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Programme Carpathian Project

Activity 2.7: Forestry and timber industry

Report on

Current State of Forest Resources in the Carpathians

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INTRODUCTION

The Carpathian Convention - SARD-F

The Carpathians are shared by seven Central and Eastern European Countries: Czech Republic, Hungary, Poland, Romania, Serbia and Montenegro, Slovak Republic and Ukraine, five of which have already joined the European Union (EU). This increases the possibilities of sustainable development based on the rich natural, environmental, cultural and human resources of the region.

On 4 January 2006, the Carpathian Convention entered into force as a new international treaty to conserve the rich wildlife, wondrous landscapes and cultural heritage of the Carpathian mountainous region. The development of the Framework Convention on the Protection and Sustainable Development of the Carpathians began in 2002, the United Nations International Year of the Mountains, and mirrors the development of the Alpine Convention which predates it. On 22 May 2003 in Kyiv, Ukraine, the seven concerned Ministers of the Environment signed the Framework Convention on the Protection and Sustainable Development of the Carpathians. The Carpathian Convention provides the framework for cooperation and multi-sectoral policy coordination, a platform for joint strategies for sustainable development, and a forum for dialogue between all stakeholders involved.

On May 2007, in the context of the Carpathian Project, the Dept. TeSAF of the University of Padova signed a contract with the Environmental Information Centre UNEP/GRID-Warsaw within INTERREG IIIB CADSES "Carpathian Project", in order to carry out the Action 2.7 "Forestry and timber industry".

The Carpathian Project has been developed by UNEP - Interim Secretariat of the Carpathian Convention and RTI Polska, together with Carpathian Convention Signatories and the broad project consortium. The Project originates from a fusion of the Carpathian Convention process with the conclusions of the INTERREG IIC Vision PlaNet Project.

The project is carried out within The EU Community Initiative INTERREG III B CADSES Neighbourhood Programme. The project duration: September 2005 - August 2008.

Objectives

The essential objectives of Action 2.7 were: - to provide a general overview of the current state of forest resources in the Carpathians and - to highlight the challenges and priorities for adapting the management of Carpathians forests to new environmental and socio-economic conditions. The outputs foreseen were two reports dealing with the forest status (first report) and forest policies (second report).

This first report presents an analysis of the current state of forest resources in the Carpathians including the following elements:

- description of natural resources of forests;
- analyses of forest management systems;
- state of nature protection and forest health in the Carpathians;
- disturbances and damages to forest resources.

Methods

The study has been carried out through a bibliographic research, information requests to experts of each country, field trips and meeting organization.

The existing databases and other sources used for the relevant analysis include data collection in the context of major studies such as:

- Carpathian Convention and Carpathian Project document and publications from Workshops, Meetings, Conferences, etc.
- UNECE Statistical Databases and publications
- FAO forest data
- UNESCO documents
- UNFF reports
- EFSOS studies
- EFI databases, research reports and proceedings,
- National CSO (Central Statistical Offices)
- EURAC studies
- EEA publications
- National reports of Ministers, Forest Management Institutes, Forest Research Institutes
- National Forest Inventories
- IUCN
- Scientific publications
- WWF REPORTS
- Other NGOs and associations (websites and publications)
- Any other documents

During the project, field trips were organized to collect further information. The visited countries were:

- Romania, with the support of Ionel Popa, Experiment Station for Spruce Silviculture (ICAS) Suceava (from 10th to 14th August 2007)
- Ukraine, with the support of Yuriy Shparyk, Ukrainian Research Institute for Mountain Forestry (URIMF) – Ivano-Frankivsk (from 16th to 20th October 2007)
- Slovakia, with the support of Mikulas Cernota, Forest Research Institute (FRI) – Zvolen (from 17th to 20th October 2007)
- Meeting organisation: Second Meeting of the Carpathian Convention Working Group on Sustainable Agriculture, Rural Development and Forestry, in collaboration with EURAC – Bolzano (see report in Annex 1). The draft of the Protocol on Sustainable Forest Management to the Framework Convention on the Protection and Sustainable Development of the Carpathians, discussed in the Meeting, is in Annex 1 of the Report on Challenges and priority for adapting the management of Carpathians forests to new environmental and socio-economic conditions.

After the first outlook of the different information sources, some problems emerged with the data, such as:

- the Carpathian boundaries have not yet been defined, so different sources report data referred to different areas;
- the available data were not homogeneous for all the Carpathian regions (i.e.: forest definition, forest types classification, etc.);
- they were most often aggregated at national level, thus considering only the Carpathian area is somewhat subjective;
- many articles, publications, laws and websites were not in the English language (countries languages).

It was therefore decided to draw up a specific questionnaire in order to collect some basic harmonized information and to send it to reference persons (experts) in each country.

Table 1 reports the list of the people completing the questionnaires. The information collected from the experts was essential for this study and the authors warmly acknowledge all the contributions. Where no sources are quoted, all the information in the text, table and figures are to be considered as the result of this research. Clearly, the authors should be held responsible for any mistake and/or incorrect data that might be found in the reports.

Country	*Contact person*	*Institute*	*Forest resources input*
Czech Republic	Otakar Holusa	Ministry of Agriculture, Forest Management Institute	Questionnaire
Hungary	Csaba Mozes	Ministry of Agriculture and Rural Development – Department of Natural Resources	Questionnaire and other data
Poland	Czeslaw Koziol	Forest Gene Banks Kostrzyca	Questionnaire and other data, correction of the report draft
	Katarzyna Loskot	Forest Gene Banks Kostrzyca	Correction of the report draft
	Tomasz Wójcik	International Cooperation Department General Directorate of State Forests	Correction of the report draft
Romania	Dragos Mihai Mihai Zotta	National Forest Administration ROMSILVA – Silvotourism Unit National Forest Administration ROMSILVA -	Questionnaire and other data Questionnaire and other data
	Mircea Verghelet	National Forest Administration ROMSILVA – Head of Protected Areas Unit	Questionnaire
	Ionel Popa	Experiment Station for Spruce Silviculture (ICAS) - Suceava	Database of Forest Management Plans of Suceava county and other data
Serbia:	Rastko Jankovic	Ministry of Agriculture Forestry and Water Management - Directorate of Forests	Questionnaire and other data
	Sasa Stamatovic	Ministry of Agriculture Forestry and Water Management - Directorate of Forests	Correction of the report draft and other data
Slovakia:	Mikulas Cernota	National Forest Centre – Forest Research Institute Zvolen	Questionnaire and other data, correction of the report draft
Ukraine	Yuriy Shparyk	Ukrainian Mountain Forestry Research Institute – Ivano-Frankivsk	Questionnaire, other data and elaborations, correction of the report draft
	Liubov Poliakova	State Forestry Committee, Kyiv	Questionnaire and other data, correction of the report draft

Tab. 1 – List of the country experts contacted during the study.

An example of the questionnaire proposed to the experts is shown in figure 1.

COUNTRY: ………..
The Agency completing the Questionnaire: …………………………………………………………………………

STATE OF FOREST RESOURCES

1. Total Forest Area (ha): …………..
2. Carpathian Forest Area: …………
3. Total Forest Area in percent of Total Land Area of Country: …………..
4. Carpathian Forest Area in percent of Total Forest Area of Country: …………..
5. Carpathian forest ratio: …………..
6. Forest area per capita:
   - national level: …………..
   - Carpathian region: …………..
7. What is the trend of the forest cover pattern in the Carpathian Region?
   ☐ increase ☐ decrease ☐ no variation
   What is the annual rate? …………..
   List the main causes:
   ……
8. Growing stock:
   - National level: …………..
   - Carpathian forests: …………..
9. Volume of wood per capita:
   - national level: …………..
   - Carpathian region: …………..
9. Annual growing increment:
   - national level: …………..
   - Carpathian forest: …………..
10. Status of the National Forest Inventory:
   - Last NFI: …………..
   - State of development of current NFI:
   ☐ NFI not available
   ☐ NFI in progress (conclusion date: …….)
   ☐ NFI concluded
11. If the NFI is in progress or completed, specify:
   - Inventory cycle: …………..
   - Field sampling design. (Describe: average distance between clusters, shape of a cluster. distance between plots in a cluster, number of plots in a temporary (permanent) cluster, etc.):

……

Estimated error for areas and growing stocks: ……………………………………………

   - Legislative reference for NFI: ………………………………………………………………...
   - Data availability of the field measurements:

……

Contact for NFI data:

……

Fig. 1 - Example of questionnaire used in this study.

12. Description of the most common forest types in the Carpathian Region in ………..
(EEA categories 2006). Select the most representative and fill in the fields with information:

- *Subalpine larch-arolla pine and dwarf pine forest (3.1)*
    - total area and growing stock: ………..
    - characteristic (FRA 2005):
        - ☐ primary
        - ☐ modified natural
        - ☐ semi-natural
        - ☐ productive plantation
        - ☐ protective plantation
    - age class distribution and forest structure: ……………………………….
    - main functions: …………………………………………………………...
    - adopted management (cutting and regeneration system):
    - availability of dendrometric data in sample areas (e.g. experimental plots)
- *Subalpine and montane spruce and montane mixed spruce and silver fir forest (3.2)*
    - total area and growing stock: ………..
    - characteristic (FRA 2005):
        - ☐ primary
        - ☐ modified natural
        - ☐ semi-natural
        - ☐ productive plantation
        - ☐ protective plantation
    - age class distribution and forest structure: ……………………………….
    - main functions: …………………………………………………………...
    - adopted management (cutting and regeneration system):
    - availability of dendrometric data in sample areas (e.g. experimental plots)
- *Alpine Scots pine and black pine forest (3.3)*
    - total area and growing stock: ………..
    - characteristic (FRA 2005):
        - ☐ primary
        - ☐ modified natural
        - ☐ semi-natural
        - ☐ productive plantation
        - ☐ protective plantation
    - age class distribution and forest structure: ……………………………….
    - main functions: …………………………………………………………...
    - adopted management (cutting and regeneration system):
    - availability of dendrometric data in sample areas (e.g. experimental plots)
- *Oak-hornbeam forests (5.1, 5.2)*
    - total area and growing stock: ……………………………………………
    - characteristic (FRA 2005):
        - ☐ primary
        - ☐ modified natural
        - ☐ semi-natural
        - ☐ productive plantation
        - ☐ protective plantation
    - age class distribution and forest structure: ……………………………….
    - main functions: …………………………………………………………...
    - adopted management (cutting and regeneration system):
    - availability of dendrometric data in sample areas (e.g. experimental plots)

Fig. 1 – Example of questionnaire used in this study, continue

- *Ash and oak-ash forests (5.3)*
  - total area and growing stock: …………………………………………….
  - characteristic (FRA 2005):
    - ☐ primary
    - ☐ modified natural
    - ☐ semi-natural
    - ☐ productive plantation
    - ☐ protective plantation
  - age class distribution and forest structure: ……………………………….
  - main functions: …………………………………………………………...
  - adopted management (cutting and regeneration system):
  - availability of dendrometric data in sample areas (e.g. experimental plots)
- *Carpathian sub-montane beech forests (6.5)*
  - total area and growing stock: …………………………………………….
  - characteristic (FRA 2005):
    - ☐ primary
    - ☐ modified natural
    - ☐ semi-natural
    - ☐ productive plantation
    - ☐ protective plantation
  - age class distribution and forest structure: ……………………………….
  - main functions: …………………………………………………………...
  - adopted management (cutting and regeneration system):
  - availability of dendrometric data in sample areas (e.g. experimental plots)
- *Carpathian montane beech forests (7.5)*
  - total area and growing stock: …………………………………………….
  - characteristic (FRA 2005):
    - ☐ primary
    - ☐ modified natural
    - ☐ semi-natural
    - ☐ productive plantation
    - ☐ protective plantation
  - age class distribution and forest structure: ……………………………….
  - main functions: …………………………………………………………...
  - adopted management (cutting and regeneration system):
  - availability of dendrometric data in sample areas (e.g. experimental plots)
- *other forest types*:…………………………………………………………………… Level of natural species composition of the forests in the Carpathian region % area:

Very low, exotic species, natural species composition under 30% …………..
Low or average, monoculture, natural species composition 30 – 50% …………..
High, very high or unique, natural species composition more than 51% ……………

13. Is current management policy oriented to the achievement of a more natural stand composition?

……

Fig. 1 – Example of questionnaire used in this study, continue

14. Major disturbances and impacts: select (X) the most important and, if possible, specify the affected area:

Abiotic and biotic factors:

	floods	erosion	droughts	windfalls	forest fires	air pollution	insects and fungi (specify)	others (specify)
Subalpine larch-arolla pine and dwarf pine forest (3.1)								
Subalpine and montane spruce and montane mixed spruce and silver fir forest (3.2)								
Alpine Scots pine and black pine forest (3.3)								
Oak-hornbeam forests (5.1, 5.2)								
Ash and oak-ash forests (5.3)								
European broadleaved forests (5.4, 5.5, 5.6, 5 .7)								
Carpathian sub-montane beech forests (6.5)								
Carpathian montane beech forests (7.5)								
other forest types								

Anthropogenic factors:

	over-intensive tree cutting in private forests	illegal cuttings	hunting / poaching	tourism/poorly regulated sporting activities	others (specify)
Subalpine larch-arolla pine and dwarf pine forest (3.1)					
Subalpine and montane spruce and montane mixed spruce and silver fir forest (3.2)					
Alpine Scots pine and black pine forest (3.3)					
Oak-hornbeam forests (5.1, 5.2)					
Ash and oak-ash forests (5.3)					
European broadleaved forests (5.4, 5.5, 5.6, 5 .7)					
Carpathian sub-montane beech forests (6.5)					
Carpathian montane beech forests (7.5)					
other forest types					

. 15. Protected areas in the Carpathian Region (add if necessary):

Fig. 1 – Example of questionnaire used in this study, continue

Other protected areas:

Title	*Area (ha)*	*Virgin forest area (ha) (if present)*	*Type of forest*	*Ongoing research activities*

- Other protected areas:
- Protected areas planned for the near future

……
……
…………………………………………………………………………………………

15. Are there any virgin forests that are NOT subject to any form of protection?

☐ **YES** ☐ **NO**

If Yes, specify:

Area: ………………

Percent on the total area of virgin forests: ……………

Fig. 1 – Example of questionnaire used in this study, continue

Overview of forest resources in the Carpathian area

Forest cover is significant in the Carpathians: its extension is about 10 M ha, which means around half of the Carpathians, although it is unequally distributed between the Carpathian countries - from 29.6% cover in Hungary to over 60% in Romania and Serbia.

Particularly steep rocky slopes and high plateaus are covered with forests. The timberline increases from 1 500 m a.s.l. in the Western Carpathians up to 1 700 m in the Green and Eastern Carpathians. In the Southern Carpathians, the timberline is located between 1 800 and 1 900 m. At lower altitudes spruce and beech grow, whereas they become increasingly fragmented in higher areas, starting from the centre of the Carpathians outwards, where other land uses become more prevalent. While in the Northern and Southern Carpathians major forests are intercepted by other land uses and natural conditions, the Green Carpathians in Ukraine are comprised of a vast connected area of forests, which ends at the southern border and differs clearly from the situation in Romania (Ruffini et al. 2006).

Table 1 reports the data on forest areas in the seven countries:

	COUNTRY AREA	**FOREST AREA**		**Carp. region / Country**		**Carp. region / Carp. Mt.s**	**FOREST AREA in the Carp region**		**Carp. forests / Country forests**	**Country Carp. forests / Carp. forests**
	Area M ha	Area M ha	%	Area M ha	%	%	Area M ha	%	%	%
Czech Republic	7.89	2.65	33.6%	0.71	9.0%	3.8%	0.31	43.4%	11.7%	3.1%
Hungary	9.30	1.98	21.3%	1.34	14.4%	7.2%	0.40	29.6%	20.1%	4.0%
Poland	31.27	9.00	28.8%	1.67	5.3%	8.9%	0.76	45.6%	8.4%	7.7%
Romania	23.84	6.43	27.0%	7.70	32.3%	41.2%	4.60	59.7%	71.6%	46.4%
Serbia	8.84	2.31	26.2%	0.07	0.8%	0.4%	0.04	60.1%	1.9%	0.4%
Slovakia	4.90	2.01	41.0%	3.51	71.5%	18.7%	2.01	57.3%	100.0%	20.2%
Ukraine	60.37	10.80	17.9%	3.70	6.1%	19.8%	1.80	48.6%	16.7%	18.1%
Carpathian mountains				**18.70**			**9.92**	**53.0%**		

Tab. 1: Forest areas in the Carpathian countries

As can be seen from figure 1, most of the Carpathian forests are located in Romania, which includes around 50% of all Carpathian forests.

Other countries with large forest areas in the Carpathians are Slovakia and Ukraine, with about 2 M ha in each Carpathian region, and Poland (less than 1 M ha).

Serbia is the country with the smallest area in the Carpathians and a Carpathian forest surface of only 0.04 M ha: the official definition of Carpathian in Serbia includes only a small area on the border with Romania, which correspond more or less to the Djerdap National Nature Park. Although a recent study (Tar 2007) shows that the area of the Carpathian region may be extended to the whole massif on the south of the actual official Carpathian Region (from 0.07 M ha to 0.86 M ha), we shall take the stricter definition of Carpathians into consideration for Serbia.

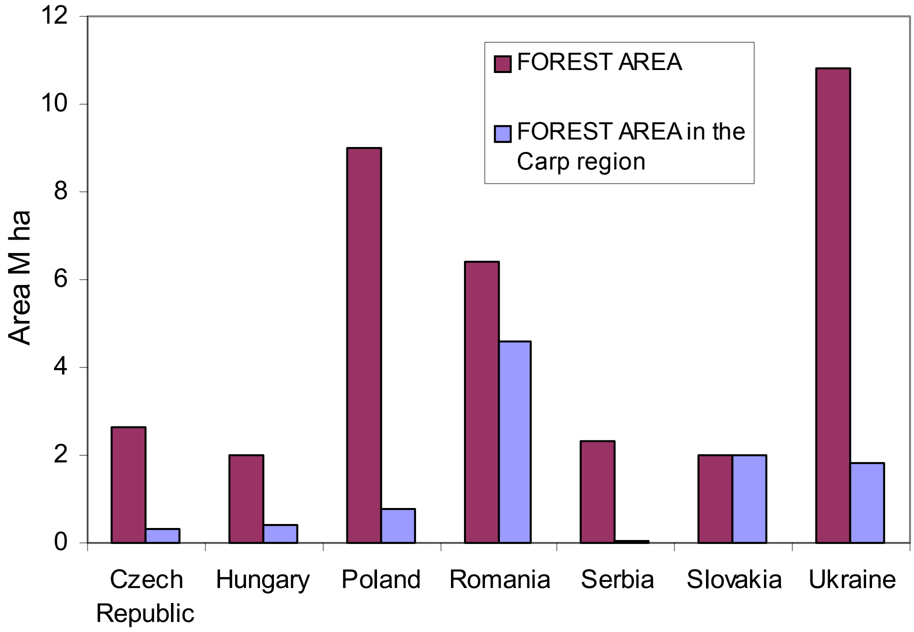

Fig. 1: share of Carpathian forests among the countries of the Carpathian Convention

Forest cover in the Carpathians shows an **increasing** trend (as highlighted also from the FRA2005 reports), as a result of the land abandonment process in course and specific afforestation/reforestation practices in degraded lands, set by national legislations. With regard to this matter, it is worth quoting a recent study (Kozak *et al*. 2007), which analysed the forest cover and pattern changes of some areas in the Northern Carpathians through a satellite-based methodology. The study area covers a section of the northern part of the mountain arch, located in Poland, Slovakia and Hungary (standard Landsat satellite scene 187_26). It encompasses diverse environments of low foothills of the northern and southern slopes of the Carpathians, several ranges of mid-altitude mountains and the eastern part of two high-altitude mountain ranges: the Tatra Mountains and the Lower Tatra Mountains. Kozak *et al.* studied the changes in forest cover through a comparison of satellite images taken in 1987 and 2000. This analysis highlights the presence of a slow forest expansion in the area (annual rate of 0.1%).

Carpathian forests are productive ecosystems: average **growing stocks** and increments of the Carpathian regions are generally higher than the national value (tab. 3):

Country	*Growing stock*				*Annual growing increment*			
	National value		*Carpathian region*		*National value*		*Carpathian region*	
	M m^3	*m^3ha^{-1}*	*M m^3*	*m^3ha^{-1}*	*M m^3*	*$m^3ha^{-1}year^{-1}$*	*M m^3*	*$m^3ha^{-1}year^{-1}$*
Czech Republic	663.7	250.5	90.9	293.2	20.5	7.7	2.8	9.0
Hungary	338.8	183.0	76.6	210.0	12.9	6.5	*n.a.*	*n.a.*
Poland	1 586.3	229.0	222.1	292.0	64.8	7.2	4.9	6.5
Romania	1 341.0	218.8	901.0	270.0	36.0	5.6	27.6	6.0
Serbia	362.5	156.9	8.3	188.6	9.1	3.9	0.2	4.5
Slovakia	4.4	229.0	4.4	229.0	12.2	6.1	12.2	6.1
Ukraine	2 119.0	221.0	556.0	267.0	43.2	4.0	9.72	5.4
Total	6 415.7	212.6	1 859.3	1 749.8	198.7	5.9	-	6.25

Tab. 3: Growing stock and annual increment of Carpathian countries

This increment data correspond to a global estimated annual carbon sink[1] of 3.6 Mg C ha^{-1} yr^{-1}. Globally, the forest utilization level in the Carpathians is lower than the annual growing increment, so it is possible to say that the growing stock is increasing in the Carpathian forests and, consequently that they work as a **carbon sinks**. According to the available data, it was estimated that the average wood removal is about 70% of the growing increment. So, the net global carbon sink in the Carpathian forests would be about 1 Mg C ha^{-1} yr^{-1}, which means a total carbon sink of about 10 M Mg yr^{-1} for all the Carpathian forests (considering only the above-ground biomass). Given that the average emission pro capita in the EU-27 is 10.5 Mg CO_2 equivalent per year (EEA 2007) (i.e. about 2.8 Mg C yr^{-1}), the actual carbon uptake of the Carpathian forests is effective in compensating the greenhouse gas emissions of about 3 500 000 people, i.e. nearly half of the entire Slovak population.

Tree composition of Carpathian forests ranges from broadleaved forests (mainly oak and oak–hornbeam, but also alder tree and sycamore forests, mostly in the Hungarian and Serbian Carpathians) in the lower belt, through pure beech and mixed oak-beech forests, mixed beech–fir, beech–spruce stands and mixed conifer forests, to conifer woodland, up to the timberline. The most represented species in the Carpathians are beech (*Fagus sylvatica*), Norway spruce (*Picea abies*) and silver fir (*Abies alba*).

As in other European countries, the current forest species composition in Carpathian countries is generally quite different from the natural one, because of the past forestry practices. The Carpathians present a high percentage of forests with a fully natural species composition (the Carpathians harbour the last pristine temperate forests), although there are also large areas with a low level of natural forest composition (e.g.: spruce monocultures).

Besides the species composition, also the **structure** of forests was modified by human intervention. Even distribution of age classes is considered fundamental for sustainable timber production. Most of the forest stands all over the Carpathians are even-aged single storey forests. Moreover, often past over-exploitation of forests led to a deficit of mature and over-mature stands, with a predominance of middle-aged stands (fig. 2). Uneven-aged and multi-storey forests cover only a small percentage of the Carpathian forests in each country (e.g.: 2% in Slovakia), and they are mostly forests located in remote places such as ravines, steep slopes or high peaks.

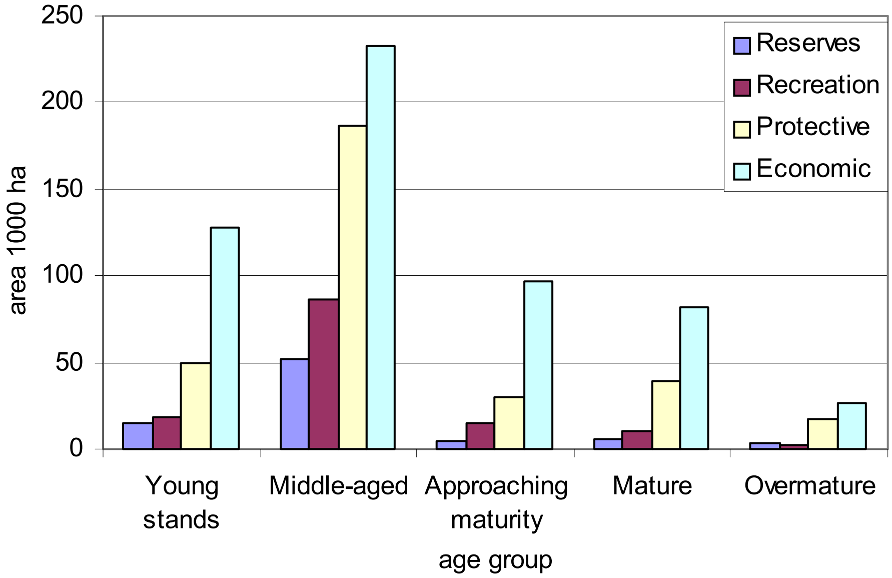

Fig. 2: age class distribution in the Ukrainian Carpathian regions

[1] For the estimation of the carbon sink we used the following equations from the Good Practice Guidance for Land Use, Land Use Change and Forestry (IPCC 2003): increment data: equation 3.2.5, BEFs table: 3A.1.10, density tables 3A.1.9-1

The change in structure and species composition is mainly due to human activities: **wood harvesting and exploitation of the forests** in the Carpathians have a long history, beginning with the Romans, continuing with the village settlement period between the 9th and 14th centuries, going on in the railway age in 19th century. It was indeed with the appearance of the railways that Carpathian forests were opened up to commercial exploitation. In this period clear cutting involved large forest areas, and after that new plantations were often established, frequently with seeds of foreign origin, different from native species. Even when indigenous species were used, for example spruce, they were planted in large monocultures, with the result of less stable and poorer habitats than the previous ones, and more vulnerable to natural hazards such as disease and storms. In the latter part of the 20th century, Carpathian forests were over-exploited because of the bias of communist regimes towards production. This meant great waste in harvesting and timber processing. Forest exploitation in the Carpathian region, however, has never caused the same extent of damage as that observed in Western Europe (Webster et al. 2001).

Under the communist system, the coordinated, centrally managed system had advantages in terms of forest management: communism tended to marginalise the mountains which continued to be farmed traditionally with livestock numbers in line with local fodder resources. Industrial growth meant that pollution became locally excessive in some resource-based industrial centres. However, most frontier zones were de facto nature reserves (additionally protected as military training grounds) while game was well-protected for the benefit of the communist hierarchy and, in some cases, was fed by wardens to provide resources in excess of the natural carrying capacity. While some forests were over-exploited and also subject to natural disasters through storm damage (aggravated by the planting of some species outside their normal altitudinal range), nationalisation prevented cutting by private owners seeking quick profits (Buza and Turnock 2004).

At present, State owned forests are returned to their original owners in the process of 'restitution', and sometimes this process is causing some problems Often the problem is that, after more than fifty years of alienation from private property, people have lost their skill and traditional knowledge of forest management, and the pressure of increasing rural poverty induces the owners to cut their forest quickly in order to obtain a rapid economic gain. It is essential to find a compromise between the use and maintaining of forests. One successful example of sustainable forestry is the increasing of certified forests, which is involving the Carpathian region as well as Western Europe, also thanks to international initiatives such as the recent promotion of the FSC forests in Eastern Europe made by the Carpathian Ecoregion Initiative, through the provision of information and setting up of national working groups to develop standards for sustainable forest management (Webster et al. 2001).

The present forest management policy of the Carpathian countries is oriented to more natural silvicultural methods. For example, concerning species composition, more attention is paid to the adjustment of stand composition through the replacement of the species not compliant with the natural habitat by native species. The conversion especially concerns spruce monocultures that are being converted into mixed stands. Moreover, in recent years natural regeneration has been favoured instead of artificial regeneration: in Romania natural regeneration it is applied to more than 70% of the forest area, and in Slovakia the percentage of natural regeneration shifted from 18.2% in 1990 to 40.5% in 2006.

As just mentioned, forest stability in the Carpathians was altered by past forest management, which favoured mono-specific plantations in order to increase the timber production. The result is that forests in the Carpathian region are often very vulnerable to **threats** such as air pollution, windthrow, floods, droughts and so on.

Several studies have been conducted on the consequences of ***air pollution*** on forest health in the Carpathians (Bytnerowicz et al. 2003, Badea et al. 2004, Bytnerowicz et al. 2004, Grodzki et al. 2004, Longauer et al. 2004, Shparyk and Parpan 2004, Bytnerowicz et al. 2005). During the period 1997–2001, forests in the Carpathian Mountains were severely affected by air pollution and natural stresses with 29.7–34.9% of the trees with defoliation degree > 26%. The broadleaves were slightly healthier than the conifers, and beech (*Fagus sylvatica*) was the least affected species. Norway spruce (*Picea abies*) has poor health status, with 42.9 – 46.6% of the trees damaged (2–4% defoliation classes). Silver fir (*Abies alba*) damage was also high, 46.0–50.9% with defoliation > 26%. Pines (primarily *Pinus sylvestris*) were the least affected of the conifers, 24.9 – 33.8% with defoliation > 26%. The results from the transnational networks show that the Carpathian forests are slightly more damaged than the European average. The correlative studies performed in individual European countries show the relationships between air pollution stresses with trends in defoliation and a possible effect of natural stresses at each site. More specifically, effects of tree age, drought, ozone and acid deposition exceeding critical levels were demonstrated to affect crown condition (Badea et al. 2004). The recently observed reduction in industrial air pollution in Central Europe caused by the decrease of industrial production, introduction of low-pollution technologies, improvement of energy efficiency in industry and housing, as well as compliance with EU regulations, contributes to a foreseeable improvement in the ecological status of protected areas in the Carpathian Mountains countries (Oszlanyi et al. 2004).

One of the most important natural damage factors is ***wind***, which particularly affects the northern Carpathians in Romania and Slovakia (the last catastrophic event in Slovakia, in November 2004, caused 5 M m^3 of forest damage). Besides catastrophic wind-induced events, endemic windthrow events, with much reduced intensity and economic effects, constitute the main disturbance factor for mountain forest ecosystems, with long-term consequences on the economy and ecology. The reduction of the impact depends largely upon the management of the forest resources and the forest economy decision systems (Popa 2007b).

Another problem that affects some areas of the Carpathians are ***floods***, particularly in the Ukrainian Carpathians in Zakarpatska Oblast, that coincides with the Ukrainian territory of the Tysa river basin. The water regulating function of forests, which depends upon nature-protective harvesting requirements, is extremely important, but, in spite of this, past over exploitation of the region and in particular of forests led to erosion processes, resulting in mud flows, landslides, shifting of the mountain river beds and streams. The last major flood event occurred in 2001 and caused damage for hundreds of millions of USA dollars in Zakarpatska and also in northeastern Hungary and Romania (Hamor 2001).

After the appearance of disaster phenomena caused mainly by abiotic threats (winds, hurricanes, snowfalls, hoarfrost, drought and pollution of forest environment), ***biotic agents*** are often activated in the weakened stands, mainly in spruce and other conifer forests: the most common insect species are *Ips typographus* and other bark beetles, some defoliators such as *Cephalcia spp., Lymantria monacha,* the larch tortrix *Zeiraphera griseana* Hbn. The most important defoliator of oak species is the gypsy moth (*Lymantria dispar*). Among fungal species, *Armillaria sp, Heterobasidion annosum, Nectria sp.* are the most common forest diseases.

Concerning ***anthropogenic disturbance factors***, it is worth quoting the impact of illegal logging. Data on illegal logging, both at national level and for the Carpathian region, are not available for all the countries, anyway, while in some it seems not to be a problem (with a total amount of illegal logging is less than 0.5%), in others it is certainly an emergency, as in the case of Romania (Brandlmaier and Hirschberger 2005).

Another emerging threat for the forests of the Carpathians is tourism. In the Carpathian region it is closely linked to forestry. Human influence in this sense has a potential for large-scale damaging effects, particularly in the context of increasing market pressures. For example, the proposed Winter Olympic games at the Tatra National Park and Biosphere Reserve has the potential for profound impacts on biodiversity. In the context of change and development pressures facing this region, the present protected area system is not sufficient to protect the valuable biodiversity of the Carpathians (Webster et al. 2001). In Romania, the cooperation between the public authorities responsible for tourism and forestry has recently improved significantly. The development of eco-tourism has become a priority action both for the forestry sector and the public authority responsible for tourism. While the presence of forests seems to have a positive impact on tourism, the latter has mainly had a relatively negative impact on forests: clear-felling to allow development and construction of hotels, restaurants, skiing facilities etc.; rubbish left in the forest by tourists; uncontrolled camping and picnicking; and forest fires caused by the negligence of tourists are relevant examples (Abrudan and Marinescu 2004)

Although there has long been human activity in forests in the Carpathians, these mountains constitute the refuge of the last European temperate **pristine forests** (tab. 5).

Country	*Virgin forest area in the Carpathian region (ha)*
Czech Republic	463
Hungary	n.a.
Poland	55 645
Romania	207 500
Serbia	3 248
Slovakia	15 428
Ukraine	40 300
Total	322 610

Tab. 5: area of virgin forests in the Carpathians

These are mainly forests situated in un-accessible locations (steep slopes, high altitudes). Despite the fact that about 225 virgin forests with areas larger than 10 ha have been identified across the Carpathian Mountains, many do not enjoy adequate protection. A variety of factors, such as poor management, pollution, tourism, over-hunting, grazing or illegal felling represent serious threats. Perhaps the greatest challenge lies in the consequences of the “restitution process”, the return of land seized in the 1940s to their original owners. In order to conserve this valuable resource for the future, it is vital that the virgin forests are mapped and recorded; something which has not yet been achieved for forests outside nature reserves. A concerted effort is required in the near future if the virgin forests of the Carpathians are to be conserved for future generations (Webster *et al.* 2001).

The importance of the primeval forests was recognised by UNESCO, and Ukrainian-Slovak “Beech primeval forests of the Carpathians” were recently included in “The List of the World Nature and Culture Heritage of UNESCO”. Protection, conservation and study of virgin forests are particularly important in order to implement a close-to-nature forest management, which is one of the priorities in order to enhance and maintain biodiversity.

At present about 16% of the total area of the Carpathian Mountains is protected, with land under protection varying between 9 and 32% of the territories in the respective countries, spanning from small-scale nature reserves to large-acreage landscape protected areas, national parks and UNESCO biosphere reserves. The largest number of protected sites is in the Slovak Carpathians (10 national parks, including four UNESCO biosphere reserves, 16 areas of protected landscape and 200 reserves) and the Polish Carpathians (six national parks, including two transboundary UNESCO biosphere reserves, 12 landscape parks and 120 nature reserves) (Oszlanyi et al. 2004).

Concluding remarks

In the light of the information collected, the most important strategies to be implemented (most of them are already ongoing in some countries), are:

- to restore original tree species composition
- to reduce the area of the clearcuts
- to enhance the natural regeneration processes
- to promote a close to nature silviculture
- to harmonize the network of protected areas
- to create ecological corridors
- to create a Model Forest network.

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Annex 1: Minutes of the Second meeting of the Working Group on SARD-F of the Carpathian Convention

Second meeting of the Working Group on SARD-F
of the Carpathian Convention

22nd-23rd November 2007
Centro Studi per l'Ambiente Alpino, San Vito di Cadore, Italy

FINAL MINUTES

Opening of the meeting on 22nd November 2007 at 9.20 a.m.

Welcome of the University of Padua (prof. Anfodillo)
Welcome of UNEP Vienna ISCC (avv. Sandei)
Welcome by the mayor of San Vito di Cadore (ing. De Vido)
Welcome on behalf of the president of the University of Padua and presentation of the university (prof. Pettenella)
Presentation of the Centro Studi per l'Ambiente Alpino and of the work of prof. Susmel (prof. Anfodillo)

Item 1 – Meeting overview, objectives and adoption of the agenda

After providing for an overview on the meeting and its objectives, the ISCC (Interim Secretariat of the Carpathian Convention) reminded that the meeting was likely to be the last one before COP 2 in Romania and encouraged the participating States to produce a draft decision for consideration by COP 2; the ISCC also reminded of the possibility of developing a follow up of the CADSES Carpathian Project within the new CENTRAL programme, also in the form, for example, of the proposal of a specific project on forests.

The participating States identified Hungary as chair of the meeting and the ISCC as facilitator. No objection was raised to the draft agenda, so the agenda was adopted by the participants.

Item 2 – Revision of the terms of reference of the Working Group on SARD-F

The ISCC announced that the Extended Bureau proposed minor changes to the ToRs, for example the change of the date of the meeting and of the exact name of the WG, from "SARD

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including forestry" to SARD and forestry", so to further mark the difference between agriculture and forestry.

The ISCC suggested holding bilateral meetings with the Contracting Parties over this issue and that of the draft study on forests in the Carpathians prepared by the University of Padua on behalf of UNEP GRID Warsaw (see below).

Hungary asked for a copy of the requests of the Extended Bureau and of the draft study of the University of Padua to be circulated.

No objection was raised to the proposed revision of the terms of reference.

Item 3 – Evaluation of the results and of the contribution to the study of the University of Padua on Forestry in the Carpathians

The University of Padua (prof. Anfodillo) presented the first part of the study on forests in the Carpathians prepared by the University of Padua on behalf of UNEP GRID Warsaw. A questionnaire was sent to the Carpathian States. While most States provided for some feedback, the Czech Republic had not provided any feedback yet; furthermore, in certain cases, data is available only for the country as a whole and not specifically for the Carpathian region. The ISCC reminded the participating States that the study should be presented to the COP 2.

The University of Padua (prof. Pettenella) presented the second part on policy and legislation issues of the study on forests in the Carpathians prepared by the University of Padua on behalf of UNEP GRID Warsaw. The participating States provided for some feedback to the University of Padua.

Austria presented the results of the INTERREG NMF project and joint final declaration Strengthening Mountain Forests in Europe, signed in Lindau, Germany, in October 2007, and produced in the framework of the project. The ISCC suggested an eventual project proposal on best practices in the Alpine and Carpathian region for the new INTERREG call; it also suggested another eventual project proposal for INTERREG CENTRAL on the harmonization of data collection, while the restrictions to funding to non-EU and non institutional partners was also mentioned.

During a tour of table, Poland raised the issue of the private management of forests; ISCC mentioned that privates have to be invited and participate to meetings: meetings under the Carpathian Convention are inclusive and open to all stakeholders, also from the private sector. Austria raised the issue of the education of forest owners and of the limited number of foresters. Romania insisted on the public role of forests. The Czech Republic mentioned, instead, the problem of illegal logging and the fight against organized crime.

The participants shall provide for feedback to the University of Padua regarding the questionnaire by 15th December 2007 and the draft study on forests by the end of December 2007.

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Item 4 – Discussion on the ToRs of a possible Protocol/Strategy on Sustainable Forest Management

The ISCC presented the logic of a protocol vis-à-vis that of a declaration, and suggested that, in this case, a protocol should render general agreements on forestry specific to the Carpathian region, including specific provisions on virgin forests, which represent a rare feature in Europe.

The ISCC introduced the contents of article 7 on sustainable agriculture and forestry of the Carpathian Convention, proposing to develop the protocol on the basis of the article, as well as of the results of the meeting in Budapest. Poland requested to include within this basis also the outcomes of the meeting in Warsaw.

Upon request of the participating States, the ISCC elucidated the pros and cons of a protocol. Furthermore, it proposed the presentation of a draft declaration to the COP 2 in spring 2007 in Romania, while that of the draft protocol to COP 3. Romania also requested to include the role of public interest in the draft protocol.

<u>The participant States decide to aim at presenting a draft protocol to the ministers at COP 3, eventually transforming it into a declaration, if no agreement is reached over the protocol.</u>

The ISCC presented the structure of the draft protocol on biodiversity. On the basis of this structure, the participants to the meeting elaborated—article by article—a draft protocol on forestry (see attachment).

The ISCC proposed the creation of a specific drafting committee, composed of Poland (Mr Koziol), the University of Padua (Prof. Pettenella), and the ISCC (Mr Sandei), to complete the first draft of the protocol.

<u>The participant States decide to authorize the abovementioned drafting committee to proceed with the revision and integration, if and where needed, of the draft protocol. The first draft of the protocol should be completed by the beginning of January 2008 and shall be submitted to the Implementation Committee for its presentation at the COP 2 together with a draft ministerial declaration, based on the contents of the draft protocol. The final version of the protocol could be signed at the COP 3, following its renegotiation by the Implementation Committee.</u>

Item 5 – Inputs and draft decision to the Second Conference of the Parties to the Carpathian Convention

<u>The participating States decide to submit the attached draft decision to the COP 2.</u>

Closure of the meeting on 23rd November 2007 at 5.30 p.m.

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Attachments

1. Draft decision for the COP 2
2. Draft protocol on forestry
3. Draft study on forests by the University of Padua
4. PowerPoint presentations by the University of Padua (prof. Anfodillo and Pettenella)
5. Invitation to the meeting by EURAC
6. Draft Terms of Reference for the WG on Sustainable Agriculture, Rural Development and Forestry
7. Report of the Workshop on Conservation and Sustainable Use of Forests, Biological and Landscape Diversity in the Carpathian Region held in Budapest, Hungary, at FAO-SEUR, on 19th-20th September 2007
8. Europe's Forests 2007, report of the 5th MCPFE held in Warsaw, Poland, on 5th-7th November 2007
9. Strengthening Mountain Forests in Europe, joint final declaration produced within the INTERREG NMF project and signed in Lindau, Germany, in October 2007
10. Preliminary Draft Declaration for Mountain Forests produced by the INTERREG NMF project
11. Remarks of the State Committee of Forestry of Ukraine
12. Draft Protocol on Biodiversity to the Carpathian Convention
13. Some recent publications by the Centro Studi per l'Ambiente Alpino

All attachments can be obtained from the organizers upon request (ISCC, piercarlo.sandei@unvienna.org; EURAC research, jchurch@eurac.edu; University of Padua, tommaso.anfodillo@unipd.it).

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COUNTRY REPORTS

1. CZECH REPUBLIC

1.1 INTRODUCTION

The Czech Republic, in central Europe, is bordered by Poland to the north, Germany to the north-west and west, Austria to the south, and Slovakia to the east. The area of the country is 7.89 M ha. It is about 490 km from east to west and about 280 km from north to south. The Czech Republic consists of five main geographic regions: the Bohemian Mountains, the Sudeten Mountains, the Bohemian Basin, the Bohemian-Moravian Highlands and the Moravian Lowlands. The Moravian Lowlands occupy the south-eastern part of the country. A section of the Carpathian Mountains extends along the Czech-Slovak border (http://www.fao.org/forestry/site/countryinfo/en/).

Fig. 1.1: Topographic map of the Czech Republic (UNEP/GRID: http://maps.grida.no/go/region)

The total forest area of Czech Republic is about 2.65 M ha which represents 33.7% of the total area of the Country. The species composition of forests in the Czech Republic was altered in the past in order to increase wood production and satisfy demand for the most frequently asked-for tree species. It has positive impacts on economics even today when market returns of softwood supplies are more profitable than those of hardwood supplies. Consequently, the ratio of coniferous tree species (76.5%) is currently disproportionately higher than that of broadleaved (Ministry of Agriculture of the Czech Republic 2003).

1.2 FOREST AREA AND FOREST AREA CHANGE

The Carpathian region in the Czech Republic extends along the Czech-Slovak border, and occupies an area of about 0.7 M ha, according to the National Proposal for the delimitation of the Carpathian area (Ruffini et al. 2006). The forest cover in the Czech Republic Carpathian region is about 0.31 M ha, which represents the 11.7% of the total forest area of the Country. Forest ratio in the Carpathian region is higher than the national value (43.4%), and also forest area per capita (0.39 ha), is also higher than the national average (0.26 ha).

The forest cover in the Carpathian region is increasing, even though the trend is very low (annual rate only to 0.0055% of the total forest area in the Carpathian region). The main causes are forestation and natural succession in agriculture areas.

1.3 FOREST FUNCTIONS

The law (Act No. 289/1995) defines forest functions as benefits conditioned by the existence of forest. These functions are wood and non-wood production. According to dominant functions there are categories of protection, special purpose and commercial forests (Ministry of Agriculture of the Czech Republic 2003).

Recent conceptual materials for the forest sector accentuate a requirement for multifunctional management of forests involving function-integrated and function-differentiated management. It also indicates a desirable trend of future amendment of the system of functional categorization of forests. Management methods in the past did not often take into account how the accentuated wood-producing function, and cheap and environmentally in-compatible technologies, would influence the potential of forest functions as a whole. Much of the forested area in the Czech Republic is far from being in natural state, and ecological stability of forests has been disturbed. As a consequence, the capacity of forests to satisfy the public need of some functions to a desirable extent is reduced, particularly if society's demand for some functions has considerably increased. The objectives of the forest sector are to achieve multifunctional management of forests while their functional potential is preserved and gradually increased, and their rational and balanced use is consistent with long-term public interests. Forests with near-natural management have a definite potential to fulfil functions without additional energy inputs in the given natural conditions. This allows a free exploitation of effects produced by the actual functional potential up to its natural level (Ministry of Agriculture of the Czech Republic 2003).

1.4 FOREST COMPOSITION

The **actual** forest composition in the Czech Republic has a generally very low level of natural species, as a consequence of forestry practices. The forests in the Carpathian region include a higher percentage of forest with inadequate natural species composition, but there are also contain twice as many forests with a fully natural species composition. These forests are mainly concentrated on the mountain tops (EURAC 2006):

Level of natural species composition of the forests	Czech Republic	Carpathian region %
Inadequate, natural species composition less than 10%	26.7	33.7
Very low, exotic species, natural species composition 11 – 30 %	5.0	5.16
Low, monoculture, natural species composition 11 – 30 %	25.3	15.66
Average, monoculture, natural species composition 31 – 50 %	17.1	13.23
High, natural species composition 51 – 70 %	10.9	10.7
Very high, natural species composition 71 – 90 %	8.6	8.3
Unique, natural species composition more than 90 %	5.1	11.36

Tab. 1.1: Level of natural species composition of the forests in the Czech Republic and Carpathian region (EURAC 2006)

Most of the monocultures are spruce plantations: traditionally, Czech forestry has been strongly focused on timber production, and this has resulted in a large proportion of highly productive monocultures, usually even-aged stands of Norway spruce. Centuries of forest management have created a species composition that differs considerably from the expected natural situation. Despite efforts to decrease the proportion of spruce in favour of broadleaved trees, commercial coniferous species still dominate (Schellaas et al. 2004):

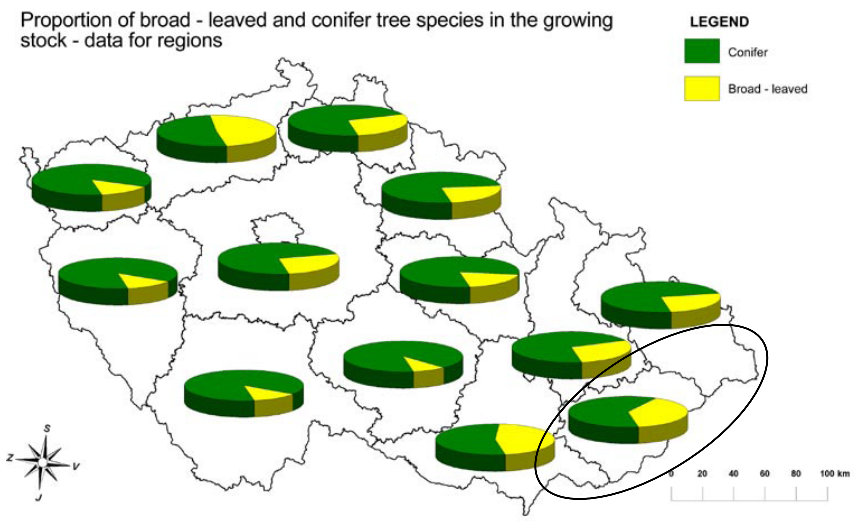

Fig. 1.2: Proportion of broad-leaved and conifer tree species in the growing stock in the Czech republic (Forest Management Institute 2004).

The **potential** species composition of the Czech Carpathians is mainly montane and sub-montane beech forests, followed by oak-hornbeam forests (tab. 1.2):

Forest types	**Area ha**	**Characteristics FRA2005**	**Main function**
Subalpine and montane spruce and montane mixed spruce and silver fir forest (3.2)*	3	modified natural	nature protection
Oak-hornbeam forests (5.1, 5.2)*	36 750	semi-natural	production
Ravine and slope forests (5.8)*	503	modified natural	soil protection
Carpathian sub-montane beech forests (6.5)*	155 023	semi-natural	production
Carpathian montane beech forests (7.5)*	114 163	semi-natural	production
Downy oak forests (8.1)*	370	semi-natural	most stands belong to the “protective forests” category
Fluvial forests (12.2)*	2 882	modified natural	water and soil protection, production
Total Czech Carpathians	309 694		

Tab. 1.2: Forest types in the Carpathian Region of Czech Republic . *the numbers refer to the EEA forest types classification (EEA 2006)

1.5 FOREST STRUCTURE

Another consequence of forest management, the present age structure mainly consists of even-aged forest stands. The representation of age classes is disproportionate. As a result of afforestation of lands cut in the course of a nun moth disaster in 1920-1925 and of other evolution factors there is an abnormally large area of stands approaching the cutting age. On the contrary, the ratio of young forests (below 60 years) is lower. Particularly, the area of age class 1 (i.e. regenerated stands) is lower than normal. The unbalanced age structure will influence production capacities of forests in the decades to come (Ministry of Agriculture of the Czech Republic 2003).

Also in the Carpathian region there are mainly even-aged stands and only some forests located in remote places such as ravine, steep slopes or high peaks still maintain more natural all-aged structure. The following figure shows the proportion of age class in the growing stock in the different regions of the Czech Republic. The middle-aged classes are predominant in all regions.

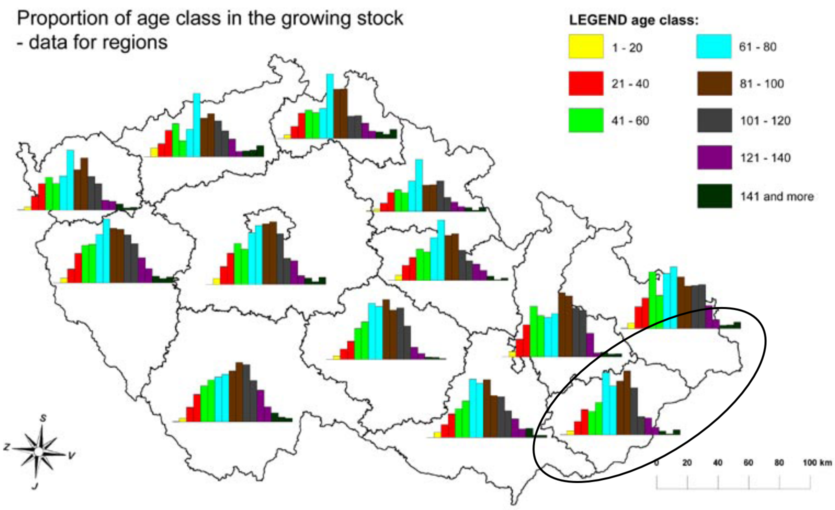

Fig. 1.3: Proportion of age class in the growing stock of Czech Republic regions (Forest Management Institute 2004).

1.6 FOREST MANAGEMENT AND MONITORING

A forest is a natural stabilisation element of the environment. This is why one of the basic aims of the forest sector is to enforce multifunctional forest management in the permanent protection and gradual increasing of the functional potential of forests is preserved and its rational balanced utilisation in agreement with long-term public interests. Multi-purpose forest management is based on ecological stability and the longevity of forest ecosystems (Ministry of the Agriculture of the Czech Republic 2005): the basic principle of forest management in the Czech Republic is sustainability, which is applied in a long-term basis, and the call for sustainable forestry that also supports other functions apart from wood production has increased considerably in recent years (Schellaas et al. 2004).

Each natural forest area has its own Regional Plan for Forest Development, which contains a wide range of data on economy and ownership, and also about management in protected areas and in parts of the territorial system of ecological stability. It also contains data on threatening factors and natural characteristics. These plans for all the natural forest areas are provided by the Forest Management Institute, and they are prepared for a period of 20 years. The natural forest areas do not correspond to any administrative units or to any protected areas, which may somewhat complicate the use of these data. Each protected landscape area has a Management Plan, following the Regional Plan for Forest Development, in which the assessment and also the strategy and measures for forest management are formulated. These plans for all natural forested areas are also provided by the Forest Management Institute (EURAC 2006).

REGIONAL PLANS OF FOREST DEVELOPMENT RPFD

The Regional Plans of Forest Development is a project defining forest management principles in relation to the natural forest regions of the Czech Republic. RPFD are legislatively defined in forest law no:289/1995 Coll. §23 and in ordinance no. 83/1996 Coll. of the Ministry of Agriculture with regards to regional plans of forest development and classification.

RPFD contain data summaries on the state of the forest and the service needs of the forest as a public interest. They stem from the principle of sustainable forest management and form conditions for minimization of collision between society interests and individual forest owners' interests. As a methodical tool of state forest policy, they serve as an aid for state administrative decision-making. They form the background for forest management plans and forest management outlines elaboration.

RPFD data is shared with the Forest Management Institute (FMI) through the Information and Data Centre (IDC). Up-to-date rules for data access are available on www.uhul.cz.

The RPFD are composed of several parts:

- Text part General definition of function potential: producing, non-producing (water, soil, recreation, genetic resources, nature protection); review of public interests (categorization) and development forecast; review of forest finality overlay; function priorities; interest collisions; natural conditions analysis- analysis of emission threats and other pollutant emissions to the forest; basic management recommendations for management set of stands; project of long-term forest protection measures including approved regional systems of ecological stability; project of allochtonous species use; data on forest state (analysis of valid forest management plans) including historical development of management; project of optimization of transport accessibility and limiting felling-transport technologies.
- Graphic and columnar reviews.
- Digital and analogue maps (1 : 10 000 - 50 000)
- Review map of forest regions, typology map, map of forest vegetation levels, map of target management, map of long-term forest protection measures, map of functional forest potential, transport map, map of forest functions declaration, map of ecological stability territorial system.
- Resulting recommendations and conclusions.
- Technical report.
- Documents on classification of forest decisions.

Regions are divided on the basis of unifying geological, climatic, orthographic and phytogeographic conditions. The Czech Republic is divided into 41 natural forest regions (FMI: http://www.uhul.cz/en/oprl/index.php).

NATIONAL FOREST INVENTORY

The Forest Management Institute works on the Inventory of Forests, which offers more detailed data according to regions (kraje). In 2004, the first phase for the collecting of data for the inventory was completed. The results are available on www.uhul.cz. Satellite photographs are used for the evaluation of the health condition of the forests in the Czech Republic (EURAC 2006).

Forest inventory realized in the Czech Republic during 2001 – 2004 is not an entirely new reality but it is the first statistical survey of this sort on Czech Republic. It is not a mere supplement to previous inventories on the level of stand groups. It delivers data – frequently not yet taken – of a different type but more easily comparable with data from inventories in the surrounding European states (Forest Management Institute 2004).

In **previous** times the outputs on local forests came from the results of particular cadastre types and from property-tax return of forest owners. The history of national forest inventories in Czech Republic begins after the Second World War with the project Forest Inventory 1950. It also included also forests with an area under 10 ha, about which there was no information till then. Other inventories followed: Forest Inventory 1960 (unfortunately with another structure) and Forest Inventory 1970. In parallel since the 1960s the so called Permanent Forest Inventory was done every year (PFI) which was a total of valid forest management plans. From 1979 Summary Forest Management Plans (SFMP) were carried out, since 1998 replaced by publication of Information on Forest Conditions. All these inventories were done from data of forest management plans (FMP) according to tree species distributed on the area of forest stand groups (Forest Management Institute 2004).

Actual forest inventory is based on independent data collection on regular grid of permanent plots dispersed in the country. It provides different data from the SFMP. Comparing the SFMP data (summary of FMP and Forest Management Guidelines) and the NFI data we must be aware of the basic differences in creation methods of both information sources. Without this knowledge no direct comparison is possible. Data obtained in the first cycle of forest inventory from 2001 to 2004 create a base for further detailed analyses, enabled by the wide range of collected data. It is a starting point and the permanency of inventory plots is a condition for other repeated survey of NFI in the Czech Republic, which will contribute to the objective evaluation of forest development. Continuation of a broad analysis and evaluation of information obtained from this Forest Inventory of the Czech Republic has been presupposed since 2005 including their evaluation in consonance with other important information resources (remote sensing, regional plans of forest development, summary information about forest condition, data from previous forest inventories etc.). With regards to amount of information and variability of their mutual links the analysis will continue in the following years. At present there are negotiations at European level within ENFIN (the European National Forest Inventory Network; a voluntary association of particular national forest inventories within Europe, established for the purpose of cooperation at a European level). Its main task is to harmonize outputs of particular national forest inventories for comparison level (Forest Management Institute 2004).

Definition of the category FOREST used in forest inventory is almost the same as the definition of forest used by UNECE/FAO in global estimation of forest resources. By the extent of taken land it exceeds the national forest definition[1], e.g. non forest land covered by trees with a density of less than 70 % (demanded permanent stand density of forest stand). Detailed classification of land to the category FOREST and NON FOREST is mentioned in the Methodology of the Field NFI Data Collection (http://www.uhul.cz/il/metodika.php).

Data of forest inventory are measured and described on plots of an area of 500 m^2. Such an inventory **plot** cannot itself give evidence about e.g. a stand where it is situated. Only quantity of plots and/or data taken on the plot gives us the possibility to evaluate such data into full scope outputs. The precision rises together with the size of the evaluated area. The inventory plots are grouped in square clusters. The distance between clusters is 2 x 2 km. The plots are 300 m apart. The total number of plots is 39 436 (14 221 in each cluster).

Outputs on two kinds of territorial units are published – the Czech Republic and its regions. The informative efficiency of results lowers with the decreasing size of the area. An important indicator is therefore the confidence interval, beside the mean value. The data are given for 95 % confidence level. Result tables have the column “Value” which represents medium value and columns „(-)“ a „(+)“ which represent lower and upper limit of the interval estimation in which the value is with 95% confidence. Null values in some tables originated mainly by rounding off of very little values. The majority of results on the territory of the Czech

[1] **Forest definition:** the definition of forest is given by law: "Forest land is land destined to fulfil the forest functions that is: land with forest stands and land after clear cutting ready for reforestation, forest line and soft road of a width less than 4 m; forest roads, water surfaces, land above timber line and other land serving for forest management." The Czech forest management instructions give 0.01 ha as a minimum area of forest, with a minimum width of 20 m. (CarboInvent JRC: http://afoludata.jrc.it/carboinvent/cimd_eufoin_data.cfm#countrylist)

Republic have a sufficient sample size so the results have suitable precision and thus also informative efficiency. Not only the size of area but also the level of grouping of concrete variables influence the lowering of informative efficiency. Therefore e.g. some results can have sufficient precision on the territory but in grouping according to other aspects the precision lowers under desired limit and sometimes even under limit of endurance (Forest Management Institute 2004).

1.7 FOREST CONDITIONS

The results of the poor forest composition are low resistance to pests, low water uptake capacity which can influence the flood situation, and a decrease in the natural biodiversity of the forest ecosystems. With the exception of the first and second zones of protected areas and natural reserves, the clear-cut method is usually used in forest management, which means destroying entire ecosystems, including the soil cover (due to the use of heavy vehicles), and renewing the forest by planting new trees that have been grown artificially. In most cases spruce monocultures are still being planted (EURAC 2006).

A decrease in ecological stability of forest stands leads to a high volume of salvage fellings (however, these have tended to decrease considerably since the early 1990s) (Ministry of Agriculture of the Czech Republic 2003).

Natural disturbances

Among the natural factors of disturbance in the Carpathian region, the most important is **wind**. Windfalls occur mainly in spruce monoculture and beech forests. The last big wind-thrown event in the Czech Republic occurred during the night of January 18th 2007, when the forest land in the Czech Republic was ravaged by the wind storm "Kyrill", which caused extensive damage to forest areas, especially in the south-west of the country. In the country the estimated damage was around 10 M m^3. The quantity of wood damaged is in many of these areas considerably bigger than the total allowable cut (fig. 1.4). The Carpathian region was one of the least damaged by the storm, even if there are some areas in which the wood loss was 50-100% of the total allowable cut.

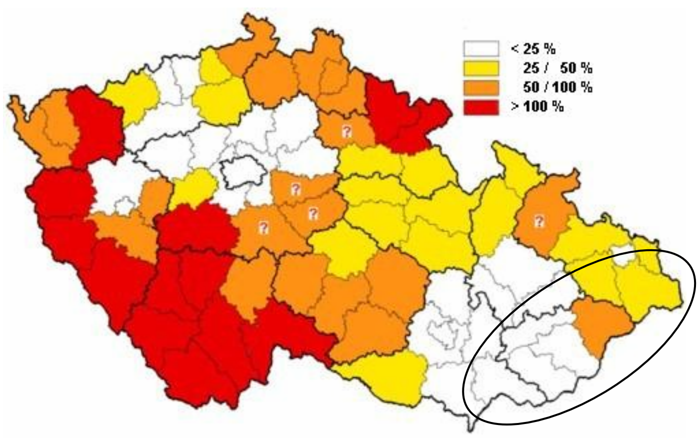

Fig. 1.4: Storm damage 18.01.2007 (% of total allowable cut). Source: FPS of the MGMRI
www.unece.org/trade/timber/storm/2007-01/czech-070507.doc

Following wind thrown events **biotic threats** are often activated: Bark beetle (*Ips typographus*) caused most damage among insect pests on spruce (records show a slight increase in population) in 2006 and *Armillaria mellea* on spruce and *Lophodermium pinastri* among fungal diseases (Ministry of the Agriculture of the Czech Republic 2006). In the Carpathian region, fungi and insect pests particularly affect spruce monoculture in oak and beech forests zones.

Another frequent problem in the beech forest zone, especially in spruce monoculture, is game (ungulates): damage caused by game in forest stands by browsing, bark-stripping and nibbling is still among the most serious harmful factors (Ministry of Agriculture of the Czech Republic 2003), because ungulates damage the newly planted trees.

Although the number of some species have decreased in some areas (for instance deer in the Chriby Mountains), the extent of the damage caused by game is still high (EURAC 2006).

Anthropogenic factors

The health status of forests in the Czech Republic is also influenced by impacts also of heavy **air pollution** stress (changes in soil chemistry and direct impacts). Tree defoliation has gradually decreased since the early 1990s, and after a substantial reduction of SO_2 emissions (except the areas with extremely high acid depositions) the threat of new area disintegration of forest stands is lower. But the effects of other factors (drought, NOx, O_3) that can cause great damage outside the usual air-pollution areas have increased (Ministry of Agriculture of the Czech Republic 2003). Air pollution seems to be a minor problem in the Czech Carpathian region.

Illegal cutting is also not recognised as a serious problem endangering mountain forests. Several cases have occurred mostly in private forests with a monoculture structure, but thanks to better control this is apparently no longer a big problem. A special range of problems is caused by **poorly regulated sports activities**, such as downhill skiing and mountain biking, and also the building of holiday cottages (EURAC 2006).

1.8 WOOD SUPPLY

The total **potential growing stock** in the Czech Carpathian region is 90.9 M m^3 (293.2 m^3ha^{-1}), i.e. 13.7% of the total growing stock of Czech forests (663.7 M m^3, or 250.4 m^3ha^{-1}). The volume pro capita is 65.25 m^3 in Czech Republic, and much higher in the Carpathian region: 111.24 m^3.

forest types	growing stock	
	m^3	m^3ha^{-1}
Subalpine and montane spruce and montane mixed spruce and silver fir forest (3.2)*	285	98.9
Oak-hornbeam forests (5.1, 5.2)*	8 134 785	221.36
Ravine and slope forests (5.8)*	116 773	232.23
Carpathian sub-montane beech forests (6.5)*	44 086 697	284.39
Carpathian montane beech forests (7.5)*	37 969 352	332.59
Downy oak forests (8.1)*	43 278	116.87
Fluvial forests (12.2)*	575 363	199.66
Total Carpathian region	90 926 533	212.29
Total Czech Republic	663 700 000	250.45

Tab. 1.3: Potential growing stock of forest types in the Carpathian Region of Czech Republic *the numbers refer to the EEA forest types classification (EEA 2006)

Table 1.4 reports the data of the National Forest Inventory related to the proportion of conifers and broadleaves in the growing stock of the regions which include the Carpathian area.

	Region	*Growing stock u. b. (m^3)*	*Proportion (m^3ha^{-1})*	*%*
Jihomoravský	Conifers	29 731 968	150.8	54.0
	Broadleaved	25 365 319	128.6	46.0
	Total	55 097 287	279.4	100
Moravskoslezský	Conifers	55 331 791	269.3	74.0
	Broadleaved	19 436 599	94.6	26.0
	Total	74 768 390	363.9	100
Zlínský	Conifers	36 579 059	228.2	60.5
	Broadleaved	23 842 706	148.7	39.5
	Total	60 421 765	376.9	100
Carpathian regions	Conifers	121 642 818	876.5	63.9
	Broadleaved	68 644 624	371.9	36.1
	Total	190 287 442	340.1	100
Czech Republic	Conifers	695 310 955	257.1	76.7
	Broadleaved	211 599 531	78.2	23.3
	Total	906 910 486	335.3	100

Tab. 1.4 Conifers and broadleaves growing stock in the three Carpathian regions (Forest Management Institute 2004)

Annual **growing increment** is 2.81 M m^3 in the Carpathian region, (20.5 M m^3 n the Czech Republic). The average value is 9.06 m^3ha^{-1} for the Carpathian region, higher than the national value (7.74 m^3ha^{-1}).

Tables 1.5 and 1.6 report estimates of wood removals in Czech Republic and in the Carpathian region. The estimates were made on the base of UNECE Forest Products Statistics 2002-2006 (UNECE – Timber Committee: http://www.unece.org/trade/timber/mis/fp-stats.htm). Where not available, data related on the Carpathian Region are estimated on the basis of proportion of the forest area cover. The complete database is in Annex to the reports.

	Coniferous					*Non-coniferous*					*Total*				
Country	*2002*	*2003*	*2004*	*2005*	*2006*	*2002*	*2003*	*2004*	*2005*	*2006*	*2002*	*2003*	*2004*	*2005*	*2006*
	1000 m^3					*1000 m^3*					*1000 m^3*				
Czech Republic	13 010	13 660	13 920	13 883	16 118	1 531	1 480	1 681	1 627	1 560	14 541	15 140	15 601	15 510	17 678
Czech Carpathians	1 522	1 598	1 628	1 624	1 886	179	173	197	190	182	1 701	1 771	1 825	1 814	2 068

Tab. 1.5: Removals of **roundwood** (Source: UNECE Trade and Timber Division – Timber Section)

	Coniferous					*Non-coniferous*					*Total*				
Country	*2002*	*2003*	*2004*	*2005*	*2006*	*2002*	*2003*	*2004*	*2005*	*2006*	*2002*	*2003*	*2004*	*2005*	*2006*
	1000 m^3					*1000 m^3*					*1000 m^3*				
Czech Republic	650	690	700	720	820	357	490	490	505	525	1 007	1 180	1 190	1 225	1 345
Czech Carpathians	76	81	82	84	96	42	57	57	59	61	118	138	139	143	157

Tab. 1.6: Removals of **wood fuel** (Source: UNECE Trade and Timber Division – Timber Section)

1.9 PROTECTED AREAS

Forests in specially protected areas are a large part of the Carpathian forests in the Czech Republic. Three landscape protected areas are situated in Carpathian region, the Beskydy, Bílė Karpaty (White Carpathians) and Palava (tab. 1.7). The Beskydy PLA includes sub-montane beech forests and sub-montane beech mixed silver fir forests, the Palava PLA comprises thermophilous oak woods. The White Carpathians, a UNESCO Biosphere Reserve, has a specific landscape structure in which patches of beech forest, meadows and pastures are most typical. Plant species belonging to the Orchideaceae are the most valuable part of the protected flora (Fišerová et al. 2002, Oszlanyi et al. 2004). Both areas are rich in fauna, being inhabited by rare animal species such as lynx inhabit these areas (Oszlanyi et al. 2004)

Act No. 114/1992 defines the categories of specially protected areas and lays down the procedure of their declaration and subsequent administration. Planning of protected areas management and potential contributions to the purpose-oriented management of lands are established in general principles. Management of forests in SPA is a part of special management plans. These management plans specify general conditions for the conservation of particular areas set down by the respective legal rules. It is necessary to clearly define the object of conservation and target of conservation. Approved plans of SPA management are background materials for working plans. When management plans are implemented into working plans, they should be harmonized with provisions of Act No. 289/1995. Particularly the aspect of their contents and liability is important, provided that the protection conditions of SPA do not allow it, the problem is solved by an exception in accordance with Act No. 114/1992 on Nature and Landscape Conservation (Ministry of Agriculture of the Czech Republic 2003).

Nature protection in landscape protected areas is classified in four zones. In the first zone the strict protection of all nature values is secured, while in the fourth zone restricted human activities are allowed. In the landscape protected areas, human activities in general are the subject of action plans, which provide the legal and administrative basis for mid- and long-term tasks of nature protection, especially plans for the protection of plants, animals, their habitats and ecosystems. They also regulate the economic activities including forestry, agriculture and tourism (Oszlanyi et al. 2004).

Title	*Area (ha)*
White Carpathians PLA/BR*	71 000
Beskydy PLA*/Natura 2000	117 319
Palava PLA*/Natura 2000	7 000
Hovoransko – Čejkovicko Natura 2000	1 412
Horní Vsacko Natura 2000	26 978
Hostýnské vrchy Natura 2000	5 177
Razula NNR*	24
Pulčín – Hradisko NNR*	73
Čantoria NNR*	39
Mionší NNR*	170
Mazák NNR*	93
Salajka NNR	22
Kněhyně – Čertův mlýn NNR*	195
Radhošť NNR*	145
Strabišov – Oulehla NNR*	70

Tab. 1.7: Protected areas in the Carpathian Region. *PLA: Protected Landscape Area, NNR: National Nature Reserve, BR: Biosphere Reserve

There are only small areas of **virgin forest** in the Carpathians: these include Mionši (194.79 ha), Razula (27.51 ha), Salajka (35.21 ha), Zimný Potok, Kelčský Javorník (122.35 ha), and Javorina (83.49 ha). Several other small nature reserves are designated as natural forests (EURAC 2006).

A complex research program on the virgin forest reserves in the Czech Republic was initiated by E. Průša in the 1970s. Between 1994 and 2000 investigations were repeated in 18 of these reserves. Three of the re-surveyed reserves (Mionší, Salajka, Razula) comprised montane fir-beech stands located in the Moravian Carpathians. It was found that the oldest generation of silver fir had declined and appears to be entering its final stage of disintegration. A younger fir trees remain sporadic, the population is critically endangered. Grazing by sheep in the 15-19th centuries favoured fir over beech, but the successive exclusion of sheep has allowed beech to regenerate strongly. There was a severe reduction in the herb layer cover across all the reserves, mainly due to increased regeneration of beech, but species composition changed only slightly. Recent changes in the composition and structure of these natural fir-beech forests in the Czech Carpathians indicate that: (i) silver fir might be eliminated in the future; (ii) sheep grazing has impacted strongly on tree regeneration, affecting both the past and potential future stand composition; (iii) increased tree regeneration has impacted on the cover of the herb layer; and (iv) levels of living and dead wood change during stand development, but form overall an average of 75% and of 25%, respectively, of the total (Vrška et al. 2003).

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2. HUNGARY

2.1 INTRODUCTION

The Republic of Hungary, located in eastern Central Europe, is bounded on the north by Slovakia, on the north-east by Ukraine, on the east by Romania, on the south by Serbia and Montenegro, Croatia, and Slovenia and on the west by Austria. The country has a total land area of 9.3 M ha, and is about 500 km from east to west and 315 km from north to south.

Most of Hungary is flat and less than 200 m a.s.l. The Matra Mountains, part of the Carpathians, lie to the south of the border with Slovakia (fig. 2.1) and have Hungary's highest point, Mount Kékes, at 1 014 m a.s.l.. Most of the rest of the country east of the Danube River is a flat plain. Western Hungary consists mainly of rolling hills and the Transdanubian Highlands, which include the Bakony Mountains in the north-west. In the far west are the foothills of the Austrian Alps and the "Little Plain" in the north-west.

The Danube River flows through the country from north to south. Tributaries of the Danube include the Tisza, Raab (Rába) and Drava (Drau) rivers. Lake Balaton (596 km^2), at the foot of the Bakony Mountains, is the largest lake in central Europe.

Hungary has a relatively dry continental climate, with cold winters and warm summers. The average daily temperature range in Budapest is -4 to 1° C in January and 16 to 28°C in July. Budapest receives an average of about 600 mm of precipitation a year. Temperature varies little throughout the country, but rainfall is higher in the west. May, June, and July are the wettest months (FAO: http://www.fao.org/forestry/site/countryinfo/en/).

Fig. 2.1: Geographical map of Hungary (UNEP/GRID: http://maps.grida.no/library/files/web_hungary_topographic_map.jpg)

Hungary is situated in a transitional biogeographic zone between the deciduous forest and the forest-steppe in the Carpathian basin. A wide range of species thus reach the borders of their distribution there, with concomitant potential for relatively fluid response to environmental change (Török et al. 2003).

Forest area in Hungary is 1.98 M ha with a forest cover of about 21% (FAO 2005a), much lower than the European average (33%), and than the 80% of land estimated to be the potential forest cover in the country. About 57% of the forest area is covered by indigenous species, and 43% by either introduced or cloned tree species (Ministry of Agriculture And Rural Development - Main Department Of Natural Resources - Department of Forestry 2006): plantation of exotic species such as black-locust (*Robinia pseudo-acacia*), black pine (*Pinus nigra*), poplar cultivars (hybrid *Populus* spp), spruce (*Picea abies*), and scots pine (*Pinus sylvestris*) (Czàjlij and Standovar 1999).

From a European conservation perspective, Hungary's most valuable forests are the remaining fragments of forested steppe (oak woodlands on sand, loess and alkaline soils), the shrub-forests of the steep southern facing slopes (dominated by *Quercus pubescens*), and the remnants of the formerly widespread riparian forests (dominated by *Quercus robur*, *Fraxinus pannonicus* and *Ulmus laevis*). However, nationally, the protection of the less unique oak- and beech-dominated forests is also a high priority. The oak forests, characteristically dominated by turkey oak (*Quercus cerris*) and sessile oak (*Quercus petraea*), form Hungary's most common forest type, while the stands dominated by beech (*Fagus sylvatica*) can mainly be found in the most humid western part of the country, and also on the highest elevations (Jávor and Gálhidy 2005).

The National Forest Program recommends the increase in forest to at least 25% (UNFF 2004). Since 1997 in Hungary the increase of forest cover annually average 10 000 ha by afforestation. This progress will be promoted in the future by the different arrangements of the National Land Fund. In the field of reforestation (regeneration) a special financial institution exists in Hungary (managed by the State Forest Service) to promote sustainable forest management: Forest Maintenance Contribution (EURAC 2006).

Current management policy is also oriented to the achievement of a more natural stand composition. The orientation covers both, the afforestation and regeneration procedures. State aid allocated for the use of indigenous tree species in afforestation is higher. Close-to-nature regeneration methods are stimulated.

2.2 FOREST AREA

The Carpathian region is one of the most forested areas in the Country, together with the other mountainous area (as can be seen from the fig. 2.2): higher forest coverage means that forestry in this area has a much higher importance and impact on some of the areas targeted by the Carpathian Framework Convention than in the rest of country (EURAC 2006).

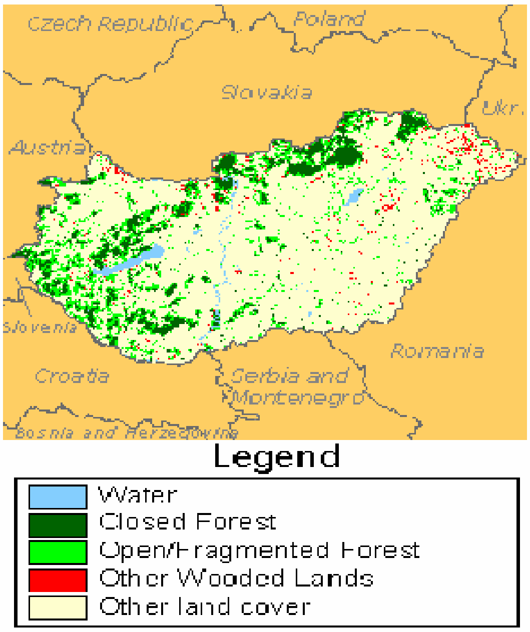

Fig 2.2: Forest cover in Hungary (FAO: http://www.fao.org/forestry/site/countryinfo/en/)

Here we consider as the Carpathian region, the sum of the area of the three regions that include part of the Carpathian mountains: Nograd, Borsod-Abauj-Zempleo and Heves. The total forest area of the Carpathian area, calculated as the sum of the forest area of these three regions, is about 0.4 M ha, which is around 20% of the total forest cover of Hungary. Forest cover in the Carpathian regions (29%) is higher than the national average (21%).

	Total area	Forest area		Other area	Total area under forest management
	ha	ha	%	ha	ha
Borsod-Abaúj-Zemplén	724 728	200 388	27.65	9 488	209 876
Heves	363 723	85 291	23.45	3 610	88 901
Nógrád	254 556	96 131	37.76	3 738	99 869
Total Carpathian regions	**1 343 007**	**381 810**	**29.26**	**16 836**	**398 646**
Hungary	**9 302 842**	**1 854 562**	**19.94**	**129 518**	**1 984 080**

Tab. 2.1: Forest area in Hungarian Carpathian regions in 2006

2.3 FOREST FUNCTIONS

In the 1996 forest law, the primary function of the forest to be selected in management plans was changed to the following: protection, wood-production, health-social, tourism, education-research functions were defined where the individual functions cannot be separated from each other, so while managing the forest these functions have to be considered contemporaneously (Institute of Forest Policy Economics and Management University of West-Hungary 2003).

The main functions of the forest are in connection with nature- and environmental protection, economic utilization and the human social-recreation-cultural activities. These do not exclude one another, in many cases they can be harmonized on the same forest area. However in many cases it is necessary to separate them (e.g. silviculture of semi-natural and plantation forests). The National Forest Program of Hungary involves either the public welfare, economic or protection purpose utilization of state and private forests.

The so-called forest based industries in connection with the products utilization belong here, as well as the development of sustainable game management. The economic competitiveness of the forests and primary wood processing is to be supported. The Program thus involves the industrial use of wood not forgetting the global environmental protection and industry development topics e.g. promotion of the atmospheric carbon fixation in wood products, or its energy absorptiion utilization in decentralized biomass based heating systems (Institute of Forest Policy Economics and Management University of West-Hungary 2003).

The following table reports the division of Hungarian Carpathian forests by main functions.

		Borsod-A.-Z.	Heves	Nógrád	Carpathian forests	% on national forests
Protection	area (ha)	99 271.3	44 005.9	34 854.3	178 131.6	
	%	47.3	49.5	34.9	44.7	9.0
Production	area (ha)	109 555.3	42 761.4	64 715.1	217 031.8	
	%	52.2	48.1	64.8	54.4	10.9
Social, recreation	area (ha)	2 098.8	889.0	998.7	3 986.5	
	%	0.5	2.3	0.3	1	0.2
Education, research	area (ha)	0	88.901	0	88.9	
	%	0	0.1	0	0.02	0.0
Total forest area (ha)		209 876	88 901	99 869	398 646	20.1
Total	area (ha)	210 925.4	87 745.3	100 568.1	399 238.8	

Tab. 2.2: Forests by primary designation – %

In the tables 2.3, 2.4 and 2.5 the division of each forest category of function is reported, according to the ownership.

	Public	Community	Private	Unknown	Total
	ha				
Borsod-A.-Z.	51 129	1 219	51 538	289	104 175
Heves	20 289	64	20 649	0	41 002
Nógrád	30 553	61	31 203	0	61 817
Carpathian regions	**101 971**	**1 344**	**103 390**	**289**	**206 994**
Hungary	**540 481**	**9 009**	**610 045**	**1 252**	**1 160 787**

Tab. 2.3: Forests primarily designated for **wood production** by ownership (ha)

	Public	Community	Private	Unknown	Total
	ha				
Borsod-A.-Z.	70 868	776	21 263	1 822	94 729
Heves	30 591	156	11 511	0	42 258
Nógrád	23 054	66	10 391	0	33 511
Carpathian regions	**124 513**	**998**	**43 165**	**1 822**	**170 498**
Hungary	**478 246**	**6 752**	**168 247**	**2 282**	**655 527**

Tab. 2.4: Forests primarily designated for **protection** by ownership (ha)

	Public	Community	Private	Unknown	Total
	ha				
Borsod-A.-Z.	71 515	917	21 591	1 822	95 845
Heves	31 746	240	12 297	0	44 283
Nógrád	23 110	106	10 634	0	33 850
Carpathian regions	**126 371**	**1 263**	**44 522**	**1 822**	**173 978**
Hungary	**495 026**	**8 638**	**173 857**	**2 284**	**679 805**

Tab. 2.5: Forests primarily designated for **special designation** by ownership

2.4 FOREST COMPOSITION

Unlike the general European situation 84,9% of the total forest land area in Hungary is broadleaved forests, conifers cover 15,1%. 85,1% of the growing stock is in broadleaved forest, with 14,9% in coniferous forests (SFS 2003). As mentioned before, 57% of the forest land area is covered by native tree species 43% is covered by introduced tree species (e.g. black locust, conifers) or improved cultivars (hybrid poplars): major land use changes during the last decade (resulting from political changes) – including increasing fragmentation and partitioning of arable plots, afforestation by exotic trees, and the decrease in the use of biocides – have contributed to plant invasions and the resulting impact on community ecology and biodiversity (Török et al. 2003).

The so-called semi-natural stands are about one third of the total forest land area with some 650,000 ha. The native tree species are 68% of the growing stock, while non-native tree species and cultivars represent 32% (Institute of Forest Policy Economics and Management University of West-Hungary 2003).

The table 2.6 and figure show the species composition of the Carpathian region n Hungary, in comparison with the national average:

Forest area by species	*Borsod-A.-Z.*	*Heves*	*Nógrád*	Total Carpathian Regions		*Total Hungary*	
	ha			*ha*	*%*	*ha*	*%*
oak	74 633	26 219	20 994	121 846	32.78	369 335	20.62
turkey oak	24 093	16 099	21 361	61 553	16.56	201 362	11.24
beech	27 207	11 495	6 044	44 746	12.04	107 088	5.98
hornbeam	20 185	6 688	4 510	31 383	8.44	95 196	5.32
black locust	14 884	11 220	28 376	54 480	14.66	415 273	23.19
other hard wood	6 151	2 194	1 460	9 805	2.64	91 343	5.10
poplar spp	5 761	1 625	858	8 244	2.22	124 870	6.97
indigenous poplars	2 413	651	155	3 219	0.87	61 372	3.43
willow	1 742	549	321	2 612	0.70	22 136	1.24
alder	786	345	897	2 028	0.55	49 649	2.77
other soft wood	1 223	359	465	2 047	0.55	27 444	1.53
scots pine	7 272	3 026	5 645	15 943	4.29	132 243	7.38
black pine	2 209	1 475	1 626	5 310	1.43	67 168	3.75
other conifers	5 307	1 640	1 497	8 444	2.27	26 374	1.47
Total	*193 866*	*83 585*	*94 209*	*371 660*	*100*	*1 790 853*	*100*

Tab. 2.6: Forest stand composition in Carpathian forests and in Hungary.

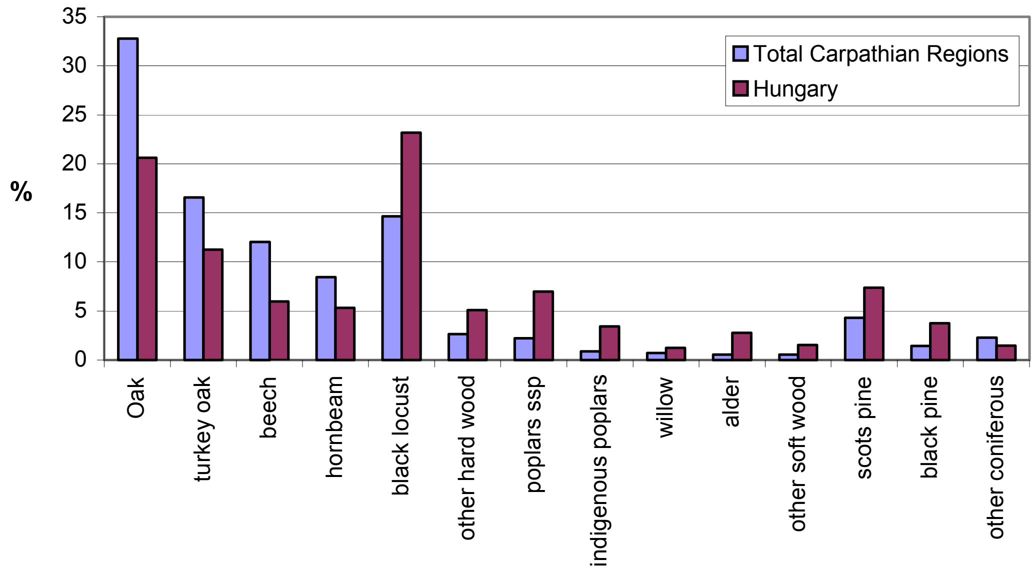

Fig. 2.3: Forest stand composition in Carpathian forests and in Hungary.

2.5 FOREST STRUCTURE

More than 59% of the Hungarian forests are less than 40 years old. This is mainly due to the forest plantation programme of the last 40 years, as well as due to the fast-growing tree species like black locust, willow and poplar, which account for a high proportion of this age group. Forest stands between 40-60 years make up 16.6%, 60-80 years 10.9%, and stands older than 80 years 10.9% of the total forest area (Nagy 2005)

2.6 FOREST MANAGEMENT AND MONITORING

In most Hungarian production forests, clearcutting and regeneration has been a standard forest management method. Clearcutting is followed by either natural or artificial regeneration, followed by alternative methods of forest management. Cleaning, selective thinning and increment thinning are the principal methods employed. Harvesting, which is mainly through clearfelling, occurs subsequently. The timing and intensity of these operations are described in the authorised forest management plans (FMP), which are obligatory in Hungary. They describe the present status and the prescribed forest operations over a ten-year period for each forest management unit. FMP are derived from a special survey that is carried out by the staff of the Forest Management Planning Service of the Ministry of Agriculture and are based on site description and the actual state of individual forest stands. The tree mass, tree stand, habitat type are all reorded and parameters such as age, diameter, height, tree species composition are also registered. A national report is prepared every year to summarise the data. A summary report is available to the public, though specific details are hard to obtain. Such data are only available to the owners and authorities. Forestry maps are registered also by the Forest Management Planning Service of the Ministry of Agriculture, which are not available from the National Institute of Cartography (Czàjlij and Standovar 1999).

Impacts of forest management in Hungarian forests

Forest management in Hungary, was very intensive in the **past** two centuries, as well as in other European Countries. As a result of this, there is no virgin forest remains in Hungary. The best examples of native forests could be classified as semi-natural (sensu Korpel), or old-growth forests. Most of them are situated in inaccessible areas, where forest operations are extremely difficult (Jávor and Gálhidy 2005).

When analysing the impact of **current** forest management on forest ecosystems the opinions of specialist working in nature conservation differ totally from the opinion of most foresters. The opinion of the people involved in conservation issues are backed by several recent studies that provide scientific evidence on the negative effect of current forest management on ecosystems. Some other ecosystems, like the ones dominated by beech and oak species which are characteristic of the Carpathian region are under great pressure from forestry management, and according to a WWF report published in 2002 more than 50% of the Hungarian close to natural forest ecosystems were threatened by the current forest management.

Researchers state that in Hungary only 6% of the current forest area can be considered natural. For ‘natural’ we understand forest ecosystems that have a similar structure to the natural potential, and the regeneration of these forests is still based on natural processes, while the rest of the forest area in Hungary is mainly replaced by forestry management. The most important threat is the technology used to regenerate forests. Still the most frequent methods of forest regeneration are those involving clear cuts, which means the forest cover is destroyed and then the area is planted with saplings. In most cases this results in even-aged, monocultures.

Another anomaly of Hungarian forestry is the fact the protected forests are in many cases managed for timber production, rather than for nature conservation purposes. A recent study conducted by a consortium from the Nyugat Magyarorszag University and Eötvös Loránd Tudomány University states that in most cases at present there is no difference regarding the so called “naturalness index” between the protected forests and the not protected forests (managed for timber production). These results undoubtedly prove that the management of the protected forests has to be improved. The situation is even more critical when considering private Natura 2000 sites. In the case of state forestry companies the implementation of these policies might work without subsidies but in the case of private owners, not.

National Forest Inventory

The institution of the National Forest Inventory was declared with Act LIV of 1996 on Forests and the Protection of Forests.

The inventory of the forest asset is continuous, every year covering one tenth part of the country’s forest area. The definition of forest used in the Inventory sets a minimum area of 0.15 ha and a minimum crown cover of 30%; the growing stock is defined as the volume of the stem (starting from ground) over bark until 5 cm in diameter of all trees with diameter at breast height > 5 cm (CarboInvent JRC: http://afoludata.jrc.it/carboinvent/cimd_eufoin_data.cfm#countrylist).

In Hungary a compartmental forest inventory system is in place. Within this aspect a full inventory of the Hungarian forest assets takes place every ten years. The inventory of the forest area is the task of the forest planning division of the Central Agriculture Office, Department of Forestry. Based on the existing data the forest planner generally inspects the field, describe the area and decide the sampling method for each sub-compartment. During surveying the methods based on aerial photographs are preferred. If aerial photographs are not available for a certain area the general rules for land survey are applicable. Within stands the use of theodolite with bow compass is allowed. Built-up basic points guides the work.

Data on the forest inventory are integrated in a National Forest Database operated by the Ministry responsible for forestry by law (Ministry of Agriculture and Rural Development, Department of Natural Resources or Central Agriculture Office, Department of Forestry). In this context, data from this database is considered an official document. On the other hand based on the data from this database the minister yearly publishes an annual communication on forests in Hungary. Only published data are available.

2.7 FOREST CONDITIONS

Tables 2.7 report the main forest natural threats in Hungarian Carpathian regions in 2005.

County	Total afforested area	Forest damage by type						
		drought	fire	other natural	insects	game	other	total
Borsod-A.-Z.	17 265.14	0.30	31.05	147.62	7.70	5.63	26.79	219.09
Heves	6 306.35	0.50	3.90	11.40	0.86	29.60	39.92	86.18
Nógrád	6 735.51	10.22	17.40	8.10	20.81	19.70	47.54	123.77
Carpathian regions	30 307	11.02	52.35	167.12	29.37	54.93	114.25	429.04
Total	180 293.76	90.00	79.25	733.89	568.38	281.52	524.33	2 277.37

Tab. 2.7: Quantitative forest damage in Hungary and in the Carpathian region in 2005 (ha)

One of the most important natural forest damage is constituted by **floods**: after a 20–30-year-long dry period in the last few years several serious flood events (Autumn, 1998; Spring, 1999, 2000, and 2001) occurred at the watershed of the Ukrainian and Hungarian parts of the river Tisza. Most of these episode cannot be explained solely by heavy precipitation episodes. The aspects of the recently increased floods that interest Tisza basin form the Ukrainian side to the Great Hungarian Plains are many, such as: recent very intense clear cutting of forest at headwaters (on steep slopes of the Eastern Carpathian Mountains), increased frequency of storms with intense precipitation, change in annual precipitation distribution over subcatchments, longer and colder winter with considerable snow accumulation, regional effect of global warming, etc (Dezso et al. 2005).

Concerning the other damage factors, it can be seen that **forest fires** are more relevant in the Carpathian region than in the whole country: the area affected by forest fires in the Carpathians is about 12% of the total damaged forest area, while the national average is much lower (about 3%).

In Hungary 99% of the wildfires are caused by humans, most of them are caused by negligence: typical forest fires causes are the incompletely estinguished fires of hikers, and illicit agricultural fires (Nagy 2005).

2.8 WOOD SUPPLY

In the Carpathian region, half of the growing stock is in forests designated for wood production, and the other half in forests with special function. So, the percentage of forests with production as primary function is slightly lower in the Carpathian than in Hungary as a whole, where almost 60% of the forests are productive forests (tab. 2.8).

	Wood production		**Special function**		**Total**	
	1000 m^3	m^3/ha	1000 m^3	m^3/ha	1000 m^3	m^3/ha
Borsod-A.-Z.	20 626	198	22 530	234	43 156	215
Heves	7 592	185	94 56	214	17 048	200
Nógrád	10 106	163	6 249	182	16 355	170
Carpathian regions	***38 324***	***182***	***38 235***	***210***	***76 559***	***195***
%	*50.1*		*49.9*		*100*	
Hungary	***197 780***	***170***	***141 065***	***203***	***338 845***	***183***
%	*58.3*		*42.7*		*100*	

Tab. 2.8: Growing stock by primary function

In table 2.9, the growing stock according to the ownership. Both in thw whole country and in the Carpathian region, most forests (about 65%) are public.

	Public	**Community**	**Private**	**Unmanaged**	**Total**	
	1000 m^3					%
Borsod-A.-Z.	29 010	242	13 478	426	43 156	12.7
Heves	11 612	44	5 392	0	17 048	5.0
Nógrád	10 279	22	6 054	0	16 355	4.8
Carpathian regions	***50 901***	***308***	***24 924***	***426***	***76 559***	***23***
Hungary	***218 211***	***2 309***	***117 576***	***749***	***338 845***	***100.0***

Tab. 2.9: Growing stock by ownership

Tables 2.10 and 2.11 report estimates of wood removals in Hungary and in the Carpathian region. The estimates were made on the base of UNECE Forest Products Statistics 2002-2006 (UNECE – Timber Committee: http://www.unece.org/trade/timber/mis/fp-stats.htm). Where not available, data related on the Carpathian Region are estimated on the basis of proportion of the forest area cover. The complete database is in annex to the report.

	Coniferous					Non-coniferous					Total				
Country	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006
	1000 m^3					1000 m^3					1000 m^3				
Hungary	620	678	861	779	802	5 216	5 107	4 799	5 161	5 111	5 83	5 78	5 66	5 94	5 91
Carp region	124	136	173	156	161	1 046	1 024	963	1 035	1 025	1 17	1 16	1 13	1 19	1 18

Tab. 2.10: Removals of **roundwood** (Source: UNECE Trade and Timber Division – Timber Section)

	Coniferous					Non-coniferous					Total				
Country	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006	2002	2003	2004	2005	2006
	1000 m^3					1000 m^3					1000 m^3				
Hungary	43	63	78	96	99	2 355	2 718	2 594	3 040	3 147	2 398	2 781	2 672	3 136	3 246
Carp region	9	13	16	19	20	472	545	520	610	631	481	558	536	629	651

Tab. 2.11: Removals of **wood fuel** (Source: UNECE Trade and Timber Division – Timber Section)

2.9 PROTECTED AREAS

About 20% of Hungarian forests are under different level of nature protection. (National Parks, Nature Protection Areas, Local Nature Protection Areas) (Institute of Forest Policy Economics and Management University of West-Hungary 2003). Legally protected forested lands belong to one of the following categories (Act no. LIII/1996 on Nature Conservation in Hungary): National Park, Landscape Protection Area, Nature Reserve, Forest Reserve (Czàjlij and Standovar 1999).

Currently 40% of the forest area in the Carpathian region is under some protection. In the near future this share will probably be increased by the designation of Natura 2000 areas. Three Hungarian National Parks (Bükk, Aggtelek, and Duna-Ipoly), out of 10, are located enterely or partly in the Carpathian region. These national parks are responsible for the management of several "landscape protection areas" and other protected areas defined by the national legislation. The official Hungarian name of these management bodies is "national park", however according to the IUCN categories[1] these protected areas are not national parks (IUCN category II) but landscape protection areas (IUCN category V.). This is due to the fact that most Hungarian national parks do not fulfil the requirements of IUCN (or other bodies active in protected area management policies: ParParks, Eurosites etc.) regarding the existence of a significant, intact, continuous core area.

We have seen that nearly 50% of the Hungarian forests are plantation forests established in counties where forest cover was destroyed several centuries ago. In the Carpathian region however, the share of close to natural forest ecosystems is still quite high. Even though these forests are close to what specialist think the natural forest type could be, the area of virgin forests in Hungary is very much reduced. These forests are included in the national Forest Reserve Network and are being managed either by national parks or the state forest companies. Table below lists the forest reserves in the Carpathian region, grouped according to national parks (EURAC 2006). In tab. 2.12, the list of forest reserves in the Hungarian Carpathians.

[1] The World Conservation Union – IUCN, defines a protected area as: "an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means". They have defined a series of protected area management categories based on management objectives. Definitions of these categories, and examples of each, are provided in Guidelines for Protected Area Management Categories. The six categories are (IUCN, 1994): 1- CATEGORY Ia: **Strict Nature Reserve** (Protected area managed mainly for science); 2- CATEGORY Ib: **Wilderness Area** (Protected area managed mainly for wilderness protection); 3- • CATEGORY II: **National Park** (Protected area managed mainly for ecosystem protection and recreation); 4- CATEGORY III: **Natural Monument** (Protected area managed mainly for conservation of specific natural features); 5- CATEGORY IV: **Habitat/Species Management Area** (Protected area managed mainly for conservation through management intervention); 6- CATEGORY V: **Protected Landscape/Seascape** (mainly for landscape/ seascape conservation and recreation); 7-CATEGORY VI: **Managed Resource Protected Area** (Protected area managed mainly for the sustainable use of natural ecosystems) (Stanišić et al. 2006)

Forest reserves	**Total area**	**Core area**	**Buffer zone**
AGGTELEK National Park			
Alsó-hegy	229.3	112.8	116.5
Haragistya-lófej Forest reserve	611.4	259.9	351.5
Nagy-oldal Forest reserve	486.3	223.8	262.5
Total	**1 327.0**	**596.5**	**730.5**
BÜKK National Park			
Csörgő-völgy Forest reserve	133.1	51.2	81.9
Kékes Forest reserve	142.8	54.8	88.0
Hór-völgy Forest reserve	439.1	61.1	378.0
Kecskés-galya Forest reserve	211.6	87.0	124.6
Vár-hegy Forest reserve	338.9	94.1	244.8
Őserdő Forest reserve	375.3	59.3	316.0
Leány-völgy Forest reserve	376.9	56.9	320.0
Paphárs-Kecskevár Forest reserve	191.5	57.8	133.7
Csókás-völgy Forest reserve	402.8	144.4	258.4
Nagy-sertéshegy Forest reserve	411.9	65.8	346.1
Pataj Forest reserve	257.1	65.7	191.4
Total	**3 281**	**798.1**	**4 594.8**
DUNA-IPOLY National Park			
Pilis-oldal Forest reserve	168.1	44.9	123.2
Prédikálószék Forest ▯iserve	170.3	27.3	143.0
Nagy Istrázsa-hegy Forest reserve	155.5	44.5	111.0
Pogány-rózsás Forest reserve	396.4	91.3	305.1
Gerecse Száz-völgy Forest Rserve	243.4	49.6	193.8
Meszes-völgy Forest reserve	131.8	46.3	85.5
Juhdöglő-völgy Forest reserve	80.8	25.7	55.1
Kisszénás Forest reserve	120.4	41.1	79.3
Ócsai Turjános Forest Rerve	70.2	22.4	47.8
Total	**1 536.9**	**393.1**	**1 143.8**

Tab. 2.12: Forest reserves in the Carpathian region in Hungary (EURAC 2006)

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3. POLAND

3.1 INTRODUCTION

The Republic of Poland, located in Central Europe, is bordered to the north by the Baltic Sea and Russia; to the east by Lithuania, Belarus, and Ukraine; to the south by the Czech Republic and Slovakia; and to the west by Germany. The area totals 31.27 M ha. Most of its territory is constituted of plains, which go from the north coast to the southern part of the country. South of the plains, the Polish Uplands consist of hills, low mountains, and plateaus.

Fertile soil covers much of the area, especially in the east. The Carpathian foothills lie within the branches of the Vistula and San rivers in south-eastern Poland. Poland's southern border is mountainous, with the Sudeten Mountains in the south-west and the western Carpathian Mountains in the south. The Carpathians, are much steeper and higher, rising to 2 499 m at Rysy peak in the Tatry range, the highest point in Poland (FAO: http://www.fao.org/forestry/site/countryinfo/en/).

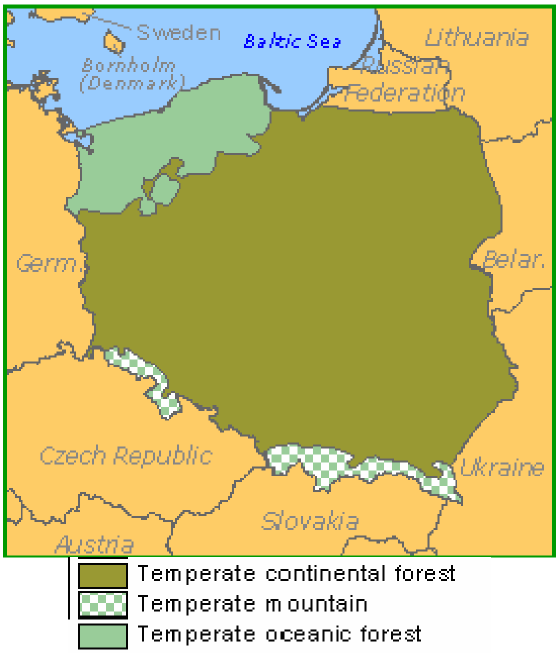


Fig. 3.1: ecological zones of Poland (FAO: http://www.fao.org/forestry/site/countryinfo/en/)

The landscape of Poland was dominated in the distant past by the vast pristine forests, with frequent wetland and bog areas. The proportion of forests has been decreasing continuously due to processes of civilisation, in particular due to the raw material needs of timber industry and expanding agriculture in particular. By 1820 the forest cover of Poland comprised only 38% of the country's area, and in 1946 only 20,8% (Lonkiewicz 1996).

The reverse process occurred between 1946-1970, when mainly as a result of afforestation of more than one million ha, the country's forest cover increased to 27%. At present the forests of Poland cover an area totalling 9 M ha, equivalent to 28.8% of the country's area (Główny Urząd Statystyczny (GUS) The State Forests Information Centre 2006).

3.2 FOREST AREA AND FOREST AREA CHANGE IN THE CARPATHIANS

The Carpathians in Poland are located along the country's southern border and occupy about 5,3% (1.67 M ha) of its total area. About 9% of the total area of the Carpathians are in Polish territory.

The forest area of the Polish Carpathian is about 0.76 M ha, which is equivalent to 8.4% of the total forest area in Poland, and covers 45.6% of the Polish Carpathian area. This means that the forest cover is much higher than the national average (28.8%).

Forest cover is increasing. One of the causes has been by the land abandonment process, which began in the second half of the twentieth century, and still continuing. Janicki (2005) studied the effects of land abandonment on landscape in the south-eastern Polish Carpathians. According to the Author, up to the second World War, the south-eastern part of the Polish Carpathian Mountains was formerly used for agriculture with intensity that varied from place to place. Foothills characterized by better soil conditions were inhabited earlier and used more intensively, mainly to produce crops. The southern region of mountains, where conditions for agricultural production are poor, was used most of all for breeding cattle and other animals. Crop production was less intensive here. In both cases, land clearing was progressing quickly. Natural landscapes build up by forests were giving way to cultural ones (agriculture) (Janicki 2005). Abandonment of land, that happened as a result of the Second World War and the following military action “Wisła” changed this situation. As much as third part of arable land of some parishes on the north and close to 100% of arable land in the mountains were abandoned. Decline in the anthropogenic change factor resulted in the spontaneous return of landscape to its more natural state. The renaturalization of the local landscape has been taking place for over 60 years and is very advanced,reaching 54% of forest cover in some parts of the Southern Carpathians (Janicki 2005).

Another cause of the increase of forest cover is the application of the Programme for Increasing Forest Cover that was drawn up in 1993 by the Department of Research and Spatial Information System of the Institute of Forest Research, prepared for the Department of Forestry in the Ministry of the Environment, and updated in 2003. In the State Forests’ area in the Carpathians, 4 593 ha are afforested and reforested annually, of which only the afforestation directly influencing the region’s forest cover amounts to 229 ha. Additionally, there was State Forest help for the afforestation of privately-owned farmland on around 721 ha (average data from 2004 to 2006) (Koziol 2007). To improve the success of reforestation, State Forests implemented a programme for the driven mycorrhizal vaccine of seedlings with a mycelium of *Hebeloma crustuliniforme* fungus, produced by the laboratories of Forest Gene Bank Kostrzyca and State Forests’ unit in Rudy Raciborskie (Koziol 2007).

3.3 FOREST FUNCTIONS

Forests serve diverse functions, either naturally or as a result of human activities.

Ecological functions ensure a favourable impact of forests on climate, both global and local, atmospheric composition and water cycling in nature. Forests counteract floods, avalanches and landslides, protect soil against erosion and the landscape against steppization (Główny Urząd Statystyczny (GUS) The State Forests Information Centre 2006). Nearly all of the mountain forests are legally protected.

The protective function of forests is also expressed also by their capacity to maintain and enhance **biodiversity**, creating the conditions to preserve the biological potential of a large number of species and ecosystems. Different kinds of protected areas have been established in large areas of the Polish Carpathians (see sect. 3.9).

The **productive functions** of forests ensure their ability to continuously produce biomass, thus enabling a sustainable use of timber and non-timber forest resources, as well as hunting. This in turn ensures profits from the sales of goods and services, as well as state and local budget revenues from taxes. In mountain areas also the productive function is also subject to the protective functions fulfilled by the forests. This is especially visible over all in the silvicultural systems, which pay great attention to the ecological bases for the development of trees and forest stands.

Finally, the **social functions** of forests ensure favourable health and recreational condition for society, the enrichment of the labour market and the strengthening of the development of clutural, science and ecological education.

3.4 STAND COMPOSITION

The Carpathian region is one of the last areas in Poland in which well-preserved natural zones can be found: the actual stand composition of the Polish Carpathians, can still often be classified as high or unique, with a natural stand composition higher than 50%. However, over the centuries, the primeval forest **species composition** changed, because of forest management that often used improper systems (monoculture plantations, lack of natural tree regeneration and type of cutting system, especially during World War II) (Grodzinska and Łukaszewska 1997).

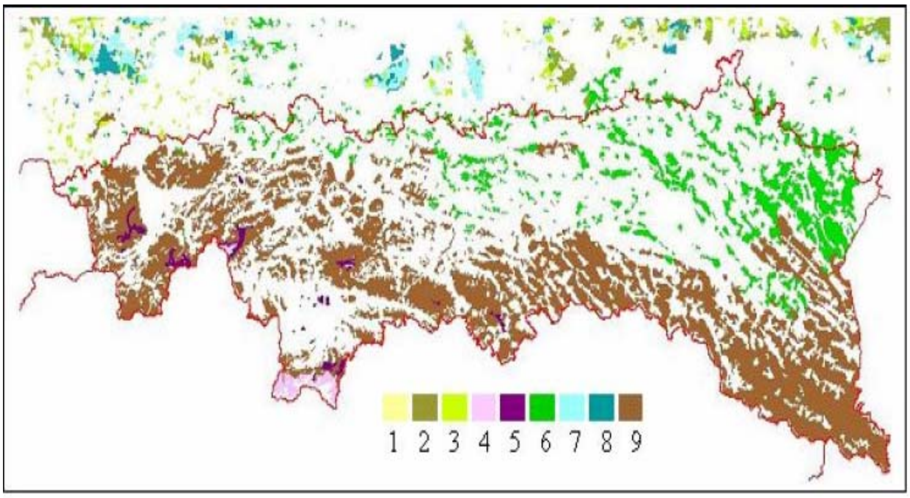
The western part of the Polish Carpathian massif is mainly covered by Norway spruce (*Picea abies* (L.) Karst) stands of an unknown origin, which are currently being converted. The central area is a multi coloured mosaic of the stand compositions which are close to being natural, with a very high share of silver fir (*Abies alba* Mill.). In some of the forest units the share of this species reaches up to 50% of the stand composition. The eastern part of the Carpathians in Poland is dominated by common beech (*Fagus sylvatica* L.), with significant share of silver fir (Koziol 2007). Another common specie in the Carpathian area is Scots Pine (*Pinus sylvestris*).

The table below reports the stand composition of forests in the Carpathians administered by State Forests (66% of the Carpathian forests):

Tree species	***% (area)***
Picea abies	16
Pinus silvestris	19
Abies alba	22
Fagus sylvatica	32
Quercus sp.	4
Betula pendula	2
Alnus glutinosa	1
Acer pseudoplatanus	1
Carpinus betulus	1
Alnus incana	2
Others	0
Total	100

Tab. 3.1: Stand compositions of forests in the Carpathians administered by State Forests NFH.
Source: (Koziol 2007)

From the figure below we ca see how the Polish Carpathians can be divided into two main forest belts: mixed upland forests, in the northern part, bordering on the hilly and then the plain region, and mountain forests, in the south, composed of coniferous and mixed forests.



1- fresh coniferous forest, 2 - fresh mixed coniferous forest, 3 - fresh mixed forest, fresh broadleaved forest, 4 - high-mountain coniferous forest, 5 - mixed mountain coniferous forest, 6 - mixed upland forest, 7 - moist mixed coniferous forest, 8 - moist mixed forest, boggy mixed forest, 9 - mountain forest, mixed mountain forest

Fig. 3.2: Distribution of main forest habitats in the Carpathians. Source: IBL and UNEP/GRID Warsaw. (Rusztecka and Ochwat-Marcinkiewicz 2007)

The most common forest types in the Carpathian forests are montane beech forests.

FOREST TYPE	Characteristics (FRA 2005)	ADOPTED MANAGEMENT	AREA (ha)
Subalpine larch-arolla pine and dwarf pine forest (3.1)*	primary	National Park – no cutting and regeneration system	3 158.47
Subalpine and montane spruce and montane mixed spruce and silver fir forest (3.2)*	primary and modified natural	potential stand types: spruce, spruce-silver fir, beech-spruce, beech-silver fir	88 397.1
Oak-hornbeam forests, ashwood and oak-ash forests (3.3)*	primary, modified natural and semi-natural	potential stand type: Oak-Maple-Sycamore maple-Hornbeam	178 490.54
Carpathian sub-montane beech forests (5.1, 5.2)*	primary, modified natural and semi-natural	potential stand type: Beech-Silver fir, Silver fir-Beech, beech, Beech-Silver fir-Spruce	32 216.51
Carpathian montane beech forests (7.5)*	primary, modified natural and semi-natural	potential stand types: beech-Silver fir, Silver fir-Beech, Larch-Spruce-Beech, Spruce-Silver fir-Beech	297 519.6
Flood plains	primary and modified natural		4 398.06
Pioneer stands – pine on post-agriculture lands			25 000
Other types, Privately owned forests** , Treeless forest areas			131 253.5

Tab. 3.2: Forest types in the Polish Carpathians *the numbers refer to the EEA forest types classification (EEA 2006) **(data partly not available concerning privately owned forests)

It can be seen that some primary forests can be found in most of the forest type. However, these primary forests are just a fraction of the primeval ones, because of the past over-exploitation of forests. Following clearance in the past many areas were replanted: in the 19th century seeds used to be transported from other regions of the Austro-Hungarian Empire. Spruce monocultures are more vulnerable ecosystems than natural or semi-natural forests, and now we there is the problem of "stand spruce decline". Current management aims to return the forest to a more natural mix of species from local origins (Sarshar 2002).

There is a **Carpathian Gene Bank** functioning in the Carpathian forests, conducting a programme of preservation of the most precious gene resources in the Carpathian stands, mainly in the in vivo form, as the living clone and family archives, but also in the ex situ form, by storing seeds of the most precious origins in the cold rooms of Wisła forest unit. The gene resources of the most valuable trees and stands from the Carpathians are also stored as well in the Forest Gene Bank Kostrzyca, which stores the genetic material of forest trees and shrubs from all over the country (Koziol 2007).

The conversion of stands is a permanent process. It usually concerns the Norway spruce monocultures in the sub-mountain zone and in the lower mountain forest zone. In some cases, the conversion of stands is a short-term process and lasts only up to about 10 years. This happens with the appearance of sudden disastrous phenomena (windbfalls, snowbreaks, decline of spruce monocultures on vast areas, e.g. in the Beskidy mountains). The conversion of stands in years 2002-2006 affected 5 070 ha of forests in the Carpathians. Of this area, 2 600 ha was in Beskid Śląski and Beskid Żywiecki. Following the ecological disaster, there 19 000 ha of tree stands have been appointed to the conversion in the regions mentioned (Koziol 2007).

3.5 FOREST STRUCTURE

As mentioned above, in the past there was a period of management that aimed at maximising timber production through planting and even-aged stand management. Over-harvesting led to a reduction in older trees, with a negative effect on the forest ecosystems. In recent years forest management practices aimed to increase the age of the forest by harvesting at levels below the annual increment, as well as extending the rotation length and cutting cycle for many forest units (Krol 1997). A recent study (Niemtur 2007) confirms negative influence of anthropogenic management by last decades and in consequences, among others, great sensitiveness for climatic changes majority of Carpathians forests.

The following age-class division is applied in forest management in Poland (tab. 3.3):

Age class	Years
I	0 – 20
II	21 – 40
III	41- 60
IV	61 -80
V	81 – 100
VI	101 – 120
VII	121 – 140
VIII	141 - 160

Tab. 3.3: Age classes in Polish forests

As we can see from the table 3.4, many forests are middle aged and in National Parks there is a domination of older age classes.

FOREST TYPES	AGE CLASS DISTRIBUTION AND FOREST STRUCTURE
Subalpine larch-arolla pine and dwarf pine forest	II and III age class
Subalpine and montane spruce and montane mixed spruce and silver fir forest	domination of age classes III-V, average age of stands 65 years. Only in the Babiogórski National Park domination of VIII age class (29%)
Oak-hornbeam forests, Ashwood and oak-ash forests	domination of age classes II-V, average age of stands 60 years. For National Parks - domination of VIII and older age classes
Carpathian sub-montane beech forests	domination of age classes IV and V, average age of stands 65 years
Carpathian montane beech forests	domination of age classes II-V, average age of stands 65 years

Tab. 3.4: Age structure in the most important forest types in Polish Carpathians

3.6 FOREST MANAGEMENT AND MONITORING

Ecological bases of forest management

According to the Order number 11a of General Director of State Forests National Forest Holding of May 11th 1999, forest management has to be based on the principles of continuing and balanced development. The Order constitutes that due to multilateral functions of forests in spatial planning of local, national and global interest, the economic activity of State Forests must take into account international criteria and indicators of a balanced development of forests and forestry, leading to:

1). Retaining the biological diversity of forests.

2). Maintaining the production richness of forests.

3). Maintaining the health and vivacity of forest ecosystems.

4). Protection of soil and water resources in forests.

5). Mantaining and intensification of forests' role in global carbon balance.

6). Maintaining and boosting long-term and multilateral social and economic benefits taken from forests.

7). The existence of legal, political and institutional solutions supporting durable development of forest management (Koziol 2007).

Within all areas of forest management, detailed principles have also been elaborated, some of which are quoted below:

• The principle of dividing the territory into seed regions; the rule of registering seeds and seedlings must be obeyed.

• It is necessary to continue the creation of the nationwide bank of gene resources' reserves.

• Natural regeneration must be favoured in all habitats.

• Use of chemicals for the tending of young-growth tending must be restricted only to necessary and reasonable cases.

• It is advised to limit the clear cut system in final cutting.

• The breadth of clear cut areas cannot exceed 30-60 m (allowed only in the lowlands)

• It is forbidden to use clear cut system in the neighbourhood of communication routes, water basins and watercourses, as well as buffer zones of the nature reserves.

• 5 % of tree groups and large tree groups of mixed and biocenotic species on cutting areas, as well as trees of dominant species should be left to the following rotation cycle.

• Complex felling systems should be preferred (in the mountains as well as in the lowlands, mainly in broad-leaved tree stands), wherever they can create the best conditions for regeneration and development of stand.

• The principle of using the nature-friendly technologies during timber harvesting must be obeyed (Koziol 2007).

Forest management plans

Management of national forest in Poland is based on management plans that are revised every ten years. The management plans are developed for each superintendency by Regional Management Planning Offices (state company under the Ministry of Treasury) and private forest management services companies. The 10 year management plans are prepared for superintendency sub-units. They do not have their own administration (Sarshar 2002).

The first part of the management plan contains background information and general descriptions on the superintendency, an overview of the past ten years, a summary of the plans for the next ten years and a brief outline of predicted management for the ten years following the planning period. The second part of the management plan contains the inventory results and the third part provides detailed information on planned management for the ten years of the plan. From 1997 the Annexes to the management plans are developed - Nature Protection Programme. The Programme describes the natural values occurring in the area of superintendence and measures for their protection (Sarshar 2002).

The forests in each superintendency are generally composed of one to three management sub-units with ranges of approximately 1 100 ha each. For management purposes, the forest area is divided into units of approximately 10 - 30 ha based on topography, forest type and past management history. These are further divided into compartments of 0.5-10 ha based on specific harvesting and silvicultural objectives.

For each compartment, detailed plans for thinning, harvesting and regeneration are given. This includes details of volumes and species to be harvested. Data on actual volumes and species are added following operations to allow comparison between planned and actual extraction levels (Sarshar 2002).

Harvest and regeneration

The most appropriate harvesting technique and the volume to be harvested for each compartment is specified in the management plan. Each year an annual plan is produced based on the data in the management plan. There is some flexibility to increase or decrease production of timber according to demand and price, provided that the total volume prescribed in the management plan is not exceeded over a 10-year period. This allows the superintendents to maximise the economic efficiency of management while respecting sustainable levels of harvesting. For each sub-unit in these areas the approximate volume of each species to be selected and harvested is specified in the management plan based on the management objectives, the inventory results and any other relevant factors. The trees are selected individually by the ranger and marked for felling. Main extraction routes are also marked using paint on trees. The control engineer from the superintendency who must approve the planned operation before it starts checks the site (Sarshar 2002).

The clearcut scheme applied is specified in the “Silviculture Principles”, based on site features and site-adapted species. No clearfelling is permitted adjacent to permanent watercourses and public roads.

The clearcut scheme in the mountainous areas is currently strictly limited. Usually it is practiced in the disaster-hit areas, for sanitary reasons. Instead of the above methods used on the lowlands, other environmentally friendly schemes are used in the mountains:

II. **Shelterwood scheme**. The scheme is based on the natural regeneration in one seed year, with the supplement of artificial regeneration when necessary. In the mountainous conditions, the scheme II c (for spruce monocultures, with maximum area of cutting 3 ha, and maximum width 30 meters) is most common.

III. **Group felling scheme**. Groups of 0,05 to 0,2 ha, with or without shelter, are cut and regenerated earlier than the remaining area, with the use of natural and/or artificial regeneration. In the mountains, in beech or oak stands, scheme IIIb can be used.

IV. **Stepwise cutting scheme**. Different types of cutting on the same area, during many seed years. Schemes IV and V and are the best (also for the ecological reasons) in the mountains, although they are not easy to perform. All the sub-types of the stepwise scheme can be applied in the mountainous areas.

V. **Selection cutting scheme**. Continual selection felling in all the stand area.

The choice of cutting scheme always depends on local conditions, therefore the principles are only general guidelines, and the schemes can be modified if necessary. In particular cases, other, less typical schemes can be used within the 5 groups of cutting schemes.

Felling is done using chainsaws, with extraction either by tractor or horses. Logs are removed to log yards at the roadside where they are stacked by assortment, marked and numbered with plastic tags, and information recorded. In so called Forest Promotional Complexes harvesters are also used.

Natural regeneration is preferred to planting wherever possible, and harvesting operations have to be planned to maximise the chance of successful natural regeneration. In selected harvest areas, trees are felled where regeneration needs releasing and damage to regeneration is avoided. In clearcut areas, seed trees are left where appropriate.

Where natural regeneration is insufficient, or there is a management objective that will not be met by natural regeneration, planting is used. The latter case usually occurs where the species mixture in a particular area is not the natural one, and the management objective is to revert to a more natural species mixture.

A general trend among RDSF is to promote natural regeneration wherever possible and avoid large mono-specific spruce and pine stands. The requirements of Decision 11 and 11A are behind these changes with the objective of improving the level of biodiversity among forests.

Planting is done using seedlings produced within the directorate from specially selected seed trees. There are specialised and protected seed stands and these seeds are sent to nurseries in either the same or neighbouring superintendencies for cultivation.

Planting is planned based on the final species mixture required for the area in the management plan. Various methods are used to protect planted seedlings from browse damage including fencing, individual mechanical protection or painting with a non-toxic repellent.

Obstacles for forest management:

There are many kinds of obstacles to forest management in the Carpathians. Those obstacles most commonly mentioned by the SF Districts and Regional Directorates are:

- rapid decline of spruce stands in Katowice Regional Directorate of State Forests
- fungal diseases (*Armillaria mellea*) and pests (*Ips typographus*)
- rapid disaster phenomena : hurricanes, floods, etc.
- damage to the existing roads, old roads that are unsuitable for heavy transport
- deficiency of forest workers, who are usually old, there is not enough avocation among young people to work in the wood harvest industry
- very high work costs caused by difficult terrain conditions
- terrain conditions often exclude the mechanization of work
- many existing protective areas cause limitations to forest management
- in some areas high numbers of hoofed game cause a lot damage to forest stands and forest cultures
- very intensive tourism.

Monitoring processes in the State Forests

Monitoring of the state of the forest

Monitoring of pests and diseases is co-ordinated for the whole of Poland by the Forest Research Institute (Instytut Badawczy Lesnichwa; IBL) and Forest Protection Enterprise (Zaklad Ochrony Lasow – ZOL). Plans for collection of samples and data are sent to the regional directorates, which in turn formulate plans with the relevant superintendencies. The samples and data collected are sent to the monitoring bodies for analyses. A summary of results is sent to the regional directorate and disseminated among the superintendents. The results for the whole of Poland are published annually (Sarshar 2002).

Monitoring of tree species mix, age distribution and understorey species in the forest is done during the ten year inventories. Following issuance of Decision 11 by the General Directorate from 1995 (amended by Dec. 11A of 1999), which prescribes a more ecological approach to the stewardship of forests, more detailed forest site assessments and evaluation of nature values in a broad sense are being conducted and results are set out in the management plans produced. A new Decision from the General Director of State Forests, Decision 23, 4 August 1997, (amended by Dec. 65 of 1999) also requires that all management plans are available for public consultation before being formally adopted (Sarshar 2002).

In the whole region, an assessment of the presence of protected, rare and endangered species was conducted in 1995. Rangers during their everyday work carry out nature monitoring, including rare and endangered species. Data collected by the rangers is passed on to the superintendency and from there to the directorate headquarters. Some information on rare species is kept confidential to protect against poaching. Further more detailed evaluations are carried out during preparation of the Nature Protection Program for superintendenices (Sarshar 2002).

Monitoring of sustainable production

Monitoring of the quantity and quality of available timber is done through the ten-year inventories taken as part of the management planning process by the Management Planning Office. Results are analysed by species, age distribution data and growth rate. This basic data serves for the elaboration of annual plans.

Costs, productivity and financial efficiency are monitored by staff at the directorate headquarters who keep detailed records that are regularly reviewed with each superintendent (Sarshar 2002).

National Forest Inventory

The Inventory is conducted according to the detailed instruction accepted by the Minister of Environment on 15.02.2005.

The aim of the Inventory is to evaluate of the forest condition and trend in forest changes on the large scale, based on the properly chosen factors. The Inventory provides cyclical and reliable information on forest, from the basic characteristics concerning biomass (volume, increment, harvest, mortality) to specialized observations. The inventory covers the forests of all forms of ownership, in all their functions (productive, protective and social).

Observations and measurements are implemented on permanent sample areas. The areas are based on the system (ICP Forest) used for the evaluation of damage to forests, consistent with the EU system (Commission Regulation (EEC) No 1969/87) based on the web 16x16 km grid, which for the needs of NFI is intensified to 4x4 km. The areas are chosen randomly, in the configuration of L-shaped routes with equal arms, located in the net 4x4 km grid. Within each route, 5 sampling areas are located (each area is 200 m apart), which gives a total number of circa 28 000 areas in the whole country. The numbers of the basic nodes of the net 16x16 km grid are multiples of 4, and the numbers of nodes in the net 4x4 km grid are complimentary to the numbers of a basic web. Within the route, the numeration of the areas is fixed, and the coordinates of the nodes are recounted from the WGS 84 system to the GUGiK 1992.

The resources are evaluated on 2 types of circular areas A and B with shared midpoints, of a size fitting to the evaluated objects. The areas are settled when the midpoint is located on the forest ground. On the A area (size: 2, 4 or 5 are), the following trees and shrubs are evaluated: standing (living and dead) trees with a diameter on 1.30 m exceeds 70 mm; dead lying trees with a diameter at the broader end exceeding

100 mm and snags with diameter exceeding 100 mm and height up to 50 cm. On the B areas (size 0,2 are), trees and shrubs with a diameter of less than 70 mm are evaluated.

The Inventory cycle is 5 years, and every year, 20% of routes are evaluated.

The data from the Inventory are not yet available. So far, i.e. during 2 years of field work, about 10 900 sample areas have been evaluated. This is equal to 40% of all areas. The data acquired so far is most accurate for the lands administered by State Forests and for the private forests. In the case of other forms of ownership (public forests not administered by SF), the data is less accurate and may contain significant errors.

The Inventory will be finished in 2009. Until that date, the data will not be publicly available.

The principles of forest inventory for a forest working cycle.

The Forest Inventory in Poland is regulated by the a combined inventory: standwise with samples. The first Forest Inventory in Poland is dated 1945, and the most recent one is that of 2004. So, six Inventory Cycles are completed (CarboInvent JRC: http://afoludata.jrc.it/carboinvent/cimd_eufoin_data.cfm#countrylist).

The Inventory cycle lasts 10 years, according to Art. 18 of the Forest Act of 28.09.1991.Due to organizational reasons, particular State Forest units and Forests of other forms of ownership are evaluated in different periods of time. In one of these the inventory is just beginning, in others it is in progress, while in some of them, the forest management plan is still valid. Unfortunately, not always the forest management plans of forests administered by the counties are not always updated according to Art. 5 of the quoted Forest Act. In cases justified by the condition of the forest, forest management plans may be elaborated for a shorter duration. Such procedure requires the acceptance of the Minister of the Environment.

The definitions used are the following (CarboInvent JRC):

Forest: a ground covered with forest vegetation, of area above 0.1 ha; it includes forest grounds temporarily deprived of forest vegetation, and grounds related to forestry (forest roads, nurseries etc.). Forest act 1991.

Growing Stock: (includes tops of stems, large branches; and excludes small branches, twigs and foliage): starting from the stump: wood volume of the stem over bark until 5 cm of diameter (branch volumes are not included) of all trees with diameter at breast height >= 5 cm

The Inventory counts 1 000 - 2 000 plots by forest districts. They are temporary circular plots, the size depending on age class. 100% of forests is covered by the inventory, 80.4% (State Forest Holding) has the inventory carried out regularly according to the periodically updated standard. Data are published every year as a Yearbook, Report on State of Forests and other reports.

Field samples are established during the inventory in order to evaluate the growing stock (a statistical representative method of evaluation of timber resources). The samples are round areas, and their number for a forest zone is counted as follows:

$$N_p = 400 + \frac{A}{50} + 1000 \times \frac{p}{A},$$

- 40 – the minimum number of trials, to which a double standard error of volume in the forest zone does not exceed 5%
- A – total area of all evaluated stands (in hectares)
- p – total area (in hectares) of stands of diverse species composition and diverse vertical structure.

The location of field sample areas in the stand is based on a grid of squares 100 x 100 m squares. The field samples are temporary and their size depends on the stand age (from 0.005 ha in age class IIa to 0.5 ha in age classes VI and older, as well as in regeneration class). In the field samples, the following values are measured: the slope, breast height diameter, heights of chosen trees of particular species. Estimated error for areas and growing stocks cannot exceed 5%.

Data availability of the field measurements: The data is saved in the source document card, and delivered to the digital database with the programme TAKSATOR. The cards are stored in the archives of the inventory contractor.

3.7 FOREST CONDITIONS

Forests in the Carpathian region are affected by several impacts, both natural and anthropogenic. The fig. below shows the area affected by some of the main forest disturbances.

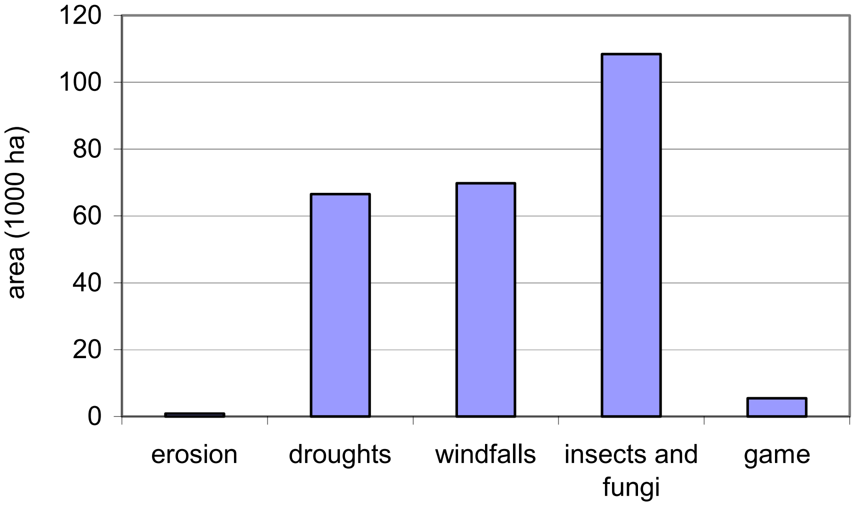


Fig. 3.3: Forest disturbances in the Polish Carpathians

One of the most dangerous living organisms, affecting the coniferous monocultures, especially of pine and spruce, is mushroom root rot (*Armillaria mellea*). It is estimated that the area of stands harmed by mycelium of the above fungus in the Carpathians is 32 177 ha, mainly in the Beskid Śląski and Beskid Żywiecki region. Other equally dangerous fungus, afflicting montane forest ecosystems is annosus root (*Fomes annosus*). There are approximately 8 546 ha of Carpathian stands administered by State Forests infected by this fungal disease (Koziol 2007).

Among the human disturbance factors, we can mention the impacts of forestry practices on the mountain ecosystem (EURAC 2006):

- over-intensive tree cutting in private forests
- removal of dead wood recognized as the habitat of dangerous wood pests
- negative results of the promotion of spruce in lower montane levels in previous decades
- afforestation practices – from the nature conservation point of view this might be dangerous to valuable non-forest habitats; this problem is characteristic of the Carpathians, where vast areas have been left fallow
- an upcoming problem is the building of infrastructure for forest management (e.g. cross-slope roads)
- the drainage of bog woodland undertaken in previous decades (e.g. in the area of the Orawa- Nowy Targ peatbogs)
- invalid water hydro- meliorations in the past.

The impact of forest practices on biodiversity is different in the state and private forests. Although the state forest authorities have some measures to control forest management on private lands there are still a lot of private areas where tree cutting is too intensive (EURAC 2006).

Other anthropogenic impacts on forest include: air pollution, illegal cuttings (estimated at 2 964 m^3 in 2006), mountain tourism and poorly regulated sport activities, which affect all the Carpathian forests. Forests fire in the Carpathian area are only of a marginal problem (Koziol 2007).

Spruce stand decline

The phenomenon of spruce stand decline in the mountains of Beskid Mały and Beskid Śląski has been observed since the 1950s. The main reason for the decline of spruce stands was industrial pollution, and the phenomenon induced the processes of stand conversion into mixed stands with dominant beech and a mixture of silver fir, sycamore maple and mountain elm. Another major reason, which has resulted in the appearance of a vast area of stands requiring fast harvesting, is lack of rainfall, in particular during summer 2006, when the rainfall amounted to only 30% of the long-term average value, and the average temperature in July was 4.2ºC above the long-term average value. July's isotherm, corresponding with the temperatures reported in 2006 in the Beskidy mountains, is typical of the regions of the Black Sea and Mediterranean Sea in Europe. Such climatic conditions were not tolerated by a species typical of the taiga region, especially taking into account the fact, that the above stands are not of local provenance (Koziol 2007).

Following the appearance of disaster phenomena, caused above all by abiotic threats (winds, hurricanes, snowfalls, hoarfrost, draught and pollution of forest environment), the biotic threats are often activated: secondary reasons of the decline of spruce stands in the Beskidy mountains were:

- mass occurrence of the mushroom root rot (*Armillaria mellea*) in the weakened stands;
- increased activity of the eight-toothed bark beetle (*Ips typographus*) and other bark beetles;
- other outbreaks of insect pests: the web-spinning larch sawfly (*Cephalcia alpina* Kl.): 1982-1985; the larch tortrix (*Zeiraphera griseana* Hbn.): 1977-1985; the spruce pamphilid (*Cephalcia abietis* L.) and the small spruce fly (*Pristiphora abietina* Christ.) since 1982;
- significant loss to foliage caused by the dehydration of needles (Koziol 2007).

3.8 WOOD SUPPLY AND PRODUCTIVE FUNCTION

The total **growing stock** is 222.05 M m^3, that means an average value of about 300 m^3ha^{-1} (292 m^3ha^{-1} in State forests, 323,5 m^3ha^{-1} in National Parks), which is more than 25% higher than the national average (229 m^3ha^{-1}). The volume pro capita is 41,53 m^3 in Poland, and more than twice in the Carpathian region: 96.38 m^3. On the other hand, annual **growing increment**, calculated as average annual gross increment of large timber, is lower in the Carpathian region than in the whole State: national average is of 7.16 $m^3ha^{-1}year^{-1}$, while in the Polish Carpathians the values go from 5.45 $m^3ha^{-1}year^{-1}$ in National Parks, to 6.54 $m^3ha^{-1}year^{-1}$ in State forests. In the Carpathian forests administrated by the State Forest National Forest Holding (NFH), about half of the total growing stock is constituted by conifers: spruce, fir and scots pine (fig. 3.4).

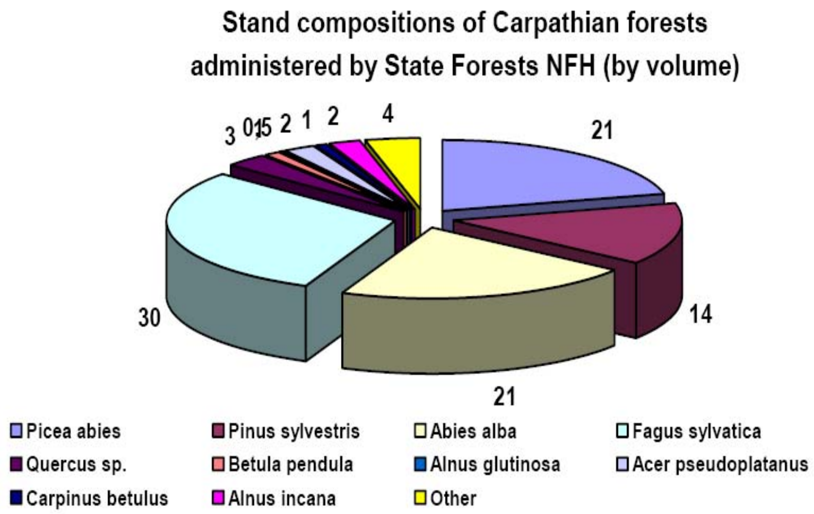


Fig. 3.4: stand composition of Carpathian forests administrated by State Forests National Forest Holding (Koziol 2007)

As seen before, the productive function of forest in mountain areas is subject to the protective ones. This principle is reflected by silvicultural systems. All stands in the Carpathian forest units are managed with the use of complex cutting systems or they form the so-called stands by conversion. Stands by conversion include mainly artificial spruce and pine stands. The principle of a permanent presence of forest ecosystem on the ground is in force. The first way of stands management (shelterwood system or stepwise cutting and selection cutting) makes the forest regenerate naturally. In the second case, the nurse crops (stands by conversion) are utilized by group cuttings and shelterwood cuttings, planting the target species. In the State Forests there is no timber harvesting in the upper forest zone, above 900 m a.s.l., on the steep slopes and rocks (Koziol 2007).

The annual volume of **prescribed cut** in State Forests in the Carpathians is 2.37 M m^3 of merchantable timber, and the actual average utilization of timber in 2002-2006 was 4.53 M m^3. The significant exceeding of the prescribed annual cut in the Regional Directorate of State Forests in Katowice is caused by the necessity of timber utilization from the outgoing, one-species, artificial spruce stands in the forests of Beskid Śląski and Beskid Żywiecki, which were introduced into these areas by their previous owners of the Habsburg dynasty (Koziol 2007). Currently these stands present some problems such as weakened, infected or dead tree stands, and this phenomenon is indicated as the “spruce stand decline”.

As Koziol (2007) reports, according to the necessity for short-term harvesting the stands in decline, forest units in the Beskidy mountains were forced to elaborate a programme to couteract the negative results of spruce stands decline and plan the conversion of monocultures into composite stands. Altogether the threatened spruce stands cover an area of 25 971 ha, which is 44% of the area covered by this species in the Regional Directorate of State Forests in Katowice. The share of privately-owned forests in the above area is 48 000 ha. Forests with other forms of ownership suffer from the spruce decline much more, as it is very difficult to convince their owners to take actions to prevent further progress of the disastrous phenomenon. Reforestation of this area is connected with the necessity of carrying out proper logistics, taking into account:

- gene preservation of the most valuable spruce provenances in the Kostrzyca Forest Gene Bank and in the Carpathian Gene Bank in Wisła;
- adjustments of the Forest Reproductive Material Act in order to enable the seed harvest of valuable forest tree species suggested for the conversion of stands of other provenances;
- ensuring the technical conditions to produce the planting material for the needs of conversion;
- ensuring the technical conditions for reforestation in the coming years;

- proper informative and educational activities aimed at the local community, and above all for the owners of private forests, to convince them of the necessity of taken actions (Koziol 2007).

A remarkable range and speed of spruce stands decline is a reason for intensifying forest work to an uncharted level, and to their implementation in specific mountain terrain. Very intensive timber harvesting and log transport, forced by sanitary reasons, will not only cause specific natural effects, but will also be a source of potential conflicts, demands and criticism towards forest management and foresters. Potential areas of criticism against the foresters will concern:

- worsening of aesthetic value of forests and their importance for the landscape shaping, as well as conditions for recreation and tourism;
- damaging influence of timber extraction and log transport on the condition of the roads and quality of water in watercourses and water basins.

NWFP in Carpathian area:

Christmas trees – each State Forests District sells Christmas trees from the areas that are not forested (e.g. beneath electrical lines), but where low trees and shrubs can be bred. In 2006 State Forest Districts in the Carpathians sold a total of 2 869 Christmas trees.

Game management is conducted by the Polish Hunting Union. Only some hunting areas are administered by State Forests (In Krosno Regional Directorate of SF, there is a Hunting Bureau “Bieszczady”, organizing commercial hunting, also for foreigners).

According to annual plans, the number of game hunted in 2007, was:

- Red Deer: 1291,
- Roe Deer: 2508,
- Wild Boar: 797.

Other products include products of forest cover, e.g. mushrooms, herbs or fruits, as well as seeds for the needs of stand regeneration, research and storage.

3.9 PROTECTIVE FUNCTION

Protective forests

As mentioned before, protective functions are expressed by a positive influence of forests on shaping global and local climate, atmospheric composition and the water cycle in nature. They counteract floods, erosion and avalanches. They protect the landscape from steppization, and affect the biodiversity of flora and fauna in forest ecosystems.

Nearly all the montane forests are protected as one of the categories below:

Protective forest category:	*Area (ha)*
Nature reserves	10 897
Soil-protecting	62 506
Water-protecting	281 631
Damaged by industry	28 240
Experimental areas	5 016
Forests of a special ecological value	6 548
Refuges	6 766
Plus seed stands	2 286
Total:	403 890

Tab. 3.5: The protective forests in the Carpathian (Koziol 2007)

The data concern State Forests and private forests administered by the SF Districts

Protected forests

There are 6 National parks in the Carpathians, covering a total area of 82 573 ha, administered by Directors who report directly to the Minister of the Environment (tab. 3.6).

TITLE	AREA (HA)	VIRGIN FOREST AREA (HA)	TYPE OF FOREST
Babiogorski National Park / Biosphere Reserve	3 390,54 + 11 829	702,49	-
Bieszczadzki National Park	29 200,96	3 423,15	Oak-hornbeam forests, Ashwood and oak-ash forests, Carpathian montane beech forests
Gorczanski National Park	7 030	4 000	Subalpine and montane spruce and montane mixed spruce and silver fir forest , Carpathian montane beech forests
Magurski National Park	19 439	12 101	Oak-hornbeam forests, Ashwood and oak-ash forests, Carpathian montane beech forests
Pieninski National Park	2 346,16		Subalpine and montane spruce and montane mixed spruce and silver fir forest, Oak-hornbeam forests, Carpathian montane beech forests
Tatrzanski National Park	21 164	7 757	Subalpine larch-arolla pine and dwarf pine forest, Subalpine and montane spruce and montane mixed spruce and silver fir forest, Oak-hornbeam forests Ashwood and oak-ash forests

Tab. 3.6: National Parks in Polish Carpathians

National Parks not only fulfil their most important aim, i.e. preserving the existing natural heritage, but also play a very important social role, that is an ecological education of the public.

Due to their unique opulence and diversity of both flora and fauna, Natura 2000 areas have been the established in the Carpathians. These areas are natural ecological corridors between the existing National Parks and Nature Reserves.

Some of these areas are:

- Special Protection Areas “SPA” -“Dolina Gòrnej Wisly”- 3 535 ha
- Special Areas at Conservation “SAC”- “Beskid Śląski”- 26 256 ha
- Special Areas at Conservation for Habitats “SAC”- “Beskid Żywiecki”- 35 326 ha
- Special Areas at Conservation “SAC”- “Beskid Mały”- 7 186 ha
- “Special Protection Areas for Birds and Habitats”-“Bieszczady”-107 318 ha
- “Special Areas at Conservation for Birds”- “Pogòrze Przemyskie”- 64 075 ha
- “Special Areas at Conservation for Birds”- “Gòry Słonne”- 55 220 ha
- “Special Areas at Conservation for Birds and Habitats”- “Beskid Niski”- 152 ha, of which about 65 000 ha are in the Krosno Regional Directorate f State Forests.

There are also other forms of biodiversity protection, such as: Landscape Parks (15- 414 761 ha), Nature and Landscape Complexes (7- 1 932 ha), Natural Monuments (439), protected zones for selected animal species (153- 6 179 ha), areas at Protected Landscape (9- 81 997 ha), Plus trees (1 222), seed orchards and seedlings seed orchards (28- 126 ha) and gene conservation stands (22- 521 ha) (Koziol 2007).

Some of the Parks are also included in the East Carpathian Biosphere reserve, an area of trilateral Polish - Slovak - Ukrainian co-operation for nature conservation and sustainable development. The Polish areas included in the Biosphere Reserve are 53,4% of total area; they are (UNESCO: http://www.unesco.org/mab/ecbr/u_mab/general.htm:

- Bieszczadzki Park Narodowy (Bieszczady National Park), 29,200.48 ha
- Park Krajobrazowy Doliny Sanu (San River Valley Landscape Park), 33,480.24 ha

- Ciniañsko-Wetliñski Park Krajobrazowy (Cisna-Wetlina Landscape Park), 51,165.69 ha

3.10 SOCIAL FUNCTION

In order to increase ecological awareness in society, particularly among children and the young, and to shape their sensitivity to the surrounding nature, each forest unit in the State Forests organized educational units, responsible for the forest and environmental education. Benefiting from the funds of State Forests, as well as from external sources of funding, a proper infrastructure was developed for the above goals.

Facility	**Number**
Educational trails	76
Environmental education centers	4
Nature/forest exhibition rooms	13
Open-air teaching sites	25
Education points	18
Total:	**136**

Tab. 7: Educational infrastructure of State Forests in the Carpathians (Koziol 2007)

In the area administered by 3 Regional Directorates of State Forests, according to the proper Orders of General Director of State Forests, 3 Promotional Forest Complexes were called into being:
Promotional Forest Complex “Lasy Birczańskie”: 29 636 ha;
Promotional Forest Complex “Lasy Beskidu Śląskiego”: 39 849 ha;
Promotional Forest Complex “Lasy Beskidu Sądeckiego”: 19 650 ha.

The setting-up of the Promotional Forest Complexes in the State Forests was a practical element in pursuit of the National Policy on Forests. In the educational centres of the Promotional Forest Complexes the public is familiarized with the pro-ecological and multifunctional forest management carried out by the foresters. Equally important goals are the shaping of an ecological awareness and the positive attitude to foresters and forestry, as well as the development of many-sided cooperation with nature conservation organizations and environmental associations. The Promotional Forest Complexes can also be regarded as areas of particular scientific and research significance. The Promotional Forest Complexes are moreover an alternative to the crowded National Parks, which plays an important role in case of the Carpathians. Thanks to the promotion of forests and their opening up to public needs, the State Forests National Forest Holding offers not only the possibility of becoming acquainted with ecological forest management principles, but also direct contact with nature, free of many restrictions concerning access and free movement in forests, which is highly significant for educating the young (Koziol 2007).

3.11 REFERENCES

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3.12 ANNEX 1: Complete list of protected areas in the Polish Carpathians

National Parks in the Polish Carpathian area

Title[1]	*Area (ha)*	Virgin forest Area (ha)	*Type of forest (EEA category code)*[2]
National Parks and Biosphere Reserves			
Babiogorski NP/BR	11 829 –RB 3 390.54 -BNP	702,49	-
Bieszczadzki NP	29 200.96	3 423,15	51, 5.2, 5.3, 7.5
Gorczanski NP	7 030	4 000	3.2, 7.5
Magurski NP	19 439	12 101	5.1, 5.2, 5.3, 7.5
Pieninski NP	2 346,16		3.2, 5.1., 5.2, 7.5
Tatrzanski NP	21 164	7 757	3.1, 3.2, 5.1, 5.2, 5.3
Other protected areas			
RLP number 6	107 598		5.1, 5.2, 7.5
“Góry Słonne” RLP	51 392	6579,86	51., 5.2, 5.3, 7.5
“Pogórze Przemyskie” RLP	61 862	8978,82	6.5, 7.5
“Przemysko-Dynowski” Area at Protected Landscape	48 921	1697,39	6.5, 7.5
NATURA2000 “Pogórze Przemyskie”	15 434,44	8951,72	6.5, 7.5, 5.3
”Polanki” NR	184,23	-	7.5
Wschodniobeskidzki RLP	259 234	-	7.5, 6.5
Czarnorzecki RLP	3 837	-	-
„ Igiełki ” NR	27.88		-
„ Łysa Góra” NR	159.53		-
„ Modrzyna “ NR	17.84		-

Title[1]	*Area (ha)*	Virgin forest Area (ha)	*Type of forest (EEA category code)*[2]
National Parks and Biosphere Reserves			
„ Tysiąclecia na Cergowej Górze" NR	61.67		
„ Wadernik " NR	10.72		
„ Kretowki " NR	95.97		
„ Prządki " NR	13,62		
„ Golesz " NR	27.45		
„ Liwocz " NR	84.23		
"Czarnorzecko – Strzyżowski" Landscape Park	25 784		
Special Protection Area -birds	4 917,82		
„Zwięzło" NR	1,89	1,89	7.5
„Źródliska Jasiołki"NR	312,78	312,78	7.5
„Przełom Osławy pod Duszatynem" NR	321,95	321,95	5.3
Jaśliski Landscape Park	25 288	-	6.5, 7.5
Cisniańsko-Wetliński Lanscape Park	51 014	-	6.5, 7.5
Beskid Niski Area at Protected Landscape	2 548	-	6.5, 7.5, 5.3
Special Protection Area „Bieszczady" PLC 180001	11 672	-	6.5, 7.5, 5.3
Special Area at Conservation „Beskid Niski" PLB 1800002	-	-	6.5, 7.5
" Skarpa Jaksmanicka" NR	0,90	-	6.5
"Przełom Hołubli" NR	46,42	-	6.5
"Leoncina" NR	8,67	-	6.5
„Sobień" NR	5,28		-
„Dyrbek" NR	130,88	120,0	-
„Nad Jeziorem Myczkowieckim" NR	164,17	130,0	-
„Przełom Sanu pod Grodziskiem" NR	100,24	95,0	-
„Grąd w Średniej Wsi" NR	58,19	55,0	-
„Przełom Osławy pod Wysoczanami" NR	129,94	100,0	-
"Dolina Sanu" Landscape Park	14 853 ha		7.5
"Hulskie" NR	190 ha		7.5
"Krywe" NR	511 ha		7.5
"Śnieżyca Wiosenna" NR	5 ha		7.5
Protective zone-eagles	136 ha		7.5
Protective zone-black stork	83 ha		6.3, 7.5
Protective zone – Esculap's snake	743 ha		7.5, 6.3
„Bukowica"NR	292,92		7.5
„Źródliska Jasiołki" NR	1 255,8		7.5
„Kamień nad Jaśliskami" NR	302,32		7.5
„Przełom Jasiołki" NR	121,32		7.5
"Herby" NR	145,85	-	-
"Góra Chełm" NR	155,26	-	-

Title[1]	*Area (ha)*	Virgin forest Area (ha)	*Type of forest (EEA category code)*[2]
National Parks and Biosphere Reserves			
"Wielki Las" NR	88,34	-	-
"Mójka" NR	288,80	-	-
"Wilcze" NR	340,86	-	6.5, 5.3
„Zakole" NR	5,25		-
Landscape Park of the Beskid Śląski	38 620		-
Landscape Park of the Beskid Mały	25 770		-
"Stok Szyndzielni" NR	57,07		-
"Jaworzyna" NR	40,03		-
" Madohora" NR	37,51	37,51	3.2, 7.5
" Zasolnica" NR	16,93	16,93	7.5
Żywiecki Landscape Park	35 870 ha		-
"Śrubita" NR	25,86	25,86	-
"Oszast" NR	47,31	47,31	-
"Muńcół" NR	45,20		7.5
"Dziobaki" NR	13,06		7.5
"Butorza"	30,08		3.2
"Barania Góra" NR	374,91	Semi-natural	3.2, 7.5
"Kopce" NR "Zadni Gaj" NR "Skarpa Wiślicka" NR "Czantoria" NR "Lasek Miejski nad Olzą" NR	14,76 5,77 24,17 97,71 3,23	14,76 2,0 24,17 88,04 3,23	7.5, 5.1, 5.2
Nature and Landscape Complex „Dolina Wapienica"	1 511		-
Nature and Landscape Complex „Cygański Las"	925		-
Protection Zone of the Babiogórski National Park	372		5.3, 6.5, 7.5

[1]BR = Biosphere Reserve, NP = National Park, NR = Natural Reserves, RLR = Regional Landscape Reserve.

[2]EEA forest types codes: 3.1: Subalpine larch-arolla pine and dwarf pine forest, 3.2: Subalpine and montane spruce and montane mixed spruce-silver fir forest, 5.1: Pedunculate oak-hornbeam forest, 5.2: Sessile oak-hornbeam forest, 5.3 Ashwood and oak-ash forest , 6.5: Carpathian submontane beech forest, 7.5: Carpathian montane beech forest.

Protected areas planned for the next future:
- „Ostoja Gorczańska"- Nature 2000 area
- Beech Forest Obnoga NR 354,39 ha
- Wołosate Watershed NR 144,92 ha
- NR Lipowska
- NR Dziobaki II
- NR „Sołowy Wierch"

4 ROMANIA

4.1 INTRODUCTION

Romania is situated in the south-eastern part of Central Europe at its contact with Eastern Europe and Balkan Europe, inside and outside of the Carpathian mountains. Within the present day boundaries, established after the last two world wars, Romania has an area of 23.84 M ha that ranks it as a medium sized European country. It borders Bulgaria on the south, Serbia on the south-west, Hungary on the west, Ukraine on the north, the north-east and the southern part of the east, Moldavia on the east, and the Black Sea on the south-east (FAO: http://www.icpa.ro/fao_glwi/#landr). The Carpathian mountains represent most of the Romanian land area (fig. 4.1)

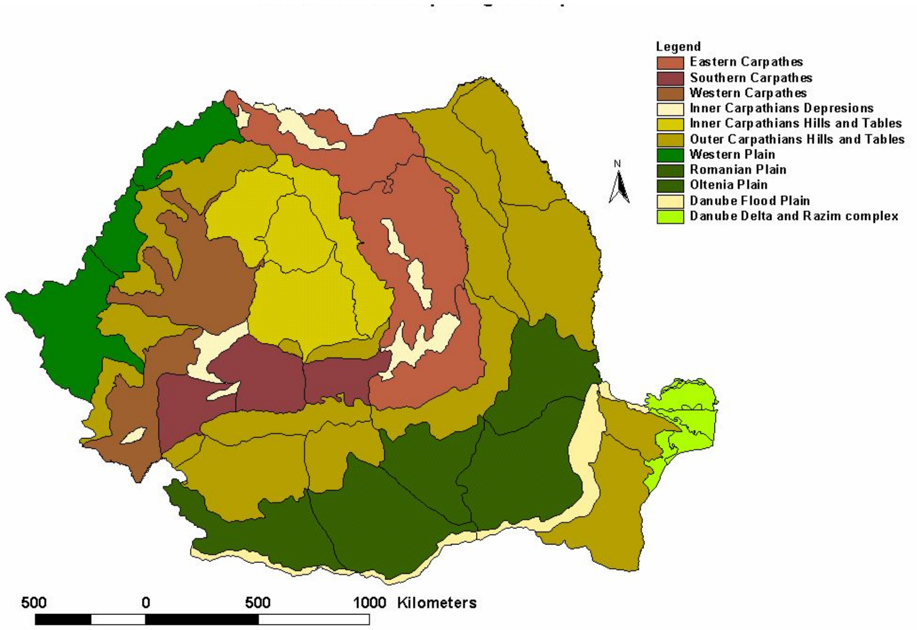

Fig. 4.1: Geomorphological map of Romania (FAO: http://www.icpa.ro/fao_glwi/romp212.htm)

The Romanian economy is still in a stage of transition from the socialist centralised system based on state and collective property to a free-market one based on private property. Agriculture and forestry are among the main economic branches.

In the past the Romanian natural forests had a surface of about 18 M ha. This covered not only Carpathian mountains but also hills and lower plains. About 79% of the Romanian territory was covered by forests. This forest landscape was documented over the centuries. Influences of agriculture and later industry and local settlements had an impact on the forests. At the end of the 19th century, the percentage of afforestation decreased from 79 to 40%. Later to 28% in 1948 and at present only 26.86% (6.43 M ha) remains. 51.9% of the forests are found in the mountains, 35.2% in the hilly regions and 12.9% on the plains.

Forest composition is varied. Conifers make up about 30%, beech (pure and mixed stands) 30%, oak species 19%, various hard broad-leaves 14% and soft broad-leaves 6%. A 'natural forest' composition model is the main goal of present-day management plans (Borlea 1997).

From 1960-1985 inappropriate native and introduced coniferous species were planted, resulting in ecological problems in artificial forest stands and low wood quality. The average growing stock is 217 m³ ha^{-1}. In 1995 there was 0.27 ha forest area per capita. On average the total volume of harvested wood was 24-27 million m³ per year for 1951-1976. In 1987 the average growing stock was 22 M m³, it was 14 M m³ in 1996 and the maximum volume of wood to be harvested for 1997, as approved by Parliament, was 14.8 M m³ (Borlea 1997).

4.2 FOREST AREA AND FOREST AREA CHANGE

In the Carpathian region, forested areas comprising mainly broad-leaved forests, coniferous forests, mixed forests and other forest vegetation such as moors and heathland and transitional woodland-scrub, cover a total of 4.6 M ha: the forest area of the Carpathians represents 71.54% of the total forest cover of Romania. Forest area per capita is estimated to be about 1.5 ha, which is twice the national average (0.3 ha).

The forest area in the Carpathian region presents a slight increasing trend. The causes are mainly: the bandonment of land that in the past were used for mountain pasture grazing; natural regeneration on private forests after clear cuttings; the changing of forest definition: meadows covered by trees were recently declared forests if tree density is higher than 40%.

SUCEAVA COUNTY: A CASE STUDY

This report aims to give an overview of the state of the Carpathian forests area in Romania. Most of the times specific information on the Carpathian area is not available, so in many cases we report information on whole Romanian forests, as a proxy. The main problem of those data is that often they refer to old sources (the last national forest inventory, made in 1984, or even older data).

Concerning the Carpathian area, we had the use of an updated database, regarding the county of Suceava (Bucovina historical province) (Data provided by Ionel Popa, ICAS – Suceava, 2007). This region is situated in the north-eastern part of the Romanian Carpathians (fig. 4.2), and lies entirely on the Carpathians. We chose it as a case study of the Carpathian forests in Romania.

The database was set up between the year 2002 and 2005. it includes approximately over 90% of the Suceava forests and comprises the databases of the management plans for the forests administrated by the National Forest Service in the 26 forest district of Suceava county. Most of them are public forests, but also some private forests are also included (which are administrated by the National Forest Service).

Fig. 4.2: Surface of the forest area on historical provinces (1998) SILV 1 Statistical Report, 1998 (Marin and al. 2004)

From the database, we analysed a total forest surface of about 400 000 ha, which is around 7% of the total forest area of the Romanian Carpathians.

Suceava county is the most forested region in Romania, as we can see from the figure below (Marin and al. 2004)

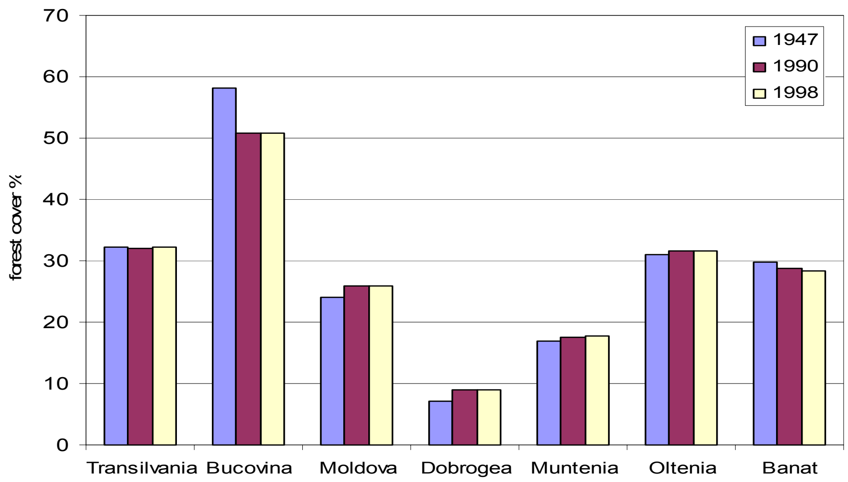

Fig. 4.3: Share of forests in the total surface on historical provinces (%) (Marin and al. 2004)

4.3 FOREST FUNCTIONS

According to the Forestry Law, forests in Romania should be divided in two functional groups depending on their functions:

- 1st group: 53,3% (Biris and Veen 2001) that includes forests with special function for water, soil, climate and national objectives protection, recreation forests, those for the protection of the gene fund, as well as the forests declared as nature monuments;

- 2nd group: 46,7% (Biris and Veen 2001) that consists of forests with production and protection forests where the main purpose is the production of high quality wood and other forest products and at the same time the protection of environment quality.

This distribution system was very important for maintaining the ecological balance of forest ecosystems. Therefore, the Decision of the Council of Ministers no. 14/1954 made official "The criteria for zoning and functional forest management", which have been applied in forest management planning and forest management (Marin and al. 2004).

The functional zoning system has been continuously developed since 1954, becoming increasingly analytical. Thus, the number of functional categories increased from 26 to 58. In the same time the concept of "functional type" was introduced; it groups together those functional categories which need similar structures of stands and, therefore, relatively similar management measures. Six functional types have been established (the first four for forests with special protection functions and the last two for the group of forests with production and protection functions) (Marin and al. 2004).

Before 1990, the percentage of forests in group 1 increased constantly. Unfortunately, during the privatisation process of 2 M ha over the last 13 years it appears that the functional approach was not working properly. The neglect of protection functions resulted in a deterioration of 75% of the forests with a protection role. The consequences of this deterioration have led to a stronger impact of floods, storms and land slides (Biris and Veen 2001).

4.4 FOREST STAND COMPOSITION

In the absence of detailed data specific for the Carpathian region, we report some figures on forests in Romania, which can as well give an idea of the general trend on the Carpathian area.

Actual forests in Romania not only cover a surface that is much more limited than the original one, but they are also very different in their structure and composition, because of human activities in forests, which altered them to obtain forests that were more productive and easy to manage: in many cases, for example, even aged pure spruce woodlands were planted, instead of the original uneven aged mixed beech forests.

Figure 4.4 reports the distribution of forest area on phytoclimatic layers.

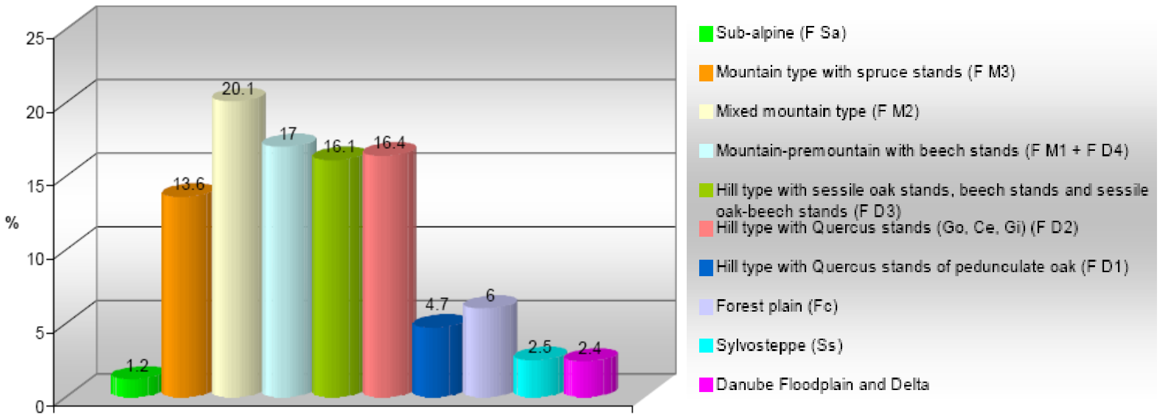

Fig. 4.4: Distribution of the forest surface on phytoclimatic layers. Source: Forest Area Inventory, 1974 (Marin and al. 2004)

The specie composition had an upward evolution over time, especially during the period 1960 and 1975, resulting from the process of conifer planting that had the purpose of increasing the quantity of cellulose wood. Special conifer crops have therefore been then established in the distribution range of the beech and even of *Quercus* species (fig. 4.5).

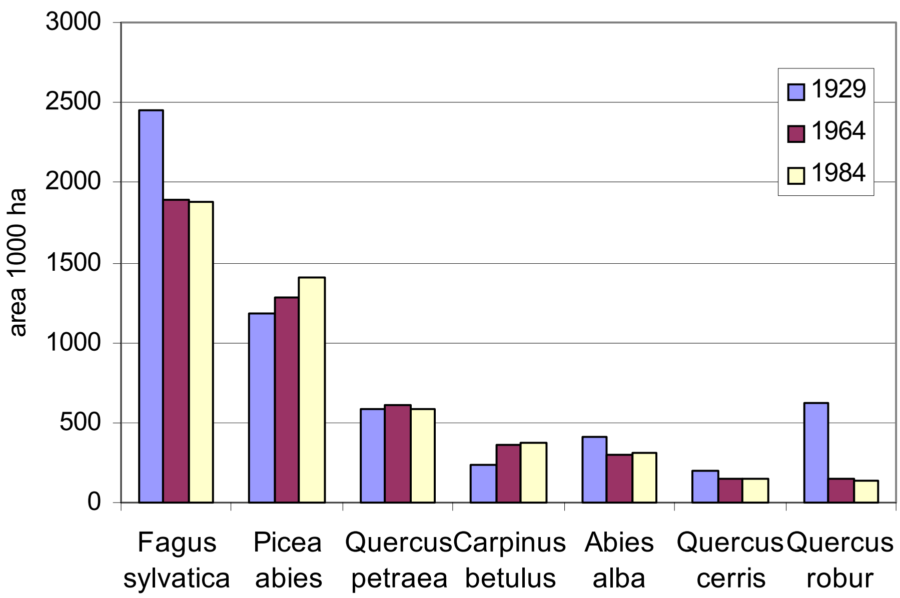

Fig. 4.5: The surface covered by the main forest species in Romania
(Source: Forestry Agenda, 1941, Forest Area Inventory, 1964 and 1985) (Marin and al. 2004)

<u>SUCEAVA COUNTY: A CASE STUDY</u>

According to the survey done in between 2002 and 2005 in Suceava county, spruce is the most frequent among the forest species, followed by beech and silver fir (fig. 4.6).

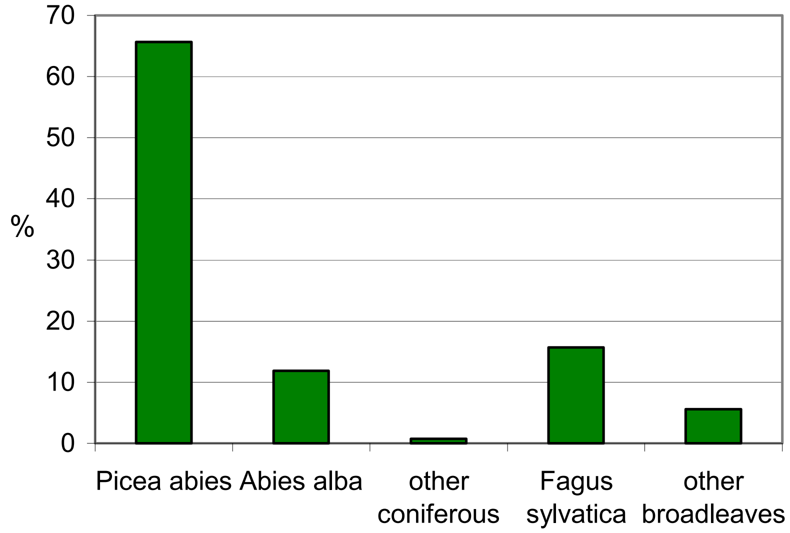

Fig.4. 6: Tree species composition in Suceava county (data provided by ICAS - Suceava, 2007)

This is a typical situation in the northern part of East Carpathians, where more than 70% of natural and artificial spruce stands are located, from 600 to 1700 m a.s.l.. Most of the pre-subalpine and timberline forests are classed as protection forests in which managed cuts are prohibited and only salvage cuts after wind and snow damage are permitted (Barbu and Cenusa 2001).

4.5 FOREST STRUCTURE

From the latest forest inventory (1984), it was proved that in Romanian forests there is a high percentage (41,8%) of young tree stands (1-40 years), a low percentage (15,4%) of so called exploitable stands (over 100 years) and a very low percentage of so called pre-exploitable stands (41-100 years) (Marin and al. 2004).

The exploitable forest stands are reduced because many forests are very old and have a protection role or are included in protected areas. The deficit of exploitable and pre-exploitable tree stands has been caused by the mass exploitation in the past. This situation will put a pressure on the virgin forests in the future (Biris and Veen 2001).

The table 4.1 reports the division of age class categories in Romanian forests:

Age class categories	Tree age
I	1 – 20
II	21 – 40
III	41 – 60
IV	61 – 80
V	81 – 100
VI	> 100

Tab. 4.1: Age classes in Romanian forests

Age class distribution in Romanian forests (Marin and al. 2004):

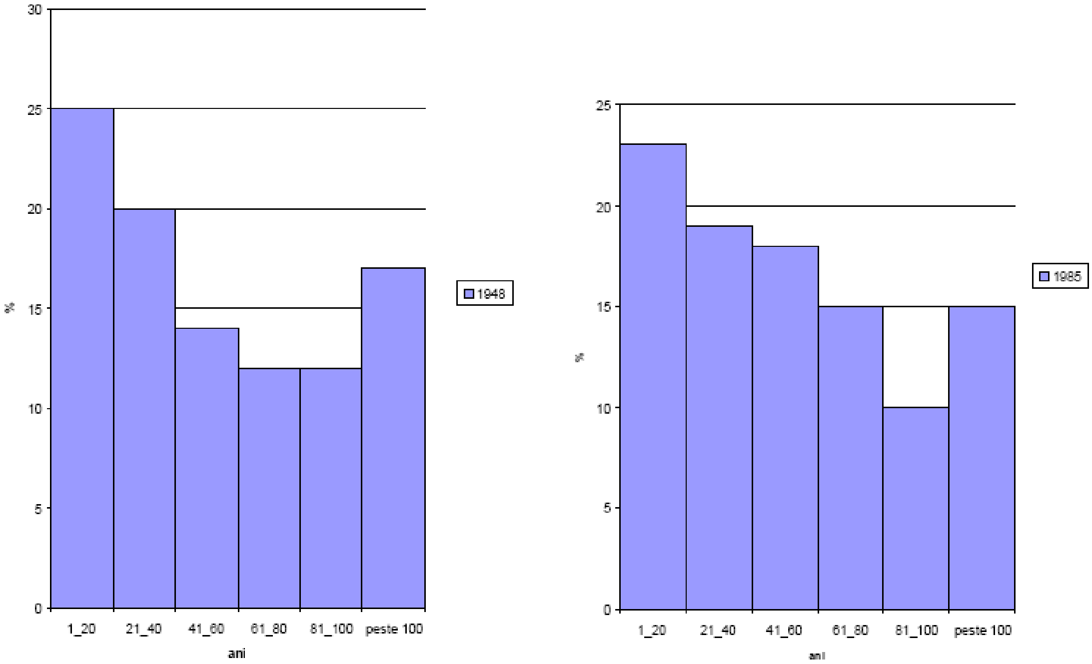

Fig. 4.7: Forest structure by age classes in 1948 and 1985 Source: Forest Area Statistics, 1948 Forest Area Inventory, 1985 (Marin and al. 2004)

SUCEAVA COUNTY: A CASE STUDY

The age class distribution in the Suceava county's forests is almost even-aged in the complex, with a slightly higher percentage of middle-aged classes and lower V and VI.

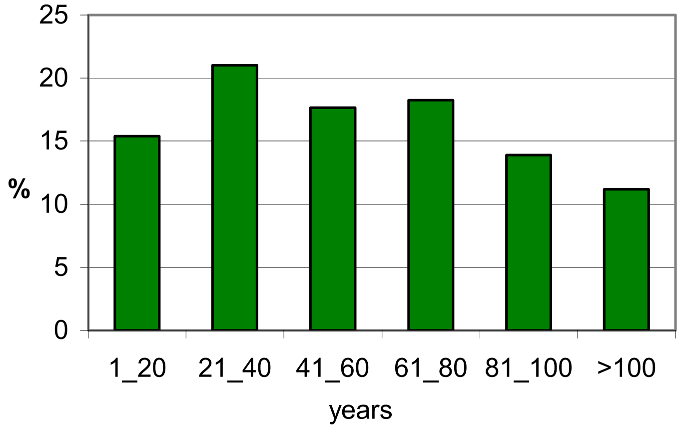

Fig. 4.8: Forest structure by age classes in Suceava county (Source: data provided by ICAS 2007)

This is also reflected also by the age structure of spruce stands (fig. 4.9),

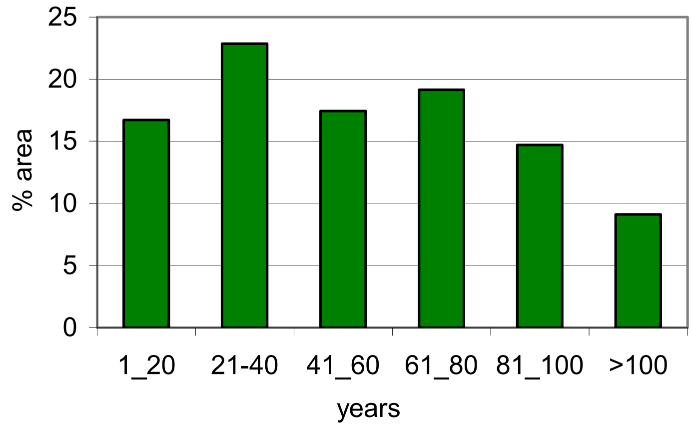

Fig. 4.9: Age class distribution of spruce in Suceava county (Source: data provided by ICAS 2007)

Silver fir shows an age class distribution with a higher percentage of older age classes (>60 years).

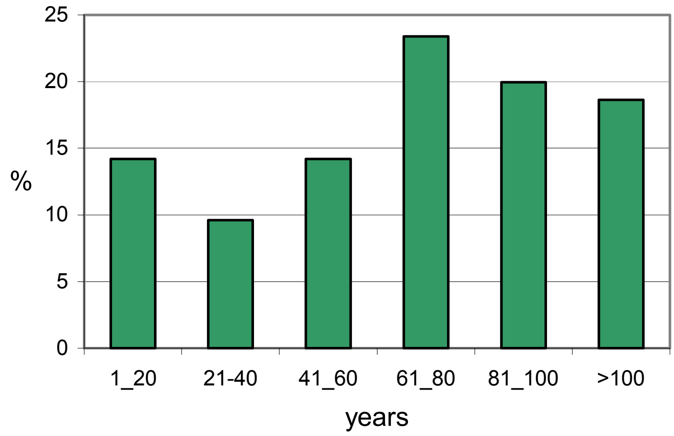

Fig. 4.10: Age class distribution of silver fir in Suceava county (Source: data provided by ICAS 2007)

Finally, the beech age class distribution is poorer in young tree stands and there are more older trees than in the other species (fig. 4.11).

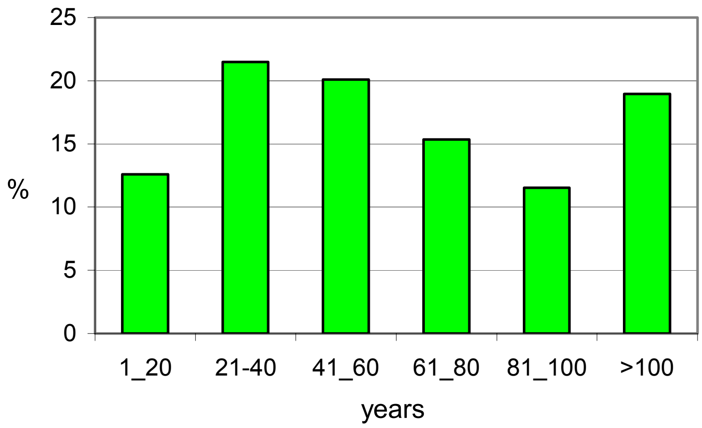

Fig. 4.11: Age class distribution of beech in Suceava county (Source: data provided by ICAS 2007)

The diameters distribution clearly shows the structure of the forests, which is the result of forest management that furthered mono-specific and mono-layered forests, more favourable for timber production.

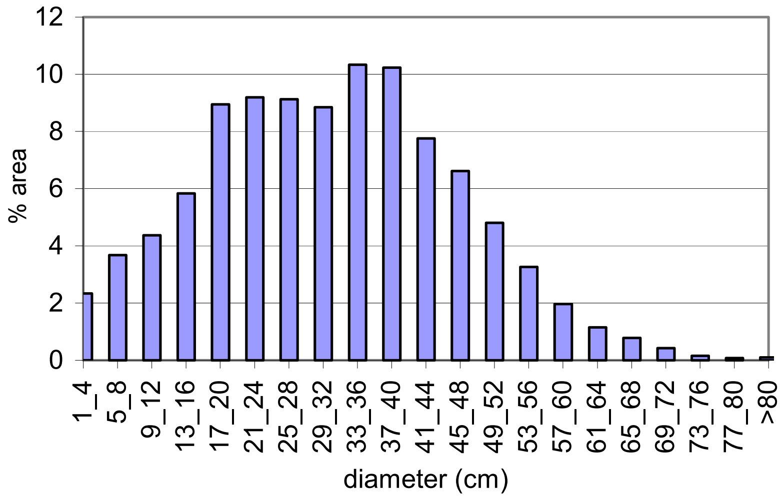

Fig. 4.12: Forest structure by diameter distribution in Suceava district (Source: data provided by ICAS 2007)

4.6 FOREST MANAGEMENT AND MONITORING

FOREST DISTRICTS AND MANAGEMENT PLANS

The Forest Code stipulates the main characteristics of Romanian forest management: functional repartition by forest zones, maintenance of natural composition in forests, utilization of natural regeneration, maintenance of a high-level rotation age for native forest species, utilization of adequate treatments to maintain the ecological balance, evolution towards multi-use forests (Brandlmaier and Hirschberger 2005).

The management units directly dealing with forest management are Forest Districts. They implement the forest policy and norms according to management plans, undertaking specific management tasks as follows (Brandlmaier and Hirschberger 2005):

- ensuring forest regeneration
- preventing and stopping illegal activities
- supervising and controlling the wood harvesting and transportation activities
- establishing and implementing operation plans mentioned in the forest management plans
- monitoring forest health
- game management, harvesting non timber forest products
- marking trees to be extracted during the harvesting process, with a numbered hummer-marker, both for state forests and private owned forests.

The management plans are developed in accordance with sustainable forest management criteria, and are revised every 10 years; these plans form the basis for all forest management activities, including annual cutting allowance (per surface unit and species). The annual allowable cut at country level is being established by cumulating the allowable cut for each forest district of the national forest area (state owned forest and private forest), based on data from the information system for Romanian forests, provided through the management plans developed for all forest districts. The allowable cut for each administrative unit is calculated using a method which is based on the data of management plans. The current method used to determine the allowable cut is based on a traditional sustained yield approach: it takes into account rotation length, average species composition, forest structure according to site indices and the existing distribution of age classes. Rotation lengths are calculated according to the maximum rent principle, and have been set according to the average increment of the target dimensional class, reflecting a very conservative policy. The conservative approach in calculating the allowable cut in Romania was a “political method”, used by the forest administration to react to the wood industry pressure and limit the cuttings during the last part of the communist period. This method is still in place, not adapted to present realities. The calculation of the allowable cut does not take into account the wood coming from other wooded areas (forested pastures such as areas used by villages as pastures, but covered with forests, or former pastures abandoned and afforested naturally, which are not included in the national forest fund; abandoned state or private agricultural land afforested naturally). The allowable cut at national level is distributed by the MAFRD to NFA-Romsilva for the State Forest and to its territorial branches (TDFRH) for private forests. NFA–Romsilva and TDFRH distribute the allowable cut to each forest district, according to the provisions in the management plans and to past and current situation of harvesting in the area (e.g. in case of unforeseen events - like wind falls – changes might occur in the distribution of allowable cut) (Brandlmaier and Hirschberger 2005).

NATURAL REGENERATION OF FORESTS

In the last 50 years, specially after the socialization of forests (1948), on the grounds of forest management plans, based on the age-class system, the majority of Carpathian forests were made accessible and extensively cut. In 1950-1980, most clear-cut areas were artificially regenerated through plantations and artificial seedlings. Most of the old mixed forests were replanted with spruce plants and are very unstable to wind and snow. After 1980, as a result of the reduction in clear-cut areas (less than 5 ha), natural regeneration is more representative in our forests (Barbu and Cenusa 2001). Natural regeneration of forests is a priority. It is applied over more than 70% of the forest surface area.

In particular, the management of natural regeneration of Norway spruce stands (naturally or artificially regenerated) represents one of the great challenges for today's silviculture in Romania, but also in Europe. Norway spruce regenerates easily, but the most difficult problem is to conduct the regeneration process with the objective of ensuring a new organization (spatial and temporal) of forests and to reach high stability against snow, wind and game (red deer) damage (Barbu and Cenusa 2001).

INCREASING OF FOREST SURFACE

Forest regeneration is one of the objectives of the National Forest Administration/Romislva. The increasing of the forest surface is achieved through reforestation and afforestation.

The reforestation activities regard all wooded surfaces on which the wood was harvested as a result of the felling of the main products. Every year the regeneration work of the National Forest Administration/Romsilva covers an area of over 18 200 ha in the state forest fund it administers. Afforestation concerns land with no forest vegetation, which has no other uses assigned through the management plan, such as the ecological reconstruction of degraded lands administered by the National Forest Administration/Romsilva, as well as of lands outside the forest fund. However, afforestation is more focused on geographical regions other than the Carpathian region, such as the Lower Danube Floodplain or the Romanian Plain.

The conclusion is that, in the Carpathian region, the focus is on reforestation activities, which are carried out on land belonging to the state on which the wood has been harvested. Non-forest valuable habitats (such as pastures or meadows) are not taken explicitly into account, but there is no priority for their afforestation because there is a lot of work still to do for the reforestation of the cut forests. In any case, a natural invasion of forests on the biodiversity-rich pastures occurs because of land abandonment (EURAC 2006).

FOREST MONITORING AND STATE OF THE NFI

An inventory of the forest area is important for forest management and is a significant part of any strategy that will address illegal logging. Forest management plans are the basis in establishing the regional and national inventory of forested areas and wood harvested volumes (Brandlmaier and Hirschberger 2005). The last national inventory was performed in 1984. It is a stand inventory, made with the occasion of the management planning measurements for the exploitable forests, i.e. those forests that should be cut in coming 10 years (CarboInvent JRC: http://afoludata.jrc.it/carboinvent/cimd_eufoin_data.cfm#countrylist).

At the moment the new NFI is in progress, and the conclusion is set for the year 2011. It is a sample inventory which has a sampling design based on square clusters of sample plots 4 km apart, every cluster is constituted by 4 plots 250 m apart.

The conditions to include a surface in forest definition are the following:

- the surface delimited by the forest vegetation must be over 0.5 ha;
- the density index of forest vegetation (the are cover by trees) must be over 10%
- the width of area over 20 m
- the minimum height at maturity of wood vegetation over 5 m.

4.7 FOREST CONDITION

Carpathian forests are less altered by human impact than the central European forests or those from the Alps: the majority of forests located up to 700-800 m a.s.l., were still primeval forests at the end of the 19th century. In the large belt of forests in the Carpathians, only the lower and the upper part (timberline and subalpine forests) were more altered by agriculture and sheep hurdling. For some regions of the Carpathians, like Bucovina and the Transylvania's Alps, where the transport of wood and forests products were favoured by rafting, the alteration of structure and composition is more evident (Barbu and Cenusa 2001).

Forest vegetation is affected by the damaging action of biotic and abiotic factors. In nature, these factors act alone or together, thus increasing the negative ecological impact. It is very important for forest health that the prognosis and assessment of the damaging factors threat level is made at the beginning of their reproduction, i.e. during the first phase, in order to stop the degradation evolving (Marin and al. 2004).

WIND DAMAGES

During the last decades, wind felling affected around 200 000 ha of forests per year on average; most of the disasters have been recorded in the conifer area (especially spruce). In broadleaved areas, wind and snow felling occurred on much smaller areas, especially in beech stands. The most serious wind fellings in conifer and mixed (beech with conifer) stands in Romania were recorded over the period 1964-1976, when the total volume accounted for about 25 M m^3. The worst affected stands were those in the northern part of the Eastern Carpathians – Suceava, Neamt, Bistrita Nasaud, Mures, Harghita counties. Of these wind fellings, the most serious ones were those on 23-26 November 1964, and on 10-14 July 1969, with volumes of 8.9 and 7.0 M m^3. The wind fellings on 24-25 November 1973 and 21-22 October 1974 affected Bistrita and Moldova areas, felling 3.1 and 1.2 M m^3. The last important wind felling was recorded on the western slope of the Eastern Carpathians in Harghita, Covasna, Mures and Brasov, on 5-6 November 1995. The volume of felled trees has been estimated at 7-8 M m^3 (Marin and al. 2004).

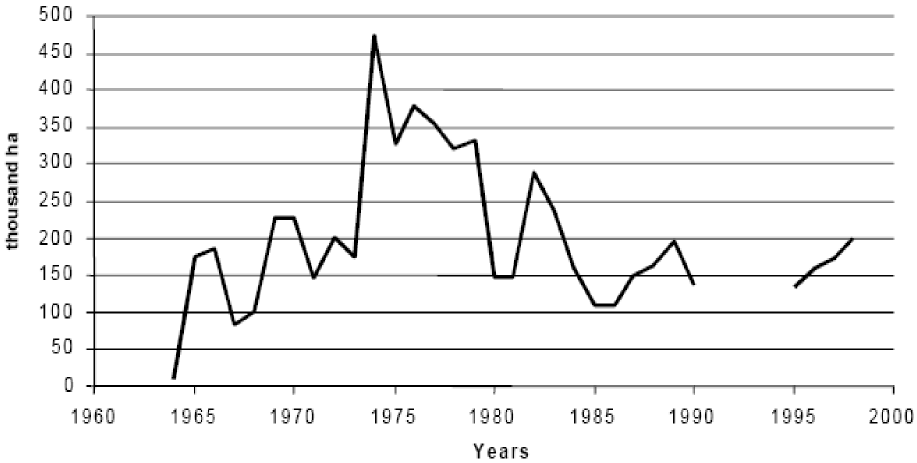

Fig. 4.13: Evolution of the surface affected by wind felling over the period 1964-1998 in Romanian forests Source: ICAS, 1965-1999 (Marin and al. 2004)

As reported by Popa (2007), in the virgin forests windthrow events are a natural process integrated in forest biogeochemical cycles and constitute a form of self thinning process together with other specific processes: on a large scale, windthrow events are not a disturbing factor for ecosystems that have reached the climax, but can be considered as self regulating events. On the contrary, forests in which human activities have altered the relations between the different components of the ecosystems are more vulnerable to windthrow events, with damage greater than self thinning intensity becoming a factor of disturbance with both economic and ecological negative effects through modification of the stand structure and the resulting economic losses.

Besides catastrophic wind-induced events, endemic windthrow events, with much reduced intensity and economic effects, constitute the main disturbance factor for mountainous forest ecosystems with long-term consequences on the economy and on ecology. The reduction of the impact depends largely upon the management of the forest resources and the forest economy decision systems.

Popa's analysis (2007) is a very detailed study on wind damages in Romania and in particular in the Suceava district, differentiating between catastrophic and endemic events. He drew up a chronology of catastrophic events since 1900, comparing the European and Romanian situation, and making an evaluation of the risk in forestry, identifying the zones of potential risk, elaborating a statistical model of tree and stand stability to wind action and implementing risk mapping systems.

Applying the stochastic modelling and simulation techniques to predict the number of windthrows within a period and the time interval between two consecutive wind damage events, at European and national level, some of the results show that:

- the likelihood of *not having* windthrow within a ten year period in very low: 5.7% for the European level and 8.9% for Romania;
- the likelihood of *having* one windthrow within a ten year period is 21.6% at Romanian level and 16.4% at European level;
- the most likely *time interval* between two subsequent windthrows is 1 year with a likelihood of 19% at Romanian level and 21.5% at European level;
- the informational characteristics, respectively the information energy and entropy of the system, have an aleatory dynamics in the case of simulation with constant number of events, and progressively diminishing with the augmentation of simulation size, in the case of simulation with a variable number of events (Popa 2001)

Applying modern analysis techniques to the seasonality of windthrow, respectively the autocorrelation function, partial autocorrelation function and spectral analysis, we have found that the dynamics of wind damage at European level shows a seasonality with a return period of 3-4 and 9 years for an damaged volume over 1 M m^3, respectively 3 and 15 years for the windthrow more 20 M m^3. At national level the return period of strong wind damage is 3-4 years, and 56 years (Popa 2007a).

In the management plans the forecast of windblown volume are set equal to zero, and this does not conform to either field or silvicultural practices. In fact, the dynamics of the harvests in Suceava's forest direction over a 20 year period shows that windblown wood represents a significant proportion of harvested wood volume: the dynamic of the annual volume harvested from windthrow per hectare ranges between 3 and 48 $m^3ha^{-1}year^{-1}$, depending in the surface on which accidental fellings were done. The calculated average index of accidental produced harvests vary between 0.4 and 1.8 $m^3ha^{-1}year^{-1}$, with an average of 1.0 $m^3ha^{-1}year^{-1}$ which represents a lot if compared to the total forested area of the Suceava county (410 000 ha). The most affected zone is the coniferous area, with an accidental production of 0.5 – 2.1 $m^3ha^{-1}year^{-1}$ and an average of 1.14 $m^3ha^{-1}year^{-1}$. Forest districts in the western and north-western areas of Suceava's forest directorate show a high risk with an average rate of windthrow above 1.0 $m^3ha^{-1}year^{-1}$, which represents around 25% of the current annual growth.

After a statistical modelling of tree and stand stability at wind action, Popa (2007) concluded that:

- in stand composed exclusively or mainly of spruce, risk is driven by age, the consistency having a minor role,

- for mixed stands (60% to 80% represented by spruce), a zone of high risk is identified for stand with degraded consistency regardless of age, and another pole vulnerable with stands over 120 years,
- a similar situation can be observed for stands in which spruce represents less than 60% of the composition, when the consistency is reduced.

Taking into account the financial difficulties involved in thinning, along with the very low demand for small-size wood on the local marketplace, it appears that a precise as possible identification is required of the stands for particular measures of consolidation (more intensive selective thinning). These measures demand a high financial effort. This is why a system of windthrow risk mapping for zones of homogeneous high air streams, with general vegetation conditions, etc., is an urgent requisite for the management of mountain forests (Popa 2007a). In the spirit of these modern ideas the Author elaborated and implemented two different windthrow risk map, which could be important in the management of risk in forest administration: the integration of risk management at the level of forest sector in the management plans constitutes a necessity for the management of the mountain forestry in the Carpathian area.

FOREST FIRES

Over the period 1965-1998, 3007 forest fires were recorded (88 fires per year) in Romanian forests. The forest surface affected was 9 390 ha (276.2 ha per year). In relation to the total surface of the forest territory in Romania, the total burnt area in those 34 years, represents 0.15%. This situation proves that the Romanian forests, by their nature, composition and structure have been slightly damaged by fires. The forest fires occurred mainly in the years with early springs and characterized by extreme dryness. Most forest fires in Romania are litter ones. They occur both in stands (about 62% of the cases), and in young plantations. In 1999 and 2000, the forest fires extended unexpectedly, due to severe and long droughts (Marin and al. 2004).

AIR POLLUTION

One of the problems for natural ecosystems in Eastern and Central Europe is air pollution due to industrial emissions. High levels of nitrogen (N) and sulphur (S) deposition and increasing concentrations of ozone (O_3) may have undesirable effects on forest ecosystems in parts of the Carpathian Mountains of Central Europe (Bytnerowicz et al. 2004).

In Romania, research on pollutant deposition monitoring in forest ecosystems started in 1996 in three forest ecosystems (Solca, Rarau, Deia) and have been expanded in 1997 to the centre and south of the country in Fundata, Stefanesti and Mihaiesti forest ecosystems. All the considered forest ecosystems are located in the Carpathians, a part from Stefanesti, which is situated in the Southern part of the country. They are included in the permanent intensive monitoring network for the main forest ecosystems in Romania (second monitoring level). In order to collect rainfall in open air and under the stand canopy special capture devices have been used and the compulsory parameters, included in the ICP Forest Handbook, have been analysed in the laboratory: pH, conductivity, alkalinity and ion SO4-, NO3-, Cl-, NH4+, Na+, Ca^{2+}, Mg2+. The estimation of the annual or cyclic flow of mineral ions in the atmosphere is based on the quantitative estimation of the rainfalls and their chemical composition.

The high variability of rainfall amount and quality leads to a cyclic and annual variability of the mineral ion flow in the atmosphere in the analysed forest ecosystems (Marin and al. 2004).

MONITORING IN THE RETEZAT MOUNTAINS

Another project for air pollution monitoring is being conducted on the Retezat Mountains. This part of the Carpathians cover about 80 000 ha, and is located in Hunedoara County (Southern Carpathian Mountains). The chain of large valleys and a large depression separate the Retezat Mountains from the main Carpathian range. Parts of the mountains (54 491 ha) are included in a National Park. The Retezat Mountains have also been selected as an international long-term ecosystem research site representing the Carpathian forests. In this project, long-term effects of air pollution and other anthropogenic stresses on forest health and biodiversity have being monitored and investigated by Bytnerowicz *et al*. (2005).

An overall objective was to characterize air pollution distribution and its potential effects on vegetation diversity. Five specific objectives were identified (Bytnerowicz et al. 2003):

- Characterize the spatial and temporal distribution of O_3, SO_2, ammonia (NH_3), and NO_x.
- Evaluate incidence and severity of air pollution injury to vegetation.
- Select native indicators of air pollutants with a special emphasis on O_3.
- Evaluate effects of O_3 and other pollutants on forest health and biodiversity.
- Evaluate effects of various land management practices on mountain ecosystems.

Concentrations of O_3, SO_2, NH_3, NO, and NO_2 were monitored during the growing seasons of 2000–2002 (May through October). The first results of the studies in the Romanian part of the Carpathians shows that in general (Bytnerowicz et al. 2005):

1. The Retezat Mountains experienced good air quality during the three years of this study.
2. Concentrations of O_3, NO_2 and SO_2 in the summer seasons 2000-2002 were low and below toxicity levels for forest trees; while NH_3 concentrations were low in 2000, the 2001 and 2002 concentrations were elevated indicating a possibility of increased N deposition to forest stands.
3. Ambient O_3 showed consistent spatial and temporal characteristics:
   - the western portion of the mountains experienced the lowest levels;
   - in 2000 and 2001 concentrations were similar throughout the season, while in 2002 concentrations after mid-August were very low;
   - seasonal average O_3 concentrations in 2002 were much lower than in the 2000 and 2001 seasons. Ambient O_3 was not related to the crown condition of European beech and Norway spruce.
4. Precipitation, throughout autumn soil solutions were highly acidic in most study sites. More than 90% of the rainfall events were acidic with pH < 5.5, contributing to increased acidity of soils.
5. Crown defoliation of spruce and beech was generally low compared with other European forest locations, however, deterioration of crown condition was observed over time. This was probably caused by drought and highly acidic precipitation.
6. The drought that occurred in the southern Carpathians between autumn 2000 and summer 2002 and frequent acidic rainfalls could cause the observed decline of forest condition.
7. Trees with higher defoliation grew less as indicated by annual growth increments.

These are the first results of the study in the Retezat Mountains. The long-term results of such monitoring efforts will help to better understand the mechanisms of change caused by air pollution and other anthropogenic stresses in forest and other ecosystems. They efforts will also help in the development of proper management practices for these areas.

INSECT PESTS

Damaging insects have infested, over the period 1954-1998, very large surfaces each year, estimated at 0.26 M ha in 1954, 1.74 M ha in 1988 and 1.32 M ha in 1998. Concerning the groups of damaging insect species, the highest share is represented by the defoliating caterpillar, followed by bark and wood attacking insects, defoliating beetles, sucking and galicole, xylophage insects, the insects that attack the root, shoot and the stem of seedlings, seed insects (Marin and al. 2004).

The most important defoliator of oak species is *Lymantria dispar*. The two biggest outbreaks of this insect occurred in 19541956 and 1987-1989. Other important defoliators of oak are *Tortrix viridana* and the Geometridae, which occurred over areas respectively in 1967 and 1989, and in 1962 respectively.

For conifers the defoliator *Lymantria monacha* had a mass reproduction over the period 1955-1957, on 60 000 ha in the spruce stands in the Brosteni-Borsec area, in the northern part of the Eastern Carpathians. As a result of chemical control in 1956-1957, the defoliator outbreak was eliminated. There have been no other mass infestations in Romania up to now (Marin and al. 2004).

The most frequent infestation with Scolitidae was noticed in spruce stands (94-97%, of total infested surface). In fir and pine stands the share of Scolitidae is much less important (2-3%, respectively 1% of infested surface). For spruce, the most important damaging pest is *Ips typographus* (80%), frequently in association with *Ips amitinus* and *Pityogenes chalcographus*, etc, which prefer thinner trunks and tree tops. For fir, the most important species is *Pityokteines curvidens*, often in association with *Cryphalus piceae*, etc., and for pine *Blastophagus piniperda*, Bl. minor, *Ips sexdentatus* and *Ips acuminatus (Marin and al. 2004)*.

INSECT PESTS AFTER WINDTHROW EVENTS: A CASE STUDY IN THE EASTERN CARPATHIANS

Insect pests often affect the forest areas damaged by windthrow events. A windfall of vast proportions occurred on November 5-6, 1995, which severely affected Romanian forest stands in the following counties: Covasna, Harghita, Mures, and Bistrița in the Eastern Carpathians (Simionescu et al. 2001).

Mihalciuc *et al.* (2002) studied the evolution and dynamics of pests attacking both windthrown and standing trees in experimental plots characterized by the presence of a variety of stands and different environmental conditions.

In the majority of circumstances, spruce trees were infested to a high level. The main pests which infested damaged trees were the following: *Ips typographus*, *Pityogenes chalcographus*, *Ips amitinus*, *Polygraphus poligraphus*, *Trypodendron lineatum*, *Hylurgops palliatus*, *Tetropium castaneum*, *Monochamus sutor*, *Urocerus gigas*, *Orthotomicus suturalis*. In the first year after the windthrow (1996), the intensity of insect attack was generally low. Intensive infestations were observed only in areas where bark beetle outbreaks had been recorded in the past. During the next years (1997-2000) the infestation increased significantly, and as a result in 2000 high and very high levels of pest attacks were recorded in all damaged areas (fig. 4.14).

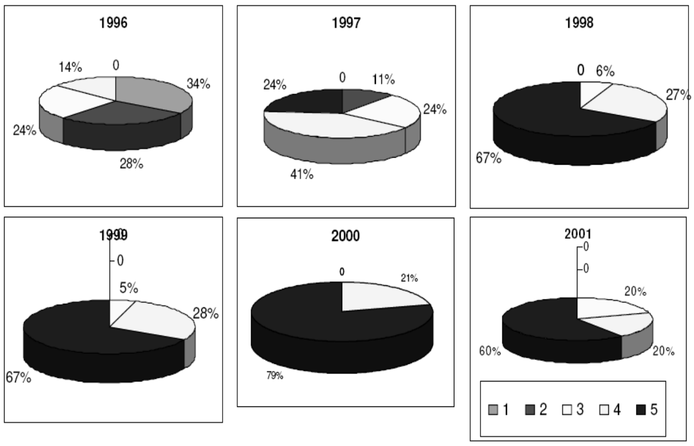

Fig. 4.14: Distribution of the intensity of bark beetle infestation after the November 5, 1995 windthrow (Counties of Covasna, Harghita, Mureş, and Bistri a; 1: very low, 2:low, 3: medium, 4: high, 5: very high) (Mihalciuc et al. 2002)

In all damaged areas, about 40% of trees were windthrown and 60% were broken at the base of trunks. The windthrown trees were still connected with the soil, and continued to vegetate during the next 1-3 years after the windthrow. During this period, the frequency of infestation by pests was 34% in 1996, 61% in 1997, and 5% in 1998. Over 90% of the broken and fallen trees were infested in 1996, and less than 5% in 1997. The period between the occurrence of damage and the time that trees were attacked varied in relation to the type of tree damage – windthrown, broken or cut trees. Cut and pruned trees were infested within 1-2 months, broken at the basal part of stem and fallen trees were infested after 6-7 months, and windthrown trees were infested within 7-18 months after windthrow.

The larger volume of damaged wood material was favourable to the development of higher bark beetle populations; however, in 2000, the number of infested standing trees was reduced significantly as a result of the protection measures which were implemented in the damaged forests during 1996-1999.

FUNGAL DISEASE

Frost, hail and heavy rains can damage beech and make them susceptible to secondary attacks by the bark fungus *Nectria ditissima* (FAO - Forestry Department Food and Agriculture Organization of the United Nations 2007)

ILLEGAL LOGGING

This is certainly the main problem that has the greatest impact on forestry practices in the mountain ecosystem. This impact is well described in the WWF report “Illegal logging in Romania” (Brandlmaier and Hirschberger 2005).

In summary, the most important aspects of illegal logging in Romania are:

- incorrect estimations (underestimations) of wood volume and quality;
- illegal harvesting operations;
- illegal wood transportation (misuse of transportation documents, lack of knowledge of timber on the part of the control personnel from the police or the financial guard);
- illegal wood imports (misuse of import documents, volumes and quality difficult for untrained customs or police personnel to estimate;
- illegal exports (misuse of export documents, wood volumes difficult for untrained customs or police personnel to estimate
- illegal logging in areas covered with forest trees that are not included in the official statistics (management plan database). No clear evidence and almost no control exists for these forests outside the officially registered national forest land.

There are also other aspects connected with the unsustainable exploitation of forests, such as the selective extraction of economically (and ecologically) important trees, and the introduction of non-native or non-autochthonous species (Douglas fir and Austrian pine), which have had a negative impact on biodiversity. It is generally accepted that these practices have reduced the quality of the biodiversity on about 1 M ha of land. In many cases forest exploitation is connected with other indirect threats, such as the sawdust that is mainly deposited along riverbanks or in ad hoc dumpsites. Large deposits of sawdust produced along rivers and streams, together with soil erosion, drastically affect the aquatic habitat quality for many fish species by reducing the oxygen content in the water and silting streambeds (Brandlmaier and Hirschberger 2005).

The new legislative framework provides for the restitution of over 70% of Romanian forests (including forests with a special protection role, those included in nature protection areas, and even primeval forests). Many specialists and NGO representatives are concerned about the effects of this measure, in the context of a weak institutional capacity for the enforcement of the forestry regime and rules in the private forests. This is combined with the illegal cutting of state forests and with overgrazing, which have degraded and fragmented forest and grassland habitats, leading to a loss of biodiversity and also playing a role in the severe floods that have affected Romania in recent years. However, the very latest news is that, after the devastating floods which hit Romania in 2005, the Romanian authorities have become more aware of the role of the forests and have ordered more active law enforcement in the field of forest management (Brandlmaier and Hirschberger 2005).

HUNTING

The management of wildlife and game species under the administration of the National Forestry Authority was very often a subject of debates between civil society organizations and the administration, focusing mainly on the accuracy of the data obtained for the evaluation of game species (especially bears or chamois) and the hunting methods used. While hunting is the visible element, there is also the hidden element of poaching, which cannot be well quantified. However, there are evaluations that show a very big reduction in populations (e.g. for chamois in the Retezat and Rodnei Mountains National Parks/Biosphere Reserves), the main reason being poaching (EURAC 2006).

TOURISM

There are close links between tourism and forestry, especially in the Carpathian region and the cooperation between the public authorities responsible for tourism and forestry has improved significantly recently. The national authority for tourism participated actively in the development of the National Forest Policy and Strategy. The development of eco-tourism has become a priority action both for the forestry sector and the public authority responsible for tourism. While the presence of forest seems to have a positive impact on tourism, the latter has mainly had a relatively negative impact on forests: clear-felling to allow development and construction of hotels, restaurants, skiing facilities etc.; garbage left in the forest by tourists; illegal camping and picnicking; and forest fires caused by the negligence of tourists are relevant examples (Abrudan and Marinescu 2004).

4.8 WOOD SUPPLY

GROWING STOCK

According to the last forest inventory (1985), the growing forest stock in the national forest area is 1.34 M m^3. Broadleaves account for 61% of the growing stock, and conifers 39%. The average wood volume is of 218 m^3 ha^{-1}.

The beech and spruce are the main forest species relating to the standing wood volume; they account for 66% of the total wood volume in Romania.

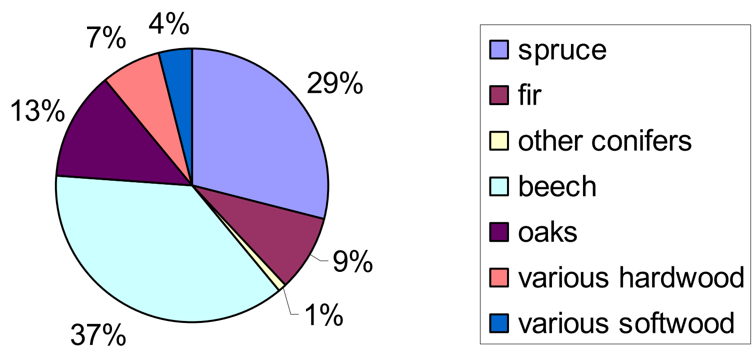

Fig. 4.15: Distribution of wood volume by main species and groups of species Source: Forest Area Inventory, 1985 (Marin and al. 2004)

According to the wood volume per ha, conifers are in the first place with an average volume of 279 m^3 ha^{-1}. Among these, fir is the most important with 395 m^3 ha^{-1} (tab. 4.2):

Species	**Volume m³ ha⁻¹**
Average volume	218
Conifers	279
Spruce	277
Fir	395
Other conifers	178
Broadleaves	216
Beech	260
Oak	155
Various hardwood	109
Various softwood	156

Tab. 4.2: Standing volume by main species and groups of species in Romanian forests
Source: forest area inventory, 1985 (Marin and al. 2004).

The standing wood volume increases from the first to the sixth age class, except for the wood volume in the fifth age class that is lower than those in the third and fourth class, due to the smaller surface with stands in this age class (only 10%, as compared to the 17% that would be normal).

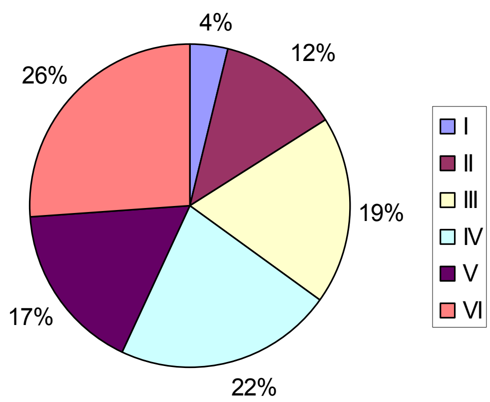

Fig. 4.16: Distribution of wood volume by age classes Source: Forest Area Inventory, 1985 (Marin and al. 2004).

The average volume per hectare by age classes shows a normal evolution of the stands and of the forest as a whole (tab. 4.3).

Age class	*Volume m^3 ha^{-1}*
I (1-20 years)	43
II (21-40 years)	131
III (41-60 years)	231
IV (61-80 years)	327
V (81-100 years)	363
VI (over 100 years)	373

Tab. 4.3: Wood volume per hectare by age classes in Romanian forests
Source: Forest Area Inventory, 1985 (Marin and al. 2004).

WOOD PRODUCTION

Forest growth is established for each management unit, usually once every 10 years during forest management planning works and is analyzed during the national forest area inventory.

For most of the forests, growth is established by using yield tables, based on composition, age, height and stand density, established during the process of plot description. The growth is established in successive inventories only in the case of the selection forests stands (Marin and al. 2004).

Table 4.4 reports the estimated annual increment in the main forest types in Carpathian region:

FOREST TYPE	*ANNUAL CURRENT INCREMENT*
Subalpine larch-arolla pine and dwarf pine forest*	2,4 $m^3ha^{-1}year^{-1}$
Subalpine and montane spruce and montane mixed spruce and silver fir forest*	7,0 $m^3ha^{-1}year^{-1}$
Alpine Scots pine and black pine forest*	3,1 $m^3ha^{-1}year^{-1}$
Oak-hornbeam forests*	4,8 $m^3ha^{-1}year^{-1}$
Ash and oak-ash forests*	4,4 $m^3ha^{-1}year^{-1}$
European broadleaved forests*	5,6 $m^3ha^{-1}year^{-1}$
Carpathian sub-montane beech forests*	5,4 $m^3ha^{-1}year^{-1}$
Carpathian montane beech forests*	5,5 $m^3ha^{-1}year^{-1}$

Tab. 4.4: Annual current increment of the main forest types in the Romanian Carpathians *EEA forest types (EEA 2006)

Various specific papers have expressed the opinion that nowadays, due to some negative phenomena (long droughts, forest damage, etc.), annual growth is up to 20% lower than in 1985. At present, Romanian forest potential (or possibility) possibility is 17.6 M m^3 (Marin and al. 2004).

The potential is established in forest management plans, usually once every ten years for each management unit. In this respect, procedures are being used specific to management planning methods based on indicating growth and age classes for regular high forests, on the functional selection system for the selection forest and fixed yearly cut in coppice forests.

Romanian forest possibility

Table 3.2.

Species	Main products (including conservation cutting)			Thinning			Cleaning			Sanitary cutting			Total		
	State forests	Private forests	Total	State forests	Private forests	Total	State forests	Private forests	Total	State forests	Private forests	Total	State forests	Private forests	Total
Conifers	2144	61	2205	1019	45	1064	104	6	110	701	71	772	3968	183	4151
Beech	5251	149	5400	1624	71	1695	119	7	126	615	62	677	7609	289	7898
Oaks	959	27	986	307	14	321	57	3	60	400	40	440	1723	84	1807
Hardwoods	934	26	960	808	35	843	156	9	165	320	32	352	2218	102	2320
Softwoods	807	23	830	363	16	379	62	3	65	110	12	122	1342	54	1396
Total	10095	286	10381	4121	181	4302	498	28	526	2146	217	2363	16860	712	17572
%	58	2	60	23	1	24	3	0	3	12	1	13	96	4	100

Tab. 4.5: Source: Forest Management Plans (1998) Study on biomass harvested in private forests (Marin and al. 2004)

The main products category also includes conservation cuttings that are carried out in mature 2nd functional type stands with protection functions, in order to maintain their health and vitality and to promote and tend the naturally regenerated seedlings.

Over the period 1950-1990, the quantity of harvested biomass, planned in five-year plans, was way beyond the forest possibility registered in forest management plans. The most intensive harvesting was registered in the period 1951-1955, during the activity of the SOVROMLEMN company, but also in 1966-1975, when the wood processing industry developed too much compared to the available wood resources.

After 1990, the volumes of harvested wood have been below the forest possibility. Besides the concern to restore the growing stock, the low accessibility of exploitable forests and the low working capacity of the harvesting units contributed to this decrease in cutting.

Due to the lack of roads, a quantity of 0.9-2.0 M m^3, out of the yearly forest possibility, is not harvested.

Period	Forest possibility			Harvested woodmass million cubic meters			Actual harvesting as compared to the possibility (%)		
	State forests	Private forests	Total	State forests	Private forests	Total	State forests	Private forests	Total
1961-1965	20.5	-	20.5	24.6	-	24.6	120	-	120
1966-1970	20.5	-	20.5	26.2	-	26.2	128	-	128
1971-1975	21.9	-	21.9	24.8	-	24.8	113	-	113
1976-1980	19.2	-	19.2	22.1	-	22.1	115	-	115
1981-1985	19.3	-	19.3	24.8	-	24.8	128	-	128
1986-1990	16.8	-	16.8	20.0	-	20.0	119	-	119
1991-1995	14.6	0.7	15.3	13.7	0.5	14.2	94	71	94
1996-1998	15.7	0.7	16.4	13.9	0.5	14.4	88	71	88

Tab. 6: Proportion of forest possibility and harvested wood during 1961-1998 (average yearly values by period) (Marin and al. 2004)

SUCEAVA COUNTY: A CASE STUDY

Table 4.7 reports the average values of height, diameter, age, volume and increment for each forest district in Suceava County.

Forest District	Mean age	Mean height (m)	Mean diameter (cm)	Mean Volume (m^3ha^{-1})	Annual growth ($m^3ha^{-1}year^{-1}$)
Adancata	49	16	22	184	6.87
Breaza	57	18	22	264	7.46
Brodina	66	22	28	331	8.39
Brosteni	55	16	21	255	7.66
Carlibab	50	15	19	232	6.82
Cosna	68	21	27	354	8.46
Crucea	71	19	26	328	7.92
Dolhasca	50	17	24	191	6.75
Dornacan	64	20	25	338	8.12
Falcau	63	20	26	328	8.69
Falticen	48	16	23	184	6.28
Frasin	75	25	35	401	8.56
Gurahu	61	22	29	359	9.67
Iacobeni	57	19	24	274	7.31
Malini	68	21	30	327	8.49
Marginea	61	20	27	304	8.19
Moldovit	71	22	29	371	8.99
Patrauti	49	16	22	184	6.87
Pojorita	68	20	26	298	7.04
Putna	64	23	31	375	9.34
Rasca	67	19	28	269	6.83
Solca	59	20	27	309	8.21
Stulpica	74	21	30	341	8.27
Tomnatec	72	23	33	368	7.82
Vama	70	21	30	345	8.63
Vatrador	66	20	26	330	7.79
Mean value	**62**	**20**	**26**	**302**	**8**
Minimum	**48**	**15**	**19**	**184**	**6**
Maximum	**75**	**25**	**35**	**401**	**10**

Tab. 4.7: average values for forest districts in Suceava County (Source: data provided by ICAS-Suceava)

The average values of each district were used to calculate the correlation between diameter and height (fig. 4.17), diameter and volumes (fig. 4.18) and mean age and volumes (fig. 4.19). All the relations present a high value of R^2, which means that the correlation between the parameters are good.

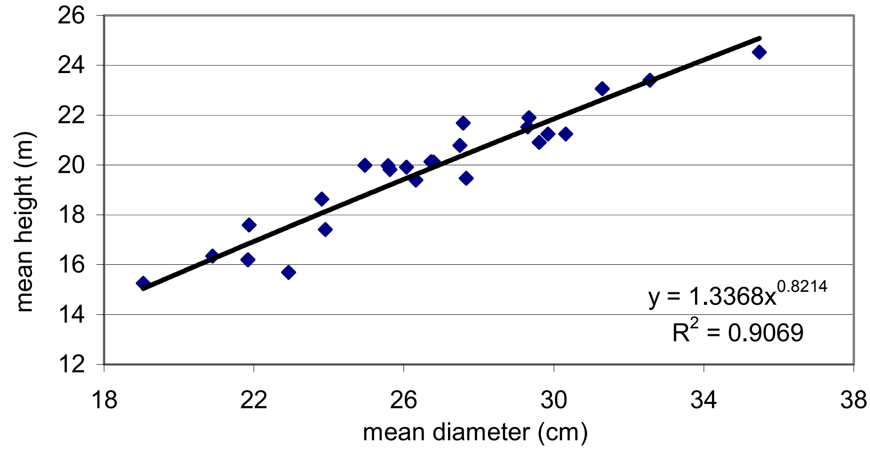

Fig. 4.17: Correlation between mean diameters and heights in forest districts of Suceava

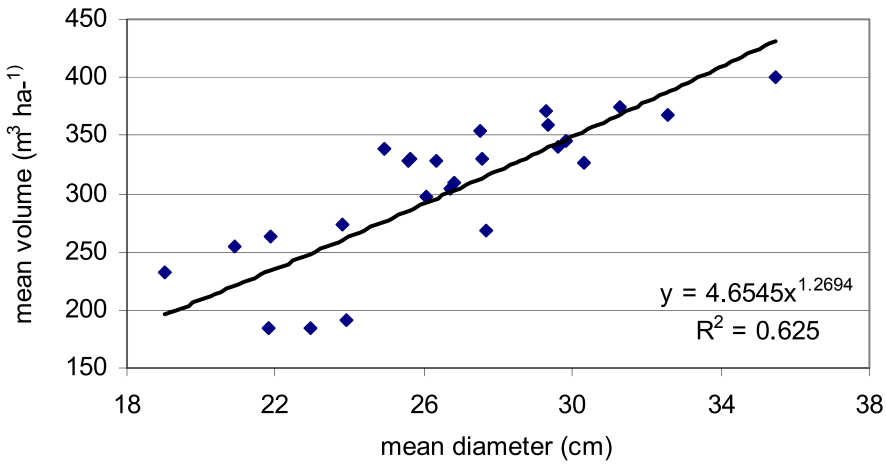

Fig. 4.18: Correlation between mean diameters and volumes in forest districts of Suceava

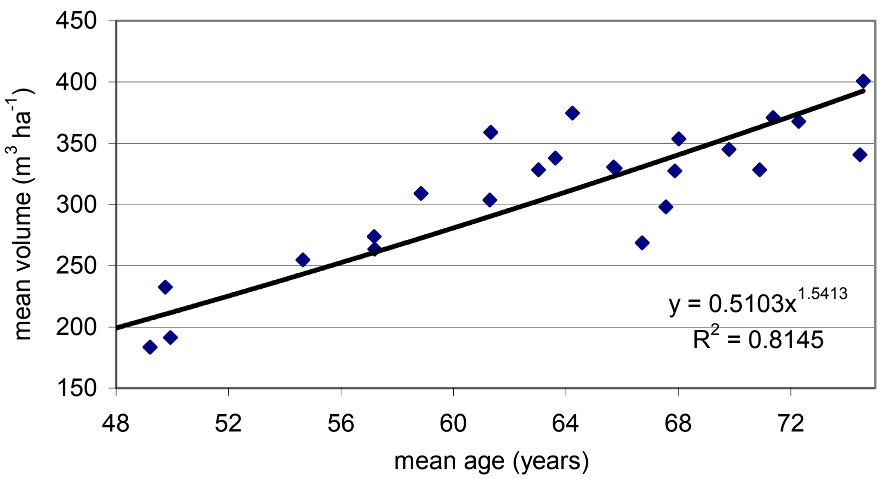

Fig. 4.18: Correlation between mean age and volumes in forest districts of Suceava

4.9 PROTECTIVE FUNCTION

PROTECTIVE FORESTS

As we have seen, forests in Romania are divided in two functional groups according to their functions, the first includes the forests with protective functions. This system of distribution was very important for maintaining the ecological balance of forest ecosystems. The forest management plans are the main information source on the areas of the protection forests. They are drawn up in accordance with the stipulations of the forestry technical norms approved by an order of the leader of the central public authority responsible for forestry and they apply the criteria for dividing the forests in groups and functional categories. The National Forest Inventory, carried out based on the forest management plans, gives data on the protection forests (Marin and al. 2004).

The forests with **soil and land protection functions** covered 6.8% of the total forest surface in 1995, and 22.6% in 1999. This shows the frailty of the soil to erosion and landslides. The present proportion of forests with soil protective functions shows the special importance granted to the protective effect of these forests, as well as the effort to delineate, plan and manage these forests differently. If we analyse the features of the relief where the Romanian forests are located, which is mainly mountain and hill, on steep slopes, on sedimentary lithological substrates etc, it can be noticed that more than 80% of the forest area undergoes degradation processes through erosion, sliding, swamping, clogging, etc of higher or lower intensity. Although many measures have been applied in order to improve the degraded lands, soil erosion could not be stopped, due to the pressure that affected the forests permanently. It is estimated that the surface of the forests with soil and land protective functions will increase greatly in the near future, especially due to the fact that the forestry sector will receive from the agriculture large areas of degraded agriculture lands to be afforested, of the 2 M ha strongly degraded or unsuitable for profitable agriculture (Marin and al. 2004).

Between 1955-1999, the proportion of forest area with **water protection** functions increased from 2.8% to 16.6%. Important increases have been registered in the last three decades when a series of hydrotechnical works and others have been performed. The 1999 percentage shows that the forests with functions mainly for water protection are in the second place after forests for soil protection. The efforts for delineating, planning and differentiated management of these forests according to the first, second and third functional types is worth mentioning (Marin and al. 2004).

PROTECTED AREAS AND VIRGIN FORESTS

Another essential function of forests is the maintenance, conservation and enhancement of **biological diversity.** Forests are ecosystems rich in biodiversity and one of the priorities of a sustainable forest management is to protect them in order to achieve the conservation of such biodiversity.

Tab. 4.8 reports the list of the main protected areas in the Romanian Carpathian region which include virgin forests. Almost all the all virgin and natural forests are declared protected areas.

National Park	*Virgin and natural forest complexes*
National Park Retezat (Hunedoara) 11,466 ha	Virgin and natural beech, mixed beech-fir-spruce and spruce forests, particularly in the scientific reserve (1840). Extensive areas with *Pinus mugo* and the largest occurrence of *Pinus cembra* in Romania. Include also alpine and subalpine shrubs and meadows, peaks, glacial lakes of unique landscape value. 1200 species of plants and a high mountain rare fauna (chamois, bear, deer, lynx). Genetic centre for *Hieracium* and *Ragenus*. Biosphere reserve (1979), declared as NP since 1935.
National Park Rodna (Maramures) 13,500 ha	Remnants of virgin and natural spruce forest with *Pinus cembra* and *Pinus mugo*. Include alpine and subalpine pastures. Biosphere reserve (1979).
National Park Domogled -Valea Cernei Caras-Severin, (Mehedinti, Gorj) 13,310 ha	Virgin beech forests in Valea Cemei and natural *Pinus mugo* var *banatica* in Domogled Mt Submediterranean species on limestone in Domogled Mt (*Quercus pubescens, Q. cerris, Q. frainetto, Carpinus orientalis, Corylus colurrna, Juglans regia, Fraxinus ornus, Prunus mahaleb*). Karst phenomena.
National Park Chele Nerei - Beusnita (Caras-Severin) 6,619 ha	Beech virgin forests in Nera forest district (Cheile Nerei, Nergana, Nerganita). Xerophyte vegetation (*Carpinus orientalis, Corylus colurna, Fraxinus ornus and Syringa vulgare*) in Beusnita. Karst phenomena.
National Park Apuseni (Bihor, Alba, Cluj) 9,526 ha	Remnants of virgin and natural spruce and beech forests in Padis and Somesul cald watersheds, as well as on the Lumea Pierduta plateau. All these forests are situated in karst area, plenty of unique geological phenomena (caves, underground gladers, lakes, waterfalls).
National Park Bucegi (Prahova, Brasov, Dambovita, Arges) 9,000 ha	Virgin and natural beech and pure silver fir forests (at 900-1200 m a.s.l.) between Sinaia and Poiana Tapului. Natural larch and larch-cembran pine stands in Piatra Arsa (1600-1800 m alt.).
National Park Semenic-Cheile Carasului (Caras- Severin) 8,522 ha	Virgin and natural beech forests. Karst phenomena and gorge Submediterranean vegetation (*Carpinus orientalis, Fraxinus ornus, Syringa vulgaris, Cotinus coggygria*).
National Park Ceahlau (Neamt) 5,424 ha	Natural forest of beech, fir and spruce and many endemic species. Natural occurrence of *Larix decidua* var. *carpatica*. Rare *Pinus mugo* and *Alnus viridis*.
National Park Cozia (Valcea) 6,747 ha	Natural and virgin forests of beech, sessile oak, spruce and fir. Occurrence of *Quercus robur* at high altitude (1800 m). Many endemic species. Include subalpine meadows.
National Park Piatra Craiului (Brasov, Arges) 4,024 ha	Quasi-virgin and natural mixed (beech, fir, spruce) forests on Jurassic limestone.s. Specific Acerato-Ulmetum in gorges. Frequent occurrence of *Pinus mugo*, *Taxus baccata* and other endemic species.
National Park Cheile Bicazului-Hasmas (Harghita, Neamt) 5,326 ha	Virgin and natural spruce-fir-beech forests with *Pinus sylvestris* and *Juniperus sabina* as relicts, in a limestone.s area with frequent karst phenomena (gorges).

Tab. 4.8: virgin and natural forest complexes in the National Parks of the Carpathian region (Borlea et al. 2006)

In total, 218.500 ha of virgin forests were identified in the framework of the project. The project experts concluded that more hectares can be included in this category in the coming 20 years. These could not be included in the list of virgin forests because they did not meet all the selection criteria like the absence of elements showing the influence by man, because of still visible traces of selective cutting and of grazing in the past. Also parcels smaller than 50 ha were excluded.

Most of the virgin forests (45%) belong *Fagus sylvatica* pure and mixed forests in mountain areas. These forests are located in the middle and lower parts of the Carpathian mountains, mainly in south-western part of the country. These forests are very typical for the Carpathian mountains in the Continental biogeographical zones of Europe. The main reason that these forests survived in the past was the low economic value of the timber of their trees. However, at this moment the economic value of this wood has increased and this causes a continuous threat that the forests will be cut.

In spite of the huge alteration due to the human exploitation of forests, there are some ecosystems in Romania that have been preserved throughout the centuries, which are considered virgin forests because no human activity has been ever documented there. Romania is one of the few European Countries that still have such uncontaminated forests. Unhappily these forests have been subject to a strong decrease in the last decades: it is enough to say that in 1974 these forests still represented about 10 – 12% of the total forest cover, while they currently represent only the 5% of total forests. To protect and conserve virgin forests' richness is fundamental because of the several functions they discharge: historical witness, valuable treasure of genes, species and representative ecosystems, sources of scientific information, ecosystems well adapted to natural impacts, natural reference to managed forests (Biris and Veen 2001).

PIN/MATRA DUTCH-ROMANIAN PROJECT

During the period 2001-2004, a virgin forest project was carried out by the Royal Dutch Society for Nature Conservation (KNNV) in co-operation with Romanian Forest Research and Management Institute (ICAS). Other project partners were IUCN-European Office and independent European experts on forestry. The Project aimed at identifying the virgin forests present in the country, and at proposing an Action Plan for their conservation (Biris and Veen 2001).

The areas where virgin forests are situated were identified through the elaboration of a set of selection criteria: the necessary conditions to classify a forest a forest as virgin forest are related to the degree of naturalness, the occurrence of different stand development stages, the minimal area of range, the occurrence of natural limits. Both these characteristics are described through some parameters (natural composition and distribution of composing species, absence of elements showing human influence, complex structures, occurrence of very old and large trees etc.)

Once the forest is recognized as virgin forest, other assessment parameters are applied for classification and hierarchical (biological, ecological) “quality weighting” purposes of the selected forests. The evaluation is based on the type of forest and on geographical location of the forest (biological and ecological diversity, absence of threats for normal forest development, knowledge and scientific stage, environmental educational function, gene bank, accessibility of the forest locations, etc). Quality is then expressed on a scale from 1 to 5 (from insufficient to excellent) (Biris and Veen 2001).

The study identified in total 218.5000 ha of virgin forests, with the possibility to include more hectares in the coming 20 years (for example including also the forests smaller than 50 ha, currently excluded). Most of the virgin forests (95%) are situated in the Carpathian area of Romania.

The most represented typological unit is “*Fagus sylvatica* pure and mixed forests in mountain areas” (45%), typical for the Carpathian mountains in the Continental biogeographical zone of Europe. These forests survived because of the low economic value of the timber of their trees. At the moment the economic value of this wood increased and this is a huge threat that the forest will be cut.

Other quite common units are “*Picea abies, Larix decidua, Pinus cembra* and *Pinus sylvestris* pure and mixed forests” (20%), and “*Abies alba* pure and mixed forests” (20%) (pure and mixed coniferous and Beech forests), typical of the higher zones of the mountains.

“*Fagus sylvatica* pure and mixed forests in hilly areas” is less common (10%) and is connected with the lower zones of the mountains. It is scarcely represented because of the higher human impact over the centuries. “*Quescus petraea* pure and mixed forests” are very rare because they are on the plains, where human occupation is very intensive (Biris and Veen 2001).

The table 4.10 shows some main characteristics of virgin forests in Romania:

Distribution of virgin forests areas on functional groups - 94% protective forests - 6% productive forests protective forests are managed with non-intervention.
Distribution of virgin forests areas on slope categories - 73% over 30° - 24% 15° – 30° - 8% near flat areas unaccessible locations are precondition for survival of these forests.
Distribution of virgin forests areas on altitude categories: - 65.5% above 1000 m a.s.l. - 27.1% between 600 and 1000 m a.s.l. most virgin forests are situated in the Carpathian massive.
Distribution of virgin forests areas according to the legal protection status (situation of protection 2000): - 75% unprotected - 16% national and natural parks - 9% natural forest reserves. From 2000 onwards, the designation of protected areas developed strongly and several locations with virgin forests were brought under protection or will be in the near future.

Tab. 4.10: some characteristics of virgin forests in Romania (Biris and Veen 2001)

Ecological network of virgin forests:

The forest vegetation map of Romania, produced by the GIS and remote sensing team of ICAS, gives a clear survey of the PINMATRA polygons of virgin forest. While at lower altitudes, the spatial connectivity is often not so favourable, in some parts of the Carpathian Mountains, mostly in high altitudes, they form large continuous areas. In such areas it can be expected that the characteristic biodiversity of the virgin forests will be conserved in a sustainable way.

As the map shows where this is the case, it is possible to investigate the places with virgin forest that are at risk of loosing their specific biodiversity in the long term. To prevent this loss of species and consequently the loss of ecosystems, restoration of the connection is an effective solution of the problem (Biris and Veen 2001).

The PINMATRA map makes it possible to develop the most effective network of connections. Therefore two questions will have to be answered.

1. What is the size of the ecological minimum area of the involved forest ecosystem types?
2. What is the maximum gap that can be bridged by their characteristic species?

These two questions must be answered for each ecosystem type that is found in the virgin forests of Romania. With this knowledge it is possible to give priority to the conservation of those virgin forests that meet the size of the ecological minimum area.

The next step is to design and manage in the proper way the ecological connection between these large size forests, with small woodlands in their neighbourhood that do not have the minimum area, and are situated at a distance longer than the gap that the species can bridge. In the case of dying out of species in small woodland, the connection makes new immigration possible from the large forest. For the same reason, a number of small woodlands can be connected with each other, even in the absence of a forest with the size of the minimum area or larger. Genetic exchange and repopulation are then possible, which is essential for sustainable existence of the virgin forest ecosystems.

The most effective ecological network can be designed by means of the information that has become available with the PINMATRA polygon map and the ecosystem specific answers to the two above mentioned questions. Such action would also reveal the parts of Romania where the existing situation meets with the ecological conditions required for sustainable conservation of virgin forest biodiversity (Biris and Veen 2001).

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4.11 ANNEX 1: Protected areas in the Romanian Carpathians

List of National Parks and other protected area in the Carpathian region

1. National and Nature parks of Carpathians in Romania:

Parks name	Total surface ha	Forest		Type of forests	strictly protection
		- ha -	%		- ha -
National Parks					
CĂLIMANI	24 041.0	16 118.5	**67.05**	**Spruce**	8 464.3
CHEILE BICAZULUI - HĂŞMAŞ	6 575.0	6 345.5	**96.51**	**Spruce**	4 823.7
CHEILE NEREI - BEUŞNIȚA	36 758.0	29 165.0	**79.34**	**Beech**	7 588.0
COZIA	17 100.0	16 055.6	**93.89**	**Mixed coniferous + decidous forests**	7 839.9
DOMOGLED - VALEA CERNEI	61 211.0	45 641.8	**74.56**		19 755.3
PIATRA CRAIULUI	14 773.0	10 170.8	**68.85**	**Spruce + mixed forests**	3 753.68
RETEZAT	38 138.0	19 254.0	**50.49**	**Mixed coniferous + decidous forests**	884.9
MUNTII RODNEI	46 399.0	27 670.3	**59.64**	**Spruce + Fir + Mixed coniferous + decidous forests**	13 323.6
SEMENIC - CHEILE CARAŞULUI	36 160.7	30 743.1	**85.02**	**Beech forests**	9 405.2
BUILA - VÂNTURARIȚA	4 186.0	3 850.7	**91.99**	**Spruce, beech forests**	1 496.9
CEAHLĂU	8 396.0	7 321.9	**87.21**	**Spruce forests**	3 243.6
DEFILEUL JIULUI	11 127.0	9 422.0	**84.68**	**Mixed decidous forests**	9 012.0
Nature Parks					
APUSENI	75 784.0	48 795.5	**64.39**	**Spruce + decidous forests**	11 647.0
BUCEGI	32 663.0	21 357.7	**65.39**	**Spruce + fir + Mixed coniferous forests**	5 805.0
GRĂDIŞTEA MUNCELULUI - CIOCLOVINA	38 184.0	26 229.7	**68.69**	**Beech forests**	4 357.1
PORȚILE DE FIER	115 655.0	63 919.5	**55.27**	**Mixed decidous forests**	9 610.4
VÂNĂTORI NEAMȚ	30 818.0	26 322.6	**85.41**	**Oaks + mixed decidous forests**	11 417.0
MUNȚII MARAMUREŞULUI	148 850.0	72 000.0	**48.37**	**Spruce + Mixed coniferous + decidous forests**	8 850.0
PUTNA - VRANCEA	38 204.0	30 563.5	**80.00**	**Coniferous + decidous forests**	6 423.2
GEOPARCUL DINOZAURILOR ȚARA HAȚEGULUI	102 392.0	45 256.0	**44.20**		0.0
GEOPARCUL PLATOUL MEHEDINȚI	106 000.0	0.0	**0.00**	**Beech forests**	0.0
Total	**993 414.7**	**556 203.7**	**55.99**		**147 700.8**

Source: ROMSILVA 2007

2. Total area of small protected area in Carpathian regions of Romania

County	Total surface	Forest
Alba	745.6	505.7
Arges	15029.4	8366.0
Bacau	201.0	191.1
Bihor	312.2	261.5
Bistrita Nasaud	741.0	396.0
Brasov	2188.1	1127.8
Buzau	1780.2	181.3
Caras - Severin	687.9	390.3
Cluj	220.7	120.7
Covasna	48.2	48.2
Dambovita	5.5	0.5
Gorj	1589.9	799.4
Harghita	1912.5	824.1
Hunedoara	849.0	2622.1
Maramures	2114.2	2392.2
Mehedinti	737.5	605.1
Neamt	1108.9	834.5
Prahova	37.1	0.2
Satu Mare	127.5	98.6
Salaj	87.1	70.1
Sibiu	18760	1172.7
Suceava	3038.9	3014.1
Valcea	413.8	157.6
Vrancea	2877.5	2860.1
TOTAL	**55613.7**	**27039.9**

Source: ROMSILVA 2007

5 SERBIA

5.1 INTRODUCTION

The Republic of Serbia occupies an area of 8.84 M ha an it is located in south-eastern Europe on the Balkan Peninsula, is bounded on the north by Hungary, on the east by Romania and Bulgaria, on the south by Albania, Montenegro and the Former Yugoslav Republic of Macedonia and on the west by Croatia and Bosnia and Herzegovina.

Fig. 5.1: Topographic map of Serbia and Montenegro (UNEP/GRID: http://maps.grida.no/go/region).

Serbia covers a region with a wide range of landscapes. The climate is mainly continental featuring a gradual transition between the four seasons of the year, warm summers and snowy winters. Average monthly temperatures vary from – 0.7 °C in January to 17.5 °C in July and August (SIEPA 2005).

Resulting from a high degree of natural diversity, a vast array of broadleaved and conifer tree species can be found throughout the country. The forest area is spread across the territory of Serbia and differs by region. There are two major natural and geographical areas:

• The Lowlands of Vojvodina, in the North, characterized by a mosaic distribution of native vegetation, meadow–steppe, woodland–steppe and sand character. Together with the wetlands and marsh terrain along and between the rivers Danube, Sava, Tisa and Tamiš, they provide extremely favourable conditions for oak and poplar.

• High–mountainous areas located in Central Serbia include the Balkan, Dinaric and Carpathian mountain chains, provide diverse climatic conditions for broadleaved trees – especially beech.

The total forest area of Serbia is about 2.3 M ha (26.1%), with a value of forest per inhabitant of 0.25 ha (UNECE/FAO 2005). Almost two thirds of forest cover in Serbia is represented by coppices (64%). The total growing stock is about 362.5 M m^3 (around 160 m^3 ha^{-1}), with a volume of wood per capita of 48.3 m^3, and an annual growing increment of 9.01 M m^3 $year^{-1}$ (3.9 m^3 ha^{-1} $year^{-1}$).

Hardwood species dominate the forests of Serbia, of which the most significant is beech with approximately 47%, followed by oak at 25%, other hardwood species at 16%, and poplar at about 1%. For the softwood species, the most significant is pine (black and white) with a share of 2%, followed by spruce 5%, and fir 3%. Other softwood and some hardwood species account for a mere 1% (UNECE/FAO 2005).

The forest area in Serbia has increased in the last decades: in the 1950s, the average forest area in Serbia was less than 20%. The increased area was achieved mainly through afforestation actions financed and organized in the period between 1960 and 1980. From 1979 to 2007, forest cover increased more than 260 000 ha only in the regions of Vojvodina and Central Serbia. Afforestation was generally carried out using coniferous species. Afforestation levels have decreased since 1982 because of a chronic shortage of funds for such purposes. The longstanding government control over the price of forestry products made it impossible to generate the necessary funds for forest reproduction. Alternative sources of funds for such purposes have gradually been removed and it has not been possible to allocate substantial funds for afforestation and cultivation in the areas exposed to erosion and degradation (EURAC 2006).

Serbia has significant forest resources that are threatened by over-harvesting, illegal logging, forest fires, and pest infestations. The promotion of the sustainable management of forests by strengthening forest institutions, increasing wood extraction fees to cover costs, and harmonizing standards and regulations within the country and internationally is needed. Excessive cutting of trees in mountainous parts of Serbia is in part responsible for increased erosion and the increased occurrence of floods (EURAC 2006).

5.2 DJERDAP NATIONAL PARK

According to the description of Serbia's territory of the Carpathian Convention, the National Proposal of the delimitation of the Carpathian region is similar to the area covered by the Djerdap National Park. In detail, it compromise the following area (Ruffini et al. 2006):

• "The entire part of the Danube called Djerdap (from the Golubac region and the Golubac municipality to the Djerdap I Hydroelectric Plant) will be included in the Carpathian Mountain Region;

• The entire territory of the Djerdap National Park will be included in the Carpathian Mountain Region;

• The proposed territory will correspond to the territory of the National Park with some extension of its borders (not national borders of the national park but borders of the Serbian Carpathians).

Risojevic summarizes that "[…] we use only natural criteria: borders of National Park, Djerdap gorge, geological diversity and biodiversity criteria".

According to this data, 0.35% (73 200 ha) of the Carpathians is located in Serbia and 0.82% of the area of Serbia is within the Carpathian region, covering mainly the territory of one of Serbia's National Parks "Djerdap".

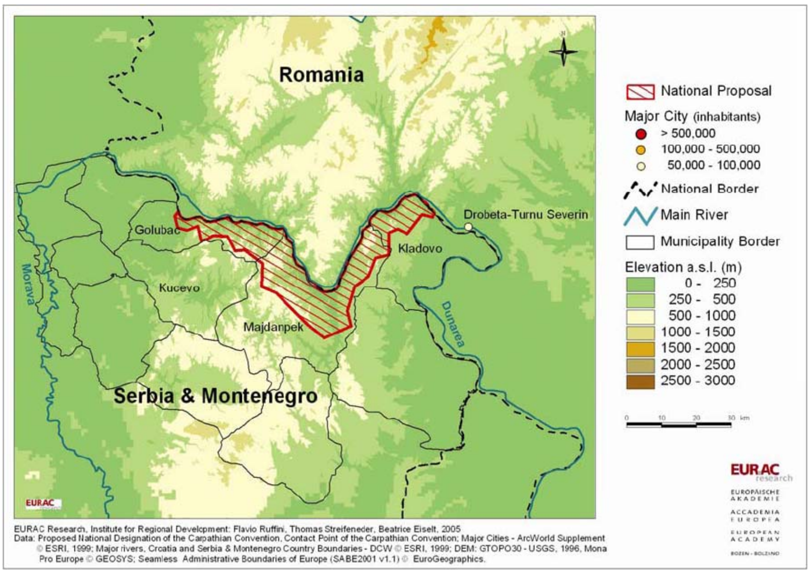

Fig. 5.2: The NP of Serbia & Montenegro. Source: UNEP, 2004 (Ruffini et al. 2006)

5.1.1 Description

There are five National Parks in Serbia (*Law on National Parks* of the Republic of Serbia, 1993). Djerdap is the largest one (Tab. 5.1). With an area that reaches almost 40% of the total area of National Parks.

National Parks	Municipalities	Area (ha)	Protection degree IUCN[1]
Djerdap	Golubac, Kladovo, Majdanpek	63 600	IV
Tara	Bajina Bašta	19 175	II
Kopaonik	Raška and Brus	11 809	V
Frušk gora	B. Palanka, Beočin, Inđija, Novi Sad, S. Mitrovica, Šid	25 525	V
Mountain Šara	Kačanik, Uroševac, Suva Reka, Prizren, Štrpce	39 000	II
Total area		159 109	

Tab. 5.1: National Parks of Serbia (Stanišić et al. 2006)*

The Djerdap National Park (Fig. 5.3) embraces part of the area of the Djerdap Canyon known as the Iron Gates in the central part of the Danube river course, and is divided by the international border running along the middle of the river into the southern - Serbian and the northern - Romanian part. The **total area of the National Park is 63 600 ha**. Total length is 100 km with an average width of 6 km on the territory of the municipalities of Golubac (18 116 ha), Majdanpek (29 467.15 ha) and Kladovo (16 024.75 ha). The protection area (buffer zone) extends over 93 967.58 ha on the territory of the municipalities of Majdanpek (33 889.40 ha), Kladovo (19 703.58 ha), Kucevo (20591.64 ha), Negotin (14 126 ha) and Golubac (5 656.96 ha) (Dimović and Hegediš 2002).

The morphological characteristics of the region which are the main source of attraction and constitute a natural phenomenon are determined by the 100 km. long Djerdap canyon forged by the Danube, the second largest river in Europe which flows through or forms the natural frontier of eight states (UNESCO: http://whc.unesco.org/en/tentativelists/1693/)

[1] The World Conservation Union – IUCN, defines a protected area as: "*an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means*". They have defined a series of protected area management categories based on management objectives. Definitions of these categories, and examples of each, are provided in Guidelines for Protected Area Management Categories. The six categories are (IUCN, 1994): 1- CATEGORY Ia: **Strict Nature Reserve** (Protected area managed mainly for science); 2- CATEGORY Ib: **Wilderness Area** (Protected area managed mainly for wilderness protection); 3- • CATEGORY II: **National Park** (Protected area managed mainly for ecosystem protection and recreation); 4- CATEGORY III: **Natural Monument** (Protected area managed mainly for conservation of specific natural features); 5- CATEGORY IV: **Habitat/Species Management Area** (Protected area managed mainly for conservation through management intervention); 6- CATEGORY V: **Protected Landscape/Seascape** (mainly for landscape/ seascape conservation and recreation); 7-CATEGORY VI: **Managed Resource Protected Area** (Protected area managed mainly for the sustainable use of natural ecosystems) (Stanišić et al. 2006)

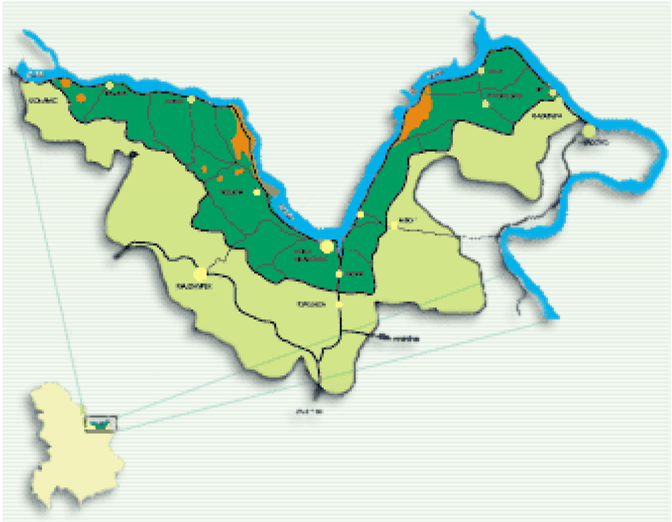

Fig. 5.3: Djerdap National Park (Djerdap NP website: http://www.npdjerdap.co.yu/e_index.html)

The region has a very complex geological history and morphology. The variety of the landscape is enhanced by the existence of a large number of gorge-like valleys formed by the Danube's tributaries, karst reliefs on limestone plateaus and other phenomena. The Djerdap Canyon is the longest fissure in Europe and a rare natural phenomenon. There are sections where the vertical cliffs rise 300 m above the level of the Danube and the measured depth of the so-called "cauldrons" goes up to 82 m. Thanks to the sheltered position of the Iron Gates more than 60 forest and shrub communities have been preserved, many of which are relicts of previous, tertiary forest communities.

Numerous plant varieties can be found including tertiary relicts and species whose range in Europe has been significantly reduced. More than 1100 plant varieties have been recorded in the Djerdap region which confirms its enormous significance in the taxonomic and ecological sense. It is important to note the presence of *Corylus colurna*, *Acer intermedium*, *Celtis australis*, *Ilex aquifolium*, *Ceterach officinarum*, etc. Rare animal and bird species can also be found in the National Park including bear, lynx, wolf, jackal, grey eagle, short-eared owl, black stork etc. Testifying to the importance of the Iron Gates section of the Danube in the past are traces of man's presence and the development of his material and spiritual culture from earliest times (the oldest archaeological localities date back to 7 000 – 5 000 B.C.) to the present.

5.1.2 Forests in Djerdap National Park

According to the official definition of "Carpathian Region" in Serbia, forest cover in this area is about 41 000 ha (Ruffini et al. 2006): the **forest cover** in the Carpathian area is about 64%, so, more than twice the national average. The forest area per capita (2.5 ha) is much higher than the national average.

Most of the forests are state owned (92%) and managed by experts from the National Park (Dimović and Hegediš 2002).

The total **growing stock** is about 8.3 M m^3 (around 202 m^3 ha^{-1}), the volume of wood per capita is about 414 m^3, and the **annual increment** is around 148 000 m^3 (3.61 m^3 ha^{-1}).

Being inside the National Park, almost all the forests in the Serbian Carpathian area are forests with **protection** and **tourist** functions.

Forest vegetation is diverse and is of outstanding ecological and biodiversity value, where specific climate, soil, complex relief, proximity of the river Danube and variety of historical factors have facilitated preservation of one of the richest and most complex relict vegetations in the southeast of Europe. The flora of the Djerdap area forests is exceptionally rich both from the point of view of taxonomy and ecology (Tar 2007).

They are mainly beech and mixed broadleaved forests. The **composition** of the different forest types is given in detail in the table 5.2:

Forest types	Area (ha)	%
Carpino-Quercetum petraeae-cerris typicum – **hornbeam-oak forest**	127.78	0.3
Querco Carpinetum – **hornbeam-oak forest**	436.67	1.2
Querco Carpinetum higrophillum – **hornbeam-oak forest on low altitude**	1 498.24	4.0
Orno polyquercetum – **oak- ash forest**	365.59	1.0
Fraxineto-carpinetum syringetum – **hornbeam-ash-lilac forest**	3 466.16	9.4
Fraxino colurnetum – **ash- constantinopole hazel forest**	612.26	1.6
Aceri fraxinetum – **maple-ash forest**	127.32	0.4
Carpino orientalis polyquercetum – **oriental hornbeam-oak forest**	1 476.27	4.0
Quercetum petraeae-cerris farnetosum – **mixed oak forest**	1 026.67	2.8
Quercetum petraeae-cerris typicum – **mixed oak forest**	597.39	1.6
Quercetum petraeae-cerris pauperum – **mixed oak forest**	1 159.58	3.1
Quercetum- montanum typicum **– sessile-flowered oak forest**	2 358.10	6.3
Quercetum- montanum tilietosum tomentosae – **oak-lime forest**	833.92	2.2
Querceto frainetto cerris – **mixed oak forest**	537.76	1.5
Querco-Fagetum typicum – **oak-beech forest**	1 955.83	5.3
Fagetum moesiacae submontanum ornetosum – **beech-ash forest**	53.05	0.1
Fago-colurnetum – **beech-constantinopole hazel forest**	91.01	0.2
Fagetum moesiacae submontanum acerotosum – **mixed beech-maple forests with noble hardwoods**	707.91	2.0
Fagetum moesiacae submontanum drymetosum – **beech forest**	6 040.50	16.3
Fagetum moesiacae submontanum typicum – **beech forest**	7 020.94	18.9
Fagetum moesiacae submontanum dentarietosum bulbifera **– beech forest**	622.86	1.7
Fagetum moesiacae montanum carpinetosum betuli – **beech – hornbeam forest**	1 231.73	3.4
Fagetum moesiacae montanum tilietosum – **beech-lime forest**	844.30	2.3
Fagetum moesiacae montanum carpinetosum betuli **mixed beech-lime forest with noble hardwoods**	1 392.56	3.8
Luzulo-Fagetum moesiacae montanum **beech forest on acid soil**	2 468.49	6.6
TOTAL	**37 052.89**	**100.0**

Tab. 5.2: forest types in the Djerdap National Park (Data sources: forest management plan of NP “Djerdap”)

In almost all the forest types, **age classes** from III to VIII (from 30 to 80 years) are present. Forest structure is not appropriate due to the existing number of trees in class VIII: there are low rate of regeneration process.

5.1.3 Management Plans

The main goals for protection and sustainable development of the Djerdap National Park area are (Dimović and Hegediš 2002):

- to carry out the main activities of the Protected Area Management Plans
- to re-categorize and make changes in the existing (boundaries, regimes, etc.) protected areas, and to declare new ones,
- to carry out activities of the Protected Species and Habitat Management Plans, including reintroduction of endangered species of wild fauna and flora
- to carry out activities for sustainable use of natural resources
- to restore habitats of endangered species, and other locations of significance to nature
- to develop educational programs
- to publish leaflets, brochures, and other nature protection promotion materials
- to establish visitor and information centre

National Parks in Serbia are divided into zones with three levels of protection, with different regimes of management. The type of protective regime for each zone is determined on the basis of the purpose and function of that particular zone (Dimović and Hegediš 2002):

- Protective zones under **1st degree** of protection cover 2 664.26 ha or 4.20% of the total NP area. This regime calls for strict protection of specific natural and cultural values of particular significance, including the surroundings of cultural monuments: nature reserves, special natural and landscape areas, natural monuments, sites offering spectacular views and all endangered species of fungi, plants and animals and their habitats. In the zones with 1st degree of protection the only activities are those of conservation, scientific research, education and presentations under special conditions.

- Protective zones of **2nd degree** cover 15 262 ha or 24% of total NP area and include zones in which protection is under the 1st degree regime, protection of segments of nature of particular value (characteristic ecosystems, landscape and other values) and nature surrounding fixed natural values. Under set conditions the following activities can be performed in areas under 2nd degree of protection: research, education, presentation of the NP, sports and recreation, water regulation and transport, forestry, agriculture and cattle raising.

- Zones under **3rd degree** of protection cover 45 682.02 ha or 71.8% of total NP area. This degree is awarded to areas other than those under 1st and 2nd degree regimes including sports and recreational areas. 3rd degree of protection covers forests outside the 1st and 2nd degree protection, and agricultural areas (arable land, fields, pastures, etc.), areas in settlements and tourist centres where construction is permitted and infrastructure used for transport, water management, energy and telecommunications. It also include mineral raw materials borrowpits (on a defined location and for a limited period of time, in accordance with the land use plan for Djerdap NP) and individual facilities used for forest management, agriculture, hunting, fishing etc. And other zones of special use as long as they are outside the scope of 1st and 2nd degree protection.

The land use plan is in principle based on the acceptance of the existing situation and its regulation. This includes the determination to end irrational land use, prevention of all degradation and creation of suitable conditions for the protection of natural, cultural and historical sites. According to morphological and functional criteria the following areas can be clearly differentiated:

- Danube coastal belt, narrow strip alongside the Danube with a high degree of urban construction with existing infrastructure and tendencies towards more intensive secondary and tertiary activities;
- Hilly and mountainous area between the settlements of Golubac and Donji Milanovac, which is without permanently inhabited villages;
- Hilly and mountainous hinterland between Donji Milanovac and Kladovo, an area of forests and pastures with permanent settlements of Petrovo Selo and Golubinje;

The coastal belt includes a wider area somewhat outside the coastal belt in the strictest sense. According to priorities of protection, three areas of highest significance for the national park stand out:

1. the Golubacka klisura stretch
2. the Gospođin vir stretch
3. the Kazan stretch

The natural environment is least changed in these areas. In them priority is given to protection of natural and cultural values and to the following activities: forest management, hunting and traditional mountain farming. Intermediate areas are destined for construction of settlements and tourist resorts, under the conditions defined by the Land Use Plan. A specific regime is foreseen for the areas where construction is permitted in the settlements of Donji Milanovac and Mosna. Other parts of the NP are open to economic activities where, except in areas with strict and targeted degree of protection (1st and 2nd degree) priority is given to forest management, mountain farming, service activities and tourism (Dimović and Hegediš 2002).

The combination of orography, microclimate, biotic factors and specific natural history in the area of Djerdap has created this exceptional natural phenomenon and unique refugium. Development of flora and vegetation, in this relatively small area, has been continual since the period of the Pliocene, resulting in the preservation of numerous relict species and associations and whole developmental series. The term natural asset here refers to those areas in which certain characteristics of flora and vegetation of relict species confirm the theory of vegetation development series in the natural history of this region.

In the area of the National Park Djerdap there are ten nature reserves, and proposals for establishment of another three reserves are under way (Dimović and Hegediš 2002).

Nature Reserve	Degree of protection area (ha)			Characteristic vegetation
	1st	2nd	3rd	
Golubacki grad nature reserve	10 450	-	0.75	tall shrubbery of lilac, oak, hornbeam and European ash (Syringeto-fraxineto-carpinetum orientalis), remnants of lilac, oak and hornbeam forests (Carpineto orientalis-quercetum mixtum), termophilous oak forests (Quercetum confertae ceris pubescente tosum) and beech forests with walnut (Fagetum montanum juglandetosum).
Bojana nature reserve	8.85	11.13	-	pure walnut (Juglans regia) surrounded by tall mixed forest of beech and walnut (Fagetum montanum juglandetosum). Turkish hazel (Corylus colurna), Montpelier maple (Acer monspesulanum), European ash (Fraxinus ornus), Carpinus ornus and hornbeam (Carpinus betulus)
Tatarski vis nature reserve	14.70	-	-	beech, penduculate oak and hornbeam
Bosman-Sokolovac nature reserve	296	-	-	low forests and shrubbery (Syringeto-monsspesuleto-colurnetum), a mixed relic association with characteristic species (Acero-fraxineto-colurnetum-mixtum) and an impoverished association of beech and Turkish hazel (Fagetum montanum-colurnetosum).
Coka Njalta sa Pesacom nature reserve	618	-	-	large refuge of relic and rare tree species and associations
Lepenski vir nature reserve	92.23	6.47	-	Southern nettle- tree (Celtis australis), walnut, (Juglans regia), downy oak (Quercus pubescens),Montpelier maple (Acer monospessulanum), lilac (Syringa vulgaris) etc.
Kanjon Boljetinske reke – Greben nature reserve	112.59	-	0.15	-
Somrda nature reserve	21.05	-	-	holly (Ilex-aquifolium L.)
Ciganski potok nature reserve	-	54	-	autochthonous forest association of walnut (Parietario-juglandetum), surrounded by mixed forests of beech and walnut Other basic forest types are mountainous beech forest with walnut (Fagetum submontanum - juglandetosum), which is an impoverished relict association, pure beech forest of contemporary type on silicates (Fagetum submontanum) and on narrow ridges there is also a pure oak forest (Quercetum montanum).
Veliki and Mali Strbac with Tabula Traiana	1 992	-	28.01	very varied and widespread vegetation with over 30 relict associations. Sixteen of these are poly-dominant and six represent successive vegetation series which indicate the origins and historic development of the ecosystem.

Tab. 5.3: Nature reserve in Djerdap National Park (Dimović and Hegediš 2002)

Forest vegetation is diverse and is of outstanding ecological and biodiversity value, where specific climate, soil, complex relief, proximity of the river Danube and variety of historical factors have facilitated preservation of one of the richest and most complex relict vegetations in the southeast of Europe. The flora of the Djerdap area forests is exceptionally rich both from the point of view of taxonomy and ecology (Tar 2007).

Forest monitoring in Serbia: NFI

The last forest inventory of Serbia was concluded on November 2007 and information will be on the web in 2008. The latest previous forest inventory was carried out in Serbia and Montenegro in 1979. Its aim was to collect data for use in forest resource and product planning, and deal with possible forestry problems in a scientific manner. The data were the foundation for pursuing a forest policy on forest resources and the timber industry. Data on growing stock obtained in 1979 were gathered on the basis of a common methodology drawn up by the former Federal Statistical Bureau. Forests with management plans were inventoried via their own internal statistics, while private forests or areas where internal data could not be provided were inventoried by assessment methods. These data were used to determine the area, wood volume, increment, types of trees, silviculture form, age, etc. Cadastral data were used to assess forest area (where it was not otherwise determined). In addition to forests, unstocked forest areas (managed by forests enterprises); plantations of deciduous and coniferous species; permanent communication structures; and public roads, which pass through forests were inventoried. During the inventory, the following terms were defined: a forest is a wooded area exceeding 0.5 ha; hedgerows, municipal parks, forest nurseries and groups of trees on areas smaller then 0.5 ha are not considered forests; plantations are forests raised from selected plant sources with intensive high yield measures (short rotation); unstocked forest land includes land which yields the best results if forests are growing on it (UNECE/FAO 2005).

5.1.4 Impacts on forests

According to the available information the main threats to the natural and cultural wealth at the territory of the National Park are (Dimović and Hegediš 2002):

a) possibility of forest fires because of the radically dry conditions during the summer months

b) possibility of accidental pollutions of the course of the Danube because of insensitive river traffic, as the unsolved loss of the communal and industrial (smaller plants at the behind of the Porecki bay at Donji Milanovac) waste waters

c) possibility of accidental pollution of the course of the Danube and river bank because of the heavy regional road traffic at the regional way that transits through the whole park near the bank of the Danube

d) problem of the illegal dumping grounds, which are usually located at the banks of the Danube

e) very intensive and organized illegal fishing.

According to the available information NP possesses only a program for fire protection. This program was not available for detailed analyses.

The table 5.4 reports the data of forest fires in Serbia since 1990. 2007 was the worst hit year, with more than 16 000 ha of burnt forest (almost one third of the total area burnt in the period 1990 – 2007).

Year	Number of forest fires	Area Ha
1990	161	2 901
1991	85	1 168
1992	126	654
1993	259	5 675
1994	116	1 009
1995	21	397
1996	87	7 016
1997	56	884
1998	124	1 749
1999	26	193
2000	339	13 201
2001	54	877
2002	134	4 608
2003	102	676
2004	22	98
2005	15	63
2006	43	715
2007	258	16 144

Tab. 5.4: Forest fires in Serbia

In 2007 there were 82 forest fires in Djerdap Nationa Park (almost 32% of total forest fires in Serbia) that involved a total area of 1056 ha, that is 6.5% of the total area of forest fires in Serbia (tab. 5.5):

	number of fire accidents	state ha			private ha			sum ha		
		forest land	non forest land (pastures, bare ground..)	total	forest land	non forest land (pastures, bare ground..)	total	forest land	non forest land (pastures, bare ground..)	total
Djerdap NP	82	667	40	707	389	290	679	1 056	330	1 386
Total Serbia	258	7 435	4 353	11 788	8 709	12 732	21 441	16 144	17 085	33 229

Tab. 5.5: forest fires in Djerdap NP and in Serbia in 2007

Among the biotic agents, the main fungal disease is *Nectria coccinea*, while the most important insect pest in Serbian broadleaf forest and also in the Carpathian region is Gipsy moth: (there were two big outbreaks in the last 10 years).

As mentioned previously, according to the management of Djerdap NP, one of the main objectives of Management Plans are forestry practices and the preservation of forest ecosystems. The activities of the Djerdap NP are aimed primarily at protecting and improving the forests under their jurisdiction. However, the low living standards of local people encourage the illegal logging of forests. In addition, the level of technology used in forest management is very low. The management of forest resources, including logging and the collection of plants, herbs and fungi, is focused primarily on economic gains and does not take due account of the need to maintain the structures and processes of forest habitats.

Sanitary cuts are one of the negative influences on forest ecosystems, especially in the protected forest areas of reservations and national parks. By removing healthy and so-called infected trees from the old and preserved forest ecosystems, precious biomass is taken away and the stable trophic and coenobiotic relationships, upon which the ecosystem stability is based, are disturbed. In order to preserve the biological and landscape diversity of forest ecosystems, it is necessary to establish a national strategy or a specific programme of activities, which has not yet happened (EURAC 2006).

5.1.5 Hunting

The tourism strategy of the Park also includes hunting and fishing tourism. The ancient beech and oak forests of the Djerdap National Park provide habitat for numerous population of deer, roebuck, wild boar, badger, marten, rabbit, wild pigeon, turtledove, etc. the rocky cliffs of Djerdapski Kazan are inhabited by chamois, eagle and falcon. Bear and lynx can still be found in the forests of the National Park, and wolves, jackals, and wild cats are quite numerous. The spacious Danube lake is the home of numerous bird species, and the surrounding fields are habitat for small game (partridge, pheasant and rabbit). It is possible to hunt in the territory of the park. The hunting ground employs the necessary qualified personnel and has all necessary equipment used in hunting.

Hunting season calendar	
Deer	01. VIII - 31. I
Doe and calf	15. VIII - 28. II
Roebuck	01. V - 30. IX
Roedeer and fawn	01. X - 31. I
Wild boar and wild pig	01. V - 31. I
Male and female chamois	01. VIII - 31. XII
Rabbit	15. X - 15. XI
Partridge	01. XI - 30. XI
Pheasant	01. X - 15. I
Pigeon and turtledove	01. VIII - 31. XII
Wild duck	01. VIII - 31. I

Tab. 5.6: Hunting season Calendar in Djerdap NP (Djerdap NP website: http://www.npdjerdap.co.yu/e_index.html)

5.2 ANOTHER DEFINITION OF THE CARPATHIAN REGION IN SERBIA

Considering the immense richness of flora and fauna, geo-diversity and cultural heritage of the area, the Ministry of Science and Environmental Protection (MSEP) of Serbia, has initiated a study on the adjustment of the territorial designation of the Carpathian area. Its preparation has been entrusted to the Geographical Institute of the Serbian Academy of Science and Arts (SASA). Further information and details can be found in the recent publication "National assessment of Policies, Institutions and Processes for SARD in the Serbian Carpathian Mountain" by Tar (2007).

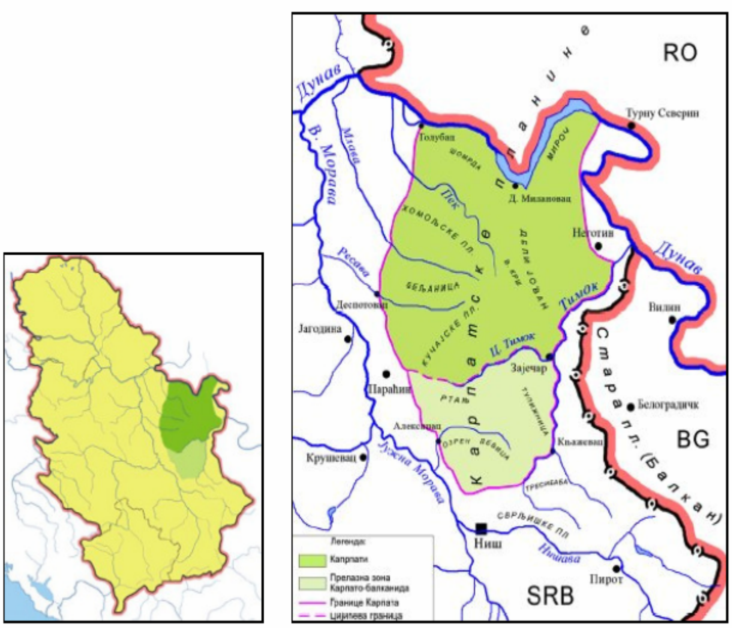

Fig. 5.4: Carpathian region in Serbia, country perspective and detailed map
Geographical Institute SASA "Dr Jovan Cvijic" (2006) (Tar 2007).

According to the new definition of "Carpathian area" the Carpathians should cover 9.7% of the total territory of Serbia (857 120 ha), with 7.3% of Serbian territory in the specific Carpathian zone and 2.4% in the Carpathian transition zone or Carpathian-Balkan massif (Geographical Institute SASA "Dr Jovan Cvijic", 2006). Highlands and mountains dominate its relief, though there are no peaks higher than 1500 m a.s.l. (apart from Rtanj Mt. 1570 m a.s.l., which is in the transition zone).

According to this alternative definition of the Carpathian region in Serbia, the forests occupy almost 40% of the Carpathian territory in Serbia (see Table 5)

Municipality	*Surface (ha)*	*Forests (ha)*	*%*
Golubac*	36 800	3 465	9.42
Zagubica	76 000	31 694	41.70
Lucevo	72 100	34 911	48.42
Negotin	108 900	27 530	25.28
Bor	85 600	31 804	37.15
Kladovo*	63 000	28 114	44.63
Despotovac	62 300	27 748	44.54
Paracin	54 200	17 910	33.04
Cuprica	28 700	5 481	19.10
Petrovac	65 500	14 326	21.87
Majdanpek*	93 200	80 592	86.47
Zajecar	106 900	28 321	26.49
Boljevac	82 700	41 155	49.76
Total	*935 900*	*373 051*	*39.86*

Tab. 5.7: Share forested land in the Carpathian region municipalities. Source: Statistical Office of the Republic of Serbia. (Tar 2007) *municipalities which include Djerdap National Park.

The forest vegetation is diverse and is of outstanding ecological and biodiversity value, particularly in the region of the Djerdap National Park, where specific climate, soil, complex relief, proximity of the river Danube and variety of historical factors have facilitated preservation of one of the richest and most complex relict vegetations in the southeast of Europe. The flora of the Djerdap area forests is exceptionally rich both from the point of view of taxonomy and ecology.

The rich forest resources bear significant potential for the economic and social development of the Carpathian region in Serbia. However, their use is currently unsustainable due to poor management practices, extensive illegal logging often done by tractor in the plains and by skidders and horses in the mountains. Exploitation of other non-wood forest resources such as forest fruits, snails, mushrooms, frogs etc. is often beyond control and no environmental impact assessment is carried out in the harvest areas.

The Djerdap National Park is situated along the international border with Romania and with the protective buffer area surrounding the Park, it covers slightly more than 10% of the territory of the Serbian Carpathians (93 967 out of 857 120 ha). In addition, the Carpathians have 8 special nature reserves, 17 natural monuments, three areas of cultural and historical significance and two landscapes of outstanding quality. Kucajske Mt. with an area of 111 500 ha, is envisaged for protection which would, once approved, significantly increase the area under legal protection. At the same time, some environmentally damaging industries are clustered in the Serbian Carpathians, posing serious threats to air and water quality, soil and biodiversity. Copper mining and smelting industry, opencast pits, metal processing (gold) industry, coal mines on several localities in the region, settlements without wastewater treatments and organized dumpsites are some of the sources (Tar 2007).

As the worst example, the area of Bor municipality is considered as one of the environmental hot spots of the whole country. Air emissions from the Mining and Smelting Company are a major environmental problem for the region since SO_2, arsenic and heavy metals are continuously present in high concentrations even when the smelter plant does not work at full capacity. Opencast mining caused severe land and soil degradation in the area and, as a result, it is estimated that approximately 1 300 ha of fertile land that would otherwise be suitable for farming, is degraded. The regular discharge and dumping of solid wastes downstream of Bor, particularly at the confluence of the Bor and Timok rivers, is causing further damage, which results in a total affected surface of damaged soil in Bor estimated at some 25 500 ha, which constitutes 60% of all agricultural soils, and results in the figure of 0.5 ha of damaged soil/capita (Tar 2007).

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6 SLOVAKIA

6.1 INTRODUCTION

The Slovak Republic, located in Central Europe, is bounded on the north-west by the Czech Republic, on the north by Poland, on the east by Ukraine, on the south by Hungary and on the south-west by Austria. The total area is 4.9 M ha (FAO: http://www.fao.org/forestry/site/countryinfo/en/).

Fig. 6.1: Topographic map of Slovakia (Source: (UNEP/GRID: http://maps.grida.no/region)

The western branches of the Carpathian Mountains cover much of Slovakia. The High Tatras extend along the northern border, while the Little Carpathians and the White Carpathians dominate much of the west and north-west. Gerlachovsky Stit, Slovakia's highest peak, rises 2 655 meters in the High Tatras. Other important mountains include the Low Tatry, in central Slovakia, and the Lesser and Greater Fatra ranges, in central and western Slovakia. At lower elevations, the land is hilly, interspersed with river valleys (FAO: http://www.fao.org/forestry/site/countryinfo/en/).

Slovakia has a continental climate, with four distinct seasons. Winters are typically cold and dry, while summers tend to be hot and humid. The average daily temperature range in Bratislava is -3° to 2° C in January and 16° to 26 °C in July. Temperatures are cooler in the mountains. Bratislava receives an average of about 650 mm of precipitation annually, while the mountains may receive up to 1 000 mm (FAO: http://www.fao.org/forestry/site/countryinfo/en/).

Slovakia has a total forest area of about 2 M ha, with a forest cover of 41%, which ranks the Slovak Republic among the most forested countries in Europe.

6.2 FOREST AREA

According to the National Proposal for the delimitation of the Carpathian region (EURAC 2006), Carpathian region covers about 71.5% (3.5 M ha) of the Slovak Republic. The whole national forest area (2.007 M ha in 2007) is located in this region, so that the forest cover of the Carpathian region is about 57%.

During the last 40 years, the total acreage of forests in Slovakia has increased by more than 10%. The total growing stock increased almost twofold; today it is 190 m^3 ha^{-1} (FRI 2002). The main causes are the abandoned agricultural land overgrown by forest species for long periods of time and reforestation (afforestation) practices, according to the Programme for the Reforestation of Lands not Suitable for Agricultural Production.

Although forests are concentrated in a small area, a wide range of original tree species have been preserved. Broad-leaved species predominate in the lowlands and hill territories of the south and east, while in the mountains of the central and northern areas there are mixed forests, with coniferous species dominating. In the mountainous areas, mixed stands of spruce, fir and beech prevail. Forest ecosystems are stable. There are untouched areas, containing many original species of fauna and flora. Populations of brown bear, lynx, wolf, golden and lesser spotted eagle, and otter exist and, in the alpine region, marmot and chamois (Hrvol 1997).

Based on the degree of naturalness, the forests are divided into several categories: primeval forests undisturbed by man, natural forests, semi-natural forests and plantations, both of production and protection type. Naturalness of a particular stand is assessed on the basis of its composition and spatial structure. The majority of Slovak forests belong to the category of natural forests (946 000 ha, 49%) and semi-natural forests (940 000 ha, 48.8%). A small percentage of forests also fall within the category of primeval forests (24 000 ha, 1.2%); the remaining 1% are plantations (19 000 ha) (Ministry of Agriculture of the Slovak Republic 2006).

6.3 FOREST FUNCTIONS

The forests are divided into several functional categories:

Forest category	Year											
	1980		1990		2000		2004		2005		2006	
	(000 ha / %)											
Commercial	1 439.1	77.3	1 367.1	71.1	1 273.8	66.3	1 294.0	67.0	1 307.7	67.7	1304.8	67.5
Protection	183.8	9.9	258.5	13.5	306.7	16.0	326.54	16.9	327.8	17.0	327.8	17.0
Special-purpose	187.6	10.1	230.9	12.0	340.9	17.7	310.2	16.1	296.1	15.3	296.1	15.7
Land base for afforestation	51.1	2.7	65.2	3.4	--	--	--	--	--	--	--	--
Together	1 861.6	100	1 921.7	100	1 921.4	100	1 930.7	100	1 931.6	100	1932.1	100
Forests available for wood supply							1 7466	90.5	1 751.2	90.7		

Tab. 6.1: Forest category area and forests available for wood supply Source: Summary data of the forests in SR (Ministry of Agriculture of the Slovak Republic 2006, 2007)

In addition to multiple production functions, most commercial forests also provide a whole range of environmental and societal benefits; provision of these may however in some cases lead to increased management costs and reduced timber yields.

All forests regardless of type provide a multitude of ecological functions. The forests where these are the main management objective are designated as protection forests. Designation and functional typing of these forests is based natural conditions such as gradient, soil conditions, etc (Ministry of Agriculture of the Slovak Republic 2006).

Forests primarily managed for social benefits fall under Slovak forest legislation into a category of special-purpose forests. In relation to these forests, the new act introduces the term “special management regime”, a draft version of which constitutes an inherent part of the application for special-purpose forest designation. If the regime somewhat restricts lawful ownership rights, the owner (steward) is entitled to financial compensation. In this instance, a compensation claim is lodged against the designation proponent. An agreement is sought on the amount and means of compensation. Implementation of special management regime often results in the following: loss or reduction of projected timber yields, restricted availability of additional forest benefits and services, and increased management cost when compared to standard methods.

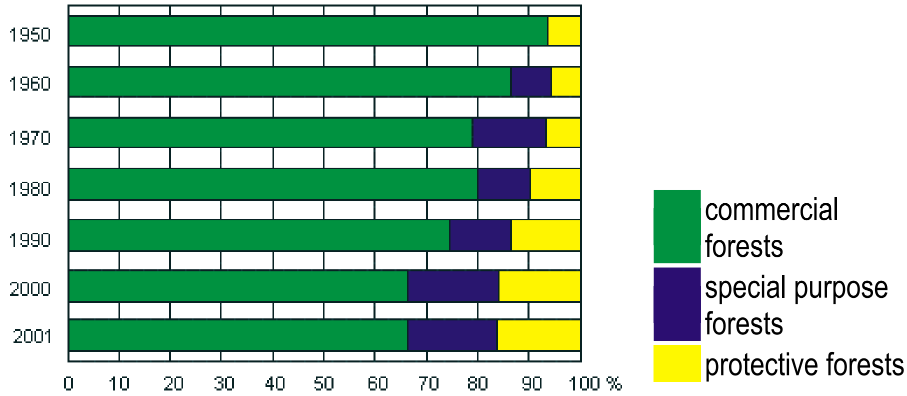


Fig. 6.2: Development of forest categories in Slovakia (FRI 2002)

6.4 FOREST TYPES

In the past, the tree species composition of Slovak forests was most influenced by the drive for maximum timber production. To meet this objective, spruce and pine were planted in large numbers. From the 1950s onwards, though, forest planners gradually started to realize the importance of species composition based on the exact conditions of a particular site. At the same time, public demand for elivery of a multitude of forest functions including non-productive forest benefits and services started to grow. At present, the demand for conservation of forest biodiversity is increasingly being recognised as one of the most fundamental objectives of modern-day forest management. This approach has significantly contributed to improved ecological stability of forest ecosystems and their sustainable development even if particular tree species suffer under dramatic changes to site conditions brought on by climate change, human activities or natural disturbances (Ministry of Agriculture of the Slovak Republic 2007).

When compared with surrounding states, a special feature of Slovak forests is that in a relatively small area there is a variety of different natural conditions and various types of forests, from lowland to mountain forests. Furthermore, a wide range of original tree species and mountain communities has been preserved. Mixed stands of spruce, fir and beech are the typical forest community of mountain areas in Slovakia (FRI 2002).

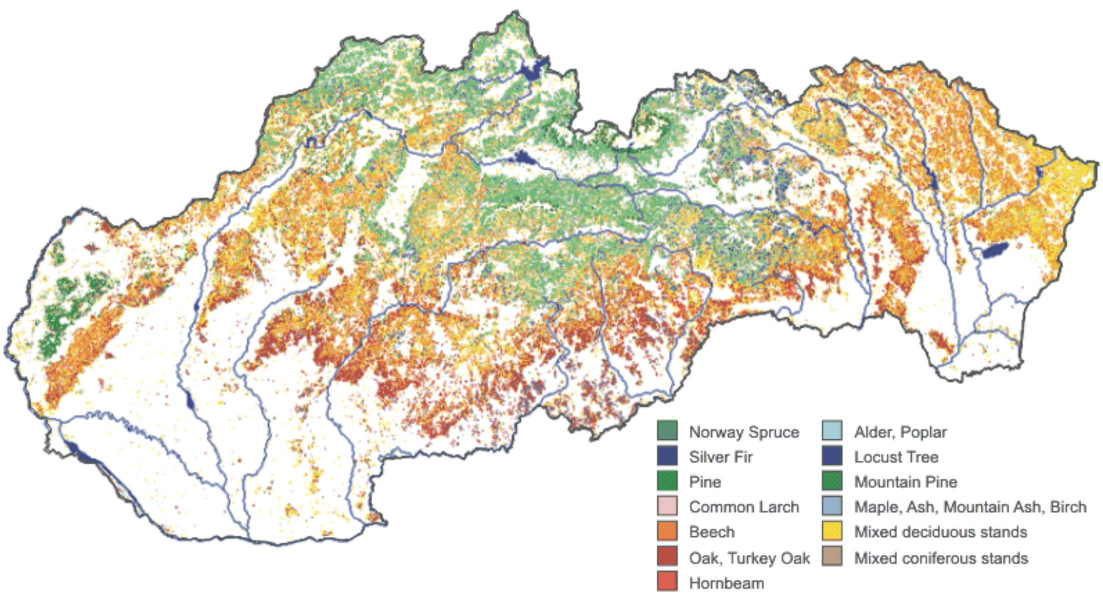
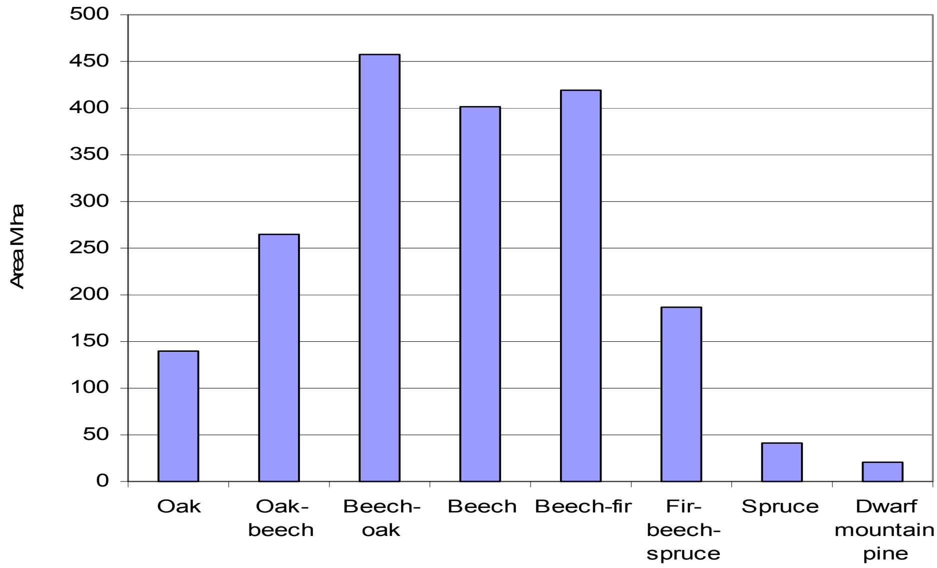


Fig. 6.3: Map of forest species in Slovakia (FRI 2000: http://www.fris.sk/en/index2.htm)

The national classification system groups forest sites into several categories based on the 8 basic vegetation zones. Particular vegetation zones differ greatly in a number of basic climatic variables such as altitude, length of vegetation period, mean annual temperature and annual precipitation. On a horizontal scale, the system is based on variables describing local soil conditions, water regime and topography. Great variableness of natural and growth conditions is responsible for the introduction of special units called forest site types. These units are further grouped into higher hierarchical units called management units of forest site types (MUFST). It is assumed that forest stands belonging to a particular MUFST respond similarly to silvicultural, harvesting and protection measures. In practical terms, these units are used to set realistic management objectives (Ministry of Agriculture of the Slovak Republic 2006).



Tab. 6.2: Forest vegetation zones. Source: Ministry of Agriculture of the Slovak Republic 2007

MUFST	Unit	Area (ha)	MUFST	Unit	Area(ha)
108	Oak – hornbeam woods on loess	24 427	402	Calcareous beech woods	31 650
111	Fertile oak – hornbeam woods	20 144	410	Fertile beech woods (drier type)	97 962
112	Oak – pine woods on most productive acid soils	26 308	411	Fertile beech woods	153 466
208	Oak – beech woods on loess	87 925	413	Moist beech woods	22 231
209	Dry oak – beech woods	39 834	416	Beech woods with *Tilia* spp. On rocky soils	22 975
211	Oak – beech woods	76 309	502	Calcareous beech – fir woods	25 117
302	Calcareous beech – oak woods	21 988	505	Acid spruce – (beech) – fir woods	49 264
305	Acid beech – oak woods	35 130	511	Fertile beech – fir woods	247 774
310	Fertile beech – oak woods (drier type)	125 733	592	Calcareous beech – fir woods (protection type)	25 083
311	Fertile beech – oak woods	170 021	605	Acid spruce – (beech) – fir woods	31 247
313	Moist beech – oak woods	36 076	611	Fertile spruce – beech – fir woods	6 598
316	Beech – oak woods with *Tilia* spp. on rocky soils	20 195	—	Other	477 592

Tab. 6. 3: The most common forest site type management units (> 20 000 ha). Source: Compendium of Slovak Forest Statistics (SFMP, PFI), 2007 (Ministry of Agriculture of the Slovak Republic 2007)

Contemporary species composition of Slovak forests results from natural site conditions and society's needs for particular forest benefits, services and products. From the long term management perspective, one of the most important challenges Slovak foresters are facing at present is to improve diversity of forest stands to strengthen their resilience and vitality.

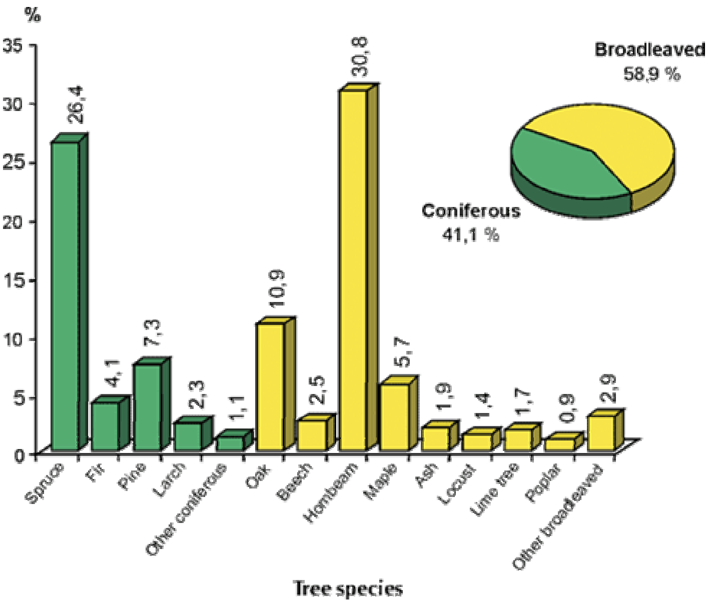


Fig. 6.4: Tree species composition in Slovakia (Lesoprojekt, 2004: http://www.lesoprojekt.sk/english/skladacka/frame.html)

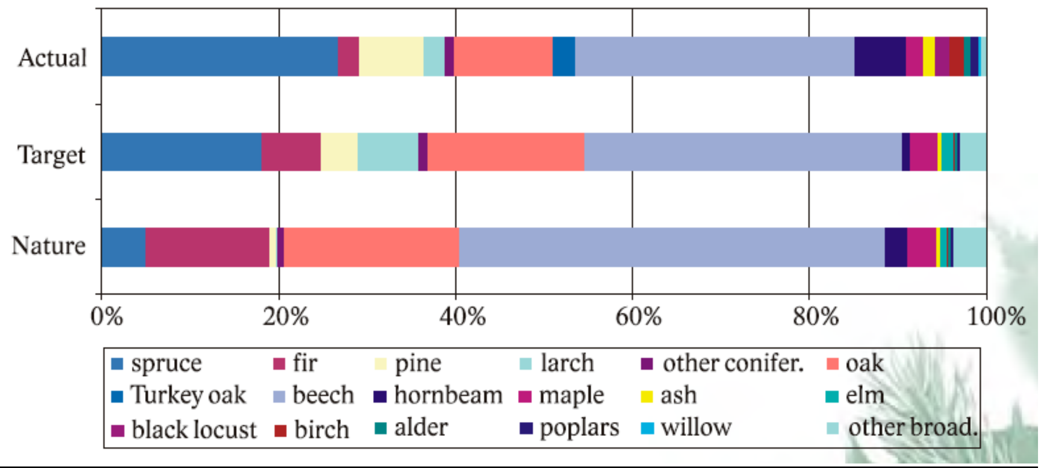


Fig. 6.5: Comparison between actual, natural and target tree species composition. Source: Natural and target species composition: FRI Zvolen 1998. Actual tree species composition: Summary data on the forests in SR, 2006 (Ministry of Agriculture of the Slovak Republic 2006)

Forest tree diversity is one of the most important prerequisite for their resilience and stability. Tables 6.4 and 6.5 show the level of forest diversity in Slovakia.

Forests with coniferous percent		*Forests with broadleaved percent*		*Mixed forests*	*Clearing*	*Total*
+91%	*75–90%*	*+91%*	*75–90%*			
478 621	121 357	816 466	141 035	362 500	11 666	1 931 645
24.8	6.3	42.3	7.3	18.7	0.6	100

Tab. 6. 4: Area of coniferous, broadleaved and mixed forests (ha / %) Source: Summary data on the forests in SR, 2006 (Ministry of Agriculture of the Slovak Republic 2006)

Number of tree species / area (ha, %)								
1	*2*	*3*	*4*	*5*	*6*	*7*	*>8*	*Clearing*
344 030	447 030	492 233	337 889	176 152	77 399	30 240	15 006	11 666
17.8	23.1	25.5	17.5	9.1	4.0	1.6	0.8	0.6

Tab. 6. 5: Area of forests by number of tree species. Summary data on the forests in SR, 2006 (Ministry of Agriculture of the Slovak Republic 2006)

A number of naturalised exotic tree species are also to be commonly found in Slovak forests. Some of these species such as Douglas fir, grand fir and northern red oak have adapted so well that they thrive in their new homeland. In recent years, the area of forests formed by exotic species has remained stable except for the continuing expansion of black locust, the competitive edge of which is well noticeable also on non-forest land (Ministry of Agriculture of the Slovak Republic 2006).

Current management policy is oriented to the achievement of a more natural stand composition: forest management plans (FMPs), which are legally binding documents are designed so, that more broadleaved species are regenerated and especially old Spruce forests are being converted to mixed stands.

6.5 FOREST STRUCTURE

The age structure of the majority of central Europe forests is a direct result of past management practices. As one of the most important forest management attributes, it fundamentally mirrors methods and scale of stand regeneration and effectiveness of silvicultural treatment applied.

Even distribution of age classes is imperative for sustainable timber production and delivery of other forest-related benefits and services. In forestry practice, the assessment of actual forest age structure is usually based on a so-called optimal area of age classes. At present, the age structure of Slovak forests partially deviates from the one seen as optimal. The deviation is most apparent in the group of middle (6 – 9) and oldest (15+) age classes, which are over represented. disproportionately high presence of forests in the oldest (15+) classes is chiefly attributed to a high per cent of over mature protection forests. For all age classes, broadleaved species prevail over conifer species.

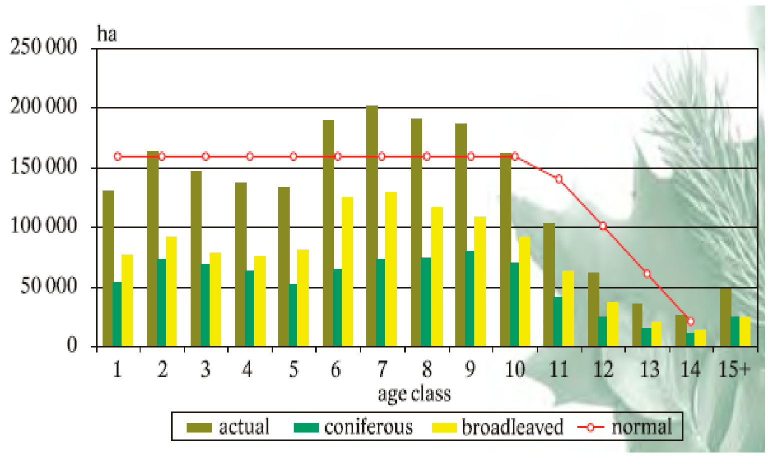


Fig. 6.6: Age structure of forests in Slovakia according to age classes (Ministry of Agriculture of the Slovak Republic 2006)

One of the most fundamental tools of ensuring sustainable and steady timber production is the rotation period. At present, the average rotation age of Slovak forests is 122 years; 108 years for commercial forests; 116 years for special-purpose forests; and 193 years for protection forests. The average length of regeneration period is given as 41 years, 30 years for commercial forests and 35 years for special-purpose forests. In protection forests, where the main management objective is to attain natural forest structure, the regeneration period is presumed permanent (Ministry of Agriculture of the Slovak Republic 2006).

In primeval and natural forests, where the spatial and age structure is very diverse, a continual replacement of over mature, diseased or natural disturbance damaged trees is an integral part of natural forest dynamics. However, this is not the case for the majority of European forests established by mankind in which age diverseness is aided by regeneration felling.

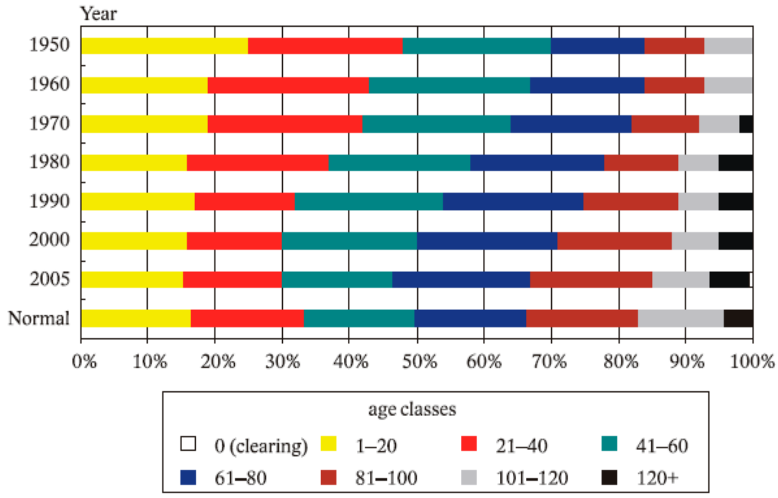


Fig. 6.7: Trend of age composition of forests according to age classes (Ministry of Agriculture of the Slovak Republic 2006).

As for the age and vertical structure, most Slovak forests belong to single-storey, age and height little differentiated forests (79%). On the contrary, three- and multi-storey forests cover only 2% of the country's forest estate.

6.6 FOREST CONDITION

The unfavourable development of the state of health of the forests due to harmful impacts, in particular the synergistic influence of emissions and climatic factors (extreme droughts and warming during recent years), which reduces the functional potential of the forests and causes huge losses not only in timber production but in fulfilling the public functions of forests as well, highlights the need to concentrate attention on enhancing the ecological stability and resistance of forest vegetation. The improvement of the situation requires an increase in the proportion of resistant plants (particularly deciduous trees). The question of the re-evaluation of the plan for target representations of woody plants in Slovak forests in relation to global warming is also urgent (EURAC 2006).

The management of fragile forest ecosystems in mountain areas is being realized mainly through the "Implementation Programme for the Removal of Damages Caused by Human Activities, in Particular by Emissions in Forest Ecosystems". The programme encompasses recovery measures in forests on almost the whole territory of Slovakia. Since this programme is extraordinarily expensive, its limitation to the most endangered areas was adopted in 1996. Projects for the areas of the Low Tatras, Kysuce, Orava and Stredný Spiš have been worked out, and have started to be implemented (EURAC 2006).

During recent years the state of forest health has started to stabilize. However, the state of health of the forests is considerably worse than the European average. The worst situation is to be found in the upper border forests, where there is a threat of destruction. The proportion of accidental felling is high (45% of all felling in 1999). In order to improve the current situation, in 2001 the Slovak Government adopted a report on the removal of damage caused by anthropogenic activities in forestry, in which it ordered the responsible ministers to elaborate a draft Programme for the Removal of Damage in Forest Ecosystems up to 2010 (EURAC 2006).

GROUND LEVEL AIR POLLUTION AND SOIL CONTAMINATION

The long-term impact of pollution, as the primary negative factor, causes destruction of forest systems in many places in the Slovak Republic. The results of seven monitoring cycles prove that this statement is valid not only for forests which are in the immediate range of pollutants, but also for forests, that are 20 km or more away from them. Due to a high density of pollution sources, forest damage of different intensities have been manifested on the entire area. Also, trans-boundary air pollution also contributes to a high percentage of damage to forests in Slovakia; above all from Poland, the Czech Republic, and from the territory of the former East Germany, as Slovakia has a very disadvantageous position in relation to them, from the point of view of prevailing winds. Then all Slovak mountains catch enormous amounts of harmful substances from precipitation. As a result, the destruction of mountain forests takes place, first of all on their upper tree line and dwarf pine stands, but also on the ridges of lower mountains (FRI 2002).

Concentrations of the majority of **air pollutants** (mainly SO_2 and heavy metals) have significantly decreased when compared to the end of 1980s. Direct impact of air pollution on the condition of Slovak forests is thus generally rather insignificant that is with the exception of high troposphere ozone concentrations in higher altitude mountain locations.

Nevertheless, indirect impact of air pollution on forest ecosystems and soils persists, although on a more limited scale then in the past. Continuing acidification of forest soils is attributed to acid depositions of sulphur and nitrogen. It is generally known that values exceeding their critical loads have a detrimental effect on soils and plant life alike. The assessment of critical loads excess, for which data for the last 50 years were used, has indicated that approximately 1/3 of Slovak forests have suffered from acid deposition. In the past, sulphur deposition typically surpassed volumes of dumped nitrogen (NO^{3-}, NH^{4+}); long-term trends, however, suggest a significant reduction in the volume of sulphur deposited on the Slovak territory and of the total acidity of precipitation. Most recent data clearly point towards ever-increasing role of nitrogen deposition in acidification processes. Towards the future, it is assumed this could become a key factor in the prosperity of Slovak forests (Ministry of Agriculture of the Slovak Republic 2006).

Lesoprojekt Zvolen and FRI Zvolen within the Partial Monitoring System on Forests and ICP International Forests Programme monitor the main indicators of sustainable production capacity of forest soils and other soil parameters. Monitoring activities involve the criteria and indicators of sustainable forest management as defined by MCPFE, namely soil reaction (pH), cation exchange capacity (CEC), base saturation (BS), carbon/nitrogen ratio (C/N), as well as other parameters associated with soil contamination and its sensitivity to ground level air pollution. Due to the long-term character of soil forming processes and a comparatively large interval of recurrent assessments, the data are not updated on an annual basis.

Remediation measures in the forests damaged by air pollutants were directed in accordance with the Programme on elimination of damage in forest ecosystems by the year 2010 (Ministry of Agriculture of the Slovak Republic 2006).

The current condition of **forest soils** in Slovakia is a direct result of ground level air pollution accumulated over several decades. Soil acidification processes are most apparent in higher elevations and regions with larger local sources of acid emissions. Measurements taken over last decade do not confirm progressing acidification of forest soils in Slovakia (if referred to pH values); in some regions, however, soils with lower buffering capacity might still be suffering from excess acidification. The problem persists with local and regional contamination of soils with heavy metals; the contamination is most noticeable in areas around major industrial facilities (Ministry of Agriculture of the Slovak Republic 2006).

OVERVIEW OF HARMFUL AGENTS

Various physical atmospheric phenomena and weather situations, or any divergence from long-term climatic norms, may have detrimental impact on forest well-being; the impact is, however, mostly temporary. Statistical data show that over the last decade there have been a number of extreme climatic events (droughts, floods, and violent wind storms) that affected both agricultural and forest production. Comparatively cold and wet spring and summer of 2005 rather discouraged rapid development of bark beetle populations and increased resistance of forest tree species against fungal infections. Despite that, the decline of forests, especially spruce woods and Austrian black pine forests, continued. In addition to the aforementioned, gypsy moth outbreaks also occurred.

The volume of incidental felling is used in Slovak forest planning practice as an indicator best describing detrimental impact of harmful agents on forest health. The indicator figure for 2005, entered into statistical record No. L–144, equalled 6.533 million m^3 (64% of the total 2005 felling) – the largest volume in the history of modern Slovak forestry (Ministry of Agriculture of the Slovak Republic 2006).

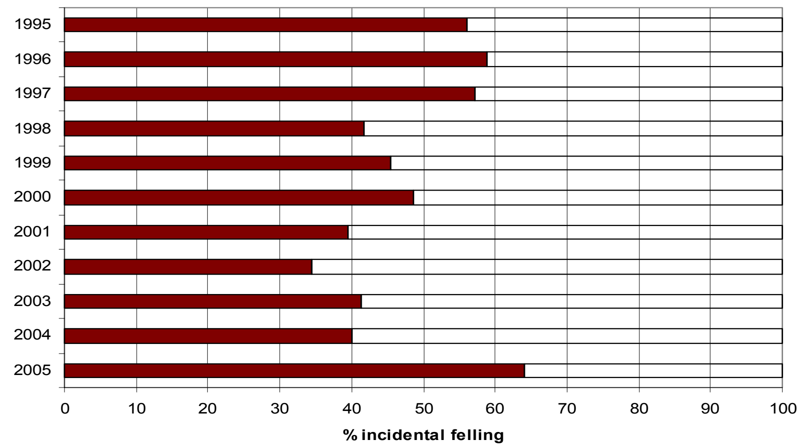


Fig. 6.8: Incidental felling percentage Source: Ministry of Agriculture of the Slovak Republic, 2006

In 2006 the incidental felling (4.27 M ha) was 51% of the total felling (Ministry of Agriculture of the Slovak Republic 2007).

The high volume of incidental felling in premature stands makes the volume of actually executed tending felling higher than planned in a long-term. In 2005 there was an extraordinarily high volume of premature incidental felling reaching 1.2 M m^3 (Tab. 6.6) and mature incidental felling in premature stands (1.7 M m^3) caused mainly by processing calamity wood after a windstorm in November 2004. The situation for coniferous tree species is very critical. Their proportion in the total volume of incidental felling in premature stands was more than 90% (Ministry of Agriculture of the Slovak Republic 2006).

Indicator	*year*			
	1990	*2000*	*2004*	*2005*
Plan (ha)	63 397	61 111	59 067	58 318
Existing situation (ha)	37 143	53 938	55 982	46 070
Plan (m^3)	1 190 418	1 220 469	1 275 606	1 284 554
Existing situation (m^3)	1 896 279	1 926 010	2 075 896	2 163 218

Tab. 6.6 Development of the extent of planned and executed thinning. Source: Summary data on the forests in SR (Ministry of Agriculture of the Slovak Republic 2006)

ABIOTIC AGENTS

The most important abiotic agent affecting Slovak forests, as well as most of the other Carpathian forests, is **wind** (Fig. 6.9).

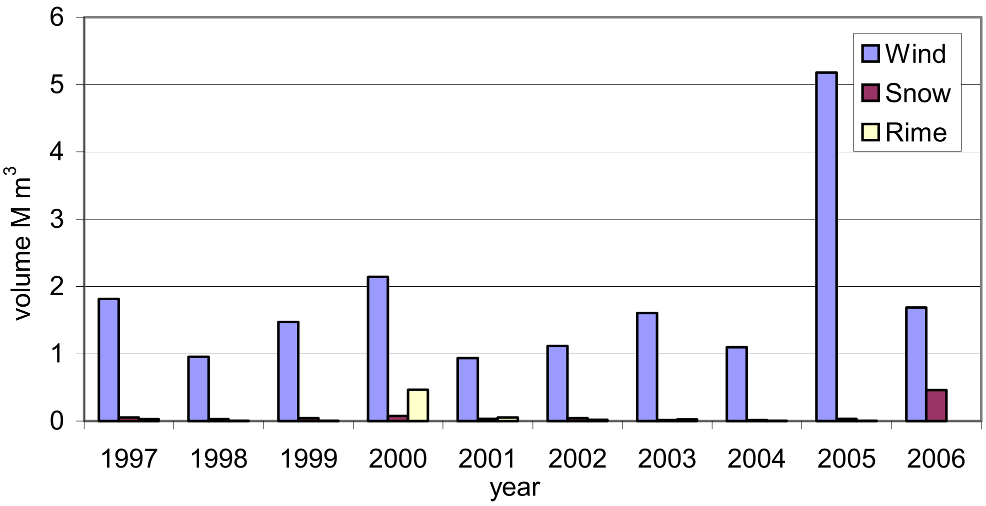


Fig. 6.9: Abiotic agents affecting Slovak forests (Ministry of Agriculture of the Slovak Republic 2006)

In terms of spatial distribution, the windthrow pattern is quite regular. Major windthrow incidents occurred in traditional “hotspots” to which primarily the northern part of Žilina and Banská Bystrica region and western part of Prešov and Košice region.

If split by particular tree species, the volume of windthrow as follows: spruce, 4 551 000 m^3; beech 205 m^3; fir 176 m^3; pine 127 m^3 (fig.6.10)

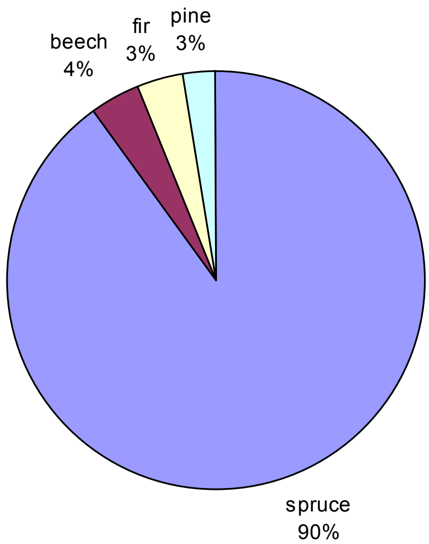


Fig. 6.10: % volume of windthrow by species, in 2005 (Ministry of Agriculture of the Slovak Republic 2006)

For the period 1996–2005, the total volume of windthrow processed timber was 17 438 m^3 with almost 30% of the volume (5.18 M m^3) processed in the year 2005 alone. Wind-induced incidental felling hence topped 2005 statistics for incidental felling caused by abiotic agents. Due to various weather extremes (wind storms, heavy snowfall, rime, and drought) and unknown abiotic agents 5.311 M m^3 of timber were processed in 2005 in total with windthrow contributing to almost 98% of the volume (Ministry of Agriculture of the Slovak Republic 2006). This high amount of wind-induced incidental felling was a consequence of the violent wind storm of Nov. 19-20, 2004. In 2005, forestry practice continued with processing of wood from that great wind disaster. Among the other abiotic agents (snow, rime and drought), it's worth mentioning drought, although the identification of drought damage is rather debatable, so the figures should be seen as a qualified estimate only. The areas with the highest percentage of drought-damaged forests include Bratislava (27 000 m^3 of salvage timber) and Trnava (24 000 m^3) regions. From the long-term perspective, drought is seen as a serious decline factor in the pinewoods of Záhorie region. The volume of drought-induced incidental felling in the pinewoods amounted to 34 000 m^3 in 2005 (Ministry of Agriculture of the Slovak Republic 2006).

Storm damage of November 2004

On Nov. 19-20, 2004 Slovakia was struck by a violent wind storm that produced enormous damage in the natural resources of the country and one death. Most damage was around the Tatras mountains in the north part of the country. News on the media reported average damage of 5 M m^3 of forest damages, of which a major part was concentrated in the area know as high Tatras. In this area, the forest in a strip of about 50 km long by 2.5 to 5 km wide was badly damaged. The affected area is situated in the north of Slovakia, near the Tatra mountains. Fig. 6.11 shows the affected area and the forest districts that were most damaged by the wind storm (Joint Research Centre 2004).

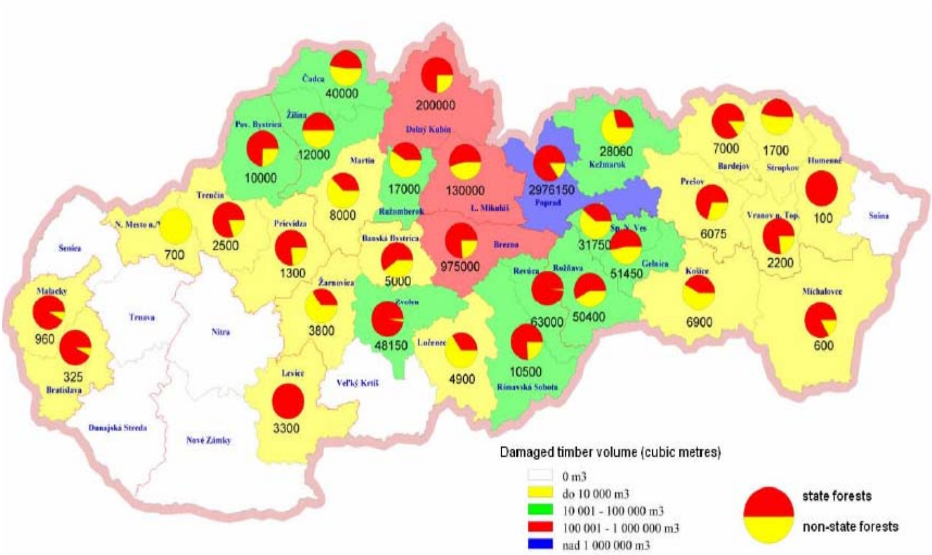


Fig. 6.11: Effects of wind storm of November 2004 on Slovak forests (m^3) by districts. Source: Lesoproject, Zvolen (Greguška 2005)

Total estimated volume of windthrown timber is about 330 000 ha, 5.4 M m^3 (total annual felling in Slovakia in 2003: 6.6 M m^3). The most damaged area was the Tatra National Park (TANAP), with damaged area over 12 000 ha. In this area, approximately 57% of damaged forest ecosystems are in the ownership of the government, while the rest is in private ownership. The affected territory was not exclusively covered with spruce monocultures and it can be stated that static and ecological stability of forest stands, with a wind strenght of about 200 km/h, did not play a major role in protection against the effects of abiotic factors. This was proved by the fact that on the affected territory, forests were also damaged that were considered stable according to evaluation criteria and, vice versa, many of those considered instable resisted the effects o the whirlwind (Ministry of Agriculture of Slovakia 2005). From the perspective of damage to stands according to age, most damaged were the stands aged 61 – 80 years (approximately 28.5%), followed by the stands 81 – 100 years old (approximately 23%) and stands 101 – 120 years old (21.8%). When quantifying the assumed volume of windthrown timber according to tree species, spruce accounts for the highest proportion (approximately 81.5%), while other species have a distinctly lower proportion (pine about 8.8%, larch approximately 7%, fir approximately 1.5%, and a small proportion of birch and alder). From the perspective of damage intensity is currently estimated that stands on approximately 73% of the total area are in a condition of complete disintegration (of which about 59% are in the ownership of the government), while about 27% (of which about 57% in the ownership of the government) are in a condition of sporadic occurrence of windthrow (Ministry of Agriculture of Slovakia 2005).

On the territory of Slovakia, excluding the region of the Tatra National Park, the total extent of the calamity is in volume of 2.5 M m^3. Of this amount, the state enterprise Forests of SR, Banská Bystrica counts 1.3 M m^3, other subjects using the state forests approximately 390 000 m^3. Damage caused by whirlwind in the non-state subjects reached the value approximately 515 000 m^3. (Ministry of Agriculture of Slovakia 2005).

Forest restoration in windthrow areas was guided by a desire to establish species-rich patch-like forests with uneven age structure to enhance their future resilience and vitality: it would be a patchwork-like mosaic of forest comprising bio groups and stabilisation belts. Forest restoration as intended is spread over a period of 15–20 years; it is based on a number of restoration projects taking into account the actual forest condition in windthrow areas (Ministry of Agriculture of the Slovak Republic 2006)

The FRI–FPS Zvolen, in line with the forest protection project drafted Forest protection measures applied in the windthrow area; the measures aimed at prevention rather than remediation of damaged stands. As for the 2005 forest monitoring, the main efforts focused on bark beetle populations in order to prevent projected infestation of windthrow-damaged forests and their adjacent areas. A combination of pheromone traps and trap trees was used to maximize the effectiveness of the implemented measures. In 2005 forest protection costs against biotic agents rose to 24 146 000 SKK in state forest of TANAP, non state forests and state enterprises (Ministry of Agriculture of the Slovak Republic 2006).

BIOTIC AGENTS

Of the biotic injurious agents of forest stands, the most dominant share on incidental felling comes from bark-beetle species and wood-borers. Other damaging agents are leaf-eating and sucking insects, rots and tracheomycosis, and game (Slovak Environmental Agency SEA 2003).

Insect pests

In 2005, forest damage caused by insect pests emulated the situation in previous years when forests were most vigorously attacked by bark beetle and woodborer species. These species damaged a total of 1.01 M m^3 of timber, of which 875 000 m^3 have been processed. Highest losses in terms of timber volume were attributed to European spruce **bark beetle** (*Ips typographus*), which damaged 899 000 m^3 of timber; 85% or 767 000 m^3 has already been removed. 2005 was the second in a row of exceptionally high bark beetle infestation in spruce woods. The year before, 888 000 m^3 of timber was killed; out of that volume 764 000 m^3 were readily removed. These rather alarming figures clearly show that bark beetle and woodborer infestation of Slovak forests has become one of the most challenging tasks forest protection has to face. Bark beetle primarily attacked standing weakened and broken trees from the 2004 calamity windthrow. It is believed that this windthrow will in due course contribute to further bark-beetle-induced decline of spruce woods. Increased activity of this beetle is expected on sites with unprocessed timber; the attack is most imminent on forest margins around windthrow openings. The intensity and scale of future attacks will very much depend on the weather as it is known that warm and dry weather considerably increases the risk of bark beetle outbreaks (Ministry of Agriculture of the Slovak Republic 2006).

High temperatures recorded in mid altitudes of Slovakia at the end of April 2006 created ideal conditions for the early spring swarming of bark beetle. Abundant terminal breakage left by the 2005–2006 snow calamities provided spruce pests with excellent breeding conditions. Snow affected areas were primarily infested by pine bark beetle; thicker branches were attacked by European spruce bark beetle and its smaller relative eight-toothed spruce bark beetle. In May and June, the bark beetle primarily attacked unsalvaged windthrows left by the November 2004 windstorm. Summer swarming started in lower altitudes in late June/early July and peaked at the end of July. The development of beetle populations was accelerated by the above-normal temperatures recorded in July and on many sites also by unsalvaged snow-damaged trees. At lower altitudes, the third swarming was observed in September. This swarming was associated with the above-normal temperatures and a lack of precipitation. Substantial swarming of northern bark beetle was also observed in the same month. In autumn, favourable weather conditions provided bark beetle, regardless of the altitude, enough time to complete their development and prepare for the next year's spring swarming, for which the majority of insect overwinter in the imago form. 2006 witnessed a number of new windthrows, very often on sites affected by the November 2004 calamity. Wind throw and breakage were fast attacked by bark beetle. Unless the timber is salvaged, the new bark beetle outbreak is projected for 2007. Statistical figures for 2006 readily confirm the largest extent of bark beetle and wood borer infestation in recent years with 1.344 M m^3 of damaged timber. Of this volume, 1.185 M m^3 have already been salvaged; the remaining 159 000 m^3 is still pending salvation (Ministry of Agriculture of the Slovak Republic 2007).

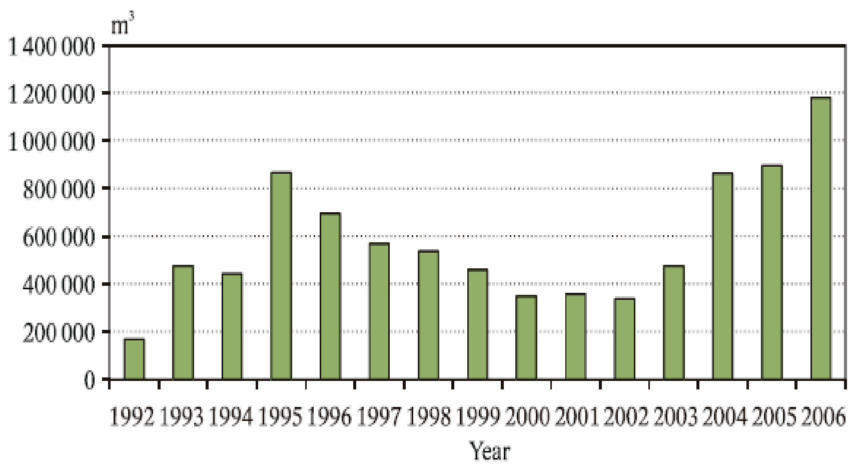


Fig. 6.12: Forest damage by European spruce bark beetle infestation (Ministry of Agriculture of the Slovak Republic 2007)

European spruce bark beetle is the most notorious pest from the group mentioned. The abundance of windthrown timber left by the calamitous windstorm in no-intervention areas set aside for conservation represents a highly powerful source of bark beetle infestation, the full force of which will be felt in 2007. Larch bark beetle *Ips cembrae* has also been recorded in some areas. It attacks larch seed trees left standing after the calamitous windthrow disturbance. A number of arolla pine specimens in the Tatra Mts. villages have been infested by European spruce bark beetle. In recent years, the introduced northern bark beetle *Ips duplicatus* has started to spread across north-western Slovakia. Monitoring efforts to keep this pest under control focused on 70 organizations of the region with 418 pheromone traps installed locally. Trap investigation confirmed almost 61 thousand imagos of this invasive pest. For the immediate future, the recommendations are to step up protection measures in selected stands of top risk areas and replace single monitoring by more effective pheromone traps. At the same time, it was suggested to continue with the pest monitoring regime as in 2006 (Ministry of Agriculture of the Slovak Republic 2007).

In 2005, the outbreak of **gypsy moth** reached its peak and for the near future a serious population decline is projected. Conclusions drawn for other leaf eating and sucking insect pests are on a more positive note with the area of forest damaged by these species steadily declining when compared to 2004. The only exception was a small increase in spruce damage by ***Cephalcia abietis*** (L.) and pine damage by pine sawfly ***Diprion pini*** (L.) (Ministry of Agriculture of the Slovak Republic 2006).

In 2006 an increase was observed in the presence of *Dreyfusia nordmannianae* sp., which regularly occurs in fir thickets of mountain regions. Aphids such as larch woolly adelgid (*Adelges laricis*) and *Sacchiphantes viridis*, sucking on larch and spruce, have since 2000/2001 caused substantial damage annually in larch thickets. Their incidence is often calamitous and is accompanied by the local/group dieback of forest on sites around Slovenská Ľupča, Beňuš, and Kriváň (Ministry of Agriculture of the Slovak Republic 2007).

Phytopathogenic microorganisms

In 2005, 274 000 m^3 of timber was entered in forest accounts as disease and pathogen damaged. Out of this volume, lower than in 2004, 248 000 m^3 were processed. Most common forest pathogens included honey mushroom *Armillaria ostoyae* and Annosum root rot *Heterobasidion annosum*. These fungi pose a serious threat to the vitality of Slovak forests and are most widespread in spruce woods of Kysuce, Orava, the High Tatra Mts. foothills, Spišská Magura Mts., Levočské vrchy Hills and Slovenské rudohorie Mts. Fungus-borne vascular diseases infected mostly oak stands (Ministry of Agriculture of the Slovak Republic, 2006). In 2006 the decline of spruce stands associated with *Armillaria ostoyae* damage continued and was further accelerated by unfavourable climatic conditions in the second half of the vegetation period, particularly extremely high summer temperatures followed by deficit rainfall in July (Ministry of Agriculture of the Slovak Republic, 2007). From the economic point of view, the increase in the incidence of dothichiza canker of poplar caused by *Cryptodiaporthe populea* was considered significant, particularly in the area of Podunajská nížina Lowland (part of the Pannonian Lowland) (Ministry of Agriculture of the Slovak Republic 2007).

Other diseases with fungus as causal agent included black pine infection by *Schaeropsis sapinea* and Scots pine suffering from *Lophodermium* needle cast symptoms (Ministry of Agriculture of the Slovak Republic 2006).

Forest game

The loss of forest revenue caused by game damage lessened between 1991 (24 501 thousand SKK) and 1999 (6.26 M SKK) with the minimum loss being experienced in the latter year. The trend was reversed in 1999 and since then the loss has gradually grown to reach 9.1 M SKK in 2006. The reduced area of young forest stands damaged or destroyed by game was 732 ha; the total financial loss was estimated at 5.8 M SKK. The damage to older forest stands was recorded on the reduced area of 159 ha; the loss of income was estimated at 3.33 M SKK. Numbers of shot deer represent a good relative indicator of their actual numbers and fairly accurately emulate long-term trends in game damage. The minimum number of shot deer (<10 000) was recorded in 1999 and 2000. Since 2001, the numbers have been rising to reach 12 000 in 2004 and 14 000 the year after. A similar trend has been observed in recent years in numbers and shot specimens of mouflon and fallow deer. For the reasons mentioned, the scale of forest damage by game is projected to rise in the coming years (Ministry of Agriculture of the Slovak Republic 2006).

ANTHROPOGENIC FACTORS

Ground level air pollution

Ground level pollution is seen as one of the most significant anthropogenic factor to blame for the compromised health of Slovak forests. Pollution-weakened forests are more susceptible to damage by abiotic and biotic agents. As previously mentioned, the level of acid deposition is despite its recent decrease still comparatively high. Despite the introduction of more environmentally friendly technologies, reduced transboundary emissions and a slump in local industrial production it will take decades for forest ecosystems to recover. The impact of pollution is most apparent in the regions of Orava and Kysuce where a so-called asymptomatic yellowing of spruce has directly been linked to worsening air quality; increased levels of sulphur oxides and heavy metals have been named as one of the main contribution factors. Among other forests hard hit by pollution are those in Gelnica, Kežmarok, and Spišská Nová Ves districts (Ministry of Agriculture of the Slovak Republic 2006).

Other anthropogenic agents

Slovakia is not known for having a serious problems concerning large wild-land **fires** and the forest fire hazard is relatively small compared to other forest land countries, but fires do occur and are feared for their potential resulting damage. Forest fires, among anthropogenic causes of forest decline, are the most prominent after pollution.

Year	*1991[1]*	*1992[1]*	*1993[1]*	*1994[1]*	*1995[1]*	*1996[1]*	*1997[1]*	*1998[1]*	*1999[1]*	*2000[1]*	*2001[1]*	*2002[2]*	*2003[2]*	*2005[3]*
Number of fires	142	305	674	366	254	662	535	1056	751	824	877	572	852	286
Total area of forest fires (ha)	233**	233**	518	96	85	220	35	32	96**	105	78**	-	-	503

Tab. 6.7: Sources: [1](UNECE/FAO 2002) [2](Slovak Environmental Agency SEA 2003) [3](Ministry of Agriculture of the Slovak Republic 2006) ** unofficial figure or secretariat estimate (When no data, received data from the previous year are carried over for inclusion in totals.)

2005 statistics record 286 forest fires with the total area of 503 ha. Out of the total number, 91 fires were a direct result of grass burning practices; 77 fires were attributed to illegal campfires; and 35 fires are believed to be caused by open fire mishandling.

Even **illegal logging** is not a serious problem, the volume of timber illegally stolen in 2006 amounted to 11 029 m^3. It is assumed that a substantial volume of timber removed from forests by poorer residents for heating and cooking went grossly unreported. The theft problem was most apparent in the districts of Čadca (1 484 m^3), Rimavská Sobota (1 150 m^3), Rožňava (705 m^3), and Vranov nad Topľou (748 m^3) (Ministry of Agriculture of the Slovak Republic 2006).

6.7 FOREST MANAGEMENT

HISTORY OF SILVICULTURAL SYSTEM

In Slovak forest management practice, high forest represents the basic forest type. The total area of coppice does not exceed 2% of the total stand land and has been continually decreasing (6.2% down since 1980). Average coppice growing stock per ha amounts to approximately 112 m^3; in high forests for timber production the respective volume is 232 m^3. Conversion of coppice to high forest is a common practice in cases when site conditions ensure significant enhancement of forest products and services in the future (Ministry of Agriculture of the Slovak Republic 2006).

The table 6.8 shows the silvicultural systems adopted for the different function of the forests.

Silvicultural system	Category					
	Commercial		Protection		Special-purpose	
	Felling area (%) / percent of forest stands (%)					
Clearcutting	37.5	36.4	21.2	6.9	28.6	25.8
Shelterwood	62.3	62.8	10.9	7.7	64.7	55.4
Selection and special purpose cutting	0.2	0.8	67.9	85.4	6.7	18.8

Tab. 6. 8: Silvicultural systems entered in valid FMP by forest categories Source: Summary data on the forests in SR (Ministry of Agriculture of the Slovak Republic 2006)

Due to the long-term positive impact of professional schools and intensive research, forest silviculture has a rich tradition in Slovakia. Nevertheless, its long history was not able to prevent many remarkable changes in the character and extent of various policies applied to it.

Silvicultural policies which were applied in the forests of Slovakia till the end of the l9th century included “nature friendly forest management”. Attempts to keep the forest's natural character dominated (in all-aged forests and in forests which varied from original tree species) both in state and non-state forests (FRI 2002).

In artificial regeneration, self setting of seeds was utilized to a high degree. The proportion of natural regeneration in this period was sometimes more then 50% of the regenerated area. Principles of selective management were applied in many forest areas, though not very consistently, this involved the felling of specific unhealthy trees, resulting in a wide variety of ages and heights and giving great durability. This policy is one of the origins of a remarkable ecology in Slovak forests today, when compared with the forests in surrounding countries.

The remarkable bias towards natural regeneration is characterized by forest silviculture at the end of the 19th and in the first half of the 20th. Regeneration of broad-leaved stands via natural regeneration, bound to variants of shelterwood cutting is considered to be an obvious choice (FRI 2002).

In the 30s and the 40s a trend towards extensive shelterwood regeneration arose (mainly in broad-leaved forests) with a shorter regeneration period, enabling the formation of more extensive non-mixed oak and beech stands in the area of the 2nd (beech – oak) and 4th (beech) altitudinal vegetation zones. Typical (originally mixed) stands began to diminish, particularly mixed soft/hardwood stands in the area of the 5th (fir – beech) and 6th (spruce – fir – beech) altitudinal vegetation zones. Regeneration procedures which were linked to border regeneration (using natural regeneration on the inner edge) were often applied in mountain softwood (particularly spruce) stands with bad accessibility – less strict variants of methods applied in Germany were used here. The application of clear-cutting regeneration procedures began. As a result, non-mixed spruce and/or pine stands arose by artificial regeneration (seeding), often on inconvenient sites (FRI 2002).

For the above reasons, the trend of applying regeneration methods increased immediately after World War II., on the basis of small-area shelterwood cutting, sometimes in combination with border cutting. This very positive trend resulted in the fact that, according to the law of 1960, the small-area shelterwood system became the basic way of management in Slovak forests. Clear-cutting was strictly limited, even prohibited. The results of typological surveys started to be applied more intensively in forest silviculture. Mixed and all-aged stands arose, which were suitable for the sites, the proportion of natural regeneration increased and intensification of care took place, with emphasis given to tending of young growth and thinning stands up to 40 years old. Specialized guidelines were issued for Slovakia’s needs for regeneration of stands, the conversion of coppice forests, the conversion of coniferous monocultures and/or on differentiated tending of stands. In connection with this, new original silvicultural methods also appeared (FRI 2002).

The 50s and the 60s were a period of biologization of all forest management, particularly of remarkable intensification of silvicultural activities in connection with the natural forest, as an integrated ecosystem. Until 1950 stereotyped clearing and thinning (with an emphasis on the principle of reduction of number, and the removal of nursery stock) prevailed in the tending of stands of saplings and thinning consisted of moderate low thinnings (specifically of trees with small-dimensions). After 1950 a rapid transition took place in the tending of young growth by removing unhealthy stock (the principle of selection was stressed) and crown thinning. This forest silviculture policy, which was strongly ecologically orientated, limited the use of heavy logging machinery, causing reduced financial returns in the short term.

Thanks to this far-sighted practice and forestry science staff, the system of improving silvicultural activities via so-called phase products was elaborated at the end of the 80s. Models of stands were defined according to typological units (established plantation, young growth after cleaning and pole-stage stand after thinning) and optimal working procedures (phytotechnology) have been designed to reach and manage them. They were verified in practice for several years and served for evaluation, financing and rewarding results of silvicultural activities.

Today, the ecologization of silvicultural activities is preferred; stricter application of more natural silvicultural methods, with an emphasis on mixed stands suited to the site, an increased proportion of natural regeneration (see Tab. 6.9), more extensive application of a commercial selection method particularly in protected forests and in special-purpose forests (FRI 2002).

Type of regeneration	*Year*				
	1990	*2000*	*2004*	*2005*	*2006*
Artificial regeneration	15 500	12 923	8 866	8 922*	9 256
Natural regeneration	3 454	2 134	5 094	4 582*	6 305
Total regeneration	18 964	15 057	13 960	13 504	15 561
Natural regeneration (%)	18.2	14.2	36.5	33.9	40.5

Tab. 6.9: Development of regeneration of forest stands in ha. Source: Summary data on the forests in SR *Artificial and natural regeneration adjusted by clearing loss due to other reasons (Ministry of Agriculture of the Slovak Republic 2006, 2007)

The new Act No. 326/2005 of the Digest on forests introduces a number of major changes to the existing management practices. According to its provisions, clear cutting as a form of planned programme of silvicultural systems throughout the life of the stand is no longer allowed. On top of that, the Act introduces a new system called a purpose cut; this system is based on the removal of individual trees to achieve a desirable forest stand structure in the protection and special-purpose forests for which it is primarily intended (Ministry of Agriculture of the Slovak Republic 2006). Due to major changes in forest ownership, the above trend is different in individual parts of Slovakia. Nevertheless, the concepts which have been elaborated and accepted, have created the basis for a remarkable improvement in silvicultural activities that will become evident in the enhanced forest condition within the next decade (FRI 2002).

The new Act also introduces "forest restoration" as a separate regeneration method in forests damaged by natural disturbances, forests with severely reduced increment, thinned and weed-choked forests, forests in need of composition improvement, and conversion forests in which site conditions for natural regeneration are no longer feasible. Forest restoration measures shall always aim at the establishment of site management and appropriate forest structures promoting the desired forest values and universal health of forest communities.

The introduction of certification according to PEFC and FSC systems will constitute a further instrument oriented to the sustainable management of forests. Up to 2003, approximately 50 000 ha of forests were certified (UNFF 2003).

CURRENT STATE OF FOREST MANAGEMENT IN SLOVAKIA

We dare to say that the system of forest management presently used in Slovakia is, in many respects, one of the most detailed and sophisticated in the whole world. Its main "tower of strength" areas are as follows:

- **Very detailed spatial division of forest into its basic units** – the entire Slovak forest land resources, that is to say all land classed as forest land according to cadastre, are divided into basic units called forest spatial division units (SPDU). These units represent a basic framework for forest management planning and forest stands assessment. In practice 4 different levels of these units are recognised:
    - *Compartments* - these are basic forest spatial division units. Therefore they should be permanent, production homogenous and manageable from the point of view of transport and logging. This prerequisite is not always possible to meet. In a more general sense of the meaning these units are equal to forest stands. Their boundaries are on clearly marked terrain and their average area varies from 5 to 10 ha.
    - *Partial plots* form sections of compartments greatly differing in age or tree species composition. It is generally assumed that they will gradually disappear following forest management measures and compartments will unify. Their boundaries are also clearly marked terrain.
    - *Parts of stands* - these form when during a regeneration phase small-scale forest management techniques are applied to larger compartments (their partial units respectively). For practical reasons they require separation into smaller temporary sections called regeneration units (in the shape of belts, groups, etc), differing mainly in age. Compartments

are again unified once regeneration has been successfully completed. Their boundaries are not marked in terrain, yet apparent age differences between individual groups are easily recognisable.
    - *Storeys* - there are usually several tree species storeys in even-aged forest stands. These differ mainly in age and height, sometimes even in tree species composition. As these units are often very important for a further development of forest stands, they are assessed separately and are considered units of detailed spatial forest division.
- **High quality forestry maps** - forest stand maps on a scale 1 : 10 000, and updated simultaneously with forest management plan renewal every ten years, form the basis of Slovak forestry mapping. They contain basic geographical data, terrain lines of all SPDU with colour distinction of their age, detailed recognition of the forest road network and footpaths and further important data relevant to forestry practice. Contour (uncoloured) forestry maps serve as a basis for the creation of various special forestry maps.
- **Whole area character of data gathering** - entire *basic* forest management data is recorded from the whole forested area of Slovakia (not only statistically). Each SPDU is assessed individually. Final measures for particular SPDU are planned equally individually. This feature of our data recording distinguishes Slovakia from many other forestry-developed countries. Whole-area survey is only one of a total 3 possible approaches to data collection as given below:
    1. *Statistical survey* - this survey is carried out on sample plots only and is suitable for the identification of the larger unit's average state. However, it is a very convenient method for trend observation. Given an adequate number of sample plots it allows strategic planning and adjustment of management measures via legislation, subsidy policy, etc. Yet, it does not provide for particular forest stand regulation. It is the most economical survey method and in Slovak terms it is used for special surveys.
    2. *Whole-area survey* - in this survey all assessed units (SPDU) are checked. It provides basic data for both strategic as well as individual planning. On principle it is costlier than statistical surveys, however, remote sensing methods used for partial data collection can dramatically decrease its cost.
    3. *Selective survey* - this method is based on the principle that whole-area data gathering is done only in selected individual forest stands. For instance those approaching maturity. Yet from the statistical point of view this method is totally worthless as it does not allow the identification of forest development trends and equally hampers practical impacts on non-selected stands.
- **General obligation of basic forest management plan indicators** - on the contrary to many other country practices, Slovak forest management plans are generally binding for all forest owners and tenure forms.
- **Complex site survey** - Slovakia is only one of a few countries that possess unified maps of site types and on top of that soil type maps for the entire area of the country. Correct interpretation of these maps requires in-depth knowledge of the subject and years of expertise. Unfortunately, at present the priorities of Lesoprojekt do not correspond with the efforts to preserve this specialisation in the future.
- **Ideal liaison between site survey and forest management** - site type maps themselves represent only a kind of *"l'art pour l'art,"* as their full importance come into light only after the formation of applied site type survey comprising of forest category type, functional type and framework planning including regeneration tree species composition, regeneration and rotation periods, etc.

FOREST MANAGEMENT PLAN (FMP)

Forest management plans are prepared for a **10-year period**. FMP is middle-range planning tool consequently projected in the short-term normally one year operating and economic plans. Basic principles of elaboration of FMP are anchored in forest Act 326/2005 and further details are in regulation No. 453/2006 of forestry planning and management. FMP is according to law tool of state, owner and manager for sustainable forest management (§40 in forest Act). Components of FMP are especially:

1. *General section of* FMP (text section) – is supplied to the forest manager in the form of single book, for the smaller owner in form of extract. It includes general survey of natural and management conditions in the area.
2.. *Description of forest units and management plan* is the most important part of FMP. It consists of single book (supplied also on data medium)
3. *Area table* contains area of all forest premises of concrete user (forest stands, unproductive areas, roads, timber storage areas etc.), summaries and comparison with cadastre.
4. *Summary tables* provide comprehensive information on forest stand status, serve mainly for analysis of logging resources and management activities
5. *Forest stand map* is necessary for using description of stands and management plan as well as basic geographical situation (edges, rivers, contour lines, ground elevations..), detailed situation of forest transportation network and forest paths and basic information on forest stands (age, forest categories, borders of protected areas etc.).
6. *Outline map* is non-coloured forest stand map, serves for the graphic part of forest management evidence and to mark changes in the field situation during validity of the FMP.

FMP execution

Detection of forest state and development and management planning is done in the following phases (§30 regulation No. 453/2006) :

1. *Complex investigation of forest state* is an investigation of data on natural, social, technical and economic conditions of forest management and forest development. Made within forest sections and sub-sections.
2. *Framework planning* is definition of the management model for the management unit in framework planning. Unit for global planning is the operative complex. It refers to forest category, silvicultural shape of forest, site conditions, stand conditions and threats. Management models are the groundwork for execution of FMP and are part of the principles for FMP execution for concrete forest unit.

Management model contains :

a) management goal – tree species composition, final timber production, final stand structure

b) basic framework of management – silvicultural system and its forms, age of cutting, regeneration period, safeguard period and rotation period

c) management principles – forest treatment, forest regeneration, forest protection and forest reconstruction

Detailed investigation of forest state is investigation of silvicultural shape, operative complex, terrain exposition and slope, area, age, stocking, stand volume, tree species composition, mean height, mean diameter, site class, defects and phenotype. For each category of forest current, mean and total increment is listed.

Detailed planning determine management arrangements for units, partial areas, stand groups and stages for the valid period of the FMP. Within management operations, responsibilities for regeneration, treatment and protection of the forest, forest amelioration and logging. According to the analysis of state of the forest stand mentioned in the general section of FMP, the executor of FMP nominates use of logging indicator. Continuously executes project of logging possibilities for next six decades.

Practice by executing and endorsement of FMP:

- forest owner or forest manager notifies the Civil Service for Forestry of the end of validity of FMP (18 months in advance),
- Civil Service for Forestry notifies owner or manager at the latest 10 days after contract was closed about execution of FMP with successful candidate
- Details for executing of the report on forest management are offered to the executor till 31st January of last year of validity of FMP through the forest manager

- Project of FMP is discussed with the forest manager before it is introduced to the county magistrate
- Into the project of FMP introduced to county magistrate till 15th December of last year of validity, are incorporated changes in cadastre and management activities during the period between field work and until last year of validity of FMP are incorporated.

Functions of FMP

- Supply data and directions for forest manager,
- Civil Service organs for forestry use FMP as a tool for control of management, state supervision as well as global information about state and development of forest fund for performance of forestry policy
- Civil Service organs for the environment have information about state and development of the forest fund necessary for administration,
- Department of forest resources and informatics uses data for executing of FMP within their databank,
- Other executors of FMP (private taxation offices) use FMP made by Lesoprojekt as groundwork for evaluation of management in the past.

MECHANISATION IN MAIN AND INTERMEDIATE FELLINGS

To reduce the cost of cutting and transporting wood, these processes were industrialized and forest biological systems were sometimes compromised.

Power saws for timber felling represent the most negative form of forest technique, through environmental contamination from lubrication oil. Currently, Slovakia is substituting mineral-based lubricants with rapeseed oil, which is highly bio-degradable by soil micro-organisms. After an initial phase of rapeseed oil use in the Tatra National Park, its use was extended to other protected areas and commercial forests. However, the level of use compared to traditional lubricants is still insufficient.

Sound silvicultural subdivision of forest land and use of a combination of skidding winch and forest tractor provide an almost certain possibility of reducing the negative effects of techniques on the forest environment.

In sloped terrain over 40%, wet land and the flysch zone, there is a tendency to use remote controlled cable systems to extract wood from stands.

Special wheeled forest tractors are used on slopes up to 50% alongside cables in mountainous terrain. A special programme has been prepared for regeneration of cable skidding, covering the entire field of Technological preparation of stands, and the construction and operation of cable facilities.

Horses are also used for the skidding.

Timber are transported by truck or by helicopter.

FOREST INVENTORY AND MONITORING

The Ministry of Agriculture supported the launch of the first national forest inventory and monitoring scheme (NFIM) in 2005. The main objective of this newly introduced scheme is to ensure that forest managers, policy makers and the general public obtain access to a periodically updated comprehensive set of forest data covering all aspects of forest resource management on both a national and regional level.

The national forest inventory (NFI) uses selective methods based on temporary sample plots with forest data collected to a specific point-in-time.

Forest monitoring, on the other hand, is defined as periodic repeating of national forest inventory (§ 46 of the Act No. 326/2005 of the Digest on forests).

Following the decision of the Ministry of Agriculture of the Slovak Republic No. 3473/2004-710 of July 1 2004, the first phase of a 2-year NFI field sampling cycle was launched in 2005.

The responsibility for data collection, controlling, task coordination and methodological support was delegated to the FRI Zvolen. Practical field sampling including the establishment of sample plots was secured in cooperation with the Lesoprojekt Zvolen (four 3-member crews) and the Euro Forest. s. r. o. (1 crew) in a 4 × 4 km sampling grid; the grid covers all area with forest vegetation, both the forest lands as well as other lands including forested farmland. In 2005, 776 sample plots out of the total number of 1 485 were investigated.

A combination of common forest mensuration equipment and latest technology (GPS, Field-Map) is used for forest data collection in the field. The scope of investigation is rather substantial as over 100 variables are routinely recorded on an each plot.

In the next step, the collected data is processed and outputs are delivered to clients in the structure and format agreed. The outputs comprise information on the following: forest area, forest production (No. of trees, growing stock, log grades, forest structure, forest regeneration, timber quality, silviculture standard), forest condition, forest damage, site conditions, ecological conditions (soil type, forest site type, functional type, degree of naturalness, damage risk, ecological stability, biodiversity, deadwood, forest game fodder, forest margins, etc.), other forest-related issues (forest road network, watercourses and water resources).

6.8 WOOD SUPPLY

GROWING STOCK AND INCREMENT

Latest statistics show a steady increase in the volume of growing stock in Slovak forests (tab. 6.10). The exact figure for 2005 was 438.9 million m^3 of timber with a top diameter greater than 7 cm under bark (u.b.). The average stock was estimated at 229 m^3 ha^{-1} of the abovementioned size timber.

When compared to 1970, the total volume of growing stock increased by 40.8% (from 313.3 M m^3 in 1970 to 438.9 in 2005); at the same time, the average "ha" volume increased by 33.9%. This increase has largely been attributed to both the uneven age structure of Slovak forests with a disproportionately high presence of 50 to 90-year old forest stands and more accurate methods of growing stock estimate (improved yield tables). A gradual annual increase of growing stock has been observed, with progressing age and height yield class for each of the selected tree species. The stand density is largely even with only a slight decline towards the 5th age class. From the 6th class onwards, a steady increase of the stocking is observed. Observations show that the aforementioned parameters are the ones largely responsible for the ever-increasing growing stock of Slovak forests.

Indicator	*1970*	*1980*	*1990*	*2000*	*2004*	*2005*	*2006*
	M m^3 u.b.						
Growing stock total	313.3	324.0	348.5	410.0	434.4	438.9	443.8
Conifers	169.0	170.0	178.9	199.1	205.6	207.4	209.8
Broadleaves	144.3	154.0	169.6	2109	228.8	231.6	234.0
Growing stock per ha (m^3)	171	174	181	215	226	229	231
Growing stock in forests available for wood supply:					398.6	403.4	409.1
- Conifers					186.1	187.9	190.8
- Broadleaves					212.6	215.5	218.3

Tab. 6.10: Growing stock. Source: Summary data on the forests in SR (Ministry of Agriculture of the Slovak Republic 2006, 2007)

The trend of the total current increment suggests a gradual increase in the volume of timber available in Slovak forests; contemporary age structure and progressive growing stock volume generate the rise (tab. 6.11) .

Indicator	*Year*					
	1980	*1993*	*2000*	*2004*	*2005*	*2006*
Total current increment (M m^3)	8.84	10.01	11.20	11.53	11.58	11.67
Total current increment / ha (m^3)	4.75	5.19	5.83	6.07	6.10	6.14
Felling volume (M m^3)	5.86	4.18	6.22	7.27	10.19*	8.357*
Felling volume/ TCI (%)	66.3	41.8	55.5	63.0	88.0	71.6

Tab. 6.11 Trend of total current increment. Source: Summary data on the forests in SR *In 2005 and 2006 felling volume was influenced by processing wood from the wind calamity of November 2004 (Ministry of Agriculture of the Slovak Republic 2006, 2007)

TIMBER FELLING

In 2005, more than 10.2 M m^3 of wood was felled in Slovak forests, of that 6.9 M m^3 of conifers (tab. 6.12). An increase of almost 3 M m^3 in comparison with 2004 was caused by the wind calamity of November 2004. The result of this disaster was 64% of incidental felling of the total timber felling (almost 89% of coniferous trees felling and 12% of broadleaved trees felling). In the interest of a fast and effective processing of wood from the wind calamity, as well as with the aim eliminating a possible expansion of bark beetles, harvester technologies were used; in the State Forests of the Tatra National Park this was 53% of the total volume of processed calamity wood. In the Lesy SR, š. p., the proportion of harvester technologies reached 8%.

Indicator	*Year*									
	1990		*2000*		*2004*		*2005*		*2006*	
	Executed felling (M m^3 of wood with dbh > 7cm u.b. and of that incidental felling (1000 m^3 of wood with dbh > 7cm u.b. / %									
coniferous	2 777	1 838	3 245.0	2 012	4 000.7	2 550.0	6 927.4	6 152.7	5 150.0	3 831. 0
		66.2		62.0		63.9		88.8		74.4
broadleaved	2 499	766	2 973.0	1 010	3 267.4	361.0	3 263.1	380.3	3207.2	435.0
		30.7		34.0		11.0		11.7		13.6
together	5 276	2 604	6 218.0	3 021	7 268.1	2 916.0	10 190.5	6 533.0	8 357.2	4 266.0
		49.3		48.6		40.1		64.1		51.0

Tab. 6.12: Development of realized timber felling. Source: Summary data on the forests in SR (Ministry of Agriculture of the Slovak Republic 2006, 2007)

In 2005 6.52 M m^3 (64%) of wood was felled in state forest, of that 4.442 M m^3 was coniferous wood and 2.077 M m^3 was broadleaved. In the non-state sector there was felled 3.695 M m^3 (36%) of wood was felled, of that 2.499 M m^3 was coniferous and 1.196 M m^3 was broadleaved wood (Ministry of Agriculture of the Slovak Republic 2006).

6.9 NON WOOD PRODUCTS

Public access is guaranteed to all state forest areas for the collection of berries and mushrooms and for recreation. The Slovak forest policy establishes public access as an "important democratic principle which makes it possible for every citizen to enjoy recreational and therapeutic time in forests" (Upton 1994).

Game management and hunting

According to the Ministry of Agriculture of the Slovak Republic (2006), the total area of the hunting land is 4 436 461 ha. The area of agricultural land is 2 328 000 ha, forest land 1 980 000 ha, water areas 51 000 ha and others 78 000 ha. In 2005 there were 1 806 hunting districts in Slovakia. 23 of these were independent game preserves and 16 pheasantries. In 2005 the average area of a hunting ground was 2 456 ha (in 1990 it was 3 391 ha, so greater by 935 ha). The number of a hunting grounds put on lease by Hunters' Association of the Slovak Hunting Union is decreasing. The number of hunting grounds leased to subjects not belonging to the Slovak Hunting Union is increasing.

Spring stock of ungulates was higher at 31 March 2005 in comparison to the previous year except for wild boar. This tendency can be observed from 1998. Another increase in the number of individuals of ungulates, except for roe deer, is undesirable because of the growing damage to forest stands and agricultural crops caused by roe deer. Shooting of red deer, fallow deer and mouflon was higher in 2005 than in previous year, but despite that the shooting plan was not fulfilled. Shooting of roe deer and wild boar was lower.

Spring stock of pheasant, rabbit and wild turkey has increased. Spring stock of hare and partridge has decreased. Litter size of carnivorous animals, except for wildcat, has increased in accordance to statistics.

The number of other rare animal species have slightly decreased in comparison to the previous year except for the otter, black cock, bison and beaver (Ministry of Agriculture of the Slovak Republic 2006).

Hunting of rare animal species is strictly regulated. Permitted shooting of bears was a total of 66, but only 35 were shot. A pursuance of permitted bear hunting has stagnates for several years. The main reason for not observing this rests on restricted conditions determined by the ministerial environment department. 74 wolves and 8 chamois of alpine origin were hunted. A considerably higher number of chamois (625) was registered than in previous year (522).

In 2005 game management revenues were 208 472 000 SKK and expenses 222 773 000 SKK, which means an economic loss of 14 301 000 SKK. In 2004 it was -10 087 000 SKK. An economic gain was observed in overhead hunting grounds of state forest enterprise Lesy SR and approximately balanced the grounds put on lease by the Hunters' Association of the Slovak Hunting Union. Other groups of hunting grounds had negative economic result (Ministry of Agriculture of the Slovak Republic 2006).

6.10 PROTECTIVE FUNCTION

As said before, the share of protection forest category, where protection, conservation and ecological functions are the main objectives, is 17%, while the "special purpose forests" category occupies 15.3% of total forest area. These forests are primarily managed for social benefits, but also for water purification, nature conservation, mitigation of air pollution etc.

Forest ecosystems represent an extremely valuable part of Specially Protected Territories (SPT) and it is here that an overlap of interests between forestry and nature and landscape protection occurs most frequently. A complex nature and landscape protection is carried out pursuant to the Act no. 543/2002 of the Digest on nature and landscape protection. Five degrees of nature protection are determined within territory protection. Protected territories can be divided into 4 zones on the basis of biotope condition (fig. 6.13): A zone with the 5th degree of protection, B zone – 4th degree of protection, C zone – 3rd degree of protection and D zone – 2nd degree of protection (Ministry of Agriculture of the Slovak Republic 2006).

Degree of protection	Protected territories	Area (ha)	Percentage of the area of SR	Forest percentage
2nd	CHKO, zone "D" CHKO Horná Orava: 491 260 ha, OP NP, zone "D" PIENAP: 267 065 ha	758 325	15.46	66.1
3rd	NP, zone "C" PIENAP: 247 654 ha, OP PR: 86 ha, OP NPR: 875 ha, OP PP: 159 ha, CHA: 601 ha, OP CHA: 2 419 ha Zone "C" CHKO Horná Orava: 14 793 ha	266 287	5.43	91.1
4th	CHA: 4 600 ha, OP PR: 158 ha, PP: 884 ha, PR: 3 376 ha, OP NPR: 1 935 ha, OP PP: 48 ha, OP NPP 27 ha, Zone "B" PIENAP: 837 ha, NPP: 58 ha, NPR: 2 319 ha, Zone "B" CHKO Horná Orava: 3 356 ha	17 598	0.36	64.7
5th	PR and private PR: 9 473 ha, NPR: 81 393 ha, PP: 660 ha, NPP: 1 ha, Zone "A" PIENAP: 277 ha, Zone "A" CHKO Horná Orava: 1 263 ha	93 067	1.90	74.0

Fig. 6.13: Area of special protection areas according to the level of protection (State to 31 December 2005) Ministry of the Environment of SR. Explanatory notes: CHKO – protected landscape area, NP – national park, CHA – protected range, (N)PR – (national) nature reserve, (N)PP – (national) nature landmark (Ministry of Agriculture of the Slovak Republic 2006)

Total area of SPT was 1 135 277 ha at 31 December 2005, including the protection zone, which constitutes 23.2% of the SR territory. Total forest cover in the 2nd–5th degree of protection is 72.6% and the importance of forest ecosystems in those territories is clear. At present the whole system of protection areas consists of 9 national parks (NP), 14 protected landscape areas (CHKO) and 701 small-area protected areas

(MCHÚ), which include national nature reserves (NPR), nature reserves (PR), national nature landmarks (NPP), nature landmarks (PP) and protected ranges (CHA). In the table 6.13, the Slovakian Nationa Parks:

National Park	Area (ha)	Of that forest land (ha)	Area of protection zone (ha)	Of that forest land (ha)	Forest types
Tatranský národný park (TANAP) NP - BR	73 800	69 829	30 703	6 446	spruce forests, with occurrence of Scots and arolla pines, polish larch, maple and beech trees
Pieninský národný park (PIENAP) NP	3 750	1 377	22 444	10 492	fir-beech forests,
Nízke Tatry (NAPANT) NP	72 842	64 481	110 162	70 049	fir-beech, spruce-beech-fir, spruce forests
Slovenský raj NP	19 763	17 571	13 011	7 637	beech, beech-fire, scots pine-larch, spruce plantations
Malá Fatra (Small Fatra) NP	22 630	18 711	23 262	9 388	beech, fir-beech, spruce-beech-fir, spruce forests, lime-acer scots pine on calcareous rocks
Muránska planina NP	20 318	17 507	21 698	14 401	mainly beech and fir-beech forests, but also planted spruce woods
Poloniny NP - BR	29 805	26 996	10 973	5 671	beech and fir-beech forests
Veľká Fatra NP	40 371	35 524	26 133	17 182	beech, fir-beech, spruce-beech-fir, spruce forests
Slovenský kras NP	34 611	27 800	11 742	5 500	deciduous forests, with oak, hornbeam and beech prevailing
Together	317 890	279 796	270 128	146 766	

Tab. 6.14: Overview of the national parks in Slovakia (Ministry of Agriculture of the Slovak Republic 2006) NP: National Park, BR: Biosphere Reserve

Other protected area with different regimes of protection are shown in tab. 6.15:

Title	*Area (ha)*	*Type of forest*
Zahorie PLA	27522	floodplain forests, Scots pine forests on aeolian sands
Male Karpaty PLA	64610	beech, oak-hornbeam forests
Biele Karpaty PLA	44568	beech forest
Strazovske vrchy PLA	30979	beech forests, oak, oak-hornbeam, Scots pine forests on calcareous rocks
Kysuce PLA	65462	beech, beech-fir forests, artificial spruce plantations
Horna Orava PLA	58738	beech-fir, beech-fir-spruce forests, subalpine spruce forests, dwarf pine
Ponitrie PLA	37665	oak, oak-hornbeam, turkey oak, beech
Dunajske luhy PLA	12284	flood plain forests (white and black poplar, willows, oak, narrow-leaved ash)
Stiavnicke vrchy PLA	77630	oak-hornbeam, turkey oak, beech, beech-oak forests, quite large proportion of exotic species (forests of former Forestry University)
Polana PLA - BR	20360	beech, beech-fir, beech-fir-spruce, subalpine spruce forests
Cerova vrchovina PLA	16771	oak, turkey oak, oak-horbeam forests
Latorica PLA	23198	flood plain forests (poplar, oak, ash)
Vihorlat PLA	17485	beech forests
Vychodne Karpaty PLA	25307	beech, beech-fir forests

Tab. 6.15: Protected Landscape Area (PLA) in Slovakia

It's worth mentioning that the Poloniny National Park and the Protected Landscape Area East Carpathians (Východné Karpaty), are included in the East Carpathian Biosphere reserve, an area of trilateral Polish - Slovak - Ukrainian co-operation for nature conservation and sustainable development. The Slovak areas included in the Biosphere Reserve are 19,1% of total area (UNESCO: http://www.unesco.org/mab/ecbr/u_mab/general.htm).

Situated in eastern Slovakia at the junction of the boundaries of Slovakia, Poland, and Ukraine, the Vychodne Karpaty/East Carpathians Biosphere Reserve is part of the tri-national Eastern Carpathians Biosphere Reserve. The area, being part of the Eastern Carpathians, coincides ecologically with the important transition between the Western and Eastern Carpathian ecosystems. This unique geographical position distinguishes the area in Slovakia, which is mostly within the Western Carpathian ecosystems (Guziova 1996).

Small-area protected territories on forest land represent the remains of the most preserved forest communities of national and European significance. Forest stands with the structure of virgin forests, natural forests or semi-natural forests and plant communities related to them, which have been slightly changed by human activity or their occurrence is considerably spatially constrained, form small-area protected territories. They are situated in locations from floodplain forests to mountain pine zone. Due to their unique character, in 2007 Carpathian virgin beech forests that are stretch to Ukraine together with the hollows of Slovenský raj with some selected karst valleys of Slovakia have been included into the List of UNESCO World Natural Heritage. The complete list of Slovakian and Ukrainian reserves included in the List can be found in UNESCO website: http://whc.unesco.org/en/list/1133.

In Slovakia, within the framework of forest reserves, there is approximately 15,428 ha of virgin forest, which represents 22% of the area of all forest reserves. Of this area 9600 ha (62%) are category I.A. virgin forest (Ia according to IUCN classification[1]), i.e. without any human influences, 4,468 ha (29%) are category I.B virgin forest and the remaining 1,300 ha (9%) are category II, with natural forest character. The list of the Slovak primeval forests is reported in Annex I of this chapter.

Independently on the national systems of protected territories the EU member states have been constructing a continual European ecological system of special protection areas Natura 2000 (Ministry of Agriculture of the Slovak Republic 2006).

In April 2004 the Slovak Republic submitted to the EC National List of Proposed Protected Bird Habitats (PBH) and National List of Proposed Territories of European Significance (TES). The list of PBH contains 38 territories with a total area of1 236 545 ha that represents 25.2% of the territory of Slovakia. Three habitats of the proposed PBH were declared at the end of 2005. They are Horná Orava (2004), Malé Karpaty (2005) and Lehnice (2005). Public notices were prepared and discussions with owners were held for other proposed PBH. In 2005 the European Commission started an expert evaluation of the National List of the TES. Slovakia submitted a sufficient proposal for 114 types of biotopes and species within the alpine bio-geographical region. Slovakia has still to add other territories to its national list for 39 types of biotopes and species. implementation of further research is necessary for 19 types of biotopes and animal species. A

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[1] The World Conservation Union – IUCN, defines a protected area as: "*an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means*". They have defined a series of protected area management categories based on management objectives. Definitions of these categories, and examples of each, are provided in Guidelines for Protected Area Management Categories. The six categories are (IUCN, 1994): 1- CATEGORY Ia: **Strict Nature Reserve** (Protected area managed mainly for science); 2- CATEGORY Ib: **Wilderness Area** (Protected area managed mainly for wilderness protection); 3- • CATEGORY II: **National Park** (Protected area managed mainly for ecosystem protection and recreation); 4- CATEGORY III: **Natural Monument** (Protected area managed mainly for conservation of specific natural features); 5- CATEGORY IV: **Habitat/Species Management Area** (Protected area managed mainly for conservation through management intervention); 6- CATEGORY V: **Protected Landscape/Seascape** (mainly for landscape/ seascape conservation and recreation); 7-CATEGORY VI: **Managed Resource Protected Area** (Protected area managed mainly for the sustainable use of natural ecosystems) (Stanišić et al. 2006).

proposal of 85 types of biotopes and species is sufficient for the Pannonian bio-geographical region (Ministry of Agriculture of the Slovak Republic 2006).

Another research has to be executed for 16 species and types of biotopes, plus other territories for 44 species and types of biotopes must be included in the national list. The SR informed the EC on the time schedule to complement the National List in accordance with suggestions from bio-geographical seminars. The Ministry of Environment of SR will declare the territories approved by the EC in national categories after discussing this issue with the owners and users of concerned lands. “Preliminary protection” is valid for proposed PBH and proposed TES. It lies in the assessment of impacts on the environment pursuant to valid legislation. It is necessary to monitor the occurrence of endangered forest species with the aim of implementing sustainable management on the national level. In 2001 the Red Book of Plants and Animals of Slovakia was drawn up, where protected plants, animals and priority species are listed. A special database for “forest” species does not exist yet due to the problems with their definition from the viewpoint of species biology (Ministry of Agriculture of the Slovak Republic 2006).

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6.12 ANNEX 1: List of the primeval forests of Slovakia

No	Virgin forest (geographical unit)	Size (ha)	Degree of origin*	Altitude (m)	Vegetation level**
1.	**Stinska (Bukovské vrchy)**	90.78	A(B)	600-910	4+5
2.	**Boky (Kremnické vrchy)**	176.49	A(B)	180-589	1+3
3.	**Kašivárová (Štiavnické vrchy)**	19.46	B (C)	475-600	2+3
4.	**Lesná (Štiavnické vrchy)**	6.11	B	550-600	2
5.	**Sitno (Štiavnické vrchy)**	45.49	A(B)	750-1011	3+4

No	Virgin forest (geographical unit)	Size (ha)	Degree of origin*	Altitude (m)	Vegetation level**
6.	**Dranec (Nízke Beskydy)**	34.22	A (C)	330-515	4
7.	**Havešová (Bukovské vrchy)**	171.32	A	550-650	4
8.	**Komárnik (Nízke Beskydy)**	23.65	A(B)	515-972	4+5
9.	**Kyjov (Vihorlat)**	53.40	A	700-920	4
10.	**Oblík (Slánske vrchy)**	89.58	A(B)	620-930	3+4+5
11.	**Pľaša (Bukovské vrchy)**	118,64	A(B)	880-1163	4+5
12.	**Jarabá Skala (Bukovské vrchy)**	359,94	A(B)	1050-1199	4+5
13.	**Rožok (Bukovské vrchy)**	67.13	A	520-796	4+5
14.	**Šimonka (Slánske vrchy)**	55.03	A(B)	830-1092	4+5+6
15.	**Badínsky prales (Kremnické vrchy)**	30,70	A(B)	710-800	4+5
16.	**Sokol (Stratenská hornatina)**	240,00	A(B)	610-1130	4+5
17.	**Dobročský prales (Slov. Rudohorie)**	101,82	A(B)	700-1000	4+5+6
18.	**Stužica (Bukovské vrchy)**	761,49	A	650-1220	4+5+6
19.	**Hrončokov Grúň (Poľana)**	55,22	A(B)	659-950	5+6
20.	**Klenovský Vepor (Slov. Rudohorie)**	129,94	A(B)	1100-1339	5+6+7
21.	**Korbelka (Velká Fatra)**	86,10	A(B)	625-1000	5+6
22.	**Kornietová (Veľká Fatra)**	84,05	A(B)	908-1254	5+6
23.	**Lipová (Veľká Fatra)**	31,27	A(B)	950-1260	5+6
24.	**Ľubietovský Vepor (Poľana)**	124,60	A(B)	950-1277	5+6
25.	**Padva (Veľká Fatra)**	325,46	A(B)	850-1440	6+7
26.	**Pod Latiborskou holou (Nízke Tatry)**	88,27	A(B)	830-1280	5+6
27.	**Rumbáre (Veľká Fatra)**	51,59	A(B)	825-1125	5+6
28.	**Turková (Nízke Tatry)**	107,00	A(B)	600-900	4+5+6
29.	**Veľká Stožka (Muráňska planina)**	209,55	A(B)	875-1242	5+6
30.	**Vtáčnik (Vtáčnik)**	195,97	A(B)	1250-1345	5+6
31.	**Čierny Kameň (Veľká Fatra)**	45,81	A(B)	1175-1480	5+6+7
32.	**Ďumbier (Nízke Tatry)**	650,00	a(b)	1200-2043	6+7
33.	**Jánošíková kolkáreň (Veľká Fatra)**	45,81	a(b)	1175-1489	5+6+7
34.	**Babia Hora (Západné Beskydy)**	530,33	A(b)	1100-1440	6+7
35.	**Kotľov žľab (Západné Tatry)**	46,94	a(B)	1250-1550	6+7
36.	**Ohnište (Nízke Tatry)**	420,00	A (C)	900-1530	6+7
37.	**Osobitá (Západné tatry)**	230,00	A(B)	1180-1680	6+7
38.	**Pilsko (Západné Beskydy)**	580,00	A(B)	1150-1557	6+7
39.	**Poľana (Poľana)**	685,84	A(B)	554-1456	5+6+7
40.	**Skalná Alpa (Veľká Fatra)**	67,46	A(B)	1070-1420	6+7
41.	**Nefcerka (Vysoké Tatry)**	1600,00	A(B)	970+1898	6+7
42.	**Chopok – Kosodrevina (Nízke Tatry)**	65,00	A(B)	1380-1430	7

Source: the TEPFOR JRC project Faculty of Forestry in Zvolen

* Degree of origin:

A – Very well protected – original, virgin state with no evidence of human influence

B –Well protected – original state with minor human influence (cutting of individual trees) or recently damaged by natural catastrophes

C – Natural forest which could have been influenced by human activity long ago or with evidence of human influence, damaged by larger natural catastrophes

** Vegetation level

1. oak, 2. beech-oak, 3. beech, 5. fir-beech, 6. spruce-beech-fir, 7. spruce forests

7 UKRAINE

7.1 INTRODUCTION

Ukraine is one of the biggest countries of Europe, both in area and population. It is located in eastern Europe, and it is bordered on the west by Poland, Slovakia, and Hungary; on the south-west by Romania and Moldova; on the south by the Black Sea and Sea of Azov; on the east and north-east by Russia; and on the north by Belarus. The country measures 1 316 km east to west and 893 km north to south (UNECE/FAO 2003), with a total area of 60.37 M ha (FAO 2005).

Until 1917 Ukraine was divided between Russia and the Austro-Hungarian Empire. After the revolution in 1917 and civil war, it was proclaimed as a Soviet socialist republic, and in 1922, became part of the USSR. Following the break-up of the Soviet Union in 1991, Ukraine became an independent State. Since independence, Ukraine has been in transition through the difficult and intense process of socio-economic reforms, establishing of national institutions, and the formation of new political relations (UNECE/FAO 2003).

The natural conditions of Ukraine are determined by its geographical position and relief. It is situated in the central part of Europe in the south-southwestern part of the East European plain (more than 94% of the area). The remaining 6% of the area lies in the Ukrainian Carpathians and Crimean mountains. There are three main botanic-geographical zones in the plains of Ukraine: a zone of mixed forests (the Ukrainian Polissya), a forest-steppe zone, and a steppe zone. The mountain areas are comprised of the Carpathian mountains in the west, and the Crimean mountains in the south of the country. The altitude of the plains is 300 - 473 m a.s.l., and the mountain areas reach 1 542 m (Roman Kosh mountain) in the Crimean mountains, and 2 061 m (Goverla mountain) in the Carpathians (UNECE/FAO 2003).

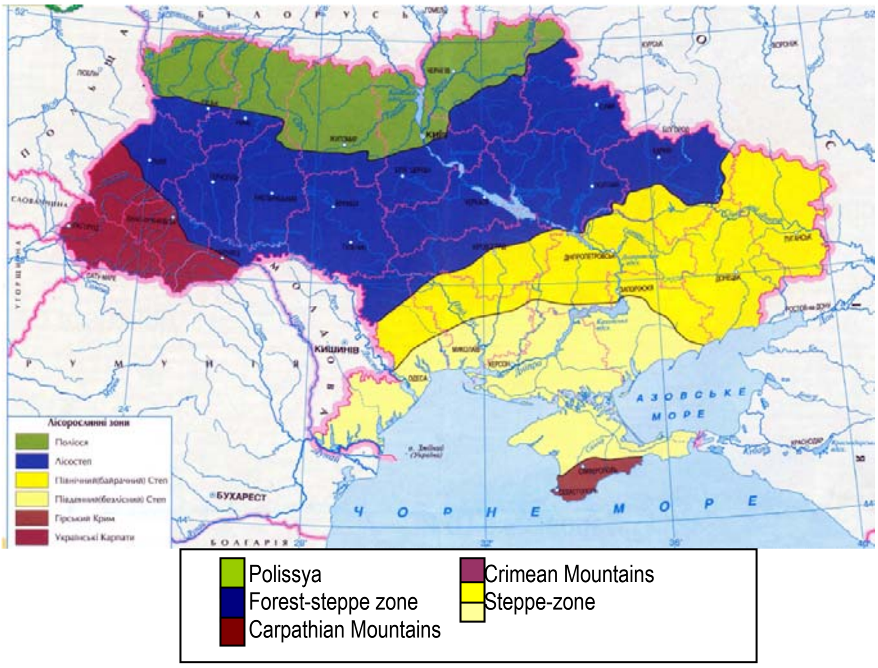


Fig. 7.1: Forest vegetation zones in Ukraine (Tkach 2007)

Total forest area of Ukraine is 9.62 M ha, with a forest cover 15.9% (FAO 2005b). The low percentage of forest cover motivates the priority of ecological and recreational forest function and their limited exploitation (Zibtsev and Tarasenko 2004). Moreover, Ukrainian forests are characterized by lack of uniformity. The largest forest areas are located in the northern (Ukrainian Polissya) and western parts (Ukrainian Carpathians) where the percentage of forest cover ranges from 30 to 50%. In comparison, the percentage of forest cover does not exceed 5% in the southern and south-eastern steppe regions. Regional heterogeneity of forest requires the development of a regional approach (Zibtsev et al. 2000, Zibtsev and Tarasenko 2004).

The main tree species are Scots pine, European oak, common beech, Norway spruce, European birch, common alder, European ash, hornbeam and silver fir. Coniferous forests (42% of the total forest cover) and especially Scots pine (33%) are predominant. As for hardwood the most important is oak and beech (32%) (Zibtsev and Tarasenko 2004).

7.2 FOREST AREA AND FOREST AREA CHANGE

The Ukrainian Carpathians are included in four regions (oblast): Lviv, Ivano-Frankivsk, Zakarpattia and Černivci. The Carpathian mountainous forest area stretches for 100–110 km in width and 270 km in length. Mountain forests grow at an altitude of 400 to 1 600 m a.s.l.. The slopes are predominantly of medium and high downhill gradient (12–350), where the greatest part of the forest cover is found (Sabadyr and Zibtsev 2001).

The Ukrainian Carpathian forests cover about 17% of the Ukrainian forest area and represent about 10% of total area of the Carpathian Mountains. This region has forest resources of high economic value, and it has retained both cultural and natural biodiversity, and many of Europe's last wilderness areas (Turnock 2002, Angelstam 2006, Elbakidze and Angelstam 2007): 2 273 plant associations are distinguished in Ukraine, of which nearly one third can be found in the Carpathians (Sheylag-Sosonko et al. 2002, Parpan et al. 2005).

As mentioned before, Carpathian Region is the most forested region in Ukraine: Ukrainian Carpathian forests represent about 16.7% of total forests of Ukraine, with an extent of about 2 M ha and a forest cover of 42% (Fig. 7.2). Forest area per capita is also much higher than the national average (2.64 ha vs. 0.2 ha. Source: State Statistics Committee of Ukraine: http://www.ukrstat.gov.ua/).

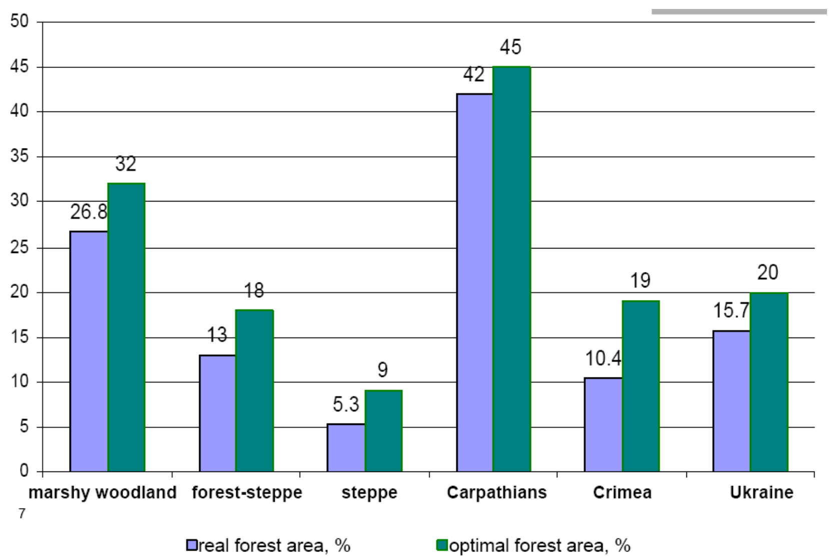


Fig. 7.2: Percentage of forest area in Ukraine (Tkach 2007)

Forest area is increasing in Ukrainian Carpathians, as well as in other Carpathian regions. During the period 1988 – 2004, forest cover increased by about 54 000 ha.

Land abandonment is the main cause of the increment of forest area in the Ukrainian Carpathians. Elbakidze and Angelstam (2007) used the Skole district as a case study that represents one of the most forested areas in Ukraine, and an integral part of the Boiko people's ethnographic area. The Authors underline the importance of the maintenance of socio-cultural values and biodiversity at local and regional levels as new important additional criteria for the implementation of sustainable forest management. The study shows how marginal lands of former collective farms of the socialist period, which are no longer used for grazing and crop production, are returning to forests due to natural ecological succession.

One practice that contributes to forest increase is afforestation practice. The largest amount of new stands in Carpathian regions was created in the 1960s and the 1970s. At the moment this practice is ordered by the State Programme “Forests of Ukraine 2002-2015”. Currently afforestation is carried out in all Carpathian oblast (in 2006 it was created 303.5 ha of new stands were created by State forestry Committee enterprises in the four Carpathian regions).

7.3 FOREST CATEGORIES AGGORDING TO MAIN FUNCTIONS

According to the Law (Forest Code, article 39), forests of Ukraine are divided into the following categories, according to their environmental and socio-economic significance and depending on their main functions:

- Protected forests (mainly water protection, ground protection and other protection functions);
- Recreational forests and sanitary forests (mainly recreational, sanitation, hygienic functions: they are mainly urban forests and forests for tourism);
- Forests for nature protection, scientific and historical-cultural purpose (special nature protection, aesthetic, scientific functions, etc.: they are different kind of forest reserves);
- Commercial forests (economic use).

The Fig. 7.3 shows the estimate of the share among the different forest categories in the Ukrainian Carpathians.

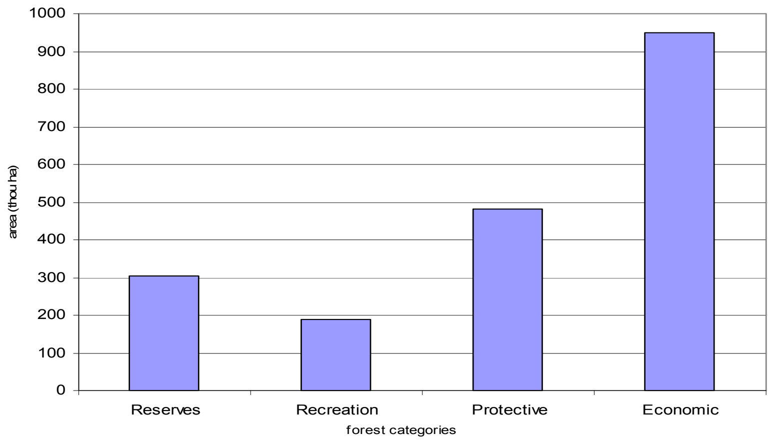


Fig. 7.3: forest categories in the Ukrainian Carpathians (estimate elaborated by Yuriy Shparyk - Ukrainian Mountain Forestry Research Institute - UMFRI, 2007)

7.4 FOREST TYPES

The most widespread species in the Ukrainian Carpathian regions are spruce (41% of the forest area), beech (35%), oak (9%) and fir (4%). Species like pine, birch, alder, ash and maple cover nearly 6% of the whole forest area. The coenofund of the forests in the Ukrainian Carpathians is the highest, represented by 801 associations belonging to 16 formations: *Abieta albae, Acereta pseudoplatanus, Alneta glutinosae, Alneta incanae, Betuleta pendulae, Carpineta betuli, Fageta sylvaticae, Fraxineta excelsioris, Piceeta abietis, Pineta sylvestris, Querceta petraeae, Querceta roboris, Tilieta argenteae, Tilieta platyphyllae* and *Tilieta cordatae* (Parpan et al. 2005).

In the Carpathian area, about 70% of forests present a high or unique level of natural species composition (higher than 51%). Though, about 30% of Ukrainian Carpathian forests present low or average level of natural species composition (under 50%), because of forest management and the establishment of productive plantations. The current forest management policy is oriented to the achievement of a natural stand composition according to forest types.

The table 7.1 reports some characteristics of the most common forest types in the Carpathian Region in Ukraine according to the forest inventory database for the forests of the State Forestry Committee of Ukraine, including about 50% of Carpathian forests.

forest types	*area*	*growing stock*	*Characteristics (FRA2005)*	*Age class distribution and forest structure*	*Main function*
	ha	M m³			
Subalpine larch-arolla pine and dwarf pine forest (3.1)*	4 477	0.13	Primary, modified natural	mainly single-storeyed mature and approaching maturity forests	forest reserve, protection of soils and water regulating
Subalpine and montane spruce and montane mixed spruce and silver fir forest (3.2)*	479 524	160.24	Modified natural, semi-natural, productive plantations	mainly middle-aged single-storeyed forests, sometimes mixed multi-storeyed forests	forest reserve, wood production, protection of soils and water regulating
Alpine Scots pine and black pine forest (3.3)	147	0.03	Primary, modified natural	single-storeyed mature and over-mature forests	forest reserve, protection of soils
Oak-hornbeam forests (5.1, 5.2)*	34 281	8.03	Modified natural, semi-natural	mainly middle-aged mixed single-storeyed forests, sometimes multi-storeyed forests	wood production and water conservation
Ash and oak-ash forests (5.3)*	2 224	0.61	Modified natural	mainly middle-aged mixed single-storeyed forests	wood production and water conservation
Carpathian sub-montane beech forests (6.5)*	19 453	5.84	Primary, modified natural	mixed multi-storeyed mature and over-mature forests	forest reserve, protection of soils and water regulating
Carpathian montane beech forests (7.5)*	294 554	99.35	Modified natural, semi-natural, productive plantations	mainly middle-aged single-storeyed forests	wood production and water conservation
Alpine spruce forest	401	0.09	Primary, modified natural	single-storeyed mature and over-mature forests	forest reserve, protection of soils
Subalpine and montane sycamore forest	2 698	0.41	Primary, modified natural	mainly mature mixed multi-storeyed forests	forest reserve, protection of soils and water regulating
Alder-tree forests	6 280	0.89	Modified natural, semi-natural	mainly middle-aged mixed single-storeyed forests	water regulating and water conservation
Spruce and mixed spruce and silver fir forests	6 127	2.13	Productive plantations	mainly middle-aged single-storeyed forests	wood production
Birch forests	3 411	0.64	Modified natural, semi-natural	mainly middle-aged mixed multi-storeyed forests	protection of soils and water conservation
Larch and Douglas fir forests	2 035	0.45	Productive plantations	mainly middle-aged mixed multi-storeyed forests	wood production

Tab. 7.1: Forest types in the Ukrainian Carpathians (estimates by Yuriy Shparyk, UNFRI, 2007). *the numbers refer to the EEA forest types classification (EEA 2006).

According to the Ukrainian classification, forest stands in the natural zone of the Ukrainian Carpathians apply to the following categories (Source: database for Ukrainian forest, which cover 70% of available forest).

1 – *Subalpine forests*: they are mainly protective forests, and cover about 25 500 ha (24 2000 ha the forested area), with a growing stock of about 8.9 M m^3. They are mainly natural forests (92%). The main species are beech (65% of territory) and spruce (34%). Other species (oak, alder and fir) represent 1%. 9 600 ha of beech forests are virgin forests.

2 – *Mountain forests:* they cover about 1023 thou ha (938 000 ha of forested area), with a growing stock of 322.9 M m^3 (Tab. 7.2).

Species	*Forested area 1000 ha*	*Growing stock M m^3*
Pine	7,6	2,48
Spruce	425,7	153,57
Fir	75,5	23,52
Larch	0,8	0,21
Oak, hornbeam	32,2	7,68
Beech	378,1	132,83
Ash	2,2	0,62
Maple	3	0,47
Acacia	0,3	0,06
Birch	3,5	0,66
Alder	3	0,39
Aspen	0,2	0,03
Other	6,2	0,35
Total	**938,3**	**322,87**

Tab. 7.2: Forest species of mountain zone of Ukrainian Carpathians

Most of the forest in the mountain area are natural forests (about 74%), 21.4 thou ha of beech forests are virgin forests. The main functions are protection and timber production (51%).

3 – *Foothill forests*: they cover about 176 thou ha (160 000 ha forested area), with a growing stock of 39.33 M m^3 (Tab. 7.3).

Species	*Forested area 1000 ha*	*Growing stock M m^3*
Pine	5,6	1,69
Spruce	6,2	1,96
Fir	11,4	3,44
Larch	0,5	0,12
Oak, hornbeam	76,4	15,02
Beech	44,3	14,07
Ash	1,6	0,4
Maple	0,5	0,11
Acacia	0,4	0,05
Birch	4,3	0,81
Aspen	0,3	0,05
Alder	7,4	1,27
Other	1,5	0,34
Total	**160,4**	**39,33**

Tab. 7.3: Forest species of foothill zone of Ukrainian Carpathians

About 70% of them are natural forests, and the main age is 21 – 60. they are commercial (48.3%) and protective forests.

7.5 FOREST STRUCTURE

As we have mentioned, according to the actual legislation forests are divided into four categories. The division of forest into age groups is the following:

Name of species	Categories of forests	Age limits for age groups, years				
		young	middle-aged	approaching maturity	mature	overmature
Pine, Spruce, Fir, Larch, Oak, Beech, Ash, Maple, Elm, Mountain Pine, Walnut	Protected, recreational, reserved.	0 - 40	41 - 100	101 - 120	121 - 140	> 140
	Commercial	0 - 40	41 - 80	81 - 100	101 - 120	> 120
Hornbeam, Oak (coppice), Black Locust, Honey-locust, Birch, Linden, Alder, Poplar, Willow (arborescent), Apricot	Protected, recreational, reserved.	0 - 20	21 - 50	51 - 60	61 - 70	> 70
	Commercial	0 - 20	21 - 40	41 - 50	51 - 60	> 60
Willow (shrubby)	Protected, recreational, reserved.	0 - 10	21-25	26 - 30	31 - 35	> 35

Tab. 7.4: Age class division according to forest categories Note. Total plan is only described in the table. Some species may have other age limits for the same age groups.

If we consider the main tree species, we can see that in spruce and beech forests the age structure is characterized by the predominance of young and middle-aged trees (62–67%), and the near-optimal age structure of mature and over-mature tree stands (16–17%). This is the result of intensive (2–3 annual allowable cuts) cutting during the war and post-war periods up to 1960 (Sabadyr and Zibtsev 2001).

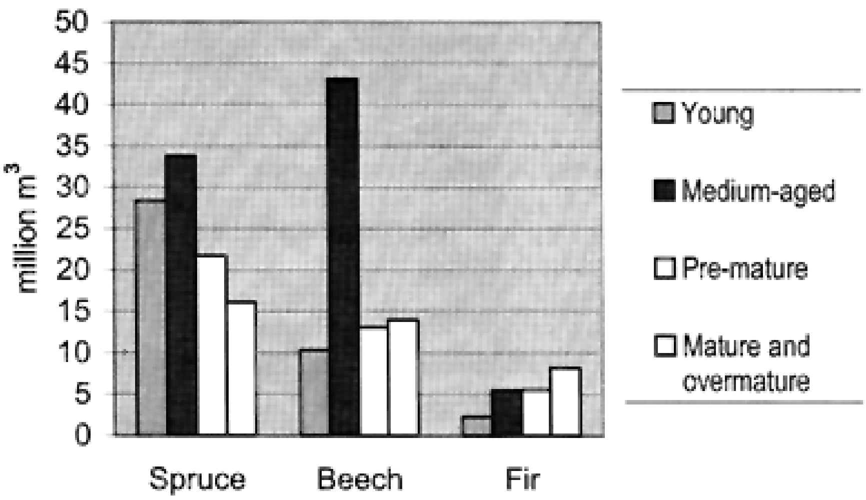
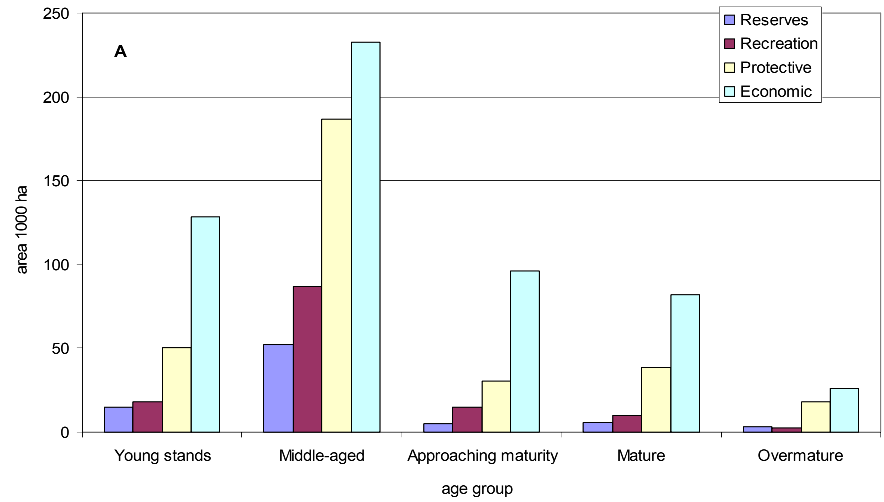


Fig. 7.4: Age-class distribution of the growing stock in commercial forests in the Carpathian Mountains (Sabadyr and Zibtsev 2001)

If we consider the age class structure of each forest category, we can still observe a predominance of middle-aged classes:



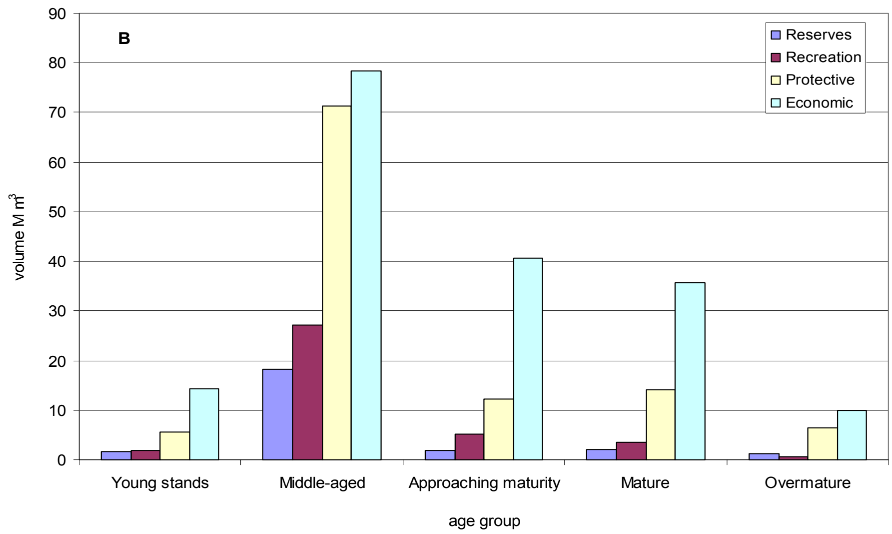


Fig. 7.5: Age structure of forests in Ukrainian Carpathian regions according to forest categories. A: by area, B: by volumes. (Estimate elaborated by Yuriy Shparyk - UMFRI, 2007).

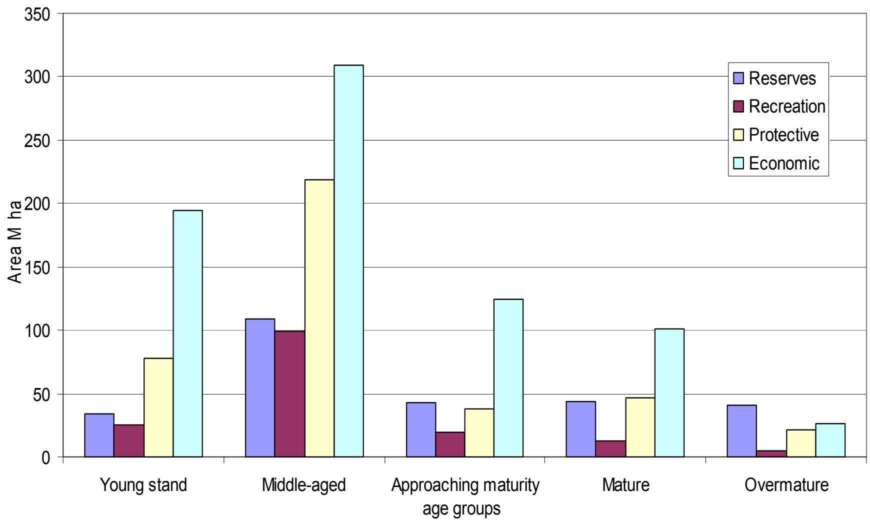


Fig. 7.6: Age structure of Ukrainian Carpathian forests according to forest categories. (Estimate elaborated by Yuriy Shparyk- UMFRI, 2007).

7.6 FOREST CONDITION

Because of past over-exploitation (up to the 1970s), the Ukrainian Carpathian forest has been exposed to many different disturbances, which in some cases are affecting the stability of the ecosystems and regions of the Ukrainian Carpathians periodically incur great human, material and moral losses from catastrophic floods and other ecological disasters, as in the case of Transcarpathian region (see below).

Massive forest cutting in the Carpathians started in the 18th century, and the oldest main forests in accessible places in the Carpathians were eliminated during the 19th century. Cutting took place on huge squares, which reached from the river valleys to the upper border of the forest. This caused the activation, at the end of the 19th century, of harmful geophysical processes, such as the surface and linear erosion of mountain soils, the appearance of sill streams, catastrophic flooding and winds. The further practice of the artificial establishment of spruce monocultures in the mountains and oak forests in pre-mountain regions caused the appearance of other harmful processes – the massive contamination of stands by root rot, pests etc., which resulted in the decrease of the biological stability of forest ecosystems, especially of artificial origin (Krynycky and Tretiak 2003, EURAC 2006).

The figure below reports the area affected by different disturbances in the State Committee forests of the Carpathian region during the last year.

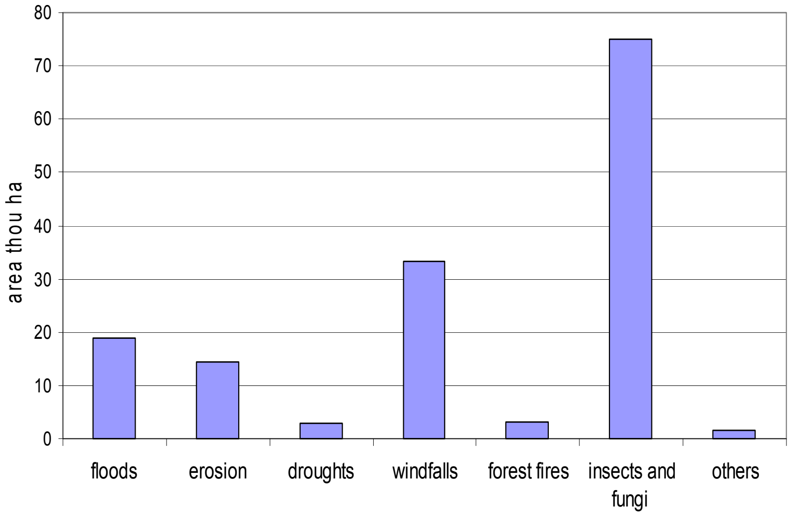


Fig. 7.7: Natural disturbances in the Ukrainian Carpathians
(estimate elaborated by Yuriy Shparyk – UMFRI, 2007)

The Ukrainian Carpathian forests are still subject to several anthropogenic factors which concur in altering the forest ecosystems' functionality and health (Fig. 7.8). The figure below reports the area affected by different anthropogenic factors in the State Committee forests of the Carpathian region during the last year.

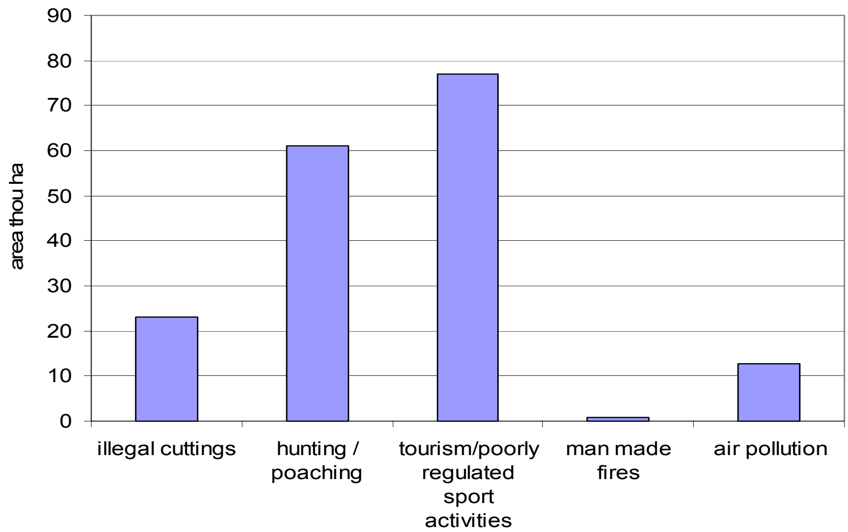


Fig. 7.8: Anthropogenic factors affecting forests in the Ukrainian Carpathians (estimate elaborated by Yuriy Shparyk – UMFRI, 2007).

THE PROBLEM OF FLOODS IN TRANSCARPATHIA

One of the peculiarities of this region is excess moisture. Annual precipitation is between 600 and 2000 mm, of which about 350 mm in winter. The soils frost zone is 220 mm. Precipitation includes heavy downpours that wash away soils and cause landslides and floods. The water regulating function of forests, which depends on nature-protective harvesting requirements, is extremely important (Sabadyr and Zibtsev 2001).

In spite of this, as in other mountain areas in Europe, over many decades the Ukrainian Carpathians, and in particular the Transcarpathia region was over-exploited through intensive management: major ploughing up of the steep slopes, degradation of meadows as a result of over-pasturing, widespread use of the tractor timber skidding from the mountains, the clear cutting of forests, unsystematic construction of roads and skidding portages, oil- and gas-pipes, lines of electrical transmission. The ploughing up of the steep slopes and over-pasturing of cattle etc. were widespread, especially from the post-war period, and caused great erosion processes, resulting in mud flows, landslides, drifting of the mountain river beds and streams (Hamor 2001).

One of the main reason for floods is excessive cutting of forests in the past and the forest management itself: the percentage decrease of woodland, lowering of the upper forest line, radical replacement of the age structure of tree-stands, transformation of mixed forests into the monocultures in large areas have essentially disturbed the water and hydrological regime of the considerable watersheds (Hamor 1999).

The most badly affected by these natural disasters are Transcarpathia and neighbouring European countries. Thus, as a results of flooding in 1969 of the rivers of Tysa and Prut, Hungary and Romania incurred losses equal to 10% of their annual national income. In 1992-1993 the floods in the Transcarpathian region caused losses equal to hundred of millions of the U.S. dollars (Hamor 1999). The losses from the floods of 1998 and 2001 are even larger.

The concurrent causes of the floods are many. The alpine grasslands agro-pedological zone has great influence on the hydrological regime of the Carpathians. Situated at altitudes of 1100 to 1450 m a.s.l., it partially covers the Zakarpatya Region and the Polonynsky mountain ridge. An excess of precipitation (1200 to 1600 mm per year, mainly in the summer) and low temperature sums are the reasons for low natural vegetation productivity in this zone. Presumably it is the alpine grasslands agro-pedological zone that causes the formation of disastrous floods typical in the Zakarpatya Region. Alpine and subalpine meadows, alpine mountain ranges (northwest - southeast) cause the collision of hot and cold air masses, resulting in precipitation (Sabadyr and Zibtsev 2001). It is worth noting that 75% of the Transcarpathian region is a mountainous area. It is crossed by many rivers, and the average density of their network is 1.7 km per 1 sq. km, which is the largest in Ukraine. Taking all this into account, Transcarpathia refers to regions with a special ecological vulnerability. Moreover, the use of clear cutting causes problems of erosion and scarce water retention which decrease the water protection of forests.

The law "On the Moratorium on Clearcuts in the Mountainous Slopes of Spruce-Beech Forests in the Carpathians" (2000) is evidence of an attempt to apply administrative command-and-control instruments to forest management (Nijnik 2002).

At European level, the project ‘Flood risk assessment and management in Zakarpattia Oblast’ was funded by the European Union TACIS programme (value of € 2.2 million), started in September 2003 and was completed in 2005. It was carried out by an international consortium of consultants: ARCADIS Euroconsult, ICWS and HKV from the Netherlands and Mott MacDonald Ltd from the UK, supported by consulting partners ULRMC and UCEWP from the Ukraine. The team worked together with the Zakarpattia Oblast administration and the (local branches of) the State Committee on Water Management (SCWM), Ukraine Hydro-meteorological Centre, the Ministry of Emergency Situations and Chernobyl Affairs, and the Ministry of Environmental Protection. For the demonstration projects, village councils were involved as well. The common goal was to improve the lives of the people living in the Ukrainian part of the Tyza river basin by reducing the effects of floods. A comprehensive programme was set up, tackling the issue on many fronts. It included the following activities: strategy formulation, development and improvement of flood forecasting and warning systems, computer modelling to assess the effectiveness of flood protection measures such as the construction of reservoirs, formulation of a sustainable management plan, GIS to improve data handling and decision support, public participation and education. Construction of actual flood protection measures was also part of the project. Because interventions in the Ukrainian part of the Tyza river can have consequences in downstream countries, cooperation was sought at an international level (The European Commission Delegation to Ukraine: http://www.delukr.ec.europa.eu/page36524.html).

HEAVY METAL POLLUTION

The Ukrainian Carpathians suffer from high air pollution caused by emissions from numerous industries. Shparyk and Parpan (2004) have been monitoring the state of forests in this region since 1989. The results of this research show that in a large portion of the Ukrainian Carpathians territory, the state of forests is good with average defoliation ranging from 10% to 30%, and the average percentage of the insect damaged trees between 5 and 15%. The Authors found levels of tree defoliation higher than 30% close to industrial emission sources and in the upper mountain forests of the Ivano-Frankivsk and Chernivtsi regions (Fig. 7.9).

Fig. 7.9: Map of the Ukrainian Carpathian forest defoliation (in %) (Shparyk and Parpan 2004)

This is caused by a combination of strong anthropogenic influences (pollution, illegal uses, recreation) as well as poor site and climatic conditions. In the Ivano-Frankivsk region there are numerous industrial emission sources. In the Ivano-Frankivsk region territory there are numerous industrial emission sources. The total volume of industrial emissions has decreased 4-fold since 1983 and a general tendency for pollution emissions stabilization has occurred since 1996. In this region, Cd and Mo accumulate in forest soils; Cr, Mo and Zn soil concentrations are higher than their limit levels; and Pb concentrations exceed toxic levels close to industrial areas (10% of the region territory). Heavy metal presence and concentration were studied in samples of snow, forest soils and litter, needles or leaves, mosses and native-grasses on permanent plots. The number of identified chemical elements decreased from snow to soil and to leaves (needles). In fact, toxic heavy metals in the Ukrainian Carpathians forests enter with precipitation and dustfall, then become fixed in soil and accumulate in leaves or needles of vascular plants and mosses (Shparyk and Parpan 2004).

Local background levels of heavy metals are greatly exceeded in snow close to industrial regions. Analysis of correlation matrices shows that the chemical elements Ba, Cd, Co, Cr, Cu, Mo, Ni, Pb, V and Zn occur at pollution levels in natural ecosystems in the Ukrainian Carpathians. Maximum concentrations of toxic elements have been found in the oak forest zone, which is the most industrially developed area of the region. Concentrations of these metals decrease with altitude: highest in the oak forests, less in beech, and lowest in the spruce forest zones. However, some chemical elements have the highest concentrations in spruce forests; V in needles, As in snow, and Ba and Al in soils (Shparyk and Parpan 2004).

7.7 FOREST UTILISATION

The following types of fellings are adopted in Ukraine:

1. final fellings.
2. fellings connected with forest management. These cuttings also are dividing into two categories: thinning (4 different types) and other cuttings (clear sanitary cuttings, selective sanitary cuttings, forest regeneration cuttings, reconstructive cuttings and other).
3. other fellings.

In 2006, in SFC forests in 4 Carpathian regions, the share (by liquid volume) of final felling is 46,2%, thinnings – 6,9%, clear sanitary cutting – 20,8%, selective sanitary cutting – 8,3%, forest regeneration cuttings – 9,2%, reconstructive cutting – 4,8% and other – 3,8%.

The table 7.5 contains some very general information on silvicultural methods adopted in different forest types according to main functions:

Forest types	*Age class distribution and forest structure*	*Main function*	*Adopted management*
Subalpine larch-arolla pine and dwarf pine forest (3.1)*	mainly single-storeyed mature and approaching maturity forests	forest reserve, protection of soils and water regulating	no cutting, natural forestry system, sometimes selection felling
Subalpine and montane spruce and montane mixed spruce and silver fir forest (3.2)*	mainly middle-aged single-storeyed forests, sometimes mixed multi-storeyed forests	forest reserve, wood production, protection of soils and water regulating	mainly clear cutting and artificial regeneration systems (outside reserves), sometimes natural regeneration system
Alpine Scots pine and black pine forest (3.3)*	single-storeyed mature and over-mature forests	forest reserve, protection of soils	no cutting, natural forestry, sometimes selection felling
Oak-hornbeam forests (5.1, 5.2)*	mainly middle-aged mixed single-storeyed forests, sometimes multi-storeyed forests	wood production and water conservation	clear cutting and artificial regeneration systems
Ash and oak-ash forests (5.3)*	mainly middle-aged mixed single-storeyed forests	wood production and water conservation	clear cutting and artificial regeneration systems
Carpathian sub-montane beech forests (6.5)*	mixed multi-storeyed mature and over-mature forests	forest reserve, protection of soils and water regulating	no cutting, natural forestry, sometimes selection felling
Carpathian montane beech forests (7.5)*	mainly middle-aged single-storeyed forests	wood production and water conservation	mainly clear cutting and natural regeneration systems (outside reserves), sometimes artificial regeneration system
Alpine spruce forest	single-storeyed mature and over-mature forests	forest reserve, protection of soils	no cutting, natural forestry, sometimes selection felling
Subalpine and montane sycamore forest	mainly mature mixed multi-storeyed forests	orest reserve, protection of soils and water regulating	no cutting, natural forestry, sometimes selection felling
Alder-tree forests	mainly middle-aged mixed single-storeyed forests	water regulating and water conservation	clear cutting and artificial regeneration systems
Spruce and mixed spruce and silver fir forests	mainly middle-aged single-storeyed forests	wood production	clear cutting and artificial regeneration systems, sometimes natural regeneration system
Larch and Douglas fir forests	mainly middle-aged mixed multi-storeyed forests	protection of soils and water conservation	clear cutting and artificial regeneration systems, sometimes natural regeneration system
Birch forests	mainly middle-aged mixed multi-storeyed forests	wood production	clear cutting and artificial regeneration systems, sometimes selection and natural regeneration systems

Tab. 7.5: Forest management in different forest types in the Ukrainian Carpathians
*the numbers refer to the EEA forest types classification (EEA 2006)

A basic point for preparation of forest management plans are the “economic sections” (groups of main forest species). All forestry actions can be prescribed only within these economic sections. The main economic sections used for the Ukrainian Carpathians are given in Annex I of this chapter.

PROBLEMS RELATED WITH FOREST MANAGEMENT AND IMPACTS ON FOREST HEALTH

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The question of the impact of forestry on forest ecosystems in the Ukrainian Carpathians is not well studied. However, most experts identify the following main impacts (EURAC 2006):

- lack of usage of environmentally safe technologies and techniques (very few cable logging facilities, the technique used is functionally depreciated);
- undeveloped network of forest roads.

Imperfect technologies and forest logging in the Carpathian Mountains resulted in complicated ecological consequences, namely:

• the average depth, damage to surface area and volume of eroded soil increased by more than five percent;
• the drainage area increased by about 50 percent;
• water turbidity increased by 30 times;
• areas of damaged verdure grew larger;
• natural recovery became longer (Ministry for Environmental Protection of Ukraine et al. 2007).

Nowadays the ways of cutting and the volumes of logging are considered to be scientifically grounded, but often the results of such activity are negative. The main working principle of activity among Ukrainian foresters is that of the continual and inexhaustible use of forest resources. However, despite the adoption of state environmental programmes, environmentally harmful activities (clear cuts, construction) are often carried out in forests. This is most apparent on the upper parts of the Tisza river basin in the Rakhivsky region.

One special problem in relation to forestry in the Carpathian region is that, during the development of forestry plans, the impact of actions (and primarily cutting) on biodiversity is only assessed in relation to forestry activities in some reserved areas. Intensive forestry in the 19th and particularly 20th centuries resulted in disproportions in the content, age and surface structure of the mountain region forests and also caused the appearance of many different problems (EURAC 2006):

° resources provision: different needs for materials and the allocation of forest plots for transport routes and settlements resulted in the specializing of the stock of wood of different structure and age group. Such selection of commercial wood by so-called forestry cuts results in the decrease of stand completeness, their biological stability, and their protective anti-erosion and water protective role;

° biodiversity conservation: in some places selective and small continuous plots of fir and oak forests are cut within nature protection areas (in reserves, NNPs, RLPs, preserves etc), which in some cases causes the loss of a valuable genetic fund (particularly with respect to some species of oak, elm, larch etc). Such intensive forestry simplifies the structure of stands and causes the partial loss of their native biodiversity, which has not been sufficiently studied; - sanitary state of forests (massive contamination of stands by root rot, pests etc):

° appearance of natural disasters (floods, windfalls), showing a tendency to periodic repetition and a gradual increase of scale. Experts consider that the volume of the floods in the Carpathians in 1998 and 2001 could have been significantly reduced if the mountain soils and present forests of the first category had not lost their water-regulating functions, as a result of being subjected to intensive sanitary and maintenance cuts. In some cases the best stands have been cut completely (masked as so-called forest renewal cuts);

° protection and counting of forest resources.

FOREST MONITORING AND NFI

An important establishment within the structure of the State Forestry Committee of Ukraine is the forest inventory service, which carries out an inventory of all forests within the country that are organizing and planning forestry development. The state inventory enterprise "Ukrderglisproect" consists of 5 forest inventory branches (expeditions); three of them are in the central part of the country (near Kiev), one - in the west (in Lviv) and one - in the east (in Kharkiv) (UNECE/FAO 2003).

The last state forest recording dates back to 1996, and is a document where summary forest characteristics are reported; it is a stand-wise inventory and concerns all Ukrainian forests. In 2002 a recording of all the State Forestry Committee forests was done. The method for the first Ukrainian NFI, based on a sample inventory, should be adopted in 2008: at the moment, pilot projects based in the Swedish and Czech methodology are being implemented and evaluated.

7.8 WOOD SUPPLY

As for the forest cover, forest growing stock and wood supply in the Ukrainian Carpathians is higher than the national average (tab. 7.6).

	Ukraine	*Ukrainian Carpathians*
Growing stock	2 119 M m^3	556 M m^3
	221 m^3ha^{-1}	267 m^3ha^{-1}
Volume of wood per capita	45.6 m^3	60.9 m^3
Annual growing increment	4.0 m^3 ha^{-1}	5.4 m^3 ha^{-1}

Tab. 7.6: Forest growing stock and wood supply in the Ukrainian Carpathians

The Carpathian forests have great social and economic importance at regional, national and international levels. Among the four Carpathian Regions, the most important mountain forests regions are Zakarpatya and Ivano-Frankovsk Regions.

In recent years forests of Ukraine were underexploited by 15–17 percent (tab. 7.7). The main reason for this underexploitation was insufficient financing and lack of equipment, caused by economic instability and reformation of the budget financing scheme, and the destruction of production facilities for wood processing and the furniture industries. This happened in a period of imperfect privatization in the 1990s when - because of lack of State control and ensuing waste because of unsound harvesting practices, such as the cutting and wasting of non-commercial wood abandoned in the cutting area - in order to fully load the equipment in the large industrial wood processing complexes, 3.5 million m^3 of timber had to be brought in (Sabadyr and Zibtsev 2001).

Year	**1970**	**1975**	**1980**	**1985**	**1990**	**1995**	**1996**	**1997**	**1998**	**1999**
Annual Increment	5.49	5.39	5.39	6.00	6.00	5.16	5.22	5.26	5.29	5.27
Real harvesting	6.03	5.38	5.64	5.92	5.79	4.66	4.42	4.49	4.34	4.41
% of Annual Increment	**110**	**100**	**105**	**99**	**97**	**90**	**85**	**85**	**82**	**84**

Tab. 7.7: Dynamics of wood harvesting in State forestry enterprises commercial forests (M m^3) (Sabadyr and Zibtsev 2001)

As Sabadyr & Zibtsev (2001) observed, today wood is harvested in ease of access to low-cost felling sites in foothills and low-lying areas. In mountain areas, where access is difficult, harvesting is impossible at present because of the lack of cable yarding systems, and this applies to the main part of mountain forests in the Carpathians.

At present, the level of use of the annual increment in Carpathian region is about 52,6% in 2006 (54% in Lviv region, 51% in Zakarpatye region, 43% in Ivano-Frankivsk region and 78% in Chernivzi region).

The percentage of wood harvested in mountain forests and supplied to consumers (91–96%) comprises spruce and beech; the rest is fir and oak (Zakarpatya and Ivano-Frankivsk Regions) (Tab. 7.8).

Region	Economic section				Total
	Spruce	Beech	Fir	Oak	
Zakarpatya	607.9	578.1	27.0	19.0	1241.9
Ivano-Frankivsk	347.7	159.2	30.3	18.2	637.7
Chernivtsy	354.4	103.0	0.0	35.5	794.0
Lviv	1 63.7	89.8	0.0	26.6	563.2
Total	**1 473.7**	**57.3**	**99.3**	**930.1**	**3 236.8**

Tab. 7.8: Supply of wood by economic section in 1000 m^3 (Sabadyr and Zibtsev 2001)

The degree of impact of harvesting operations on the forest environment depends on their type. Territory and volume distribution of annually harvested wood is presented in Tab. 7.11 (year 1999). In the territories available for main felling, 67 to 70% of forests are usually clear-cut. Clear-cutting has a very negative impact on the environment. In 1999, 4.28 thousand ha of forests were clear-cut. That constitutes about 0.4% of forests available for wood supply. In the rest of the territory covered with forests (30%), gradual and selective methods of cutting were used. Environmental harvesting includes sanitary cutting (60–68%) and different intermediate cutting (18–39%). Regeneration and reproduction cutting methods are used in the smallest territories.

Kind of cutting	Real cutting			
	Volume		Territory	
	1 000 m^3	%	1 000 ha	%
Final felling				
Clear-cutting	1 010.3	67.3	4.28	70.0
Gradual and selective	491.9	32.7	1.83	30.0
Total	**1 502.2**	**100**	**6.11**	**100**
Forest management felling				
Selective-sanitary	381	35.2	36.6	56.6
Thinning	20.5	1.9	15.5	24.0
Severance felling	180.8	16.7	9.9	15.3
Clear sanitary	355.2	32.8	1.8	2.8
Forestation felling	144.9	13.4	0.9	1.4
Total for forest management felling	**1 082.4**	**100**	**64.71**	**100**

Tab. 7.11: Volume and territory distribution of harvested wood in 1999 (Sabadyr and Zibtsev 2001)

Last year, in 4 Carpathian regions 4.35 M m^3 was harvested in a total. 11 100 m^3 was harvested illegally. The highest volume of illegal cutting is carried out in forests subordinated to bodies of the Ministry of Agricultural Policy. Some foresters consider that illegal cutting does not create an essential environmental problem, as volumes are not significant (0.006% of all timber) and the felling is done only on specific kinds of wood. This is why, in their opinion, this problem is more legal than environmental. However, some experts consider (and this is verified by the detection of huge bodies of illegal cutting) that official data for the volumes of illegal cutting are often understated by as much as 6 to 10 times. Such conclusions are based on the analysis of a number of illegal saw-mills operating in the region, and on the volume of processed wood (EURAC 2006).

7.9 PROTECTED AREAS AND VIRGIN FORESTS

In the Ukrainian Carpathians there are 1140 different reserves. Under State Forestry Committee responsibility:

- Lviv region – 107 reserves 73.7 thou ha
- Ivano-Frankivsk region - 312 reserves 64.6 thou ha
- Chernivzi region - 98 reserves 54.9 thou ha
- Zakarpatie region - 194 reserves 49.2 thou ha

The table 7.12 reports the most important (largest) protected area in the Carpathian Region. The complete list of Protected areas in the Ukrainian Carpathians is in Annex I of this chapte:

Title	Area (ha)	Virgin forest Area, ha	Type of forest
Carpathian BR[1]	53 630	14 600	Virgin beech forest, mixed virgin forest (fir, spruce and beech), spruce and silver fir forest
Carpathian NNP[2]	50 303	10 000	mixed beech-fir-spruce and pure spruce forests, arolla pine and dwarf pine forests, alpine grasslands
Synevir NNP[2]	40 400	6 000	spruce and silver fir forests
Uzhansky NNP[2]	39 159	2 000	mixed old-growth spruce, fir and beech forests
Skolivsky Beskydy NNP[2]	35 684	1 000	pure spruce and mixed beech, fir, and spruce forests
Guzulschyna NNP[2]	32 271	500	pure spruce and mixed oak, beech, fir, and spruce forests
Nadsyanskyi RLP[4]	19 428	-	mixed spruce, fir and beech forests
Chornyj Lis[4]	15 100	-	mixed oak, spruce, fir and beech forests
Zubrovytsya[4]	11 736	-	mixed spruce, fir and beech forests
Verkhno-Dnistrovski Beskydy[4]	8 536	1 000	mixed spruce, fir and beech forests
Vyzhnytsky NNP[2]	7 928	1 000	spruce forests and alpine grasslands
Chyvchyno-Grynyavskyj[4]	6 646	2 000	pure spruce forests
Cheremoshskyj[4]	6 556	1 000	mixed spruce, fir and beech forests
Rika Svicha[4]	5 940	-	mixed spruce, fir and beech forests
Gorgany NR[3]	5 344	1 200	mixed beech-fir-spruce and pure spruce forests, arolla pine and dwarf pine forests, alpine grasslands
Ilma[4]	3 294	-	mixed spruce, fir and beech forests
Rika Limnytsya[4]	2 064	-	mixed oak, fir and beech forests
Morshynskyj[4]	3 084	-	mixed oak forests
Grofa[4]	2 534	-	mixed spruce forests

Tab. 7.12: Protected areas in the Carpathian region in Ukraine.
[1] Biosphere Reserve [2] National Natural Park [3] Natural Reserve [4] Regional Reserve

It's worth mentioning that Uzhansky National Nature Park and Nadsyansky Regional Landscape Park are included in the East Carpathian Biosphere reserve, an area of trilateral Polish - Slovak - Ukrainian co-operation for nature conservation and sustainable development. The Ukrainian areas included in the Biosphere Reserve are 27,5% of total area (UNESCO: http://www.unesco.org/mab/ecbr/u_mab/general.htm).

VIRGIN FORESTS

Among Ukrainian forests, Parpan *et al.* (2005) distinguish three levels of "naturalness": 1 – virgin forests, which are the forests that have never been exposed to human impact and which show natural structures and dynamics; 2 – secondary virgin forests, or quasi-virgin forests, which are ecosystems where traces of anthropogenic impact may be noticed in some areas, but which are able to regain the coenotic structure of primary virgin forests after eliminating these impacts; 3 – natural forests, or forest ecosystems of natural origin that have been subject to a certain anthropogenic impact which has changed its the authentic coenotic structure only slightly.

Moreover, Parpan *et al.* (2005), observe that, in spite of intensive forestry management for two centuries, nearly half of the Ukrainian forests have remained natural. A high percentage of the natural forest inf Ukraine is situated in the Carpathian region (in the Ukrainian Carpathians 60.7% of the forests are natural), and the highest percentage of virgin and quasi-virgin fir and spruce forests have remained in the Carpathians. Also a high percentage of beech virgin forests are present in the Carpathian region.

The importance of the primeval forests was recognised by UNESCO, and Ukrainian-Slovak “Beech primeval forests of the Carpathians” were recently included in “The List of the World Nature and Culture Heritage of UNESCO”.

The study of virgin forests is particularly important in order to implement a close-to-nature forest management, which is one of the priorities if we want to enhance and maintain biodiversity In the Ukrainian Carpathian forests. Many scientific researches are conducted, and some of these are undertaken by international research groups. For example, there is the Ukrainian – Dutch Project “Virgin Forests in the Transcarpathia (Ukraine) as the core areas of Pan-European ecological network” (BBI-MATRA Project 2006-2007) (Veen Ecology Ltd, 16 February 2007), and the Ukrainian – Swiss collaboration between the Ukrainian Research Institute of Mountain Forestry, the Carpathian Biosphere Reserve, and the Swiss Federal Research Institute (WSL), for the study of the virgin beech forests of Ukraine and the managed beech forests in Switzerland (Commarmot et al. 2005). These studies are significant in order to understand for instance the main structural differences between a natural and a managed forest, which of them presents the most self-regulating structures, which are the most suitable silvicultural methods to achieve them, and the consequences of reducing or stopping tending and thinning operations in managed beech forests.

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7.11 ANNEX 1 - Economic sections in Ukrainian forests

Species	*Growth classes**	*Final felling ages for categories of forests, years*	
		Protected, recreational, reserved	*Commercial*
Pinus sylvestris	I and >	111–120	91–100
	II and <	101 – 110	81 – 90
Pinus mugo, Pinus cembra	All classes	141–150	–
Pinus sylvestris out forest lands	All classes	61–70	51–60
Picea abies	Ia and >	101–110	91–100
	I and <	111–120	101–110
Picea abies out its forest types	All classes	61–70	51–60
Abies alba	All classes	121–130	101–110
Taxus baccata	All classes	221–230	–
Larix decidua	All classes	71–80	61–70
Larix polonica	All classes	51–60	41–50

Species	*Growth classes**	*Final felling ages for categories of forests, years*	
		Protected, recreational, reserved	*Commercial*
Quercus robur, Quercus petrae (seminal)	I and >	151 – 160	131 – 140
	II	131 – 140	111 – 120
	III and <	111 – 120	91 – 100
Quercus robur, Quercus petrae (coppice)	II and >	131 – 140	101 – 110
	III and <	71 – 80	61 – 70
Fagus silvatica, Acer pseudoplatanus, Ulmus glabra in mountains	All classes	121–130	101–110
Fagus silvatica, Acer pseudoplatanus, Ulmus sp. on plain	All classes	101–110	91–100
Carpinus betulus	All classes	61 – 70	51 – 60
Junglas sp.	All classes	81–90	61–70
Fraxinus exelsior, Acer platanoides, Quercus rubra	All classes	91–100	81–90
Ulmus sp. without *Ulmus glabra*, *Fraxinus viridis*, *Acer* sp. without *Acer pseudoplatanus* and *Acer platanoides*	All classes	41 – 45	31 – 35
Robinia pseudoacacia, Gleditsia triacanthos, Sophora japonica	All classes	31–35	26–30
Populus tremula, Alnus incana	All classes	41–50	41–50
Alnus glutinosa	All classes	71–80	61–70
Betula sp.	All classes	61–70	51–60
Tilia sp.	All classes	81–90	71–80
Fruit species	All classes	51 – 60	51–60
Populus alba	All classes	36 – 40	31 – 35
Populus sp. without *Populus alba* and *Salix* sp. (only arborescent)	All classes	31 – 35	26 – 30
Shrub species	All classes	21–25	21–25

* "growth classes" are classes of height and age dependence for forest species (stands), and they are contained in normative tables.

7.12 ANNEX 2 - List of the protected areas in the Ukrainian Carpathians

*Title**	*Area** (ha)*	*Virgin forest Area, ha*	*Type of forest*
*Carpathian BR[1]	53 630	14 600	Virgin beech forest, mixed virgin forest (fir, spruce and beech), spruce and silver fir forest
*Gorgany NR[3]	5 344	1 200	mixed beech-fir-spruce and pure spruce forests, arolla pine and dwarf pine forests, alpine grasslands
*Carpathian NNP[2]	50 303	10 000	mixed beech-fir-spruce and pure spruce forests, arolla pine and dwarf pine forests, alpine grasslands
*Vyzhnytsky NNP[2]	7 928	1 000	spruce forests and alpine grasslands
*Guzulschyna NNP[2]	32 271	500	pure spruce and mixed oak, beech, fir, and spruce forests
*Synevir NNP[2]	40 400	6 000	spruce and silver fir forests
Galytskyj NNP[2]	12 159	-	mixed oak forests
*Skolivsky	35 684	1 000	pure spruce and mixed beech, fir, and spruce forests

*Title**	*Area** (ha)*	*Virgin forest Area, ha*	*Type of forest*
Beskydy NNP[2]			
Yavorivskyj NNP[2]	7 079	-	mixed oak, beech and pine with beech forests
*Uzhansky NNP[2]	39 159	2 000	mixed old-growth spruce, fir and beech forests
*Nadsyanskyi RLP[4]	19 428	-	mixed spruce, fir and beech forests
*Chorna Gora[4]	823	-	mixed oak forests
*Rosishnyj[4]	461	-	mixed beech forests
*Dibrova[4]	712	-	mixed beech-oak forests
*Radyanski Karpaty[4]	649	-	mixed coniferous forests
Rostochchya NR[3]	2 084	-	mixed oak, beech and pine with beech forests
*Verkhno-Dnistrovski Beskydy[4]	8 536	1 000	mixed spruce, fir and beech forests
*Berdo[4]	1 085	-	spruce forests
*Pikuj[4]	711	-	spruce forests
Velykyj Lis[4]	1 649	-	Scots pine forests
Gryada[4]	1 149	-	mixed pine and beech forests
Zavadivskyj[4]	3 561	-	mixed pine and beech forests
Lyubinskyj[4]	2 078	-	mixed pine and beech forests
Vunnukivsyj[4]	848	-	mixed oak and beech forests
*Morshynskyj[4]	3 084	-	mixed oak forests
Lvivskyj[4]	523	-	mixed oak and beech forests
Dnistrovskyj[4]	19 656	-	mixed oak forests
*Polyanytskyj[4]	1 070	-	pure spruce forests
*Grofa[4]	2 534	-	mixed spruce forests
*Maryno[4]	763	-	mixed spruce, fir and beech forests
*Chyvchyno-Grynyavskyj[4]	6 646	2 000	pure spruce forests
*Rika Svicha[4]	5 940	-	mixed spruce, fir and beech forests
*Rika Limnytsya[4]	2 064	-	mixed oak, fir and beech forests
*Ilma[4]	3 294	-	mixed spruce, fir and beech forests
*Chornyj Lis[4]	15 100	-	mixed oak, spruce, fir and beech forests
Chernivetskyj[4]	21 504	-	mixed oak forests
*Cheremoshskyj[4]	6 556	1 000	mixed spruce, fir and beech forests
*Zubrovytsya[4]	11 736	-	mixed spruce, fir and beech forests
*Borgynya[4]	470	-	mixed spruce forests

* - marks of reserves situated in Ukrainian Carpathians;

** - It is a total area of reserve. Usually it consists of State Forestry Committee of Ukraine forests too.

[1] Biosphere Reserve, [2] National Natural Park, [3] Natural Reserve, [4] Regional Reserv

Other protected areas: There are 1,140 different reserves at the Ukrainian Carpathians region
Protected areas planned for the near future: Verkhovynskyj NNP, Cheremoshskyj NNP

ANNEX I - REFERENCES: COMPLETE LIST

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