, introduced general conditions for performing various waste management procedures/activities, special rules for the management of municipal and hazardous wastes, and waste management planning tasks.

Waste management in Slovakia

Since 1991, when the first Waste Act entered into force, Slovakia achieved many significant results, although the country still faces important challenges. Waste management is now a comprehensive system covering waste prevention, collection and treatment.

Slovak waste legislation has been harmonised with relevant EU directives. While the directives lay down overall frameworks and principles, the organisation of waste management and implementation of the directives is a national task. Slovakia's central legislative instrument, Act No. 223/2001 on their implementation, is regulated by a set of Orders issued by the Ministry of the Environment.

In order to attain the objectives set by legal regulations, waste management plans are developed on a five-year basis. Plans should represent the baseline for measures to minimise waste generation, waste handling and the preparation of territorial planning documents. The Waste Management Plan of the Slovak Republic is prepared by the Ministry of Environment, based on source materials from the regional and district authorities, and adopted by the Government.

In February 2006, the Government of the Slovak Republic approved the Waste Management Plan for the period 2006 to 2010, the fourth since 1992. The Plan sets down quantitative objectives for 2010 including 70% of the total amount of waste to be recycled, 15% to be recovered for energy production and only 15% to be disposed of in landfills. The obligatory part of the Plan contains particular objectives for a number of priority waste streams.

Waste holders and waste operators are obliged to prepare their own plans and keep records of the waste types and quantities handled, and their recovery and disposal, and report stipulated data from the records to the respective state administration bodies in waste management. These reports are sent to the Regional Waste Information System (RISO) operated by the Slovak Environmental Agency. Data on municipal waste are processed by the Statistical Office of the Slovak Republic. The data are published in the annual 'State of the Environment Reports of the Slovak Republic' (www.sazp.sk).

In 2004, from the treated amount of waste, 27% was recovered while 27% of hazardous wastes and 47% of other wastes were dumped in landfills. All 165 operational landfills in Slovakia comply with waste legislation requirements.

According to the Act on waste, municipalities shall introduce separate collection of paper, plastic, metals, glass and biodegradable waste no later than January 1, 2010. To achieve this objective, municipalities can also benefit from the Recycling Fund, a non-state special purpose fund to pool financial means to support the collection, recovery and processing of wastes. (Šimkovicová and Huba 2006)

Table 3.13 Waste generation and treatment in Slovakia in 2004 (t)

Waste	Generation	Treatment by Authorised Companies
Hazardous	1,021,201	432,257
Other	14,885,578	8,974,972
Municipal (included in other waste)	1,475,122	1,475,122
TOTAL	**15,906,979**	**9,407,229**

Source: Slovak Environmental Agency, Statistical Office of the Slovak Republic
Note: The difference (6,499,750 t) is the amount treated directly by producers at their utilities.

Conclusions

It is clear that the annual volume of solid waste generated in Carpathian countries will continue to grow during the next decade, due to the increasing affluence of residents, as well as changing lifestyles and consumption patterns (e.g. more households, rising consumption of single-use goods). Waste management practices need to improve as well. It is probable that a higher share of municipal waste will be recycled, and that the environmental standards for both landfill disposals and incinerators will improve.

The majority of the landfills in the Carpathian EU member states do not comply with the standards elaborated in the EU Landfill Directive. The non-complying landfills will have to be either closed down and the sites rehabilitated, or upgraded to comply with EU standards. Considerable investment is thus needed in this area.

National Waste Management Plans are important strategic documents to reach full compliance with EU standards. These Plans cover aspects such as compliance with National and Community waste policy, in particular reaching the proposed targets, establishment of sufficient capacities and investment requests.

On the other hand, waste legislation at the EU level is evolving, particularly with the recent revision of the Waste Framework Directive in June 2007, addressing in particular the challenge of establishing a system of efficient and environmentally-friendly incineration of waste, characterised by energy recovery and cross-border trade in waste between EU member states. The Directive also introduces a five-step hierarchical "order of priority" for dealing with wastes as follows:

1. prevention of waste;
2. re-use of products;
3. recycling/composting;
4. recovery of energy by incineration, and;
5. landfill disposal.

This hierarchy is to be applied "flexibly" by member states, whose first priorities in the Carpathian region must still be considered as the needs to reduce landfill disposals, and increase the recycled share of waste.

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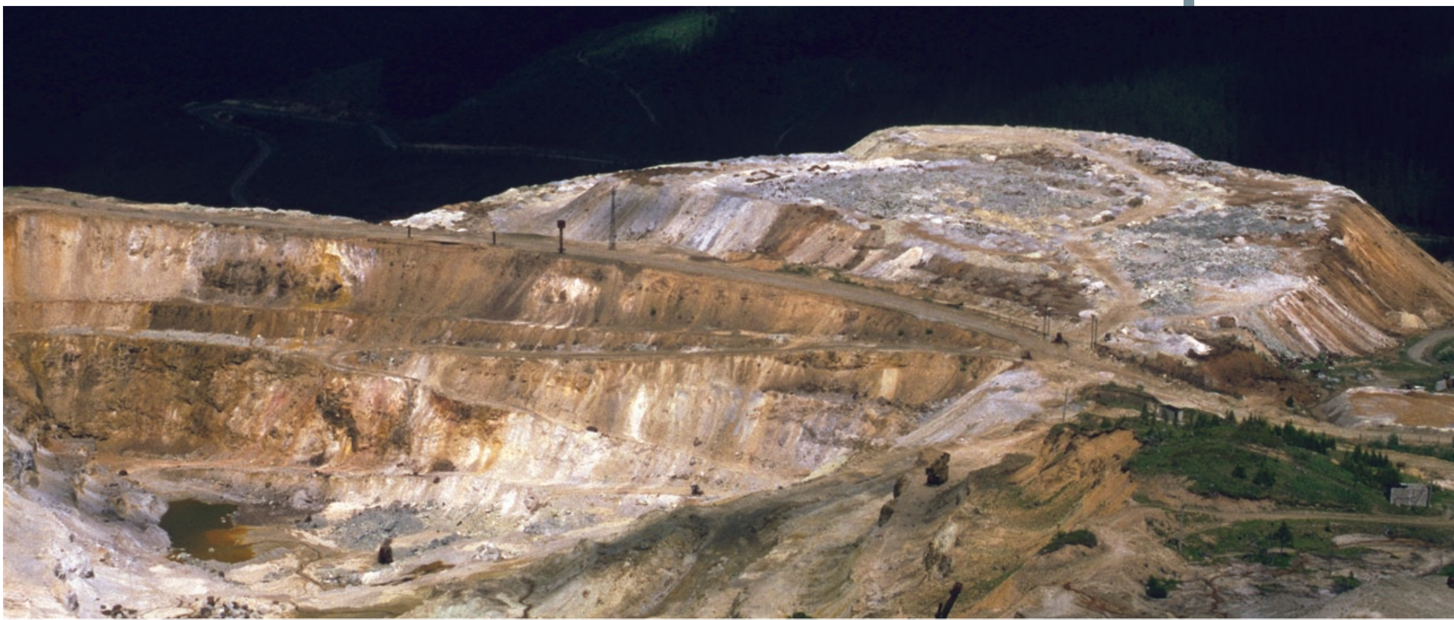


3.8 Environmental Security

Environmental security issues are related to both natural and technological risks and hazards, which are as well increasingly interconnected. Many environmental security issues are of growing importance in the Carpathians due to the pressures of global climate change, as well as the large number of obsolete technologies and legacy environmental problems existing in the region. This section deals with natural hazards such as floods, drought, soil degradation, seismic activities and risks, and geomorphological hazards including landslides, karst and mining subsidence and collapse, snow avalanches, water and wind erosion. Technological hazards such as those related to radioactive substances, the chemical industry, accidental pollution from hydrocarbons and other noxious substances, accidents from mining and tailing dam deposits, and damaged river dams and other waterworks are also analysed.

Floods in the Carpathian Region (1990-2005)

Background

Floods, often referred to as extreme hydrological phenomena, are in most cases unavoidable natural threats. In most years an extensive flood with the character of a 10-year extreme high water event occurs somewhere in the region. Floods originate from the Carpathian Mountains, but their consequences are evident in lowlands, particularly in the Danube River Basin, and thus the issue of floods is addressed in the context of the wider Carpathian region.

Several risk factors contribute to increased flood hazards in the Carpathians (Hanušin 2006, Wyžga 2006). One of the most important is the shape of the hydrographical network. The high concentration of several lower river reaches in a relatively small area in the Carpathian Mountains, closing three sides of the central Danube lowland, determines high flood risks. The hydrographical network of the Bodrog River in Eastern Slovakia and the Crisul/Körös system in Western Romania/Eastern Hungary have similar shapes. The geological substratum consisting of rocks with low permeability, and the character of the relief caused by the young tectonics of the Carpathian range, are additional natural factors that contribute to the occurrence of floods in the region.

Human activities in the Carpathians contributed to landscape transformations which may have impacted the hydrological cycle. For example, Dutch engineers built a hydro-technological system in the mid-19th century in the Tisza Basin (including the Tisza, Bodrog and Ondava rivers) that led to straightening and shortening of streams, construction of dikes and drainage canals, and draining of wetlands. These appeared to be positive measures at the time, and similar approaches were gradually applied to other parts of the region. In the 1950s and 1970s, numerous dams and water reservoirs were built to control flood discharges, and drainage systems were developed to remove surplus water from the land.

The collectivisation of agriculture led to significant changes in land use and contributed to accelerated runoff. Technocratic procedures, relying on efforts to achieve the fastest possible draining of runoff from the basin and to capture surplus flood discharge in artificial reservoirs, were applied for flood control. In spite of the suggestions and warnings of hydrologists, it long appeared that this approach was correct and sustainable due to the absence of extensive or intensive floods over several decades. However, this technocratic vision gave rise to construction activities in territories within the immediate reach of potential floods.

Impacts

As a result, the Danube alone, the main water receiving body in the Carpathian region, lost 80% of its original floodplains by area. In Hungary, 4,200 km of dikes were built to protect 23% of the country against floods, but they also

Table 3.14 Overview of largest flood events in the Carpathian region (Hanušin 2006)

Year, Month	River basin /Country	Number of victims	Flooded territory (km2)	Number of directly impacted inhabitants
1991, July	Siret/RO	71		10000 evacuated
1993, December	Upper Tisza/UA	5		25000 evacuated
1996, January	Cris, Somes, Siret/RO	2		19000 evacuated
1997, July	Morava/CZ; Váh/SK; Odra/PL	about 10-15 in Carpathian region	240 (only on the Slovak side)	20 000 (only on the Slovak side)
1998, June	Siret, Mures/RO	23	1000	more than 10 000
1998, July (flash flood)	Svinka/SK	47	several tens km2	10 000
1998, November	Upper Tisza with tributaries/UA,RO,HU,SK	16	3500	25000 evacuated
1999, June	RO	16	230	About 7000
1999, November	Upper Tisza /UA, HU, SK		several hundreds km2	150-170 000
2000, February	HU	0	3250	?
2000, March, April	Upper Tisza, Crisul/Körös, Muresul/ Maros/HU,RO; Olt, Timis, Siret/RO	9	3500	about 45 000
2001, July, August	Upper Vistula/PL	30	290	16 000 evacuated
2001, March	Upper Tisza, Somes, Mures, Siret/RO	8	450	91 000
2001, June	Mures, Olt/RO	7	500	About 10000
2005, April, May	Tisza, Crisul, Mures,Olt/RO	40	2000	About100 000
2005, July	Siret/RO	23	1500	13000 evacuated

limited the natural spread of floodwaters. Slovakia has more than 38,000 km of streams administered by water authorities, and 21% of them are secured by more than 2,800 km of dikes.

These protective measures are concentrated in lowlands that are outside the Carpathians. The 150 years of transformations to the river landscape and basins in the Carpathian region resulted in major changes to the original river network and shape of river channels, mostly in lowlands, that are now associated with diminishing natural floodplains. Population increase, expanding urbanization and inadequate agricultural and forestry management in river basins have also heightened flood threats in the region. These threats became evident in the 1990s when the frequency of disastrous floods increased. Fluctuating climate parameters, particularly mean temperature rise and higher incidence of extreme rainfall events, are the evident causes of the observed increase in flood frequency.

Table 3.14 identifies the largest floods in the Carpathian region during the 1991-2005 period. High flood incidence areas are located in the Romanian river basins, particularly the upper and middle reaches of the tributaries Tisza, Cris, Mures and Olt, the Ukrainian and northeastern Slovak Carpathians and their rivers such as the Laborec, Uh and Latorica, and the middle reach of the Tisza in Hungary.

Floods cause both damage to and complete destruction of dwellings, buildings and infrastructure. One major flood impact was the contribution to the collapse of walls of a mine tailings reservoir in Baia Mare, Romania, in January 2000, which led to a huge cyanide spill and contamination with other pollutants in local water bodies and the Tisza River (and Danube). Increased heavy metal concentrations were detected in the drainage basins of Lăpuş/Someş and Vişeu/Tisza, in the vicinity of mining and industrial centres (Macklin et al. 2003).

High flood waves and overflows also have severe effects on settlements, communication routes and terrains. The deforestation of various Carpathian areas has increased the risk of overflows through higher discharge velocity, erosion processes, sediment transport and deposition, as well as over-elevation of channel beds in the plains. One typical example is the last flood events that affected more than 50% of Romanian territory in July-August 2002 (Stănescu and Drobot 2002).

Solutions

Flood control strategies are slowly being modified in response to many extensive flood events at the end of the last century. Under the pressure of newly-gained experiences, many hydrologists from the region have now agreed that an exclusively technocratic approach is unsustainable. Alternative and more sustainable measures are slowly being reintroduced, such as widening the area between dikes, creating accumulation polders for capturing flood waves instead of permanent reservoirs, revitalizing streams and increasing natural retention capacities. Unfortunately, in most cases, these efforts remain at the 'conceptual' and 'visionary' stage. In addition, the EU's most important water-related legislation the Water Framework Directive (EU Directive 2000/60), does not explicitly address the issue of floods.

Early warning systems, based on meteorological and hydrological data, are also important for minimizing flood hazards. Flood warning systems are being established both at national and regional levels. The European Flood Alert System (EFAS) is the most important flood man-

The early warning system in Slovakia

Slovakia's Comprehensive Monitoring and Information System for the Environment, adopted in 2000, consists of partial monitoring systems dealing with individual components of the environment (e.g. water, air, biota, forests, soil, wastes). The system is comparable with similar monitoring systems in the EU and OECD countries. The overview of data related to the environment is enabled by a meta-information system 'Catalogue of environmental data sources' operated by the Slovak Environment Agency, and compatible with those implemented in other EU countries. The catalogue is interconnected with a multilingual environmental thesaurus published by the European Environment Agency. The Information System on Monitoring (ISM) is defined as a subsystem of the Information System on the Environment. Its task is to maintain integrated whole-area monitoring. The ISM is an interdepartmental information system operated by the Ministry of the Environment.

agement tool in the Carpathian region. Some countries are simultaneously preparing their own alarm systems compatible with the EFAS. In addition, the Action Programme of Sustainable Protection against Floods in the Danube Basin should be implemented by 2009.

Flood control financing is problematic in most parts of the region. Flood damages are estimated at tens of millions of euros (see Table 3.14) and represent large burdens for most national budgetary systems. For example, during the period 1998 to 2002, floods produced damage equalling 0.19% of the Romanian GDP, 0.13% of the Hungarian GDP and 0.76% of the GDP in the Czech Republic. In the Polish Carpathians, significant impacts were also observed within hydro-technical structures such as dikes and dams.

Unexpected floods also expose governments to calls for reclamation from victims. Among possible solutions, practical approaches including financing for immediate counter-measures are a necessity. At times, the issue becomes a political tool, bypassing the need for realistic and preventive flood-control. For example, Slovakia's ambitious flood control plan approved by the Government in 2000 failed; from the proposed budget of 21 billion Slovak Crowns, only 15% was actually allocated for measures that immediately followed floods.

State of knowledge of flood causes and effects in different parts of the Carpathians

Several natural and human-related factors determining the degree of flood hazards in the Polish Carpathians over the past century are specified below. The expertise from Poland can be generalised for the majority of the Carpathians territory (Wyzga 2006).

Low retentiveness of flysch bedrock**:** Steep slopes, typical of mountain areas, induce rapid runoff over the entire Carpathian area. In the Polish Carpathians, the rapidity of the runoff is further increased due to the bedrock character, as the vast majority of the area is constituted by flysch rocks with a very low potential for groundwater retention.

Erosional character of floods in mountain areas**:** Flood hazards connected with high-energy mountain rivers mainly result from rapid erosional and sedimentary processes, with less danger caused by the inundation of valley floor areas.

Reduction in peak discharges of flood waves from mountainous areas in the Polish Carpathian river basins**:** A comparison of mean annual floods calculated for the periods 1921 to 1955 and 1956 to 2000 indicate some reduction in peak discharges of flood waves generated by the mountainous areas of the Polish Carpathian river basins in the second period. In the eastern part of the Polish Carpathians, the reduction was approximately -30%, reflecting both the change in the precipitation pattern and the regulatory effect of reforestation (this part of the Polish Carpathians was rapidly depopulated in the 1940s, with a subsequent considerable increase in forest cover) (Lach and Wyżga 2002).

Loss of floodplain retention due to deep channel incisions in Polish Carpathian rivers**:** During the 20th century, the rivers draining the Polish Carpathians became deeply incised (up to 3.8 m), mostly in their foothill and foreland reaches. One effect of this process was a loss of floodplain retention and a temporal increase in peak discharges recorded at the downstream end of the Vistula tributaries.

Negative consequences of floods in Polish Carpathians, common for all Carpathians and Sub-Carpathian regions

Economic losses: In the 20th century, 46% of the flood-related economic losses within the upper Vistula drainage basin were caused by floods of low and moderate magnitude, up to 10-year flood events (Roszkowski and Hennig 1991). Damage to hydro-technical infrastructure such as bank-protection structures, weirs and flood embankments constituted a considerable part of the total economic damage. This means that a significant proportion of losses resulted from positive feedback of the hydro-technical infrastructure. In other words, increasing the number of hydro-technical structures led to increased destruction and damage during flood events.

Negative effects on the natural environment**:** Generally, floods have been a natural component of the environment for millions of years. Furthermore, affected ecosystems adapt to repeated flood disturbances. As a consequence, the impact of large floods on ecosystems is only minor and ephemeral (Denisiuk 2002). It is actually the lack of flood disturbance that considerably reduces the rejuvenation of habitats.

Source: Wyzga 2006

Drought, Desertification and other Forms of Soil Degradation

According to the European Soil Bureau, the Carpathians belong to the "dry" areas of Europe. The recent climate evolution is the main factor behind drought episodes, with adverse impacts on the outflow of surface water, groundwater and soil humidity (Bujnovský et al. 2005).

The degree of soil and land degradation is influenced by particular soil and land uses. Agricultural soil degradation often results from improper agricultural practices related to soil, fertiliser and crop management. Soils were considered to be a tool of production that served to satisfy increasing consumer needs. In urban and industrial areas, the main threats to soil are pollution and compaction. While building new infrastructure requires the conversion of agricultural land, the restoration of brownfields is considered less attractive for investors.

Drought episodes last more than 20 days in some Carpathian regions. Several periods of severe drought have occurred over the last century, causing large economic losses and rural poverty. For example, the drought period of 2000 to 2003 proved to be disastrous for the Romanian economy, and led to enhanced desertification processes in areas already subject to intense human pressures (Bălteanu et al. 2006). In the Romanian Carpathians, highly eroded soils cover 20.6% of agricultural lands, moderately eroded soils represent 19% and slightly eroded soils 3% of the agricultural area.

The consequences of soil degradation have a gradual and long-term character, with negative impacts on the provision of environmental functions and biomass production. Improper soil use and management also affects the health of people through its contamination with toxic elements.

At the global level, the UN Convention to Combat Desertification (CCD), to which Carpathian countries are signatories, addresses the issue of drought and its consequences. According to the CCD, Carpathian countries are both developed and, at the same time, affected countries. They are therefore obliged to address their own desertification, degradation and drought problems, and engage in organizing expert (or other forms of) aid to countries that are intensively impacted by desertification, soil degradation and drought (mainly developing countries).

According to the CCD, the term "drought" is defined as the ratio between annual precipitation volumes and evapotranspiration. The majority of the Carpathians is not significantly endangered by drought; the problem is more relevant to Southeastern Europe, and therefore to southern Carpathian slopes, as well as foothills in the Western, Eastern and mostly Southern Carpathians. Annex V of the CCD deals with Central and Eastern European (CEE) countries, including the Carpathians. CEE countries are obliged to adopt national action programmes as an integral part of their policy framework for sustainable development, and address in an appropriate manner various forms of land degradation and desertification.

Windstorms in the Slovakian Carpathians

The number of registered windstorms with negative impacts on the environment in the Slovakian Carpathians increased during the period 1996 to 2005. The largest number (15) occurred in the Brezno District in 2005, followed by the Poprad District (10) in the years 2002 and 2005. These districts cover the territory of the highest mountains in Slovakia as well as the Tatras. 2000 and 2005 had the highest number of windstorms (152), followed by the year 2003 (123).

In 2004, there were "only" 111 windstorms, but the largest one on 19 November destroyed large forest areas in the High Tatras, Low Tatras, Orava Beskyds and Muránska planina plateau. It swept through the transboundary Tatras National Park and Tatry Biosphere Reserve (BR) shared by Slovakia and Poland, seriously damaging 14% of the total area of the Tatry BR in Slovakia (approximately 12,500 ha or 2.7 mil m^3) and affecting 7.1% of small-scale strictly protected areas in the BR.

Geomorphological Hazards

In the Carpathians, the contact zone between the Eastern and Western Carpathians, and the southwestern margin of the Southern Carpathians, are most relevant from the seismic point of view and associated risks. The southern and western parts of the Western Carpathians and the southeastern part of the Eastern Carpathians between Hungary, Ukraine and Romania have moderate seismic activity and lower risks (Giordiny, Jimenez and Grundthal 2003).

Romania is a high seismic risk country, with the epicentre of many events located in the Vrancea region. On 4 March 1977, an earthquake led to 1,570 deaths, 33,000 buildings being destroyed and 763 factories damaged, with estimated losses of over two billion US$ (Bălan, Cristescu and Cornea 1982). In the epicentral area, the earthquake reactivated fault lines with the formation of mud volcanoes, landslides, rockfalls and variously sized fissures (Bălteanu 1983).

Although the territory of Slovakia is not ranked among the most hazardous regions of the world, geomorphological hazards represent a serious problem for the economy and development of the country. The morpho-structural effect of tectonic movements, natural conditions, and human interventions in the Slovak part of the Carpathians has led to a relatively high degree of geomorphological hazards such as earthquakes, landslides and related phenomena, karst and mining subsidence and collapse, snow avalanches, water and wind erosion and floods, many of which are interlinked (Minár et al. 2006).

The risk of **landslides and related phenomena** is relatively high due to the predominantly mountainous character of the region. The regional extent of slope failures depends on the geological structure and rock type, as well as geomorphologic, hydro-geologic and climatic conditions. The most affected areas are flysch uplands, intra-mountain basins and the marginal parts of young volcanic mountains.

Karst and mining subsidence and collapse constitute another geomorphological hazard in the Carpathians. According to Jakál (2000), the high degree of near-surface karstification induces high risks, particularly in areas where carbonate massifs are strongly affected by tectonics, and cave levels are located close to the surface. Subsidence and collapse are also typical phenomena for mining areas, and occur frequently in geological contact zones.

Floods, accidents and natural disasters in Slovakia

Water-related accidents	1995	1996	1997	1998	1999	2000
	129	117	109	117	88	82

Largest loss of human life (July 1998): Eastern Slovakia – 46 victims, 4 persons missing. The peak discharge was of a 1000-year extreme water event. In 1999, damage costs represented 4,528.6 Slovak Crowns, in 2000 – 1,298.6 mil. Slovak Crowns

Largest flood in 20th century: 16 June 1965 in Číčov near the Danube River (flow rate 9,000 cubic meters per second, height 9 m)

Largest landslide: Handlová (1960-1961) 1,630 m long, 1,200 m wide, maximum thickness 30 m, 20 million cubic meters

Highest measured speed of wind: Hurricane (10 Beaufort scale), Skalnaté Mountain Lake – 78.6 meters per second

Fire accidents in Slovakia (2000): Agriculture 2,346; habitation 1,940; transport 1,230; forestry 937

Highest percentage of fires (2000): agriculture (20 percent of all fire accidents)

Highest number of fire accidents (2000): nature (3,949 fire accidents)

Source: Environment of the Slovak Republic, Ministry of the Environment, Bratislava, 2001

Snow avalanches are a significant geomorphological hazard in the Western Carpathians' high mountains. Up to 300 avalanches are registered in each winter season in the Slovak Carpathians alone (Midriak 2002). From 2000 to 2005, avalanches killed 24 people and injured 33. Skiers, mountain climbers and hikers are among the most vulnerable groups.

Technological Hazards and Risks

Technological hazards and risks in the Carpathians are varied. As the population has been concentrated in urban agglomerations, buildings have been constructed in flood- and/or landslide-prone areas. Interactions between humans and the environment have become increasingly complex, and the damage incurred by extreme events is ever-greater. The lack of legislation in this in field during the first part of the transition period contributed to further deterioration in environmental conditions through deforestation, destruction of protected forest belts and development of irrigation systems, enhancing the impact of both technological and natural hazards on society.

Technological hazards in the Romanian Carpathians

Technological hazards are the result of errors in designing industrial installations and/or poor management of enterprises. Following Romania's accession to the EU, the 96/82 CE Seveso II Directive concerning the management of major accidents caused by dangerous substances became the main instrument in managing technological hazards. 333 locations are listed under this Directive (245 of major risk and 88 of low risk), the majority belonging to the chemical and petrochemical industry (Balteanu et al. 2006).

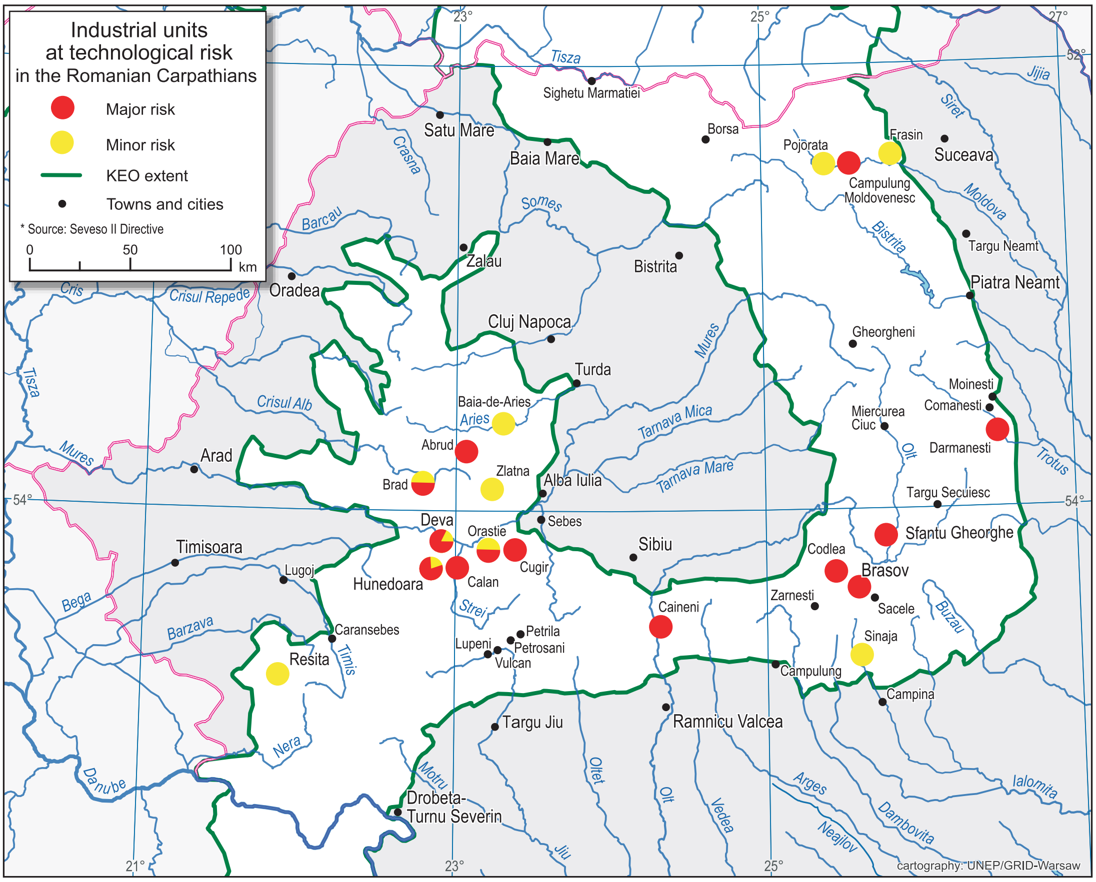
Hazards related to radioactive substances can pose great risks for humans. Romania has one nuclear station at Cernavodă, operated with advanced Candu-type technology. Among other nuclear hazard sources, the reactors used at the Institute of Nuclear Physics Bucharest-Măgurele, Piteşti-Mioveni and the Heavy Water Works at Drobeta Turnu-Severin are the most important. The major risk for the western part of the Romanian Plain comes from the Bulgarian nuclear electrical generation plant located at Kozlodui, which is based on outdated technology. The Chernobyl (Ukraine) nuclear accident in April 1986 affected northeastern Romania, where the incidence of thyroid cancers and malformed newborns increased significantly.

Nearly 140 enterprises in Romania use noxious substances in their production processes (e.g. highly toxic substances, substances with specific toxic properties, inflammables and explosives). These enterprises operate under the provisions of national legislation. They also observe ISO 14000 norms, EU regulations regarding the management of the environment, and the IPPC 61 EC Directive authorizing industrial installations under the Seveso II Directive on the management of major accidents triggered by dangerous substances (Ozunu 2000) (see Map 3.16).

Accidental pollution with hydrocarbons and other noxious substances is due to advanced wear and flawed design of installations in the power industry, hydrocarbon transport and distribution network. Accidents occurring in oil extraction and processing areas entail heavy pollution of soil, surface waters and underground sheets. Pipes may be broken by floods or quake-induced fissures, leading to massive leaks of fluid fuels. In 2002, the Prahova River was heavily polluted over a distance of eight kilometres near the junction with Ialomița.

Hazards related to damaged hydro-technical constructions may affect approximately 1,600 embankment works (8,700 km) and 1,353 dams (total volume 13.8 billion m^3). The partial failure or collapse of dams is caused by high flood-waves followed by catastrophic overflows. Outdated technologies are among high risk factors.

Map 3.16 Industrial units at technological risk in the Romanian Carpathians (2003) according to Seveso II Directive



The high flood-waves on the Tazlău River (July 29-29, 1991) that destroyed the Belci dam, followed by the sudden flooding of the valley downstream, produced 25 deaths (Stănescu 1995). In 1991, flood-waves destroyed 47 km of dams and nearly 117 km of maintained river banks, killing 110 people. The collapse of dams may also have cross-border effects. For example, in April 2000, the dam across the Crişul Alb river near the Hungarian border failed and flooded the Ineu-Chişineu Criş sector.

Forest fires in the Czech Republic and Slovakia

In the period 1995 to 2005, the Carpathian district of the Czech Republic most affected by forest fires was Breclav, in the southern part of the Moravian Carpathians. Other frequently affected districts are Prerov and Prostejov. In Slovakia, during the same period, the number of people affected or killed by fires fluctuated between 37 in 1997 to 68 in 1992, with an average of 53 victims per year.

Table 3.15 Fires in the Carpathian districts of the Czech Republic (1995-2005)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Number	24	39	9	21	14	28	7	13	34	27	20
Territory (ha)	15.19	46.27	4.67	14.46	8.32	7.91	5.28	7.06	11.81	8.13	16.98
Damages in mil. Czech krowns	1.022	2.773	0.331	0.986	0.814	0.702	0.680	1.367	1.595	1.342	1.636

Conclusions

In the field of environmental security, the greatest set of problems is related to global climate change and its regional/local manifestations such as floods and drought. A special category of negative climate change impacts in the Carpathians is strong windstorms, with growing catastrophic impacts on settlements and forests.

Natural and technological risks and hazards are increasingly interlinked. Their diversity and importance is very high in the Carpathians. For example, some accidents involving casualties and environmental pollution are produced by obsolete technologies, waste deposits or the transport of noxious substances. In certain situations, technological accidents, such as dam failure or explosions at installations may occur due to natural causes (e.g. earthquakes, floods), triggering a chain reaction of events. Certain technological disasters happening in one country may have impacts of a trans-border, regional or even macro-regional character. Research and monitoring, as well as adequate policy measures and their application in this field, should play an increasingly important role in the Carpathians.

3.9 Urban Environment and Cultural Heritage

Urban Development

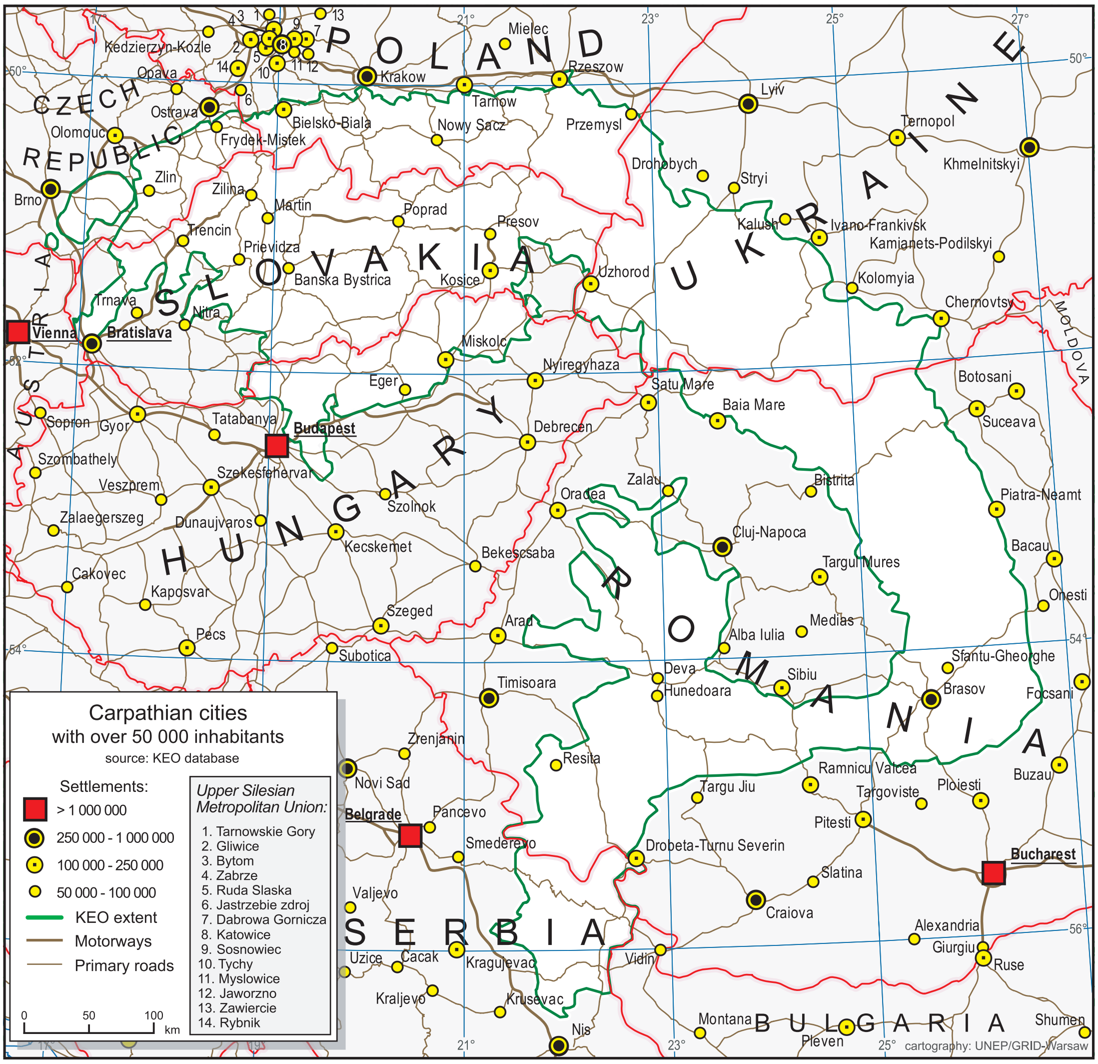
The urban environment and related issues are gaining in importance in the Carpathians. Rapid urbanization within the region is having the effect of putting additional pressure on the surrounding rural and natural environment, including biodiversity and traditional landscapes.

The legacy that past communist regimes left to Carpathian urban areas is still discernable. The growth and actual state of most urban areas during the communist era had little in common with today's concept of "sustainable" cities or towns. In fact, urban development during this period typically ignored inhabitants' requirements for a sound and healthy environment, as well as economic and social needs of future generations (Huba et al. 2000a).

The main aim of post-war industrialisation and urbanisation policy in the Carpathian region was largely attained through a gradual transition from prevailing traditional rural-agrarian structures to an urban-industrial society. This process was accelerated during the second part of the 20th century, significantly influencing the regional urban and suburban environment (Balteanu et al. 2006). As a consequence, most Carpathian countries today have large urban populations. For example, national statistics show that approximately 65 per cent of the population in the Czech Republic, Poland and Hungary, and 60 per cent in Slovakia, currently live in an urban setting.

In the period from 1950 to 1970, the Carpathians observed high rates of rural-to-urban migration. Between 1970 and 1990, industries were commonly located within or near residential areas. Air and water pollution, solid waste, noise, odours and soil contamination represented typical externalities (Vaishar et al. 2006). Furthermore, public and private transportation and related infrastructure depreciated the residential environment through noise, emission, vibrations and accidents.

Map 3.17 Carpathian cities with over 50,000 inhabitants (Hanusin and Huba 2007)



In terms of housing, a typical approach in the Carpathians during communism was Soviet-style urbanization based on large concentrated urban settlements, consisting mainly of concrete panel block buildings. These were common features of Carpathians' cities and towns, characterized by a lack of green space, proximity of polluting central heating plants, inadequate maintenance (e.g. low energy efficiency) and insufficient wastewater and solid waste management facilities.

In the Carpathians and their environs, one finds a single metropolitan city with more than one million inhabitants (Budapest), 13 cities with between 200,000 and one million inhabitants (e.g. Brasov, Bratislava, Kosice) and 22 towns and cities with between 50,000 and 200,000 inhabitants (see Map 3.17). Some other cities and towns are closely linked to the Carpathian region, while being geographically beyond its boundary. These large cities and towns, together with several industrial 'hot spots' in smaller settlements, are major driving forces behind environmental pollution and hazards within the Carpathians.

Threats to and Impacts on the Urban Environment

Since the fall of communism and over the last 18 years of transition, changes to the urban environment and its forms and structures have been significant. Carpathian cities and towns have continued to face various negative effects from urban development. Changes were most spectacular in larger cities, but similar tendencies also emerged in other municipalities. Transport became the main cause of both air and noise pollution (Vaishar et al. 2006).

The transformation of the urban environment was influenced by political changes occurring since 1989 and the subsequent economic, social, environmental and institutional transition from a centrally-planned system to a market economy. Globalisation and its effects also contributed to urban change in large post-communist cities. As a consequence, a profound reorganization of urban management approaches has taken place, impacting the lives of millions of urban residents in the Carpathians. Post-communist towns and cities in the Carpathians are now characterised by a gradual development of new lifestyles, changes in demographic structure and behaviour, and social, economic and environmental changes.

Environmental transformations in urban areas in post-communist Carpathian countries combine the restructuring of the built environment with underlying processes and forces of socio-economic reforms. The liberalization of the property market, growing disparity of income levels and formation of a well-paid upper/upper-middle class due to economic changes are having major influences on the urban environment. The problem of the creation of economic "ghettos" in larger cities is also connected with social differentiation.

During the past 18 years, important demographic changes occurred in many towns and cities. Reduced population growth caused by low birth rates has important implications for urban change. The rise of consumerism and the propagation of more materialistic values is a dominant cultural trend. These recent trends result in an emphasis on private property as an expression of wealth and status, especially by the new middle and upper classes. This includes the growing importance of private cars and living in suburban homes and apartment complexes.

Since the 1990s, the Carpathian economy entered a substantially different phase in terms of "production". Many industrial facilities were closed down and/or transformed, leading to lower industrial air pollution levels. The dominant trend has been the shift from manufacturing industries toward the development of a service sector, especially in city centres, where specialised shops, financial and business services have become concentrated. Another major outcome of the recent urban changes has been the re-industrialisation of some urban centres and adjacent areas. Green space is generally limited in inner-city areas, while extensive green areas in their surroundings sometimes compensates for this lack.

Technological advances that have transformed the means of interacting, living and working also had implications for urban reorganisation. The widespread commercial development of new technologies that have emerged during the 1990s (e.g. high-speed computing, advanced telecommunications) impacted the development of service systems and new forms and standards of residential environments (Ira 2003). Many post-communist cities changed their focus from industrial activities to services with high ambitions in the commercial, financial, cultural and educational spheres. Tourism has become an additional specific problem for the urban environment, due to its often intensive nature.

Urban Sprawl and Suburbanization

Today, all Carpathians countries are undergoing a trend, often strongly manifested, towards suburbanization, particularly on the outskirts of capitals and other large cities (Gremlica 2002). The migration of urban populations into surrounding open spaces accelerated during the 1990s, causing mostly negative effects. Building in greenbelts is accompanied by ecosystem destruction and deterioration of living conditions due to more frequent car use, new roads, urban sprawl and fragmentation of natural areas. Inefficient and unregulated land-use patterns are thus formed, threatening sustainable urban development in the longer term (Gremlica 2002). Conversely, mainly from the perspective of quality of life and reduction of pressures experienced in the inner city, suburbanization can also be positive.

"Urban sprawl" is by definition uncontrolled and unorganised growth, which can indeed be seen in all Carpathian major cities. The situation is further complicated by the fact that land use and spatial planning have declined over the last 15 years due to several reasons; for example, corruption in decision-making at the local level with respect to land use contracts and permits, governmental policies stimulating new investments in "greenfields", while leaving extensive "brownfields"[7] all but untouched. In the Czech Republic, the agency Czechoinvest offered investors 2,130 hectares of greenfields compared to only 320 hectares of brownfields. As a result, built-up areas are rapidly increasing with serious effects for local water cycles, traditional landscapes, local climates, and biological and cultural diversity.

Typical Carpathian suburbanization, except in some marginal cases, does not create new complete satellite settlements. Rather, new fragments, differing in the size of space and plots, are linked with existing village formations, infrastructure and amenities. There is little integration with the previously existing settlements, and the new patterns do not match the historic ones, leading to unattractive aesthetic results.

[7] Land previously used for industrial purposes or other commercial uses, that may be contaminated by low concentrations of hazardous waste or pollution.

Urban Transportation

The transport sector in large urban areas is a major factor leading to negative environmental impacts. Since 1990, cities and towns in the Carpathians have experienced several common features and trends related to city transport (Hanušin 2006):

- Substantial growth of individual/private car transport and a decline in the public transport systems in most cities and towns in the region;
- New construction and improved transport infrastructure (e.g. parking, roads, highways);
- Increase in the number and gravity of accidents;
- Improvement in the technical parameters and thus performance of cars.

The growth in the share of bus transport in public transport is nevertheless a reality in most Carpathian countries: the increase ranges from 69% in 1993 to 82% in 2004 in the Czech Republic; 52% in 1993 to 71% in 2004 in the Slovak Republic; and 65% in 1995 to 79% in 2004 in Poland. Only in Hungary has the share of bus transport slightly decreased since the early 1990s.

Table 3.16 Changes in the number of passenger cars in selected Carpathian cities/districts in Slovakia after 1989

NUTS 4	1990	1991	1992	1993	1994	1995	1996
Prievidza	21708	22403	23537	24471	24268	24721	26323
Čadca	10618	10958	11761	12488	12727	13273	14632
Martin	18186	18768	18807	19755	19052	18995	20217
Žilina	24620	25408	27113	29148	28813	29676	30933
B.Bystrica	31825	32844	35663	39330	41845	44958	50368
Lučenec	16628	17160	18608	18766	18789	19152	20118
Rim.Sobota	16723	17259	18114	18632	18540	18821	16981
Veľký Krtíš	9183	9477	9696	9724	9490	9360	9671
Zvolen	23857	24621	25875	25967	25740	26002	27408
Bardejov	11448	11815	12224	12620	12675	12717	12301
Humenné	17582	18142	16233	16519	16488	16900	18593
Poprad	22701	23428	24476	23964	24080	24663	26478
Prešov	29266	30203	32711	31788	31835	32236	34864
Košice	45129	46573	50711	52842	52837	52277	57929
Rožňava	13394	13823	14455	14693	14700	14812	17548

Source: Slovak Environment Agency, 2006, adopted by Huba 2007

The main negative impacts from city transport are emissions, noise, congestion and land use changes for new transport infrastructure, as well as accidents. These impacts are more intensive, socially complicated and problematic than similar impacts outside urban areas due to the greater concentration of people and their activities within a relatively limited space.

Figure 3.17 Two transport modes in Romanian Carpathians

The main pollutants produced by the transport sector are volatile organic compounds (VOCs), carbon monoxide, nitrogen oxides, sulphur dioxide, particulates, heavy metals and greenhouse gases. Increased pollution from more intense traffic levels in Carpathian cities and towns was partially compensated for by improvements made to technical parameters of cars and the use of unleaded petrol, resulting in an relative reduction of pollutants emitted, with the exception of carbon dioxide.

Nevertheless, cities contribute to increased concentrations of air pollutants from road transport, particularly when located in a basin with weak natural ventilation. This situation is typical for the Carpathians; for example in Brasov, Romania and to some extent in Kosice, Slovakia. Streets and squares suffer from similar effects, with concentration of emissions from car transport reaching high values. In addition, maximum noise limits in residential areas (as established by WHO) are frequently exceeded in Carpathian cities.

Intensive car transport and expanding road networks are in conflict with the historical design of many Carpathian cities. The result is traffic congestion, with many negative impacts such as increased emissions and noise, often at the cost of disturbing historical city centres, or sometimes even their partial destruction to make way for new infrastructure.

The increase in the number of private cars in cities induces new demands and considerations for transport, such as the necessity for new parking spaces and new and/or wider roads and crossroads. Urban development trends are generally driven by car transport requirements. For example, new shopping centres located on the margins of cities are only designed for urban dwellers having cars. Furthermore, transport construction may disturb the integrity of cities; for example, the motorway crossing the historical centre of old Bratislava now separates the town into two distinct parts.

In addition, the intensive development of car transport in the Carpathians does not correspond to what is often the inappropriate nature of current road infrastructure. This has led to a rapid growth in the number of car accidents in the Carpathians and consequent injuries/deaths.

Figure 3.18 Local train in Romanian Carpathians

Policy Measures and Responses

The concept of the "sustainable city" (Prodanovic 2006) opens the way to a new vision of Carpathian urban development. The aim is to provide theoretical, sociological and urban interpretations of the city concept through formulation of models, assessment of public views and opinions, the media's role and impact, sustainable production and consumption patterns, as

Proposed instruments for the implementation of a sustainable development transportation policy in Poland

In the area of landscape management (utilization of land):
• restrict the expansion of towns/cities, maintain an adequate urban intensity and preserve open landscapes;
• locate office and trade activities in urban centres or in other places that have good access to public transport;
• restrict car traffic by determining the lowest acceptable number of parking spaces;
• increase housing intensity in centres and internal urban area;
• re-locate parking spaces from the inner urban area to outside urban areas (i.e. park & ride);
• set aside areas close to existing transport networks for the purpose of constructing facilities for the distribution of goods;
• create incentives for urban development around existing public transport routes and stations;
• construct networks of bicycle and pedestrian routes;
• establish car-free areas.

In the area of environmental protection:
• tighten standards to reduce emissions and the noise level from new vehicles;
• promote incentives to lower fuel consumption by new vehicles;
• promote the use of low-emission buses and ban/limit truck traffic at night in sensitive areas;
• apply fiscal instruments in order to promote environmentally friendly fuels and less polluting cars, trucks and buses;
• use sign-posting and traffic engineering in order to keep traffic flow at levels of ecological acceptance.

Source: Kassenberg (2002)

The perception of their environment by the inhabitants of Bratislava

Bratislava is one of the smallest capitals in Europe with a population of 430,000 people, situated on the edge of the Carpathian region. It is Slovakia's largest city as well as its administrative, economic, financial and cultural centre.

In 2000, a survey focusing on the perception of negative and positive developmental aspects of urban environmental change was conducted in Bratislava (Ira 2003). Information from individuals was collected via a formal questionnaire.

Major positive features relating to the city's development over ten years of transition were identified, including the development and improvement of infrastructure, renewal and reconstruction of historical town, better-quality services including tourism and recreation facilities, improved quality of greenery, higher aesthetic quality and tidiness. Some negative features were also identified: environmental pollution and overall deterioration of the environmental quality, degradation of public transport, higher incidence of drugs, crime and vandalism, higher unemployment, and lower aesthetic quality of the urban environment in some marginalized areas/districts.

The questionnaire also focused on opinions concerning sustainable development trends related to functional zones and municipal areas. A positive development trend towards a more sustainable situation was perceived by 76.1 per cent of respondents. The Old Town was estimated as the most sustainable city zone by 74 per cent of participants (this despite its near-separation into two parts by a new major cross-city route). In contrast, the development of the large-scale housing estate Petržalka (one of the largest in the region) was estimated as unsustainable by 46 per cent of respondents.

Source: Ira (2006)

well as the relevance of Local Agenda 21 strategic documents.

The ecological attributes of Carpathian cities and their hinterland is not unilaterally related to their natural resources and values, but also to indigenous knowledge and practices, based on cultural codes, which are relatively well-preserved in Carpathians cities and settlements. On the other hand, the quality of the environment in Carpathian cities and settlements needs to be improved as well. One sustainable solution to achieve this ecological target is the promotion of bio-climatic architecture based on the sustainable use of natural resources, protection of biodiversity, landscape identity and related "artefacts".

Last but not least, urban management can be understood as a function of the municipal authority, governing the development of the urban land, marketing the city as a public good, controlling housing policy, rent and maintenance of housing stocks, as well as micro-credit schemes, the organization of the building industry, and to a certain extent acting to moderate pure market forces.

Cultural Heritage

The Carpathian region has always been a crossroads for business routes, human migrations and military expeditions. It was a territory where raids from many directions and empires (the Roman Empire, Germans, Swedes, Soviet forces, Tatars and Turks) were frequently halted or neutralized (see Chapter 1). For ages, it was an area where different tribes and ethnic and religious groups and nations – including the Austrians, Bohemians, Boykos, Czechs, Hungarians, Lemkos, Poles, Romanians, Ruthenians, Slovaks, Ukrainians and Wallachians – met, fought, colonized and finally assimilated with each other, as in a melting pot. These clashes and inter-minglings explain the region's richness, diversity and cultural significance.

Today as in the past, nature, culture and a shared history bind the many Carpathian peoples together with a common spirit and to a cultural/historical area. This common heritage serves to unite peoples who from birth share the same

UNESCO cultural heritage sites in the Carpathians and/or Carpathian foothills

Czech Republic
1. Lednice-Valtice Cultural Landscape
2. Gardens and Castle at Kroměříž

Hungary
3. Tokaj Wine Region Historical Cultural Landscape
4. Old Village of Hollókő and its Surroundings
5. Budapest, including the Banks of the Danube, the Buda Castle Quarter and Andrássy Avenue

Poland
6. Kalwaria Zebrzydowska: the Mannerist Architerctural and Park Landscape Complex
7. Wieliczka Salt Mine
8. Wooden Churches of Southern Little Poland
9. Krakow: old town

Romania
10. Churches in Moldavia
11. Hurezi Monastery
12. Villages with Fortified Churches in Transylvania
13. Dacian Fortresses of the Oraştie Mountains
14. Wooden Churches of Maramureş Serbia (under preparation)

Slovakia
15. Banská Štiavnica
16. Spišský Hrad and its Associated Cultural Monuments
17. Vlkolínec
18. Bardejov Town Historical Monument Reserve

hardships and joys of mountain life. Many practices and traditions survive, including Carpathian music and dance, harvest festivals, traditional agricultural products such as sheep cheese and plum brandy, magnificent wooden architecture, and local costumes and folklore.

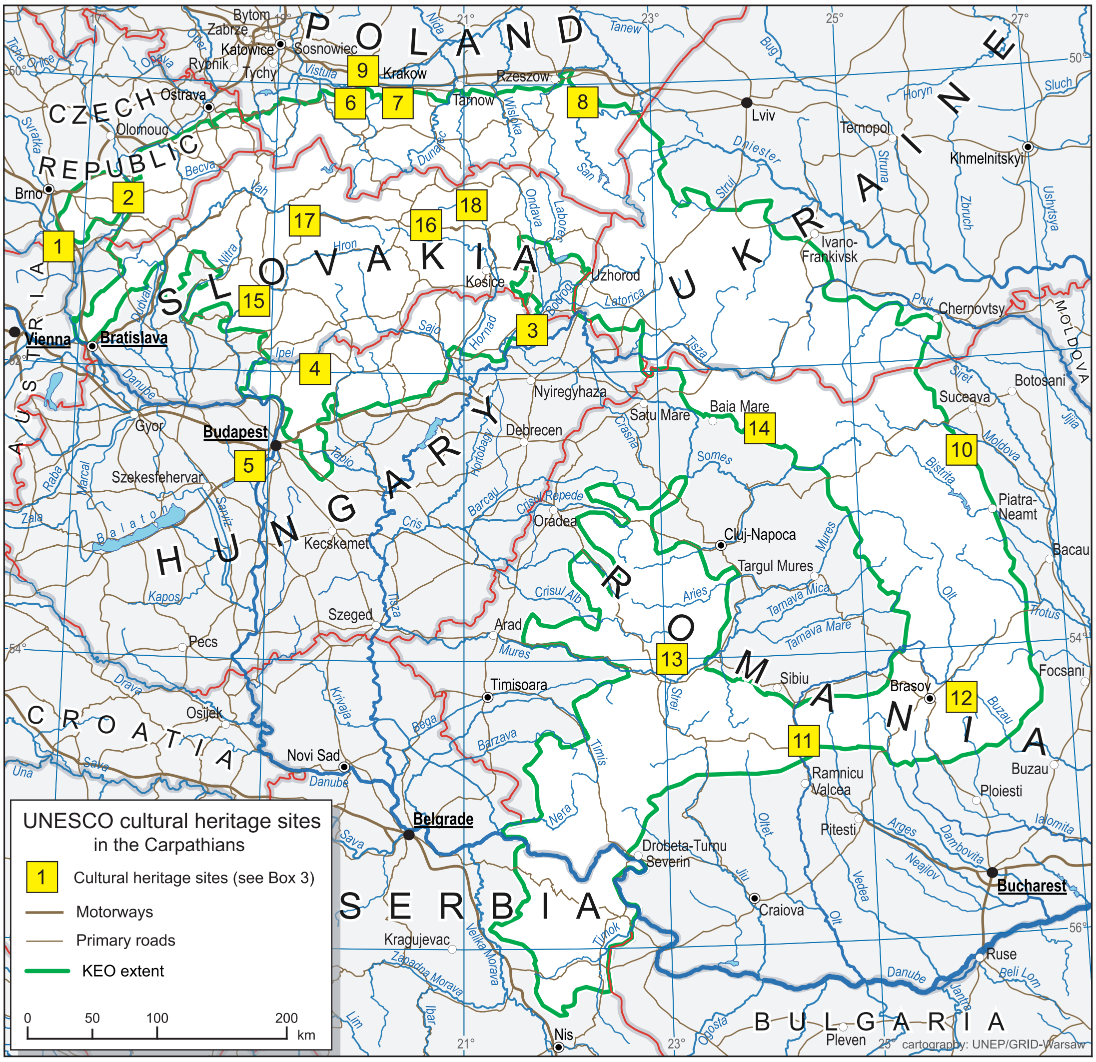
Many historical and cultural monuments and structures also survive. They represent important evidence of historical development and lifestyles as manifestations of human creativity and work in all fields of activity with revolutionary, historical, artistic, scientific or technical value. They also have a direct relationship to important personalities and historical events. Some of the historical patrimony has received official protection, particularly sites designated as UNESCO World Heritage Sites (see Box above and Map 3.18). There are thousands of others that are not part of any official lists but which remain valuable for other reasons (e.g. contribution to the identity, amenity and quality of life). Cultural heritage is socially relevant because it attaches individuals to their past personally and collectively through its physical, cultural, emotional, intellectual and spiritual aspects. The stories and events, people and aspirations that communities associate with their heritage give meaning to their past, present and future.

This common Carpathian heritage survives in spite of national boundaries and major transformations in the region's economy, political structure and ideology, legal system and stratification of society. The post-war period of intensive industrialisation and collectivisation caused a rapid disappearance of historical structures. In particular, technological advances sustaining a high-technology society place emphasis on engineering and science rather than religion or culture, thus altering the fundamental societal values. The result is that a deterioration of both natural and historical-cultural patrimony may occur.

There is a need to preserve relatively untouched ecosystems and revitalise transformed and/or

Figure 3.19 Banska Štiavnica, World Heritage site (Lacika)

Map 3.18 UNESCO cultural heritage sites in the Carpathians (Huba 2007)



denaturalised contemporary landscapes and environments. The protection and revitalisation of landscapes modified during centuries by predecessors of the contemporary society is a prerequisite for sustainable development in the region. These landscapes were and still are typical for the Carpathian mountains and sub-mountain systems: traditional environments of the countryside (e.g. villages, fields, meadows, vineyards, ancient towns, historical mining regions and technical monuments, historical parks, gardens, cemeteries, etc.), and give the region its unique character and appearance (Huba 2000b).

'Nature' and 'culture' represent two interconnected elements of the Carpathian landscape in the Central/South-Eastern European space, which is rich in cultural and historical transformations of nature and equally profuse in both natural and cultural diversity (and authenticity) in comparison to much of Western Europe. On the other hand, a substantial part of the cultural heritage is non-material, in the form of literature and folk traditions.

Preservation of cultural heritage in the Slovak Carpathians

In the Slovak Carpathians, there is a high density and large diversity of valuable cultural heritage sites. Examples include: archaeological sites in Bíňa, Nižná Myšla, Spišský Štvrtok and Nitra; wooden folk architecture in Vlkolínec, Podbiel, Podšíp, Osturňa and Ždiar; wooden churches in Eastern Slovakia, castles such as Spišský hrad, Strečno, Trenčín, Devín and Krásna Hôrka; technical monuments in Banská Štiavnica and preserved areas in the towns and cities of Banská Bystrica, Banská Štiavnica, Bardejov, Bratislava, Kežmarok, Kremnica, Levoča, Nitra, Podolínec, Poprad, Spišská Kapitula, Štiavnické Bane, Trenčín, Prešov, Košice, Spišská Sobota, Žilina and others. Overall, there are nearly 13,000 officially designated immovable cultural monuments (historical buildings and monuments, archaeological sites, architectural ensembles and complexes, historical town centres and other populated areas, streets, squares, cemeteries, etc.) together with more than 30,000 movable ones (individual objects – archaeological findings, antiquities, historical relics, works of art, manuscripts, etc.), mostly concentrated in museums and galleries.

During the communist period, the process of urbanisation, collectivisation and industrialisation of rural areas had adverse impacts on traditional social structures and forms of settlements, for example through uniform housing development. However, there are signals of a possible revival of rural areas through the return of former inhabitants.

Numerous threats to these sites and cultural heritage remain, including new construction, the abandonment of traditional agriculture and non-traditional renovation of old buildings (e.g. not using thatch roofs or wooden windows). It is difficult to find qualified craftsmen with traditional skills for maintaining and restoring cultural monuments; therefore, alternative technological solutions are often applied. Furthermore, the depopulation of rural areas, where much cultural heritage and traditional knowledge is concentrated, continues with adverse impacts on the protection and maintenance of cultural heritage.

Other problems include insufficient historical and national awareness, evanescence of traditional cultural values, and often a preference for imported items.

On the positive side, achievements include the growing involvement of NGOs and local authorities in the protection of monuments and their use for sustainable tourism, a system of protection for historical monuments, and the inclusion of several monuments in the UNESCO list of World Cultural Heritage sites (see above).

Selected tools supporting the preservation of monuments in the Slovak Carpathians include:

- General obligations in the Constitution
- Slovak Act No. 49/2002 on the protection of monuments and historic sites.
- Act 237/2000 on land-use planning.
- The National Plan for Rural Development, adopted by the Slovak Government and the European Commission in 2000 (adoption of this plan was a pre-condition for access to EU funds); and
- National Programme of Restoration and Renewal of Cultural Monuments (Belčáková 2006).

Conclusions

The urban system (including its environment) acquires new characteristics and dimensions in the Carpathians. As part of the economic and socio-political development targets set for the beginning of the third millennium, and with a view to integration in the European urban system, the industrial city – representative of typical Carpathian urban settlement types – is being gradually replaced by the multi-functional and service type of urban area.

The protection of cultural and historical monuments can be seen as a form of environmental protection, requiring a common base of classification of the urban heritage in the Carpathians, thorough analyses of ways and means of restoration, consideration of ethnological aspects of conservation of archaeological sites, protection of cultural scenery, and management of monuments. New problems and challenges are related to the protection of "genus loci", a location's distinctive cultural essence and heritage.

Important questions arise with respect to stakeholders' responsibility vis-à-vis the cultural and historical heritage, such as who is responsible and which sectors of society should care: governments, citizens, NGOs, market forces; some or all of the preceding? Challenges include issues such as new information and communication technologies, information management and knowledge about the historical heritage, the expansion of tourism, and environment and sustainability. The temporal aspect is very important in the Carpathians, due to the extremely high speed of modernisation and globalisation trends, threatening sensitive historical structures and traditional behavioural patterns. The very definition of cultural and historical heritage needs to be reconsidered due to these recent developments.

The Carpathian region represents certain values, both environmental and cultural, which may serve as guides towards a more sustainable way of living and can potentially trigger successful development in the region. The desired development pattern for the region needs to be collectively pursued in a strong partnership, and based on regional and international cooperation involving all elements of the society, in the Carpathian countries and the world. The unique life experience and natural and cultural heritage of the Carpathians are meaningful to local populations, but they could also become a positive example for people living elsewhere in marginalized and/or threatened environments.

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