RESEARCH IN FOREST RESERVES AND NATURAL FORESTS IN EUROPEAN COUNTRIES

Country Reports for the COST Action E4: Forest Reserves Research Network

Edited by Jari Parviainen, Declan Little, Marie Doyle,
Aileen O'Sullivan, Minna Kettunen and Minna Korhonen

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PREFACE

Natural and semi-natural forests mainly exist as forest reserves in different European countries. The occurrence of original forest structures has decreased during the last centuries. The political forum and the public have become aware of this decline. The high degree of biological diversity in these forests, the high potential of genetic variability, their naturnalness and uniqueness are important from the points of view of forest protection, forest management planning and silvicultural practices. International activities, such as the Earth Summit in Rio de Janeiro, 1992, and the Ministerial Conference on the Protection of Forests in Europe in Helsinki, 1993, and the follow-up of the Helsinki process for developing indicators and criteria for sustainable forest management, also underline these facts.

The EU COST Action E4 "Forest Reserves Research Network" was launched on 11 November, 1995. The end of this Action is scheduled for 7 November 1999. Its objective is to create a European network of forest reserves in order to collect ongoing research and unify research methodologies, and create a central data bank for the exchange of research results. The following tasks are outlined:

- to achieve a common understanding of definition, terminology and management approaches to forest reserves and other categories of forest protection,
- to survey and analyse current information available on forest reserves and ongoing research,
- to collect the published research reports on structure and forest dynamics in forest reserves,
- to collect, compare and harmonise research methodology for monitoring the stand structure and changes,
- to promote the establishment of a common permanent sampling plot system, and to create a data bank for the gathered information.

To initiate scientific discussion and exchange of information, preliminary country reports were presented in the 2nd Management Committee meeting, which was held between 12-14 September, 1996, in Fontainebleau, France. These proceedings contain the final reports written and approved by the country delegates.

Jari Parviainen et al. (eds.)
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In addition to various approaches to research, the most important research reports, ongoing projects, research groups, institutions and research emphasis areas, these country reports also contain brief summaries about the historical perspectives of the establishment of forest protection areas and past milestones.

January 1999

Jari Parviainen
Chairman
COST Action E4

STRICT FOREST RESERVES IN EUROPE -- EFFORTS TO ENHANCE BIODIVERSITY AND STRENGHTEN RESEARCH RELATED TO NATURAL FORESTS IN EUROPE

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ABSTRACT

Original forest structures are very rare in Europe. In 1995, COST Action E4: Forest Reserves Research Network was introduced by the COST Commission in order to promote co-ordination and enhance research in natural forests. The objectives are to create a European network of forest reserves, to collect ongoing research, to unify and standardise research methodology and to provide general access to a central data bank on forest reserves.

In order to maintain forest biodiversity in Europe, it is necessary to protect totally untouched reserves and to apply nature-oriented silviculture in production forests. Natural forests are generally accepted as being a good model on which to base nature-oriented silviculture. There are still approximately 3 mill. hectares of natural forests left in Europe (1.7% of the total forest area). The widest, continuous natural forests can be found in Finland and Sweden and in remote mountainous areas of Central and Eastern Europe.

Key elements of forest biodiversity have been identified, such as fire disturbance, dead wood component, etc., but their quantification is still very vague and speculative. The application of realistic nature-oriented silviculture requires a concerted effort to protect indigenous biodiversity, the influence of which has been underestimated in discussions on forest protection.

Due to the wide variation of human impact on forests, fragmentation, the degree of 'naturalness' of forests, vegetation zones and tree species composition, the concept of nature-oriented silviculture in the Nordic countries differs markedly from that in Central Europe. In the boreal zone the main emphasis lies on maintaining biodiversity, whereas in Central Europe the goal is to manipulate forest stand development towards the potential, original forest cover. In Central Europe, production forests are mainly artificial through alteration and cultivation practices (50-70%), whereas production forests in Finland and Sweden are semi-natural; here between 70 and 75% of forests result from natural regeneration.

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1. INTRODUCTION

Forestry and silviculture have attracted unprecedented public attention in the 1990s world wide and throughout Europe. The following events have contributed to this development:

- Forest sustainability conferences and international conventions, protocols and agreements (Rio-declaration 1992, Ministerial Conferences for the Protection of Forests in Europe, in Strasbourg 1990 and Helsinki 1993, Helsinki Process, 1993, IPF-IFF United Nations Initiatives, since 1994)
- Forest-certification discussions (ITTO criteria, development of FSC, ISO-14000-norms, EMAS-environmental accreditation-systems and the introduced "country of origin-"labels)
- Climate change forecast and agreements (Kyoto 1997, Forests as sinks in carbon balance calculations)
- Low economic profitability in wood production and the use of wood as a renewable natural resource in Europe (ecobalance calculations)
- World wide campaigns promoting forest protection and those against the deforestation of tropical forests (e.g. introduced 10% – limit of WWF-International, i.e. protection areas 'hot spots')

Due to these developments, demands to change silvicultural practices and to protect the remaining remnants of natural forests in Europe have increased perceptibly. The application of traditional silviculture practice has changed and terminology has had to be reassessed. As a result of these developments and discussions, the current concept of silviculture includes, apart from wood production, an emphasis on maintaining forest biodiversity, recreational, landscape, protective and socio-economic, as well as cultural issues.

Biodiversity in forest ecosystems

The Helsinki process in 1994 defined the components of biodiversity in forest ecosystems (see Ministerial Conference on the Protection of Forests in Europe 1993, 1994 and 1996, Interim Reports on the Follow-Up of the Second Ministerial Conference 1995). With an ever-increasing amount of knowledge currently being generated these definitions seem to have been validated. Based on these definitions, endangered species are seen as indicators of change in forest ecosystems. Changes in the number and frequency of endangered species act as a warning if biodiversity becomes impoverished due to silviculture techniques. Thus, a number of endangered species have to be continuously monitored in order to asses 'forest quality'.

There are two approaches to maintaining biodiversity in forests: protection of vulnerable and rare ecosystems and sympathetic silvicultural-oriented practices being applied in production forests. For example, at a regional level, each country must implement protection measures in relation to rare and valuable forest ecosystems and a network of protection areas should be created. The density, representatives, size and the

total protection areas in the network depends on the variability and types of forest stands, vegetation zones and forest condition. The general concept is that the protection network should include, apart from old forests, other stand compartments at various stages of the development cycle.

Because total protection only secures a certain number of habitats and rare species at a very local scale, silviculture is essential for maintaining large-scale biodiversity in production forests, regionally. This includes the majority of forested areas, which in many countries means at least 80-90% of the total forest area. Silvicultural orientation in forestry practices determines the amount of forested areas, which are to be left completely outside commercial forestry activities. The hypothesis is that the closer to nature management activities are in production forests, the less there is a need for total protection of forests.

Natural forest is generally accepted as a suitable model for the realisation of nature-oriented silviculture. It is, therefore, necessary to study the various types of natural forests extant in Europe and apply results obtained to silviculture, where possible. The following summary outlines some preliminary results from the European-scale research project COST Action E4.

2. COST ACTION E4: FOREST RESERVES RESEARCH NETWORK

The primary aim of the COST Action E4: Forest Reserves Research Network, which was introduced by the COST Commission in 1995, is to promote the co-ordination and enhancement of research effort in natural forests in Europe. This would be achieved by the creation of a European network of forest reserves in order to gather ongoing research, to unify and standardise research methodology and to provide access to a central data bank for the exchange of research results.

COST is a framework for scientific and technical co-operation, which encourages the co-ordination of national research programmes on a European level. Within this framework financial support is given for the organisation of meetings, specific co-ordination tasks such as data bank construction and for the exchange of scientists through the Short Term Scientific Missions-programme. The research being co-ordinated is funded nationally. GOALS of the Action are to:

- compile and analyse all available information on forest reserves and ongoing research
- provide an inventory of published research reports on natural forests and forest reserves
- develop and harmonise research methodology for monitoring forest structure and ecosystem change
- promote the establishment of a permanent sampling plot system
- create a data bank for gathering information on forest reserves
- achieve a common consensus on terminology, management approach and protection status for forest reserves

The main outputs of the action will be a publication of country reports with data and definitions on forest protection and an inventory of research in natural forests and reserves, and a review of the models and methods for describing the structure of natural forests. A data bank on forest reserves, organisations, publications, research and primary results with unrestricted access for the participants will be established. This data bank on European forest reserves will be located at the European Forest Institute, Joensuu, Finland.

Of all the "natural forests" in Europe the most relevant category to this Action are those which are strictly protected. They have been left to develop uninterfered with by man, in a state which is as original as possible. Most of these remnants are located in forest reserves and are generally protected by statute (see Figure 1).

19 European countries are involved in the project. The project is scheduled to last for four years ending in November 1999.

Detailed information was collected before the approval of this project between 1992 and 1995. The IBN-DLO Institute in the Netherlands organised the first European Forest Reserves Workshop in 1992 in Wageningen and devised a questionnaire on forest reserves (Broekmeyer and Vos 1993).

A feasibility study on undisturbed and semi-natural forests in Europe was carried out by the European Forest Institute (EFI) in 1993, which was later accepted by the EU as a COST project. As its output, in 1994 EFI produced a series of research reviews on structure, succession and biodiversity of undisturbed and semi-natural forests and woodlands in Europe (Schuck, Parviainen and Bücking 1994; Parviainen, Schuck and Bücking 1995). The Action is currently structured around three working groups:

Management Committee (consisting of country delegates) Chairman: Jari Parviainen, Finland; Vicechairman: Konstantinos Kassioumis, Greece	
Working Group I Network creation Winfried Bücking, Germany	• definitions and terminology of protection areas • characteristics of existing reserves • a bibliography inventory
Working Group II Research methodology Eduard Hochbichler, Austria	• criteria for measuring forest stand,structure and regeneration • layout of the sampling plot system in forest reserves
Task Force / Working Group III Data bank Risto Päivinen, EFI, Finland	• creation of a typical on-line electronic database for for forest reserves • standardisation of data collection

Prior to the end of October1998 the Action had organised the following meetings and excursions:

- 1st Management Committee Meeting in Brussels, Belgium, 4th of March, 1996
- 2nd Management Committee Meeting in Fontainebleau, France, 12/14th of September, 1996

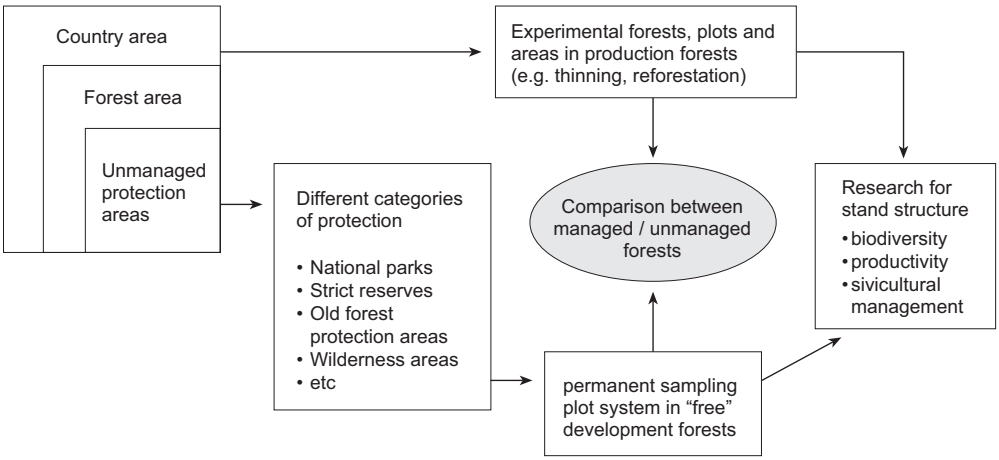

Figure 1. Forests relevant for the research in COST Action E4.

- WG 1 meeting in Freiburg, Germany, 23/24th of January, 1997
- WG 2 meeting in Göttingen, Germany, 21-23rd of April, 1997
- 3rd Management Committee Meeting and Working Group 1 and 2 joint meeting in Finland, 30th of July-3rd of August, 1997 including a scientific excursion to forest reserves in Finnish Lapland and Russian Karelia
- 4th Management Committee and WG 1 and 2 joint meeting in Brussels, 24-25th of November, 1997
- 5th Management Committee and WG 1 and 2 joint meeting in Ljubljana, Slovenia, 26.-28th of May, 1998, including a scientific excursion
- 6th Management Committee and WG 1 and 2 joint meeting in Vienna, Austria, 15.-18th of October, 1998, including a scientific excursion

The Action has also promoted research exchange under two calls of the Short Term Scientific Missions (STSM): scientists from 15 countries took part during 1997 and 1998 in a total of 20 missions.

3. PRIMARY RESULTS FROM THE COUNTRY REPORTS AND SOME OF THEIR POTENTIAL APPLICATIONS

3.1. Types of natural forests extant in Europe

It is difficult to provide a conclusive summary of the amount and area of natural forests in Europe because the policies and degree of forest protection varies a greatly from country to country. Apart from local climatic and edaphic conditions, reasons for these differences include traditional use of forests, their degree of originality, regional variation in continuous forest cover and concepts of protected areas, as well as permitted interventions.

During last 10-20 years in the Nordic countries, the primary goal of forest protection has been the preservation of old forest remnants. This type of forest protection maintains fauna, flora and other living organisms not subject to commercial forest operations. In contrast forests in Central Europe are protected as part of the wider landscape, as cultural entities or as specimens of 'original' nature.

In North America and Canada the reserve ideology applied in forest protection results in large, continuous areas being demarcated and left untouched. This kind of protection strategy is suitable in areas which, due to low population pressure, have not been affected by man to any great extent. Canada has been able to declare over 12% of its forests as legally protected. In addition, roughly 30% of commercial forests are essentially reserves because some of them are situated far from populated areas and have therefore, no human or industrial value.

This type of 'reservation' concept cannot be applied to the densely populated European Continent, where forests have been subjected to human influence for thousands of years. In Southern and Central Europe forests gave way to human settlements and were reduced to forest islands during the Middle Ages at the latest. Because of settlement activities such as hunting, mining, glass works and traffic, forested areas adjacent agricultural land were under constant pressure due to human activities (Bücking et al. 1994: Romane 1997).

Contrary to what is generally believed, human impact on forests in Northern Europe has also been extensive, though not as continually as in Southern and Central Europe, lasting mainly for only for 300-400 years. In Finland, between the 17th and the 19th centuries, forests were used for tar production, hunting and reindeer husbandry (Parviainen and Seppänen 1994). During the same period, forests in Central-Sweden and Central-Norway were largely impacted upon by the ore mining industry (Esseen et al. 1997).

The principal activity which had most impact on Finnish forests was slash and burn agriculture; it was especially used during the settlement period of the entire southern part of Finland and was initiated during the 16th century. According to Heikinheimo (1915), as much as 50-75% of the Finnish forests were subjected to the slash and burn method before the beginning of this century. However, in Finland and Sweden, the most significant changes to the forest environment occurred during the last century, due to the rapid expansion of the forest industry.

Due to the continuous use of forests historically, there are few original, untouched virgin forests remaining in Europe. The largest virgin forests can be found in the boreal forest zone from the European side of the Russian Federation, in the states of Komi and Archangelsk and in some parts of north-west Karelia near the Finnish border.

The European forest protection concept has been devised to be more versatile than that which exists in America. Forest protection includes different degrees and types of restrictions on forest areas with regard to their use. Forests selected on a regional basis combine to form a network. In Finland, for example, protected forest areas are located in the following areas: national parks, strict nature reserves, wilderness areas, protected peatlands, protected old forest areas, protected lake shores, herb-rich forest protection areas, ridge protection areas and protection forests of Lapland created to prevent shifting of the northern timber line. The EU/Natura 2000 -programme focuses on the protection of habitats which are especially valuable for birds and flora. In Finland, the

protected forest areas with different categories amount to 15% of the total forested area (see Fig. 2, cf Table 1).

In terms of protecting mammals and birds there is a significant difference between Central European and Nordic countries where, in the latter, protected forests and production forest compartments are adjacent one another. Due to the continuous mosaic-like forest cover, large land animals, such as the bear, are able to move freely over the entire Southern Finnish region. Compressed by people, Central European forests have been fragmented into forest islands. Forests are mainly bordered by fields, settlement, roads or industrial plants. There are plenty of buffer zones, but large, continuous forest cover has disappeared. Borders between protected and production forests are generally vague in Nordic countries compared to the rest of Europe.

When comparing forest protection areas in different European countries the most interesting feature is the amount of strictly protected forests (Fig.1). They have been left to develop freely in a state which is as original as possible. The COST project, Forest Reserves Research Network, has outlined the various concepts and definitions related to protected areas and the amount of untouched forests extant in different European countries (Schuck et al.1994 – see Table 1 in Appendix 1). Preliminary estimates suggest that there are about 3 mill. ha of natural forests left in Europe, i.e. 1.7% of the total forest area. Their number cannot be further increased, but what is left, must to be carefully preserved and protected. The majority of these natural forest remnants are legally protected.

The largest continuous natural forest areas occur in Finland and Sweden, and in the mountainous regions of Central and Eastern Europe. The proportions of natural forest

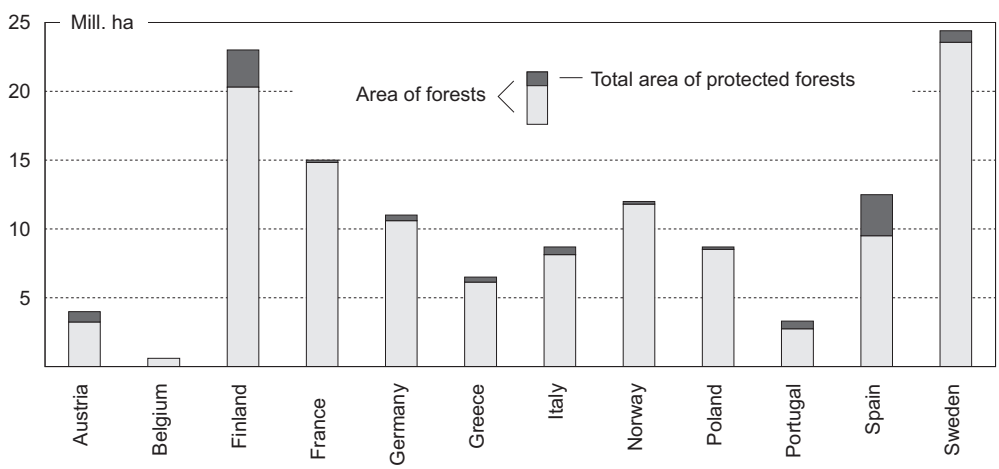

Figure 2. The area of forests and other wooded land and the total area of protected forests in selected European countries in 1998. (The different categories of protected forests outside of normal forest operations, mainly protected forest areas with rare and vulnerable ecological value, not areas for landscape management or protection from avalanches or erosion. Definitions based on national definitions. See also Table 1 in Appendix 1).

of the total forest area in Bulgaria, Romania, Finland, Austria, and Germany is 8%, 6%, 5.5%, 3% and 0.8% respectively. No natural forests remain in the Netherlands, whilst in Finland, there are 1.3 mill. ha of natural forest, which is circa one percent of the total forested area of Europe and nearly 43% of the European natural forest estate.

3.2. The use of 'Natural forests' in silvicultural model

It is generally accepted that natural forests are a basic model for the realisation of nature-oriented silviculture (Leibundgut 1978, 1982, 1986, 1989; Schütz 1986; Schmidt-Vogt 1991; Thomasius 1992; Sturm 1993; Parviainen and Seppänen 1994). It is, therefore, necessary to analyse what types of natural forest exist in Europe and how they can be utilised as experimental areas for silviculture.

Though natural forests may be the basis for the realisation of nature-oriented silviculture, the natural forest model needs some conceptual clarification. It is necessary to distinguish between close-to-nature and nature-like silviculture (Leibundgut 1986; Schmidt-Vogt 1991; Thomasius 1992; Sturm 1993; Eder 1997). The definition of close-to-nature silviculture implies that the development cycles of natural forests are mimicked and nature's own development potential and productivity are used in production forestry. In other words, management activities are guided, as far as is practical, by observed, natural forest dynamics. In nature-like silviculture, natural forest processes are transferred directly into silviculture. The latter, however, cannot always be the primary goal of sensible forest management because hazards and risks are not controlled in nature. If left entirely at the vagaries of natural forces, forestry would become economically unsustainable and would occasionally result in disasters occurring over large areas, e.g. fire, devastation by insects.

Natural forests develop in different ways throughout the various alternative vegetation zones. The development of northern, natural boreal forests is interrupted by disturbances and catastrophes, which destroy forest over large areas, thereby promoting forest regeneration. The most important disturbance factor in the boreal ecosystem is fire. Even today, millions of hectares of forest in any one year may be destroyed by fire over vast, untouched forest areas in Canada and Russian Siberia. Depending on factors such as moisture and the tree species composition, forest fires occur at intervals of between 30 and 120 years in the boreal zone (Esseen et. al. 1997). In peatland, on wet soils and on islands, forest have probably been able to develop for centuries without disturbances, including fire. In such cases, forest regeneration occurs through gap dynamics, i.e. through the death of solitary trees in so-called short cycles (Kuuluvainen 1994).

In contrast, large scale disturbances and natural disasters are an exception in the temperate forest zones of Central Europe (Schmidt-Vogt 1991; Thomasius 1992). Occasionally, storms destroy forests on a large scale. The decisive factor here is the prevailence of the short cycle, which results in forest regeneration through gap dynamics. In Central Europe, this is especially true in the typical mixed beech/spruce/fir natural forests where shade-tolerant trees are able to regenerate, even under a very dense canopy layer.

Due to differences in the development cycles of natural forests, area of forest cover and differences in traditional forest uses, the concept of nature-oriented silviculture is different in the Nordic countries compared to Central Europe. In Nordic countries, in particular, silvicultural trends focus on the differences between long and short rotations or cycles, fire ecology and those stand characteristics which are crucial with respect to the preservation of living organisms. These factors include the presence of charred wood, the proportion of decaying wood, small biotopes and an emphasis on deciduous trees occurring throughout the stand. Silviculture is the management of coniferous forests. In order to maintain biodiversity on a regional scale, landscape ecology planning policies have been developed, the primary aim being the maintenance of a mosaic-like structure at a regional level (Kouki 1994; Angelstam 1947; Angelstam and Petterson 1997). Today, remaining remnants of natural forests may serve as valuable reference areas and research areas to aid in the attainment of objectives related to silvicultural management.

In Central Europe the basic principles of close-to-nature silviculture have generally been based upon gap dynamics, especially disturbances and light factors inherent in short forest cycles. The main goal is to elucidate, on a site-specific basis, the potential, original vegetation cover so that the altered tree species composition can be managed towards the original tree species composition for each particular site, as far as is practical (Thomasius 1996). Silviculture favours mixed forests dominated by deciduous trees (Schütz 1986). There is some demand for leaving strict reserves adjacent to production forests, which could serve as reference sites, thereby enhancing nature-oriented development in production forests (Der Wald hat ein Problem ... 1996; Mayer and Spellmann 1997).

The most relevant guiding factor in Central European silviculture has been the definition of naturalness (Thomasius 1996; Koch et.al. 1997; Naturnähe Österreichischer Wälder. Bildatlas 1997; Peterken 1997). Generally speaking, naturalness in silviculture refers to those conditions and processes which have been affected negligably by man. The concept of hemeroby is thus defined, as applied to forestry. It implies the development of forest, uninterrupted or impeded by man, towards a natural climax state. This means potentially natural forest association where man has no longer interrupted the development and the vegetation has had time to develop up to its final state. In addition, the definition of naturalness helps to define the present quality and state of forests that exists in different countries.

The definition of naturalness is, however, not clearcut. There are many overlapping or closely related terms such as native, ancient woodland, virgin forest, old growth forest, primary forest and old forest (Peterken 1997). Furthermore, decisions will have to be made on how human impact will be accounted for in the definition. Account must be taken of domestic-use of wood, the acquisition of heating and firewood or past selective felling, the results of which are still visible in the stand, and the impact of forestry practices which occurred 100 years ago. Also ‘naturalness’ classes will have to be defined on a proportional basis and adjusted to fit local conditions.

Austria, during the early 1990’s, was the first country in Europe to carry out an inventory of the naturalness of its entire forest estate (Naturnähe Österreichischer Wälder. Bildatlas 1997). The following figures provide some examples of the naturalness of forests extant in a number of European countries:

Austria	Inventory results, published 1997, forest area 3.9 mill. ha		
	natural forests	3%	
	semi-natural forests	22%	
	moderately altered forests	41%	
	altered	27%	
	artificial	7%	
	total	100%	
Germany	Alteration of tree species composition in the Black Forest (Bücking et. al., 1994).	Prior to change	
		at time Ch.b.	today
	spruce	3%	45%
	beech	53%	19%
	conifers	23%	65%
	broadleaves	77%	35%
	exotic tree species (douglas fir, red oak in whole Germany)	-	4%
Great Britain	(Peterken 1997)		
	67% plantations with exotic tree species (sitka, spruce and others) 83% of all ancient woods extend to no more than 20 ha		
Finland	(Parviainen and Seppänen 1994)		
	regenerated trough planting or by sowing	5.2 mill. ha	23%
	natural regeneration	17.8 mill. ha	77%
	in total	23.0 mill. ha	100%
	absence of exotic tree species		
Sweden	(Esseen et. al., 1997, Statistik årbok för skog, 1996)		
	regenerated by planting	6.5 mill. ha	28%
	natural regeneration	17.1 mill. ha	72%
	in total	23.6 mill. ha	100%
	exotic tree species, plantings with P. Contorta	0.5 mill. ha	2%

From current and historical data and records on forest structure, it is clear that Central European production forests are mainly altered or cultivated, whereas in Nordic countries, they are semi-natural. Even though about a quarter of forests have been established by sowing or planting in Finland and in Sweden, many resemble primary forest after fire succession due to the presence of natural seedlings in the regeneration areas, and the development of to be more or less mixed forests. Stand development is primarily influenced by management of these seedlings, especially thinning.

3.3. The need to elucidate biodiversity factors

The most important silvicultural development in the 1990s has been the focus on biodiversity factors in management. Research on forest biodiversity has expanded rapidly in recent years. In spite of this, quantification of, for example, how much dead wood to leave or how many key-biotopes should be left in forests to preserve threatened species, has not as yet been clarified. Decaying and hollow trees are important for the maintenance of biodiversity in both deciduous and coniferous forests because they support thousands of species, especially insects and decay fungi. In northern boreal forests, it has been calculated that about 35% of all threatened species are dependent on dead wood (Annila 1998). To put biodiversity into perspective, when all species in the Nordic countries are considered (c. 25 000), only 3,6% of the threatened category occur in forests. According to OECD- statistics (1991), 38% of mammals, 33% of birds, and 16% of vascular plants are threatened in Western and Middle European countries. The respective numbers for Finland are 11%, 6%, and 6%.

In Nordic countries it is estimated that not more than 2/3 of the known, threatened species can be preserved by silvicultural practices (Annila 1998). Little is known of up to 1/3 of these, some of which are extremely rare. Such species are most likely to have been rare even before the commencement of intensive forest production. There have been only occasional observations made of these species. In contrast, studies show that the number of threatened species in temperate zone forests varies according to the development stage of the forest and tree species composition. Both species number and diversity vary, depending on the age of the forest.

According to recent Finnish studies on threatened species, 90% survive adequately in production forests. The majority of the remaining species have always been rare and only appear in specific sites that differ markedly from the neighbouring ecosystems. These habitat types, which are known as key biotopes, are hardwood stands, herb-rich forests, grassland forests, ridges, rocks and gorges. These key biotopes are not considered for silvicultural purposes and are left untouched in order to preserve rare species. According to ‘quality’ analyses of silvicultural methods implemented in private forests, the key biotopes cover approximately 6% of the total forest area of Southern Finland (Niemelä and Arnkil 1997). Co-incidentally, this figure is very similar to an estimate of key biotopes in German forests, i.e. 6-8% of the total forest area (Naturschutz im Wald 1997).

The recommended share of dead wood in production forests obviously depends on the composition of tree species and the stand-structure. A general recommendation is to leave 2-3% dead wood of the total growing stock, which in Nordic countries amounts to about 5-8m^3 per hectare (Parviainen and Seppänen 1994; Wollschläger 1996). A similar percentage has also been estimated for central European forests. In the temperate zone, however, a figure of 2-3% means double the amount of dead wood per hectare must be left compared to the boreal forest zone (Naturschutz im Wald 1997). An alternative method is to estimate the share of dead wood in each stand relative to a corresponding natural forest stand and to leave 10-12% of the volume of dead wood normally found in the latter (Korpel 1997). Research is inconclusive as to what proportions of the total dead timber should be fallen and standing. Most common estimates suggest that the bulk of dead wood should be fallen, decaying wood.

Recommendations of the amount of fallen, decaying wood vary from 60 to 80% of the total dead wood component.

From the point of view of preserving living organisms and enhancing biodiversity, open areas should also be created in forests. If regeneration in high forests was replaced entirely by selection forests, open areas and their attendant living organisms, would disappear. In Finland, there are dozens of such species. Correspondingly, one of the drawbacks of fire prevention in modern silviculture is the extinction of living organisms, which are dependent on charcoal wood. There are about 40 such species in the Nordic countries. This is why the modern silvicultural guidelines recommend controlled burning in production forests in order to ensure adequate micro-habitats on a small scale for those organisms which are dependent on fire and charcoal wood (Annila 1998).

3.4. Additional costs to modern silviculture as a result of managing biodiversity

To date, no detailed economical calculations as to how much additional expenses will be incurred due to the incorporation of biodiversity aspects in silvicultural management, and whether wood production is reduced significantly. In practice, if the deadwood component is made up poor quality timber, useless for logging, it will not cause unreasonable additional costs to maintain the required deadwood volume. Practical guidelines favour fallen dead wood, because manual logging can be dangerous if standing dead trees fall during forest operations. However, if mechanical harvesting is applied, this danger can be averted.

According to a report on private forests in Finland, volumes would decrease by 5 to 7% if key biotopes are left, in addition to the required proportion of dead/decaying wood (Niemelä and Arnkil 1997). Preliminary calculations for Southern Finland suggest that the application of such techniques in modern silviculture would cause a reduction of about 10-12%, at most, in wood production, over the long term (Järveläinen et al. 1997).

Similarly, here are no precise, published estimates in Middle Europe or Germany on the differences between ecological- and wood production-oriented silviculture. The city of Lübeck forests are a rare and important example of the implementation of ecological silviculture, which began in 1994. In Germany, a so-called Naturland-certificate may be awarded if ecological silviculture is applied. The requirements are: no clear cutting, no exotic tree species, no chemicals, selective felling only is allowed, 10% of the forest areas must be set aside as reference areas, i.e. strict reserve areas, and the dead wood component must amount to 10% of the total tree volume.

The forest area around the city of Lübeck is an optimal site for European beech (*Fagus sylvatica*). During previous commercial forest activities, exotic tree species – especially Norway spruce, but also red oak and Douglas fir – were planted in the region. The long-term plan now is to develop the forest into beech dominated stands and to remove Norway spruce stands in favour of mixed forests. Other exotic tree species, such as Douglas fir, will not be maintained.

In January 1998, an independent evaluator (Borchers) published a report on the forests of the city of Lübeck, which assessed the economic implications as a result of

current forest management. According to this report, the reduction in the level of silviculture and the establishment of reference areas created losses in wood production and increased the expenses related to silvicultural management amounting to between 80 and 240 DM /year/ ha. In conclusion, Borchers stated that this kind of forest management is only possible in forest parks, where there are no silviculture-related expenses. Thus, this type of silvicultural model is really only applicable in forests which are owned by cities or communities like Lübeck, where the additional costs can be covered by tax revenues. In private forests such silvicultural practices are unprofitable. However, the silvicultural model applied in the city of Lübeck does sets guidelines for ecological silviculture and quantifies the economic losses resulting from its implementation, which is of considerable benefit to the forest community generally.

4. CONCLUSIONS: NO UNIFORM SILVICULTURAL MODEL EXISTS

There is no uniform silvicultural model in Europe. In order to maintain biodiversity, different silvicultural and regeneration methods are required. Which methods to choose depends on the following parameters; climate, soil and tree species characteristics. At present, the main trend in European forestry is toward nature-oriented silviculture. The basic elements of nature-oriented silviculture are known for each forest zone, but the quantification of the properties that dictate how ‘natural’ silviculture is, have not been studied sufficiently and are not well understood. Quantification is required of such aspects as the amount of deadwood and the key biotopes that should be left. There is general agreement that by leaving deadwood and micro-biotopes in production forests a proportion of threatened species may be conserved. Nature-oriented silviculture serves both as large-scale protection of biodiversity and timber production, but thus far, the significance of the former remains underestimated in the general debate on forest protection. The feasibility of nature-oriented silviculture must always be evaluated on economic grounds. Experience shows that sustainable forest management has been most successful when forestry is profitable.

In order to preserve natural species diversity there must be open areas created in forests. If silvicultural orientation favours selection forests only, those species that live at the edge of forests and in open areas would become increasingly rare. It is necessary to carry out prescribed, controlled burning during regeneration procedures in Nordic countries, in order to conserve those species that are dependent on wood charcoal.

Research on biodiversity factors should be further consolidated and enhanced. There is an increasing need for an inter- and multi-disciplinary approach in order to link silvicultural management to zoological and botanical disciplines. Old, comparative, permanent experimental plots are important, because by re-analysing them, new data on untouched forests, and to varying degrees, managed forests, may be obtained, even in the short term. By increasing knowledge relevant to the implementation of nature-oriented silviculture, it will be possible to offset the continuing clamour for changes in silvicultural management.

Though nature-oriented silviculture in Europe must be defined carefully as knowledge increases, it can be concluded that the greatest threat to the quality of forests

and their sustainability in Europe are external factors that emanate outside the forest, as opposed to underdeveloped silvicultural method. Air pollution poses an increasing threat to Central European forests. Carbon dioxide emissions and greenhouse gases, resulting in possible global warming are threats to forests, especially in peripheral areas in the north and on mountain slopes. It is necessary to reduce and monitor emissions on an international scale. Silvicultural procedures cannot eliminate for these effects. However, these effects can be offset, to some degree, by altering silvicultural operations.

In Europe, a serious problem is the underutilisation of forest growth. Annual fellings are only 65-77% of the annual growth. In order to maintain forests' resistance to outside factors, wood usage in Central Europe as well as in the Nordic countries should be increased. If forests are not managed and thinned, they become old and dense and consequently, there is an increasing amount of dead and drawn trees. The most serious practical problem is the thinning of young forests. If this procedure is neglected, the optimal, natural production capacity of forests may be lost.

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APPENDIX 1. SUMMARY OF THE COST E4 COUNTRY REPORTS

1. PROTECTION OF FORESTS AND STRICT FOREST RESERVES

The first forest reserves in Europe were established as early as the beginning of the 19th century. On the other hand, agriculture has been the predominant form of land use and natural forests, more often than not, have survived only in sites unsuitable for cultivation or where logging is unprofitable. This has also affected the ecological representatives of the resultant protected areas. Improving the representatives of forest reserves has been the primary aim of forest protection in recent times.

Many of the countries engaged in the COST E4 Action have undertaken detailed programmes aimed at the protection of natural forest ecosystems. In addition, nature conservation legislation has recently been reformed in many countries and new forest reserves have been created. These countries include Austria, Belgium, Finland, Denmark, Germany, Hungary, Ireland, the Netherlands, Norway, Russia, Slovenia and Sweden. In general, it can be stated that the need to conserve natural forest ecotypes has been recognised and has lead to the establishment of forest and nature reserves in all of the participating COST E4 Action countries.

Due to past, diverse land use pressures, natural forests area has decreased extensively in all European countries. However, few detailed nation-wide inventories on the naturalness of forests have been made. In several countries serious efforts have been made to increase forest area. In the majority of countries, forests have been altered significantly. Thus, European countries differ widely in relation to forest protection policy and its implementation.

Short summary by countries

Austria carried out an inventory of ‘forest naturalness’ in the 1990's. The Natural Forest Reserves Programme was initiated in 1995 and contributes to the implementation of an overall strategy of maintaining and improving forest biodiversity. The objective is to provide at least one Natural Forest Reserve for each natural forest community in the ecoregions. In addition to forest reserves, nearly one fifth of the total forest estate is classified as ‘protection forest’. These forests, which include protective, recreational or general economical functions, will be preserved through limited forest utilisation and specific silvicultural management operations.

In Belgium the Law on Nature Protection enacted in 1973 promotes nature protection throughout the country. The three regions of Belgium, i.e. Brussels, Flanders and Wallonia, have their own separate administration and legislation for forestry and nature protection, and only in Flanders does there exist a specific Forest Decree. The Flemish

Forest Decree, passed in 1990, has lead to the establishment of strict and specially managed forest reserves. In all three regions, forests are also protected in official nature reserves.

In Denmark both forest and protected forest areas have increased rapidly during the 1990s. The Danish National Strategy for Natural Forests, published in 1994, outlines a medium-term strategy up to the year 2040. One of the goals is to preserve the remaining natural forests, in addition to traditional management systems. Protected forests should, by 2040, account for 10% of the total forest area. A network of strict forest reserves was established in 1994.

In Finland large areas of forests are strictly protected under different categories of protected areas. The areas that are afforded legal protection are, as a rule, left untouched. The Revised Nature Conservation Act came into force in 1997. The basic network of reserves has been complemented by programmes aimed at the conservation of specific habitat types, i.e. 290 000 ha of old growth forests, herb rich forests, peatlands etc. The implementation of the EU NATURA 2000 programme will include previously unprotected forest areas. In addition, in a similar area of forest, restricted wood production occurs. Such areas include areas near the northern timber line and forests managed for recreation.

About 1% of the forests in **France** are subject to various statutory nature conservation measures. These include Bio-reserves, which are areas of distinct ecological interest. Bio-reserves in forests are divided into special and strict forest reserves. It is planned that the network of Bio-reserves would reach a total area of at least 30,000 ha by the end of the century.

In Germany unmanaged, protected forests can be found in the network of strict Natural Forest Reserves, established for nature conservancy and scientific purposes, and in unmanaged areas of National Parks and the Biosphere reserves. Initially, the goal was to preserve the complete range of forest communities, but lately the need for larger areas has been recognised. Policy and management of protection areas varies widely in the 16German states.

In Greece a law introduced in 1971 added new categories of protected areas. The law includes forestry legislation that addresses faunal, floral and habitat protection. The categories important for forest protection are the strictly protected core areas and peripheral zones of National Parks and Aesthetic Forests. In the protected Natural Monuments category there are also valuable forest areas.

In Hungary, legally protected forests occur in National Parks, Landscape Protection Areas, Nature Reserves or Forest Reserves. The Hungarian Forest Reserve Network was established in 1991. The reserves are forest areas set aside to monitor natural dynamics of forest ecosystems and thus, any intervention is prohibited. The areas are located within existing nature reserves.

Ireland is at present launching two new categories of conservation areas: National Heritage Areas and Specific Areas for Conservation. These areas include all Nature Reserves and National Parks, as well as important semi-natural forests, which lie outside Parks and Reserves. These areas are situated both on state-owned and private lands. The total area of woodland within all these areas has not yet been fully quantified.

In Italy during the 1970's two lists of the most important biotopes were published. These lists have formed the basis for the subsequent establishment of a large network of Parks, and State and Regional reserves. Most of the areas include a strict reserve core where access is only allowed for scientific purposes.

In the Netherlands forests, where nature conservation is the main management goal, cover 30% of the total forest area, and only a fraction of these are Strict Forest Reserves. In many cases these areas are also managed for recreation, landscape or low level wood production. The Dutch Forest Reserves Programme was initiated in 1983, with the principal aim being scientific research. Although the areas are strictly protected, planted forests can also be included. Each forest reserve represents a specific site and forest type.

Norway has large National Parks, mainly in the alpine regions. The first reserves consisted of either wilderness or typical biotypes. In the last decade, focus has increased on the conservation of biodiversity; e.g. productive forest areas in the lowlands, and special threatened areas in newly created ecosystems, e.g. scrub development. There are separate action plans designed to create a network of forest reserves for both broad-leaved, deciduous forests and coniferous forests. An additional plan aims to protect 120 km^2 of productive coniferous forests before year 2000.

Environmental legislation in **Portugal** has been reformed recently and contain new protection categories, in addition to the existing National parks and Nature reserves. Protected areas may contain special zones called 'Strict Nature Reserves', where human activities are restricted to scientific studies only. Semi-natural forest sites have also been included in the EU NATURA 2000 Network.

The **Russian** network of reserves and other protection categories has been developed since the beginning of 20th century. A priority is to increase the area of forest reserves in the near future. In addition, a large area of forests belong to a special category, which is managed for specific purposes, such as pre-tundra forests, protected riverine zones, research and educational forests.

Protected forests in **Slovakia** can be divided into protective forests with conservation and ecological functions, and special purpose forests, which are situated in watershed and emission areas. In addition to all other categories of protected areas, there are strictly protected forest reserves, many of which are part of National Parks, Biosphere reserves and protected landscapes.

In **Slovenia** the expansion of forest reserve network to increase the representatives of forest biotypes began in the 1970's. During the 1990s the area covered by the network has reached 1% of the total forest area. These reserves are strictly protected, with the principal aims being nature conservation and research. In addition to reserves, forests are also protected in protective forests, forests with subordinate productive functions, and in ecocells.

In Spain many protected areas have been created during the last 15 years. The Natural Parks are the most important category of protected areas, however, they do not fully represent the range of natural forests in Spain. Stronger protection is afforded in small Nature Reserves, especially where they occur as special zones in National Parks and Natural Parks. Because these areas often have their own separate administration, there is no integrated information available about the total protected forest area.

Sweden is currently revising the National Park system, where more emphasis will be put on regions outside the previously protected arctic-alpine mountain region. Natural forests were intensively studied during the first nation-wide inventory of valuable forests in between 1972 and 1985. Most of the forests identified in the inventory were protected by 1992 and a new programme is being implemented to systematically protect valuable forests. Generally, forest reserves, as well as other legally protected areas, are left to develop freely.

In the United Kingdom, a new law enacted during the 1980s, afforded greater protection to conservation areas. Woodland is protected via a variety of mechanisms including the designation as Sites of Specific Scientific Interest (SSSI), ownership/management by conservation organisations, and local or national bodies sympathetic to nature conservation. SSSIs have been selected to represent the range of British woodland types and to conserve rare species. Many of these areas are managed as coppice, high forest, wood-pasture or minimum intervention areas according to the characteristics of the site and the management of the immediate, surrounding area. Nature conservation agencies aim to establish a series of minimum intervention sites, where no silvicultural treatments will be permitted.

2. RESEARCH IN FOREST RESERVES AND NATURAL FORESTS

Most countries participating in the COST E4 Action are determined to establish a representative network of strict forest reserves. These areas are scientifically important, particularly in countries where natural forests represent only a small proportion of the total forest area. Forest reserves are important for research on natural forest dynamics, especially in Central-European countries. In Scandinavia, natural forests outside reserves have been, and still are, very valuable for research.

Traditional basic research on vegetation and structure of natural ecosystems has increased, particularly during the 1990s, with greater emphasis on silvicultural techniques, as a result of the current focus on sustainable forest management and the

preservation of biodiversity in managed forests. Knowledge on the dynamics of natural forests is very relevant to current and future forest management. Due to the demand for more ecologically-oriented silviculture, many countries have launched research programmes focusing on biodiversity and/or ecological research in forest reserves.

Short summary by countries

In Austria, research to date on natural forests has focused mainly on the survey, documentation and evaluation of forest structure-related data. The main activities on natural forests at present, are linked to the Natural Forest Reserves Programme. A network of observation plots has been established in forest reserves.

In Belgium forest research initially focused on productivity and the potential of exotic species. A more ecologically-oriented research programme has developed since the 1980s. Current research topics include, ecology of old forest plant species, evaluation of endangered species, methodology for the quantification of biodiversity and basic inventories of forest reserves.

In Denmark a basic research and a long term monitoring programme in natural forests have been formulated. Although forest dynamics have not previously been studied widely, pollen analysis has been used to study vegetation dynamics. Studies in natural forests are considered important in the process of developing nature-based forest management, especially as a result of extensive reforestation programmes

In Finland natural forests have been studied since the 1920s when, at that time, basic knowledge of natural forests dynamics was gathered. Up to the 1990‘s there has been little research activity specifically on natural forests, although results of forest management studies have often been compared to undisturbed forests. In recent years several research programmes concerned with natural forests have been established focusing on fire ecology, forest dynamics and structures of natural forests. The most important permanent plot network in natural forests was established in 1993 by Metla including more than 250 different natural forests.

Strict forest reserves have been established in **France** to study and observe forest dynamics and environments, untouched by man. In each region, a scientific committee controls the inventory and scientific programme within the reserves.

In Germany, most research activities have focused on vegetation studies: stand type, stand structure, vegetation mapping and plant inventories. Recently, faunistic studies have been initiated. In addition, an initiative to implement a monitoring programme in unmanaged beech ecosystems has been suggested. Research often focuses on the dynamics of natural forest reserves for the benefit of silviculture in production forests. Ongoing research includes standard surveys of permanent plots or core areas in forest reserves.

In Greece the Forest Research Institute of Athens established a large number of experimental plots throughout the country in the 1960s. The control plots on unmanaged areas provide data on natural forest development. Recently, the creation of a network of plots in forest reserves has been discussed. At present, a number of studies are focusing on silvicultural research in natural forests.

Traditional forest research in **Hungary** has focused on either floristic, faunistic or succession in managed oak woods. Presently, a network of forest reserves in natural forests is being established for research purposes. A standard monitoring scheme is being planned for these areas, and systematic research has already been ongoing in some reserves since the 1980s.

A number of research projects concerning various aspects of oakwood ecology were initiated in **Ireland** during the 1970s. In general, there is a paucity of published stand structure data for Irish woodlands. Presently, a comprehensive programme of monitoring and scientific research is being undertaken in a semi-natural oakwood, which serves as the flagship site of a proposed Irish Ecological Monitoring Network. Palynological and soil research techniques have also been traditionally employed to study the development of natural forests.

The **Italian** Forest Research Institute established a research programme on forest areas of peculiar interest in 1952. Of the network of permanent plots some still remain. The aim was to study the evolutive trends of the main forest ecosystems. Recently, new research areas have been established within several Natural Parks. Phytosociological methods are being used to classify forest ecosystems in order to characterise their dynamics. In addition, the impact of recreation on the protected areas is being assessed

Research-related goals of the Forest Reserve Programme in **the Netherlands** are inventory and analysis of spontaneous forest processes. For these purposes, permanent plots have been established. The information gathered is also important for the implementation of the Dutch National Long-term Forestry Plans, which aim at more natural forest-oriented management.

Few research projects have been carried out in **Norway**, in nature reserves, though considerable research has been done in natural and managed forests outside of reserves. This work has focused on forest history, utilisation and disturbance of forests, forests structure and dynamics, fragmentation, multiple use of forests etc. Natural forests will be the focus of research, – for example a current, large research project on biodiversity, – although no project is specifically targeted on forests reserves.

There is no special research programme focused on protected areas in **Portugal**. The most common studies have dealt with vegetation dynamics. Since fire is a major cause for concern in Portugal, issues related to fire prevention and vegetation recovery after fire have been studied in protected areas. In addition, faunistic studies of endangered species have been carried out.

Almost all forest research in the **Russian** taiga zone has been carried out in natural forests subject to various forms of disturbance. During the early years of the 20th century, information on forest resources was collected, a classification system of forest types was created and a permanent sample plot experiment was established. Presently, State Forest Reserves and National Parks have their own research programmes. Other institutions study natural taiga forests and natural forest are included in a number of other studies. Forest biodiversity and the effects of climate change are the current focus areas.

Research on the structure of natural forests has a long tradition in **Slovakia**. Current research of untouched forests can be classified into two categories: (1) detailed investigations of selected virgin forests, i.e. structure and development, growth and yield, regeneration processes and life cycle and (2) studies on anthropogenic impacts on forests, i.e. regeneration under different degrees of pollution stress, changes in soil chemical composition and physiological processes measured by dry mass extracts.

During the earliest phase of forest research in **Slovenia** the primary focus was toward stand structure and dynamics. Subsequently, research on stand structure continued and a new network of permanent sample plots was established. Since the 1980s, more emphasis has been placed on an interdisciplinary approach and on comparative research between forest reserves and managed forests, which have developed under similar edaphic conditions.

Nature reserves in **Spain** are not monitored in a co-ordinated fashion, although a pilot monitoring programme has been carried out in one of the National parks. Most work on the ecology of forests has been done in a limited number of the various forest types extant in Spain. However, a lot of research has been done on holm oak forests. Other forest types have been studied from a biogeochemical point of view.

Swedish Nature Reserves are monitored in permanent plots within the National Forest Inventory, i.e. measurements extended to reserves in 1994, and in the national network of integrated monitoring plots established in the late 1970s. A lot of research has been carried out on silvicultural methods, especially in experimental forests, which were established nearly 70 years ago throughout the country. Scientific research has not been systematically directed to, or carried out in the Natural Parks. Recently, new projects concerning threatened species, indicators of biodiversity and lichens as environmental indicators have been initiated

In the United Kingdom research has been carried out on natural processes or on species specifically associated with minimum intervention management, in addition to direct studies of minimum intervention areas themselves. For example, historical and palaeoecological studies of past species composition have been done as well as studies on woodland management, succession, species indicative of old growth conditions, comparative studies of protected and managed forests, and the structure and dynamics of canopy, shrub layer and ground floral zones.

Specifications for the statistics of the forest area and forest protection

The headings in Table 1 are explained in more detail as follows:

1. **Forest and other wooded land,** area of forests
   - see explanations as separate page
   - use national definition / or FAO 1992 definition (indicate which definition is used)

2. **Naturalness** (degree of human influence on forests)

a) natural forests = virgin forests, primeval forests,untouched, old growth forests
   - original forest cover (only natural regeneration can occure)
   - uninfluenced by human activities for specified time

b) semi-natural forests = consist of tree species which occure naturally on a specific site
   - only natural regeneration (no planting, no seeding)
   - human influence allowed (traditional uses like selection cutting, coppicing, slash and burn cultivations)
   - mainly multipurpose or production forests at present

c) altered forests = no more necessarily original forest composition (mainly production forests)
   - planted / sowing after cutting, artificial regeneration
   - includes also exotic tree species, or native species out of their natural range
   - afforestation of abandoned agricultural land

3. **Strict forest reserves** = strictly protected forests (left for free development without human influence) Note! This is the most important fragment for COST E4.
   - total area in hectares
   - number of reserves
   - average size / or range

4. **Total area of forest reserves** = different categories of protected forests, forest areas outside of normal forest operation (management)
   - mainly protected forest areas of rare and vulnerable ecological / biodiversity value
   - not forest areas for lanscape management
   - not forest areas for protection of erosion, water, avalanches

Definitions: see more detailed in: Schuck, A., Parviainen, J. and Bücking, W. 1994. A review of approaches to forestry research on structure, succession and biodiversity of undisturbed and semi-natural forests and woodlands in Europe. European Forest Institute, Working papers 3. 62 p.

Table 1. Area of strict forest reserves and natural forests in European countries. Data based on country reports and forests statistics. For explanations, see "Specifications" on previous page.

Country	Area of forests (1000 ha)	Forests of total land area (%)	Natural and seminatural forests (% of for. area)	Altered forests (% of for. area)	Area of strict forests reserves (ha)	Number of strict forests reserves	Ave. size or range of strict forest reserve (ha)	Total area of protected forest (ha)	Total area of protected forest (% of forests)
Austria	3924	47	25%	75%	6072	159		755000	19,2 %
Belgium	623	11	*	mainly	1734	46	39	~5000	0,1 %
Bosnia-Herzeg.	2589	51	85%	15%	3125	27		25506	1,0 %
Bulgaria	3357	30	13%	87%				335000	10,0 %
Croatia	2485	44			2856	32		181405	7,3 %
Czech	2637	33	16%	84%	25000	103	2-2500	175000	6,6 %
Denmark	445	11	5%	95%	5086	292	17	890	0,2 %
Finland	23000	76	77%	23%	1300000	311	4180	2700000	10,7 %
France	15156	28	20%	mainly	14000	30	1-500	180000	1,2 %
Germany	10700	30	22%	mainly	24000	659	36	400000	4,0 %
Greece	6513	49	6290000 ha	224000 ha	142000	39		951700	14,6 %
Hungary	1738	18		mainly	4000	69	58 / 3.4-300	327178	18,8 %
Ireland	570	8	18%	82%	5736	33	174	5736	1,0 %
Italy	8700	29		mainly	1841	4		560409	6,4 %
The Nether.	334	10	**	90%	2198	48	5-500	18500	5,5 %
Norway	11950	37	mainly		148000	160		199500	1,7 %
Poland	8726	28	70%	30%	3687	106	44	183246	2,1 %
Portugal	3306	37	10%	mainly	1841	4		560409	6,3 %
Romania	6370	27	70%	30%		55		527000	8,3 %
Russia (eur.)	132341	39			1726			39956	3,0 %
Slovakia	1920	42			15428	76 (19)	203	270000	14,0 %
Slovenia	1050	52	mainly		10420	186	56		
Spain	12511	25		mainly	32644	87	375	3000000	24,0 %
Sweden	24400	59	73%	27%				832370	3,4 %
Switzerland	1186	29	21%	79%	1018	39	30	13529	1,1 %
UK	2300	10	19%	81%	81				

* part of broad leaved
** ancient forests, 10%

Factors affecting the comparability of the forest area data

This review is based on Köhl,M., Päivinen,R. Traub, B. and Miina, S.: European Forestry Information and Communication System. Reports on forestry inventory and survey systems. European Commission 1997. Volume 2. Comparative study, pp. 1265-1322.

One major cause of differences is the definition of forest (Table 2.). For instance, the Scandinavian countries define the forest land using the productivity and tree growth as the defining factor. In the most European countries the definition of forest land can be based on crown cover combined with tree height. The FAO definition requires, that area classified as forest should have a crown cover of 10% and a heigth of trees of 5 meters.

Figure 1 shows the variation of the growing stock volume depending on the density and structure of the forests classified according to the forest land area.

Also other definitions are used differently in different countries due to their management practices and land use history. The most of the Southern European countries have large areas of schrubland and coppice forests and only a few amount of high forests. The naturalness of forests is often described with different classifications or the definitions have different meaning. Only few countries have made a nation-wide inventory where naturalness of the forests has been evaluated.

The statistics available varies as well, because often the data is collected with different methods. The accuracy of the data can alternate also because of the inventory methods used. Exact information does necessarily not exist about all specific subjects and approximations have to be used. For example, the precise area of forests in the nature reserves is often not known.

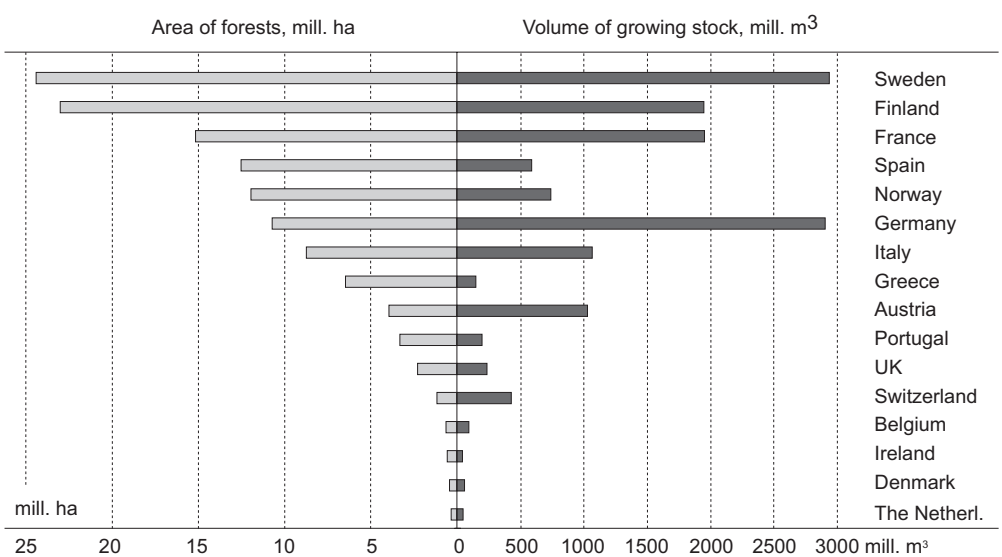

Figure 1. The total volume of the forests in some European countries classified according to the forest area.

Table 2. Definition of forest area and other wooded land in several European countries.

Country	Min. width	Min.crown cover	Min. area	Min. potential production	Comments
Austria	10 m	30 %	0.05 ha	-	
Belgium	9 m / 25 m	- / 20 %	0.1 / 0.5 ha	-	
Denmark	20 m	-	0.5 ha	-	trees in the forests should be able to grow taller than 6 m
Finland	-	-	0.25 ha	1 m^3/ha/a	
France	15 m	10 % or 500 stems/ ha with c.b.h. < 24.5 cm	0.05 ha	-	
Germany	10 m	-	0.1 ha	-	
Greece	30 m	10 %	0.1 ha	-	large coppice forest
Ireland	40 m	20 %	0.5 ha	4 m^3/ha/a (conifer) 2 m^3/ha/a (broadleaf)	
Italy	20 m	20 %	0.2 ha	-	large coppice forest
the Netherlands	30 m	20 %	0.5 ha	-	
Norway	-	-	0.1 ha	1 m^3/ha/a	
Portugal	15 m	10 %	0.2 ha	-	large coppice forest
Spain	20 m	5 %	0.25 ha	-	large coppice forest
Sweden	-	-	0.25 ha	1m^3/ha/a	
the United Kingdom	50 m	20 %	2 ha	-	

Source: Study on European Forestry Information and Communication System. Reports on forestry inventory and survey systems. European Commission 1997. Volume 2. Comparative study, pp. 1265-1322.

AUSTRIA

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ABSTRACT

Austria can look back on a long tradition with respect to the establishment and maintenance of natural forest reserves. Currently, a national reserves network is being established and research priorities are being re-formulated. The network now comprises 159 natural forest reserves and natural forest stands, with a total area of 6,072 ha. The established reserves include 80 of the 125 natural forest communities in Austria. The objective of the Natural Forest Reserves Programme is to provide at least one natural forest reserve for each and every potential natural forest community in the forest ecoregions. The present report describes the relevant legal situation in Austria, the specific role natural forest reserves play in the Alpine region, and the ”Natural Forest Reserves” project, as well as some relevant research results.

1. INTRODUCTION

In Austria, the establishment and maintenance of natural forest reserves has been ongoing for several decades. The process was undertaken and promoted by a few outstanding forest scientists, forest-tenants, and forest practitioners, though not within the framework of a national programme.

We are presently working to implement the ”Austrian Natural Forest Reserves Programme” initiated in 1995. This Programme aims at systematically establishing a representative network of natural forest reserves and can be regarded as a direct response to the Helsinki Resolution H2, ”General Guidelines for the Conservation of Biodiversity in European Forests”. In this context, the Natural Forest Reserves project essentially contributes to the implementation of the overall strategy of maintaining and improving forest biodiversity, which is considered a basic requirement of forest sustainability and effective forest functioning.

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Today, Austria has 159 natural forest reserves, occupying an area of 6,072 ha or 0.15 % of the country‘s total forest area (Figure 5). Natural forest areas are rapidly increasing both in numbers and size; observations occurring within them are primarily oriented to ascertain and monitor the occurrence of potential natural forest communities. As many as 125 forest communities are represented, due to Austria’s location at the juncture of alpine, sub-continental and sub-Atlantic climatic influences. All typical forest communities occurring in the 22 defined forest ecoregions (Kilian et al. 1994) will be represented by at least one reserve per forest ecoregion and forest community.

Please note that the figures given in this report refer to present observations and are liable to change within a very short time.

2. GENERAL INFORMATION ON AUSTRIAN FORESTS

2.1 Data from the Austrian Forest Inventory

According to the most recent evaluation of the Forest Inventory, 3.92 mil. ha of Austria’s national territory are occupied by forests (46.8%). Since the first Austrian Forest Inventory in 1961, Austria’s forest area has gradually increased. In general, broad-leaved forests, and mixed forests with a high proportion of broad-leaved trees, have increased, whereas the proportion of pure coniferous stands have decreased (Russ 1997).

Table 1. Percentages of silvicultural management methods and types of ownership in Austrian forests.

Austria‘s national territory	8,385,000 ha
Current forest area	3,924,000 ha
Forest area as a percentage of the total land area	46.8 %
Population	8,046,500
Population density	96/km²
Forest area per inhabitant	0.49 ha
Silvicultural management methods	
Production forests	75.7 %
Protection forests with commercial yield	7.4 %
Protection forests without commercial yield	11.9 %
Forested area without commercial yield	2.6 %
Coppice stands	2.4 %
Types of ownership	
Private forests (<200 ha)	53.4 %
Industrial forests	31.6 %
ÖBF-AG (State-owned forests)	15.0 %

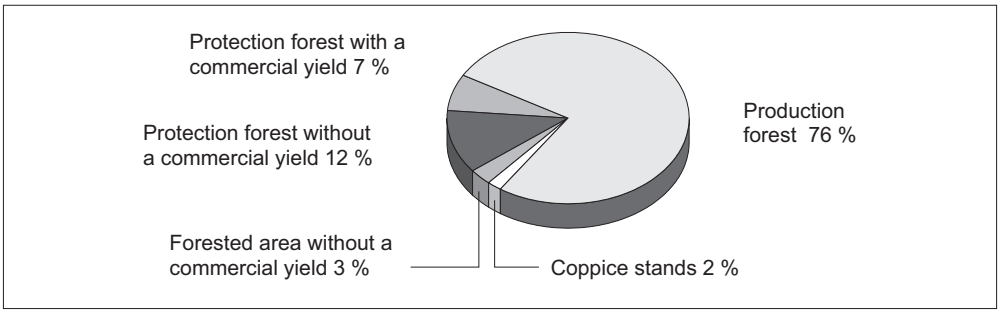

Figure 1. Relative proportions of silvicultural management methods applied in Austrian forests.

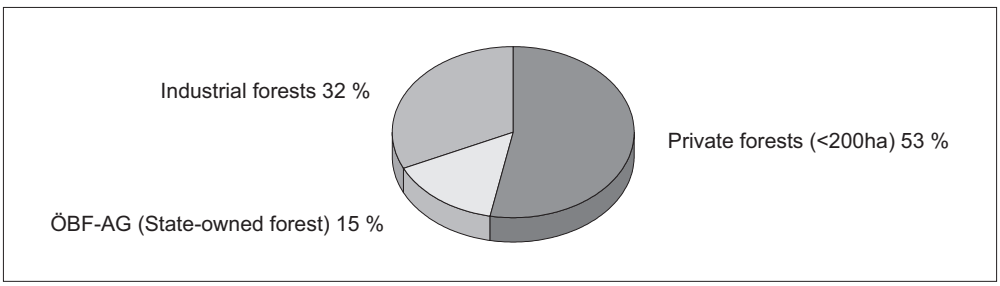

Figure 2. Percentage breakdown of ownership status of Austrian forests.

2.2 Protection forests – unmanaged forests

Approximately 755,000 ha (19.3%) of Austrian forests are classified as protection forests. In contrast to other countries, however, Austrian forest legislation does not define protection forests as classified protection areas using nature conservation criteria. Rather, they identify forests, which must be preserved through limited forest utilisation, using specific silvicultural techniques. The purpose of protecting such forests is to maintain certain beneficial attributes for man, e.g. protective and social, recreational, and general economic functions.

According to the definition of the Forest Act, protection forests include all forests on soils which, unless occupied by forests, would be eroded by wind, water and weathering, and where reafforestation would be extremely difficult. On extreme sites, protection forests must be able to perpetuate themselves in order to be sustainable. They protect soil, especially on steeply sloping sites.

Since the first Austrian Forest Inventory in 1961, protection forests have been classified to include ”protection forests with a commercial yield” and ”protection forests without a commercial yield”. Economic considerations were instrumental in the development of this classification system: in protection forests with a commercial yield (7.4% of the entire forest area) economic exploitation is possible provided the

protective function is accounted for, whereas protection forests without a commercial yield (11.9% of the entire forested area) cannot be utilised, to any appreciable extent. The latter include forests at locations, which are very inaccessible and very low yielding stands on poor sites. The result is, is that human intervention is virtually impossible and that these forests are very much in harmony with nature (Schadauer et al. 1997).

Due to their inaccessibility and other site characteristics, such forests (approx. one fifth of the forest area) have many properties, which are identical to those of forest protection areas. For this reason it is frequently proposed to replace natural forest reserves with them. However, a critical analysis of such an approach highlights a number of difficulties:

- Protection forests without a commercial yield are generally located at the subalpine altitudinal forest level; they represent few native forest communities and support only a few tree species. According to the most recent results of the Austrian Forest Inventory, 75% of the protection forests without commercial yield are composed of only 4 coniferous tree species.
- A high percentage (26%) of protection forests without commercial yields are made up of shrub ecosystems, such as *Pinus mugo*. Such forests are of minor importance to Austrian forests and do not provide new information relevant to high-forest management.
- At present, natural forest reserves are over-represented at the montane and subalpine altitudinal levels, and particularly in protection forests. This is true for both numbers and sizes. In contrast, there is a lack of representation of forest communities outside those areas.

2.3 Hemeroby of Austrian forest ecosystems – Degree of modification due to human intervention

As in other European countries with large forest areas, the degree of naturalness in forests is an essential requirement in commercial forestry, environmental protection and in most research disciplines, especially in natural forest research. Subsequent to the completion of the research project ”Man and the Biosphere” carried out at the University of Vienna, we are now, at last, in a position to provide soundly-based scientific answers to the delicate question ”to what extent are forests in harmony with nature” (Grabherr et al. 1995).

This project was unique in that hemeroby, i.e. the extent of modification through human intervention, was assessed using a standardised evaluation process. A stratified random procedure was used to evaluate Austria‘s entire forest area (Reiter and Kirchmeir 1997). To survey the degree of naturalness of forests, 4,892 field plots within the Austrian Forest Monitoring System were used to determine the extent to which the present forest condition differs from potential natural forest communities. To this end, a list of clearly measurable and repeatable criteria were established and surveyed according to a clearly defined code.

Degrees of naturalness (degrees of hemeroby) are assessed by combining 11 separate criteria, among them ”naturalness of tree species composition”, ”naturalness of ground flora”, ”intensity of utilisation”, and ”amount and quality of dead wood”. In the course of the evaluation process, the surveyed values (solid cubic meters of dead wood, stratification, etc.) were transformed into a comparable ordinal scale of 1 (polyhemerobic, artificial) to 9 (ahemerobic; without impact – seminatural/utilised). Transformation of the surveyed values into relative values allows one to combine two of the measured criteria for each hemeroby value (Koch and Kirchmeir 1997). This method of evaluation makes the process reproducible and transparent. For practical purposes, 10 of the stages were combined to form 5 degrees of naturalness (Grabherr et al. 1997). With few modifications, this newly developed systematic procedure could be applied also in other countries.

Results indicate that 3% of Austria’s forest area have not been subject to human impact and that 22% are seminatural. Forests classified as natural or seminatural occur mainly in the subalpine, inner parts of the Alps and are dominated by coniferous trees. Most Austrian forests, i.e. 41%, are moderately altered. The study also shows which regions have been affected most by human impact and where natural or semi-natural forests no longer remain. The latter category occurs mainly in the outer zones of the Alps, where the potential natural forest communities would predominantly be composed of mixed beech and oak forests. 34% of all Austrian forests are altered or artificial (Koch et al. 1997). Here, it will be necessary to implement specific programmes for these areas in order to improve forest condition.

3. HISTORICAL BACKGROUND OF NATURAL FOREST RESERVES IN AUSTRIA

3.1 Impacts of historical forms of utilisation

Very few of Austria’s natural forest reserves are true remnants of virgin forest and even these are relatively small and, in some cases, comprise only a few hectares. In the past, Austrian forests were much more intensively exploited by man than they are today. Wood was not only an important construction material, but also the main source of energy. Entire valleys were clear-cut to supply the energy demands of the iron and steel industries, saltworks and the demand for fuel in the flourishing towns. As a result of permanent pasturing and litter-use over hundreds of years many of the original forests were transformed into open, park-like landscapes. Many forest ecosystems have never recovered from these phases of intensive agricultural exploitation.

For the above reasons, it is quite understandable that virgin forest remnants have only survived in areas which are either very inaccessible or unsuitable for agricultural use, due to the difficult terrain and soil conditions. Historical landuse explains why formerly, reserves were primarily established in montane and subalpine altitudinal levels, particularly in the Limestone Alps. It is one of our objectives today to correct this unfavourable, unbalanced representation.

3.2 Background

The protection of the remaining virgin forests, which were located mainly in the Northern and Southern Limestone Alps began as early as the last century, by forest-tenants that were responsible for them. Maintenance of nature for future generations was a key priority.

Since 1965, new activities have been undertaken in relation to scientific activities in reserves. These developments are closely associated with the two forest scientists, namely Hannes Mayer and Kurt Zukrigl. Even at this early stage, efforts were made to build up a network of natural forest reserves, which would eventually represent all important forest communities in proportion to their significance. A major part of work involved in the establishment of existing reserves, which is documented in monographs, is due to the efforts of these two scientists (Mayer et al. 1987; Zukrigl et al. 1990).

Examples of outstanding initiatives included the designation of primarily small areas (termed natural forest stands), through private-law contracts drawn up by the ”Tiroler Forstverein” with private or communal forest-tenants. In addition, the establishment of natural forest reserves in parts of the Vienna Forests located close to the city by the Forest Office of Vienna, was also a far-sighted achievement. In 1986, as a result of initiatives by Hannes Mayer and Kurt Zukringl, a contractual agreement was arranged between the University of Agriculture and Forestry and the Austrian Federal Forests (ÖBF) to make the reserves located on ÖBF properties available for research. According to recent information, the ÖBF’s share of the total natural forest reserves area is approximately 15%, which also corresponds to its share of the total forest area.

This brief historical summary clearly indicates that private forest-tenants have, from the very beginning, played a major role in the establishment of natural forest reserves in Austria and that the establishment of forest reserves did not occur exclusively in State forests. By the end of 1994, Austria had as many as 86 natural forest reserves with a total area of 3,224 ha (Frank 1995).

3.3 Consequences of the Helsinki Resolution, H2

Subsequent to the agreements made at the Ministerial Conference for the Protection of Forests in Europe, a working group was established in 1994 to develop a framework concept for the establishment of a nation-wide network of natural forest reserves in Austria. From the outset, people representing the interests of forest-tenants, administrative forest experts, forest scientists, and forest practitioners were included in the process, which finally lead to an ”Austrian Programme for Natural Forest Reserves”.

The Federal Forest Research Centre (FBVA) has been entrusted with the technical implementation of the Programme. Administrative and financial tasks are the responsibility of the Federal Ministry of Agriculture and Forestry.

At present, systematic expansion of the network is the top priority. We are, therefore, concentrating our efforts on assessing the suitability of potential new areas and on documenting the original conditions of new reserves as precisely as possible. Due to the lack of staff, scientific investigation of existing reserves must be limited to urgent periodic surveys of the field plots, some of which have been in place for more than 30 years.

4. CLASSIFICATION AND LEGAL STATUS OF PROTECTION AREAS

4.1 Legal background

The Austrian Federal Constitution does not charge one uniform authority with the responsibility of environmental protection. Environmental law still has a somewhat multi-sectional character (Welan and Kind 1995).

Legal authority regarding legislation and implementation of provisions regarding nature and landscape protection usually lies with the nine Federal Provinces. Hence, Austria does not have one federal law on the protection or conservation of nature, but nine provincial laws, which means that, from a legal point of view, the Federal Government is not responsible for the protection of nature. Exceptions to this rule occurs with respect to international agreements, such as the ”Convention on the Alps”, the ”Ramsar Convention” or the ”Convention of Bern”, and relevant European Commission programmes. In contrast, forest activities are entirely regulated by federal laws.

With regard to the establishment of natural forest reserves, it should be pointed out that, contrary to other European countries, the term ”natural forest reserves” is not mentioned in the Austrian Forest Act. Furthermore, with the exception of Salzburg, the Provincial Nature Conservation Acts do not provide explicit definitions of the term.

This is why in former times, protected areas – which corresponded to our present natural forest reserves – were established as nature reserves or protected landscapes (see below) by decree and through the application of legal instruments on nature conservation, which were available at that time (Zukrigl 1990). Some of the reserves located on ÖBF properties were secured by administrative agreements with scientific institutions. However, the majority old reserves were secured on the basis of informal promises by the owners or on simple agreements under civil law.

It was only after Austria the Resolutions of the Ministerial Conference for the Protection of Forests in Europe, in particular Resolution H2, General Guidelines for the Conservation of the Biodiversity of European Forests, in 1993 in Helsinki, that a national Programme for the Establishment of Natural Forest Reserves was initiated. This Programme laid the foundations for the systematic expansion of a representative natural forest reserves network nation-wide. Under this Programme, new reserves are generally not established by decree, but on the basis of private-law contracts between the Republic of Austria and forest-tenants.

4.2 Protection categories nature conservation laws of the Federal Provinces

Nature reserves

Suitable for designation as nature reserves are areas where the maintenance and conservation of natural and sustainable ecosystems or ecosystem complexes with a high abundance of species and great structural diversity are ensured; which offer habitats and refuge areas for rare animal and plant species, or which for other reasons, are of high scientific importance. According to the above criteria, primary or relictic forests are worthy of conservation (cf. Druml 1992). Apart from specific conservation areas in

national parks, nature reserves are the strictest form of area protection in all Federal Provinces (Tiefenbach 1993). However, exceptions to the laws occur in five of the provinces, which allow certain agricultural and silvicultural practices to be carried out in these areas.

When the first nature reserves were established in response to the first European Nature Conservation Year in 1970, biotopes principally without forests, i.e. dry meadows, wetlands or alpine biotopes, were considered. Hence, of the 328 nature preserves (with a total area of 281,814 ha or 3.3% of the national territory; Tiefenbach 1993) only 26 (4,698 ha or 0.06% of the national territory) are pure forest biotopes. However, the percentage of forests in the total area of nature reserves is much higher because numerous non-forest designated conservation areas contain small areas of forest. Regrettably, no exact data on the amount of forest in the total area of nature reserves are currently available, due to the lack of a nation-wide survey on the subject.

Landscape conservation area

Areas of outstanding beauty or of special importance in relation to local population or tourism belong in this category (Druml 1992). Landscape conservation areas afford far less protection than nature reserves. In such areas, measures, which may have long-term impacts on the landscape, are subject to approval. In landscape conservation areas, effective protection of species in tandem with other activities is not necessarily provided, because management measures often include agricultural or silvicultural activities, which may conflict with nature conservation objectives. Landscape conservation areas are predominantly oriented to the maintenance of traditional farming methods, and are therefore, not suited to secure natural forest areas.

Protected landscape segments; Green belts

Small landscape segments, which are characteristic of particular landscapes, villages or towns, or which are of special ecological importance, local climate, flora and fauna belong to this protection category (Druml 1992).

This category is provided for in all relevant provincial laws, except in one Federal Province. It includes parts of landscapes (frequently located in landscape conservation areas), which are preserved in order to protect particular mosaics or individual parts of landscapes. Such areas afford similar protection as nature reserves, however at a much smaller scale; due to their small size, parts of the landscape in this category are most suitable for protecting natural forest stands.

Wildlife parks

Areas inclusive of nature reserves or landscape conservation areas are often included in wildlife parks. However, the principal purpose of wildlife parks is to serve human recreational needs rather than the conservation of nature. Since they are open to the public, the objectives of this category do not correspond very well to those of natural forest reserves and are hence, unsuitable for the latter (cf. Wolkinger 1996).

National parks

The regulations applicable to national parks are laid down in separate provincial laws. National parks are conservation areas with characteristic landscapes, animal or plant

species, which are of outstanding significance nationally (cf. Wolkinger 1996; Druml 1992; Tiefenbach 1993). They serve scientific and recreational needs and are generally open to the public. Provincial laws distinguish between core and peripheral zones of national parks. In core zones, all forms of utilisation are prohibited, whereas in most peripheral zones, agricultural and silvicultural activities are allowed.

Thus far, 5 national parks have been established in Austria, which together contain about 40,800 ha of forests[1]. These forest areas are located in peripheral zones and thus, do not enjoy especial protection. (Exceptions to this case are the ”Limestone Alps” and ”Wetlands of the Danube” national parks, which are afforded greater protection). For this reason only a small portion of forests in such areas are protected against intervention and most cannot freely develop vis a vis natural forest reserves.

Protection *ex lege*

Recent provincial laws on nature conservation include provision for *ex lege* protection of ecologically sensitive habitats, which may prohibit any intervention in such habitats. This applies mainly to the protection of lakes and rivers, banks, wetlands, and alpine areas. However, very few natural forest reserves are protected under this category except swamp forests or riparian gallery forests, within other habitats.

Gene conservation forests

Since 1986, the Federal Forest Research Centre has been working on a project aimed at conserving genetic diversity of forest trees (Müller 1994; Litschauer 1994). Apart from the establishment of seed banks and seed orchards, one of the pillars of the project is selective identification of gene reserves and the appropriate management of such areas by their owners.

Gene reserves and gene conservation forests are, but not exclusively, natural forest reserves. Such stands are aimed at preserving the genetic diversity of forest trees and the adaptive capacity of tree species. Gene reserves also serve to maintain rare, uncompetitive tree species, which is not a priority objective in natural forest reserves. In contrast, natural forest reserves are oriented towards the maintenance of whole-forest ecosystem biodiversity.

To attain the objectives of gene reserves, active measures, i.e. facilitating natural regeneration, protection of individual trees, regulation of competition, etc., are permitted and sometimes even required, while in natural forest reserves, all forms of intervention (except for hunting) are prohibited once they are established. This is the only way to ensure natural development without disturbance, which can subsequently be studied. Only in exceptional cases are natural forest reserves identical to gene conservation forests. A combination of natural forest reserves and gene conservation forests could be used to attain each of their objectives; close-to-nature managed buffer zones in natural forest reserves could act as gene conservation forests.

In Austria, about 8,500 ha of forests are operated as gene conservation forests. Hence, gene conservation forests are important close-to-nature control plots.

[1] Source: Telephone inquiries 11/95 and 1/98 to the administrative offices of the national parks. Similar to the situation regarding natural forest reserves, no official nation-wide statistics of the percentage of forests in national parks (cf. 4.1) are available.

5. SCIENTIFIC RESEARCH AND ESTABLISHMENT OF NATURAL FOREST RESERVES IN AUSTRIA

Natural forest reserves are particularly suited to long-term forest-ecological research, because the dynamics of these forest ecosystems are not interfered with by human activities. At the outset of natural forest research, vegetational and silvicultural aspects were primarily investigated. Today, investigations of biodiversity, of population-genetic connections, stress sensitivity or the adaptive capacity of forest ecosystems to potential climate changes are becoming increasingly important. Applied research specifically aims to develop an ecologically oriented, close-to-nature form of forest management. Natural forest reserves are examples of the natural forest communities and can serve as reference areas for biotope assessment and ecological monitoring.

In 1994, the situation regarding forest reserves in Austria was very unsatisfactory. Most natural forest reserves and / or natural forest stands were small (< 5 ha) and represented only a fraction of the total forest area. Moreover, reserves were not evenly distributed among forest communities, altitudinal levels and forest ecoregions. Large-scale zonal forest communities were predominantly represented by subalpine and montane coniferous mixed forests. Above all, there were no reserves located in beech and oak-hornbeam mixed forests. In addition, of Austria's 125 forest communities only a few special communities (azonal and extrazonal forests) were included (cf. Zukrigl 1990; Frank 1995).

5.1 Framework concept for a national network of natural forest reserves

The signing of the Helsinki Resolutions was the impetus to elaborate the framework concept for the establishment of a national network of natural forest reserves. This concept is being developed at the Federal Forest Research Centre, Vienna, in the context of the "Natural Forest Reserves" project.

The first step in the management of natural forest reserves is to allow natural development of forests to occur by ceasing all direct human activities, even if current stand development does not, as yet, correspond to the development of natural forests. The most important precondition of a natural forest reserve is the declaration of intent by its owner, or the relevant authority of the respective forest, that no interventions of any kind will be made in future and that the forest area will become part of the reserve network.

5.2 Categories of natural forest reserves

In accordance with the objectives of natural forest reserves and in consideration of the existing reserves and research results, a distinction is made between three different categories of natural forest reserves.

Standard reserves

Standard reserves must be sufficiently large to ensure that the complete developmental

cycle is sustainable (minimum structural area). A basic monitoring programme, comprising vegetation mapping and a network of permanent sample plots, is necessary for long-term monitoring and documentation of forest development.

Point-of-main-effort reserves
Due to special conditions or specific features (size, degree of naturalness, etc.) such reserves are particularly well suited for special-purpose research programmes. The category also includes reserves, which are suited for providing information to the public while simultaneously re-directing the flow of visitors away from other reserves.

Natural forest stands
Natural forest stands represent a specific type of natural forest reserve. They are too small to ensure sustainable and balanced development of all developmental phases and mainly serve as specimen stands of natural forest communities; moreover, they play an important part in the integration of habitats.

Natural forest stands must be large enough to comprise a community-specific local forest entity. Depending on the potential natural forest community, this size is between 0.5 and 1 ha.

5.3 The "Natural Forest Reserves" project at the Federal Forest Research Centre

The most important goal of natural forest reserves is to maintain the biological diversity, characteristic of the respective forest communities. The aim is not to preserve current forest condition, but to allow the uninterrupted dynamics of all processes (including natural disturbances and catastrophes).

In 1995, a keynote paper outlining the planning and establishment of a network of natural forest reserves, by experts of the Forest Authorities, administration representatives, forest-tenants, and the Federal Forest Research Centre, was produced. Experience from other countries was taken into account and existing international programmes were integrated into the concept.

The "Natural Forest Reserve" project includes recommendations for the selection, establishment and protection of new reserves, in addition to the organisation and outline of a new research programme for each reserve. Special emphasis is laid on the representative distribution of reserves, covering all forest communities occurring in Austria. At present, an information database on the reserve network is being established. A network of standardised observation plots serves long-term documentation of natural development and the effects of man-made stresses.

Apart from the degree of naturalness, representivity – which varies depending on ecoregion – is an important criterion for the selection of natural forest reserves.

5.4 Criteria for the selection of natural forest reserves

A standardised and reproducible list of criteria was established for selecting suitable forest areas as reserves. The essential criteria include:

Naturalness of the vegetation. Tree species composition of the existing stand must correspond with that of the potential natural vegetation.

Structure, age, texture of stand. Sustainability of all developmental phases of the stand within the reserve.

Minimum size. The minimum structural area, i.e. the area necessary for every forest community to be sustainably represented, determines the minimum size of a natural forest reserve (with the exception of natural forest stands). The minimum structural area varies with forest type and, according to current research, this is between 10 and 50 ha.

Topographic unit. Consistency of orogoraphic units must be accounted for.

Rareness and endangered stands. All rare and unique forest communities should be registered; the minimum area criterion may be ignored for rare and / or endangered forest communities.

Buffer zones. Buffer zones can minimise external influences on the reserves, which is why a sufficient number of such zones should be maintained or established. Buffer zones should have a width of 1 to 3 times the height of the tree canopy and only close-to-nature forest management is permitted.

Disturbance from the use of roads, trails, right of ways. Disturbances may not produce negative influences on the inner climate or core area of forest communities or hinder forest dynamics generally.

Consideration of game. Game populations must be allow be allowed to reproduce successfully and sustainably; the latter must include tree and bush species of the potential natural forest community.

5.4.1 Criteria for non-selection and exclusion

Non-selection only applies to areas, which are currently being examined for their suitability as natural forest reserves, whereas exclusion refers to existing reserves. They include the following criteria:

- protected forests are not suitable as natural forest reserves
- below the minimum size required
- present forest community differs too much from the potential natural forest community
- too fragmented
- management of buffer zones not possible
- excessive populations of game
- site used for grazing livestock

- site modifications and external influences
- forest destruction
- significant air-pollution impacts
- forests function alterations
- changes due to public interest/access

5.4.2 Schedule for establishing reserves

The establishment of natural forest reserves follows a standardised procedure and includes the following steps:

1. Registration of forest areas by forest-tenants and forest staff.
2. Preliminary examination of the proposed areas by representatives of the Federal Forest Research Centre and experts of the Provincial Forest Authorities.
3. Selection of suitable reserves and demarcation of the areas.
4. Basic survey by specially trained survey teams using a grid system of permanent sample plots for future monitoring and compensation assessment. The most important features of these surveys are: vegetation survey (using Braun-Blanquet 1964), determination and mapping of potential natural forest communities, stand parameters, Bitterlich sampling, overall site assessment and stand quality.
5. Determination of the annual amount of compensation to be paid to the owner using a uniform formula for calculation after consideration of expert opinion.
6. Drawing up a 20-year contract between the Republic of Austria and the forest-tenant.

Existing reserves are subject to regular control e.g. site visits by the relevant authorities.

5.5 Present state of the establishment of natural forest reserves

Since 1995, newly registered forest areas were examined for their suitability and pre-selected as natural forest reserves. By 1997, 71 new reserves were established (Figure 5).

Prior to the ”Natural Forest Reserve” project, 86 reserves amounting to 3,224 ha in total (Frank 1995) existed in Austria. This number has almost doubled since the beginning of 1998 and forest reserves now occupy a total area of 6,072 ha (Figure 3 and Table 2).

As can be seen from Figure 3, most reserves are between 5 and 20 ha, while only few reserves are larger than 100 ha. However, compared to 1995, the number of large reserves has doubled. This corresponds to international strategies, which favour large preserves (cf. Noss and Cooperrider 1994). The diagram also indicates that 55% of small reserves (< 5 ha of forest area) represent only 12% of the entire reserve area. In contrast, 9% of large reserves (> 100 ha) represent 47% of the entire reserve area in Austria.

In Table 2, 125 forest communities are combined into forest groups in order to describe the distribution of natural forest reserves. Most natural forest reserves occur in mixed spruce-fir-beech forests and in subalpine spruce forests. All other forest types are represented by considerably lower numbers of reserves. With respect to size, special

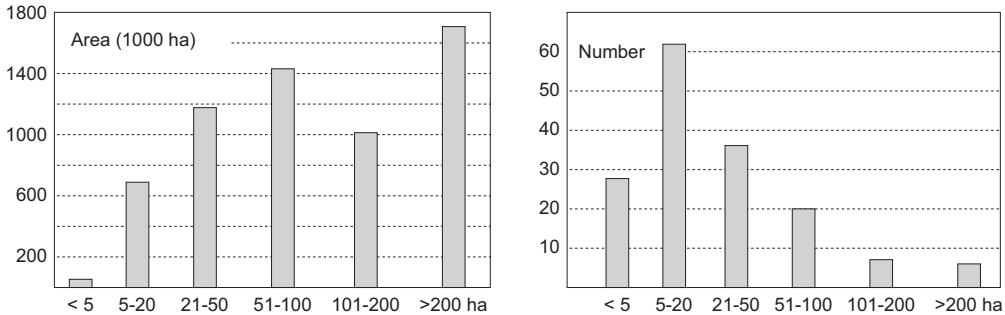

Figure 3. Natural forest reserves; areas and number of reserves in 6 size classes.

Table 2. Distribution of the natural forest reserves according to types of forests.

Forests type	Number	Area (ha)
mountainous mixed forest	38	2,224.2
subalpine spruce forests	34	1,468.39
spruce-silver fir forests	13	473.39
high-subalpine larch and *Pinus cembra* forests	9	411.26
oak-hornbeam forest	15	380.01
beech forests	23	312.5
montane spruce forests	2	204
mixed oak-forests	4	175.7
subcontinental oak forests	6	112.65
Pinus nigra forests	2	90.26
Pinus uncinata forests	2	70.5
”hard” swamp forests	3	55.16
dry and warm downy oak forests	3	34.98
larch forests	2	22
mixed linden forests	1	18
”soft” swamp forests	1	14
mixed maple-ash forests	1	5
Total	159	6,072

azonal forest types are at present, severely under-represented. Fortunately, additional oak-hornbeam forests and beech forests have been established in the last few years. However, these areas do not yet correspond proportionally to their representation in Austrian forest area and some important types are not yet represented.

5.6 Ongoing projects outside the ”Natural Forest Reserves” project of the Federal Forest Research Centre

Before the nation-wide ”Natural Forest Reserves” project was launched, research on

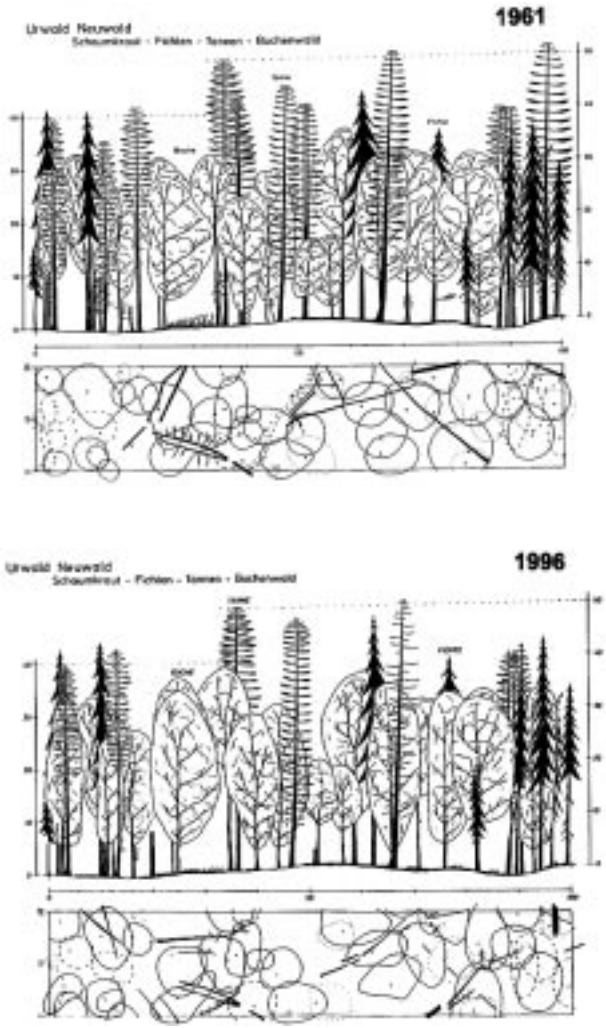

Figure 4. Comparison of stand surveys in the virgin forest ”Neuwald” (Initial survey: 1961, Follow-up survey: 1996).

natural forests focused mainly on survey, documentation and evaluation of structure-related stand characteristics. Comprehensive data are available on all the above (e.g. Mayer 1967; Mayer and Neumann 1981; Mayer et al. 1972; Mayer et al. 1987; Zukrigl et al. 1963; Zukrigl 1966; Zukrigl 1990; Zukrigl 1991; Frank 1991; Neumann 1978: Schrempf 1978).

Hence, future investigations can follow up on existing data and it is possible to carry out comparative, repeat surveys on the same sample plots and to determine forest ecosystem developmental changes. An example of such a follow-up survey was that of the virgin forest ”Neuwald”. In Figure 4, two stand structure surveys carried out in 1961

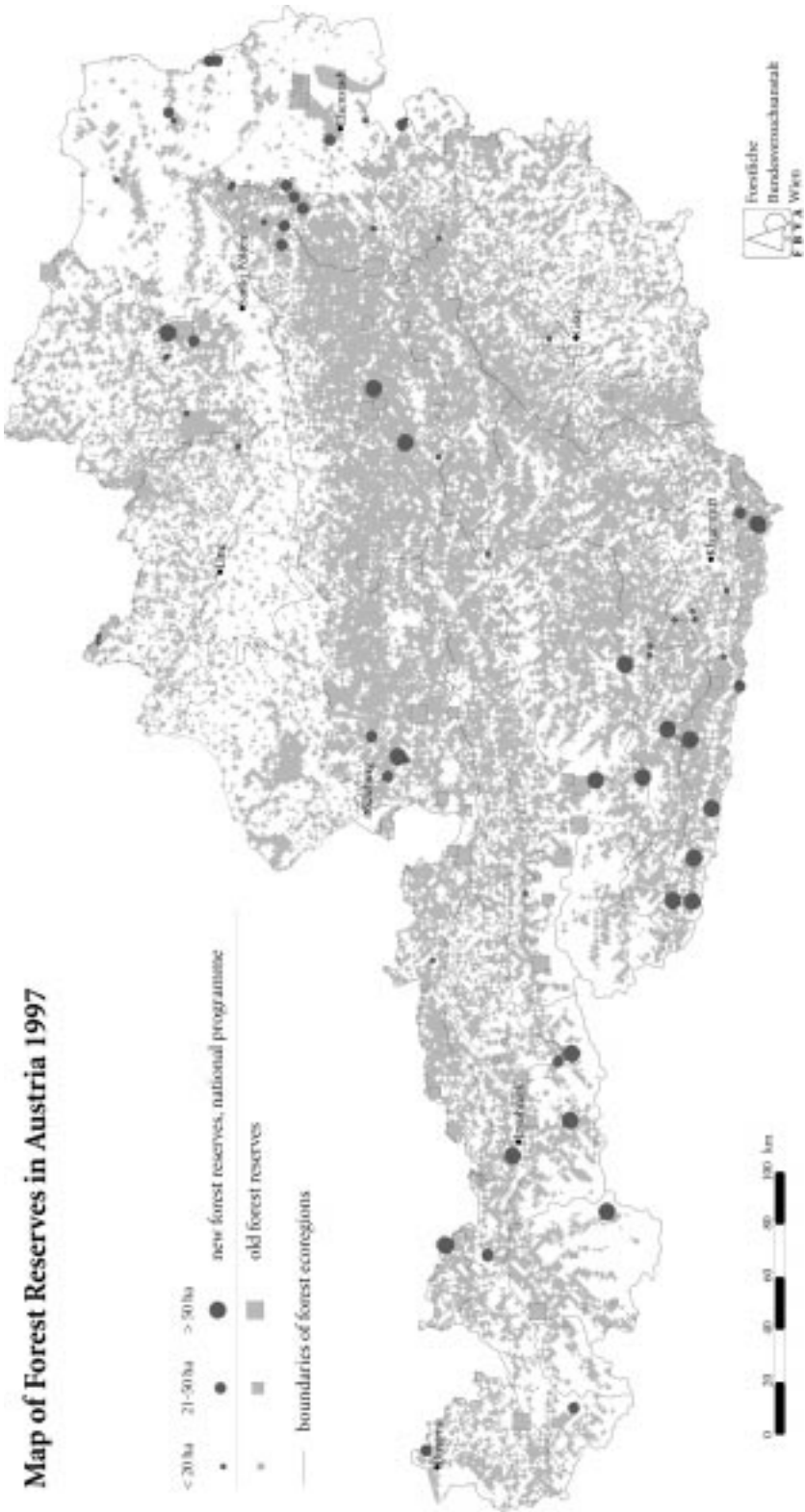

Figure 5. Map of natural forest reserves in Austria.

and 1996 are compared.

For newly established natural forest reserves, a research concept is currently being worked out which will provide for a survey programme of varying intensity, depending on the category of the reserve (standard reserve, natural forest stand, point-of-main-effort reserve). The programme takes into account the specific needs of Austrian natural forest reserves, but is also oriented to the requirements of international proposals, i.e. COST E4, and agreements. It also utilises the experience of other countries (Project group Natural Forest Reserves of the circle Site Mapping in the working group Forest Management 1993; Thomas et al. 1994, etc.).

5.6.1 Site-related projects:

”Microbial budgets in soils of natural forest communities”. This project is carried out by the University of Vienna together with the Federal Forest Research Centre. Microbiological processes in soils are surveyed in order to deduce indicators for the naturalness of forest ecosystems. Excluding any human influences, reference values for soil-microbiological activities are determined (Zechmeister-Boltenstern, personal communication.).

Another aspect of the project is the elucidation of the nitrogen budget in forests. It endeavours to quantify N accumulation and N loss. Natural forest reserves serve as reference areas for natural nitrogen leaching processes.

The project also includes investigations of ethylene and methane losses in natural forest ecosystems and the microbial diversity of such forests.

5.6.2 Vegetation-related projects:

The University of Salzburg and the ”House of Nature” in Salzburg carries out mycological and lichen investigations in natural forest reserves (Rückert and Wittmann 1995; Türk 1989, etc.). These investigations endeavour to extrapolate the degree of naturalness of forests from cryptogamete flora, and to use basic data on endangered fungi and lichens to develop new legal protection concepts.

Apart from the above research projects, diplomal and doctoral theses at the University for Agriculture and Forestry and the Universities of Vienna and Salzburg contribute to ongoing investigations in natural forest reserves; they include the initial vegetation surveys in reserves as well as very specific investigations of lichen populations.

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BELGIUM

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1. HISTORICAL PERSPECTIVE OF FORESTS AND FOREST MANAGEMENT IN BELGIUM

There are no natural forests remaining in Belgium. Species composition and stand structure is very different from the potential natural vegetation, due to human impact over the millennia.

1.1. Evolution of forest stands and species composition

In historical times, forest area gradually diminished. After an initial period of rapid decline during the early Middle-ages, a period of stabilisation and even forest expansion followed – especially in the Flanders – lasting from the 14th century up to the end of the 18th century. After this remarkable period of forest expansion the trend of deforestation recurred, so that the area of forest reached its lowest point around 1850. At that time, forests occupied only 450,000 ha, which is 14% of the total area of the country.

Management depended on the owner and the area. Small and middle sized forests were mostly owned by farmers and communities and were generally managed as coppice or coppice with standards (with a limited number of standards). Management was very intensive, as the forest provided all kinds of goods, i.e. firewood, charcoal and construction wood, acorns (for pigs), and even litter and brambles were thoroughly removed for agricultural fertilisation and domestic use. Grazing was also a common practice in forests.

On sandy soils, which were mostly located in commonage, intensive use of forests lead to accelerated degradation and eventually, to virtually complete deforestation. This resulted in the occurrence of vast heathland areas.

The remaining large forest entities were primarily owned by the nobility and by the church. Management in forests owned by the nobility was secondary to the main

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objective, which was hunting. They were generally well protected and most were managed as coppice with standards, though occasionally as high forest, favouring important woods for construction purposes, such as oak and beech at the expense of secondary species like lime and ash. The forests owned by the church were generally well-managed, using coppice-with-standards.

During the Austrian occupation (1750-1800 approx.) forest management was strongly influenced by Central European forest systems, i.e. shelterwood and group felling. They also introduced a more respectful attitude towards the forest. It was no longer seen primarily as a resource merely to be exploited and more attention was paid to forest perpetuation and sustainability. This influence made its impact latterly in the management of high forests.

During the 19th century, forest area continued to diminish, especially due to secularisation and exploitation of forests formerly owned by monasteries and the nobility, in addition to an increasing demand during famines for more agricultural land.

At the end of the 19th century, when agriculture became increasingly intensive and the need for self-sufficiency in this area became less important, a period of forest expansion began, which lasted for more than 100 years. There was a strong demand for more wood, especially from industrial sources and the developing coal-mining industry. In 1970, forest area had increased by 150,000 ha. In the Flemish region this re-forestation occurred, particularly on the sandy soils of the Campine region. On the other hand, valuable old forests continued to disappear due to urbanisation. In addition, the two world wars had disastrous effects on old forest stands.

During the last 2 to 3 decades a new phase of forest expansion took place in Flanders – estimated at about 15% of the area – some by further extension of new forests on sandy soils, but mainly by afforestation of marginal meadows.

These modern plantations were mostly established in an ‘industrial way’, i.e. even-aged monocultures. On sandy soils Scots pine (and later also Corsican pine) were predominantly planted. In Wallonia, the forest area almost doubled and the predominant tree species here was Norway spruce. The more recent plantations on meadow land consisted of fast growing Poplars.

The above historical account outlines the principal developments in forestry, which explain current species composition and forest-age distribution in Belgium. The following table illustrates tree species composition in Flanders and Wallonia.

The map on the following page make it possible to compare forest area around 1770 (Ferraris-maps) to the situation existing currently (Fig. 1). A substantial increase in the forest-area is evident, however, most of these plantations have been established using monocultures of Norway spruce in Wallonia and Pine in Flanders.

Forest area in Wallonia is much higher than elsewhere; in Flanders it is about 9%, while in Wallonia it is about 30%. The principal reason for this is that urbanisation and industrialisation is much lower in Flanders than in Wallonia. In addition, it is important to recognise that over half of the forests in Belgium are privately owned. In Flanders, this number is even higher, i.e. 70% is private forest.

Another important aspect of Belgian forestry is its fragmented nature; this applies not only to the forest area itself, but also to its ownership status. Private parcels of 1 ha or less are very common.

Table 1. Species composition and area of forest in Flanders and Wallonia.

Species composition	Flanders (ha)		Wallonia (ha)	
Oak	11 500	(8%)	85 000	(17%)
Beech	5 000	(4%)	37 000	(8%)
Mixed/other	33 000	(25%)	118 000	(24%)
Poplar	25 000	(17%)		-
Total Broadleaves	74 500	(54%)	240 000	(49%)
Scots Pine	40 000	(30%)	20 000	(3%)
Norway spruce	3 000	(3%)	200 000	(41%)
Other	19 000	(13%)	27 000	(5%)
(of which Corsican pine:)	11 000			
Total Coniferous	62 000	(46%)	247 000	(51%)
Total forest area	136 500		487 000	

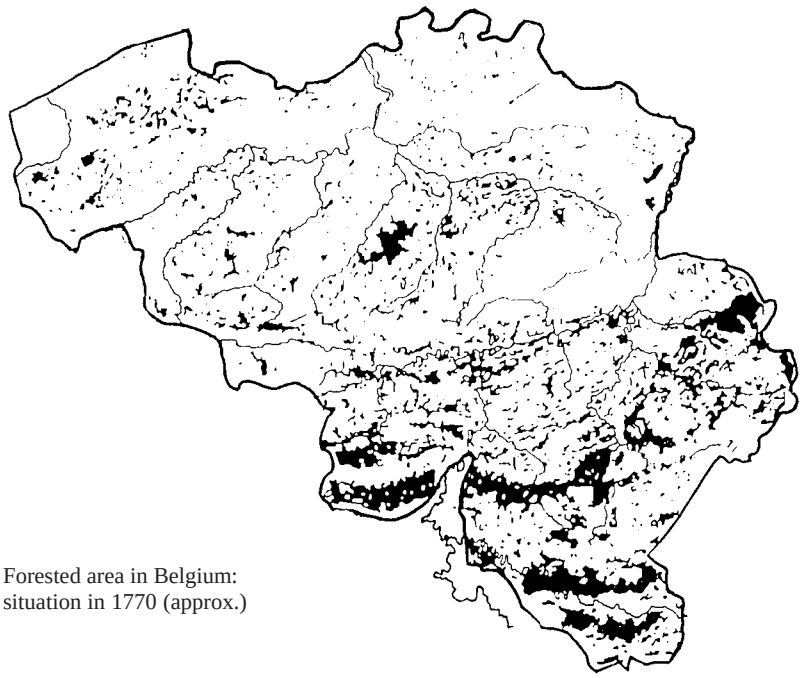
With respect to species composition, about half of the land area in Belgium is occupied by young to middle-aged coniferous stands. In addition, the area occupied by poplar plantations is very significant in Flanders.

However, there is an appreciable amount of broad-leaved stands, a significant proportion of which are considered ‘old forest stands’. Evidence for their status as old growth stands comes from old topographical maps and by investigation of the herb layer, where of old forest indicator species persist.

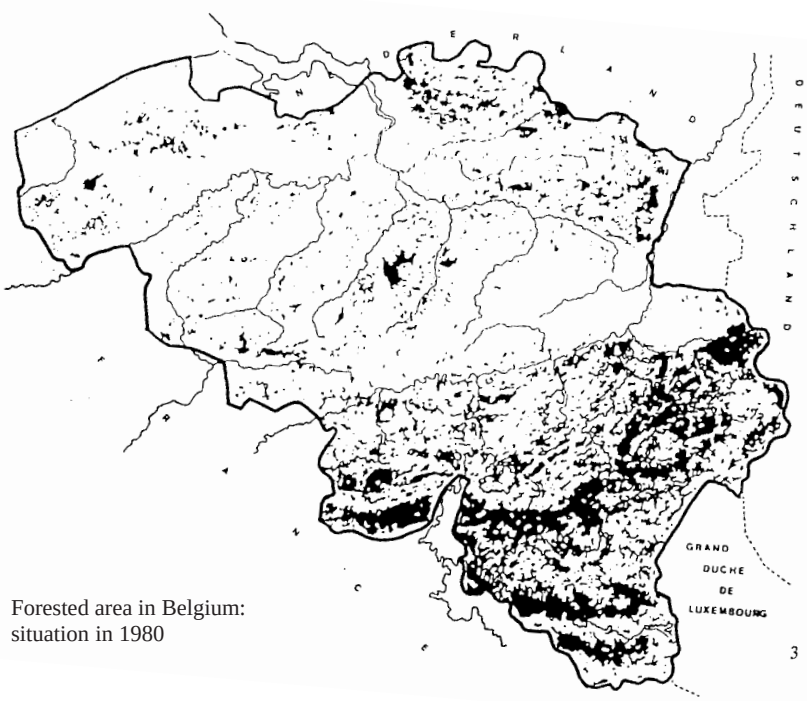
The composition and structure of the tree layer considerably altered in general, however, the natural value and potential of these forests is nonetheless, quite high. Central-European forest management systems have been favoured and consequently practised in many of these forests. In Flanders the most important forest vegetation types are the following:

- On sandy soils: Atlantic oak-birch and oak-beech-forest
  Sub-Atlantic oak-birch and oak-beech-forest
- On richer loamy soils: on acid loam: *Milio-Fagetum*
  on rich loam: Atlantic mixed oak-and beech-forest
  (Endymio-Carpinetum / Endymio-Fagetum)
  Sub-Atlantic oak-and beech-forest
  (Stellario-Carpinetum)
- Alluvial areas: *Alno-Padion*
- Swamp-areas: *Alneta*, especially *Carici elongatae-Alnetum*
- Some rare forest types: Fontinal Ash-Alderwood
  (Carici remotae- Fraxinetum)
  Atlantic oligotr. Alderwood
  (Carici laevigatae-Alnetum)

In Wallonia, these forest-types also occur, however, the most widespread type is *Luzulo-Fagetum* (and its degradation stadium *Luzulo-Quercetum*). In addition, on rich



Forested area in Belgium:
situation in 1770 (approx.)



Forested area in Belgium:
situation in 1980

Figure 1. Forested area in Belgium – situation in 1770 compared with 1980.

calcareous soils *Melico-Fagetum* occurs. Some special rarer forest types here are: *Carici-Fagetum, Stellario-Alnetum, Aceri-Fraxinetum.*

1.2. Ecological function in forest-management and legislation – development of forest-reserves

As mentioned previously, the most significant impact on forests in the past was deforestation. Hence, traditionally, most forest legislation has been focused on protection, especially against illegal felling and deforestation, and regulations governing rights of use by local communities. This trend was continued in the Forest Act of 1854, which regulated the exploitation of State forests, deforestation in the private sector and outlined legislation pertaining to poaching, wood theft, etc.

No regulations about nature protection in forests were included and over-exploitation was still possible in private forests. The latter was addressed under a special law on private forests in 1931.

The first official initiatives on nature protection were taken in 1957, when two Nature reserves were created, and the enactment of a law on country planning in 1962, which endeavoured to halt the uncontrolled expansion of industry and urbanisation.

The first piece of legislation on nature protection within forests was enacted in 1973 and called the 'Law for Nature Protection'. This law officially provided for the creation of Forest reserves (adjacent to Nature reserves).

Since the beginning of the century, the forest administration was preoccupied with afforestation, which was very much oriented towards production. Even during the seventies, management was still very traditional, and although more attention was paid to multiple function-forestry (with special emphasis on recreation), very little attention was given to the creation of Forest reserves. Moreover, the procedure for selection and recognition of these reserves was far too complicated.

Between 1975 and 1980 the forest and nature protection sector was 'regionalised', i.e. forest management, policy and legislation became the responsibility of authorities in each of the three regions, Flanders, Wallonia and Brussels.

In Flanders, separate administrations were established for forests and for nature protection. However, in Wallonia and Brussels both areas are still linked and are the responsibility of the forest administration. In Flanders a new forest law, called the 'Flemish Forest Decree' was enacted in 1990. This document is extremely important for forest management as a whole, and for the ecological function of forests, in particular.

In this Decree, special attention is paid to aspects of nature protection in forest management, and also caters for the creation of Forest reserves. Previously devised, impractical regulations on Forest reserves were abolished, and a new procedure was stipulated in an 'Implementation Order on Forest Reserves' in 1993. In 1995, the first series of Forest reserves were officially established.

This does not mean that prior to 1995 protected forests did not exist in Flanders. As early as the beginning of this century, protection initiatives for nature and typical forest landscapes were implemented. A good example of such initiatives was the creation of the 'Canton Pittoresque' in Zoniënwoud (Forêt de Soignes). As in Fontainebleau, part of the forest was selected by the Academy of Art for aesthetic reasons. Unfortunately, a

decision was not made at that time to make it a strict reserve and specific felling and pruning activities were performed to create 'picturesque trees'. This type of management was abolished in the 1950s.

Another important initiative was the creation of *unofficial forest reserves*. Around 1970, they already existed in Neigembos and a special nature conservancy-management plan was implemented.

In 1986, an old beech-stand in Zoniënwoud, 18 ha in area, was designated as an unofficial 'strict reserve'. These two unofficial reserves were included in the first series of official Forest reserves in 1995.

Some forests are also protected as official *nature reserves.* They used to fall under the 1973 national Law for Nature Conservation. Recently however, a new Decree on Nature Conservation was adopted by the Flemish parliament. In addition to providing for the administration of management in Nature reserves, this law also provides for the creation of new Nature reserves, which would form part of a larger 'Ecological Network for Flanders', totalling 50,000 ha.

The administration for nature protection is responsible for the management of all State Nature reserves, including those containing forest. Although official management plans are not yet completed, it is envisaged that parts of these reserves will become strict reserves. If agreements can be made with the administrations concerned, some of these are potential candidates for inclusion in a monitoring network. At present, six forests in Flanders are protected as Nature reserves, occupying a total area of about 500 ha.

In Wallonia, there are eight State Forest reserves with a total area of 244 ha. They have been established under the old 1973 Law for Nature Protection. These Forest reserves are all 'specifically managed', according to a special management plan. No fundamental research has been carried out in any of them.

There are two private Forest reserves, one of which is designated as a 'strict reserve' (Forêt de Rognac). Some dendrometric measurements have been carried out by the official administration for Nature and Forest (Mr. Stein). There is no Forest Decree in Wallonia, nor any other Forest reserves legislation, as of yet. The list of Wallonian Forest reserves is given below.

In the Brussels Region**,** there are two Forest reserves (Rood Klooster and Vuylbeek), in addition to several small Nature reserves in Zoniënwoud, which is under their jurisdiction. All of them are managed reserves, selected for botanical or historical reasons, i.e. a neolithic site. Some detailed vegetation studies have been performed there by the University of Brussels (VUB).

1.3. Summary on legal status of protected forests in Belgium

Nature reserves: areas protected under the 1973 Law on Nature Protection (Wallonia & Brussels) or by the 1997 Decree for Nature Conservation (Flanders). The main objectives are the maintenance and enhancement of the natural value and diversity of the area.

There are recognised private nature reserves, owned by environmental organisations, for which an official recognition dossier, complete with management plans have been approved by the administration for nature protection. Forested areas are poorly represented in this category, i.e. only a few hundred hectares.

Table 2. Forest reserves in Wallonia.

Name	Area	Owner	Forest-type (rough classification)
Bois d'Ellinchamps	29.8 ha	State	?
Bois de Marmont	44.5 ha	State	?
Ouren	1.1 ha	State	*Luzulo-Fagetum*
Rurbusch	108.4 ha	State	*Sphagno-Alnetum* > *Luzulo-Fagetum* > *Melico-Fagetum*
Bois Lembrée	10.6 ha	State	*Quercion robori-petraeae*
Grande Va	7.0 ha	State	*Carici-Carpinetum* > *Mesobromion*
Bois de Faacht	13.5 ha	State	*Luzulo-Fagetum* > *Primulo-Carpinetum*
Ave-et-Auffe	29.4 ha	State	*Carici-Carpinetum* > *Mesobromion*
Forêt de Rognac	10.1 ha	RNOB	*Luzulo-Fagetum* > *Stellario-Carpinetum* > *Carici remotae Frax.*
Forêt de Grimonster	106.0 ha	Private	*Luzulo-Fagetum* > *Stellario-Carpinetum* > *Carici remotae Frax.*
Total	360.5 ha		

Official Nature reserves are State owned, for which management plans are made. They may be strict, or partially strict reserves. If the area is dominated by forest they are called 'State Nature reserves with forest character' – in Flanders they amount to about 500 ha – and 'Forest reserve' in Wallonia, which total about 250 ha.

Forest reserves in Flanders are protected under the Flemish Forest Decree (1990). The main objective of this protection status is scientific in nature, namely to provide knowledge about forest ecosystems and their dynamics. These can be 'integral reserves', which means 'strict reserve', or 'directed reserve', which means that specific management operations are carried out. Forest reserves in Wallonia and Brussels are protected by the 1973 Law on Nature Protection and are all managed by their respective administrations.

Belgium only has one *National Park*, i.e. Hohes Venn, which is predominantly a peat bog ecosystem.

2. NETWORK OF FOREST RESERVES IN FLANDERS: ACTUAL SITUATION

Since 1995, a total of 25 Forest reserves have been established. This chapter gives general information on their area, forest type and location.

Existing Reserves		Reserves in procedure	
Number of reserves	35	Number	6
Area	1374 ha	Area	164 ha
Average area	39 ha		

Table 3. Forest reserves in Flanders: present situation (total 1,373.83 ha).

Name	Area	Location	Owner	Forest-type (rough classification)
Beiaardbos	17.06 ha	Kluisbergen	State	*Endymio-Carpinetum*
Bos Terrijst	28.59 ha	Pepingen	State	*Endymio-Carpinetum*
Coolhembos	78.64 ha	Puurs	State	Alnetum
Dilserbos- Platte Lendenberg	58.16 ha	Dilsen	State	*Fago-uercetum petraeae*
Galgenberg	29.82 ha	Hasselt	State	*Quercion* > *oligotrophous* swamp-forest
Gasthuisbos	11.02 ha	Diest	Community	*Quercion* > *Stellario-Carpinetum*
Grootbroek	136.41 ha	Kinrooi	State	*Quercion* > *Oligotrophous* swamp-forest
Hallerbos (4 areas)	63.78 ha	Halle	State	*Quercion* > *Endymio- Carpinetum* > *Alno-Padion*
Heverlee: De grote omheining	32.2 ha	Leuven	State	*Quercion*
Heverlee: Putten + Klein moerassen	15.0 ha	Leuven	State	*Fagion Carpin* > *Alno-Padion*
In de Brand	11.44 ha	Hechtel	State	*Quercion*
Jagersborg	86.54 ha	Maaseik	State	*Quercion*
Jongenbos	82.04 ha	Kortessem	State	*Quercion* > *Stellario-carpinetum*
Koeimook	39.47 ha	Mol-Postel	Private	*Quercion*
Kolmontbos	18.58 ha	Tongeren	State	*Stellario-Carpinetum* > *Carici-Fagetum*
Lanklaarderbos-Saenhoeve	83.69 ha	Dilsen	State	*Fago-Quercetum petraeae*
Meerdaalwoud: Grote konijnepijp	25.2 ha	Leuven	State	*Quercion*
Meerdaalwoud: Veldkant Renissart	19.0 ha	Leuven	State	*Milio-Fagetum*
Meerdaalwoud: De drie eiken	7.3 ha	Leuven	State	*Quercion*
Meerdaalwoud: Everzwijnbad	27.5 ha	Leuven	State	*Milio-Fagetum*
Meerdaalwoud: Mommedeel	25.3 ha	Leuven	State	*Quercion* > *Carici laevigatae.-Alnetum*
Meerdaalwoud: Pruikenmakers	38.7 ha	Leuven	State	*Milio-Fagetum*
Melisbroek-Vieversel	34.86 ha	Zolder +	State	*Quercion* > *oligotrophous* swamp-forest
Neigembos	45.01 ha	Meerbeke	State	*Endymio-Fagetum Carpinetum*
Op den Aenhof	35.71 ha	Zolder	State	*oligotrophous* swamp-forest
Parikebos	9.33 ha	Brakel	State	*Endymio-Fagetum* > *Alno-Padion*
Pijnven: het Ven	15 ha	Hechtel	State	*oligotrophous* swamp-forest
Pijnven: Droog gedeelte	22 ha	Hechtel	State	*Quercion*
Sevendonck	67.60 ha	Turnhout	State	*Quercion* > *Alnetum*
Wijnendaele-bos	91.60 ha	Torhout	State	*Fago-Quercetum*
Zoniën: Harras	26.60 ha	Hoeilaart	State	*Endymio-Carpinetum* + *Milio-Fagetum*
Zoniën: Kersselaerspleyn	90.60 ha	Hoeilaart	State	*Milio-Fagetum*

Table 4. Forest reserves in Flanders: proposed reserves (in the process of being established).

Name	Area	Forest-type (rough classification)
Helschot	56 ha	*Quercion* > *Endymio-Carpinetum* > *Alno-Padion*
Muizenbos	33 ha	calcarous alder-elm > alder-ash > *Quercion*
RTT-domein Liedekerke	23 ha	*Quercion* > *Stellario-Carpinetum*
Arkenbos	15 ha	*Quercion* + alder swamp-forest
De Kampanje	18.8 ha	*Endymio-Carpinetum*
Withoefse heide	18 ha	*Quercion*
Total	ca. 164 ha	

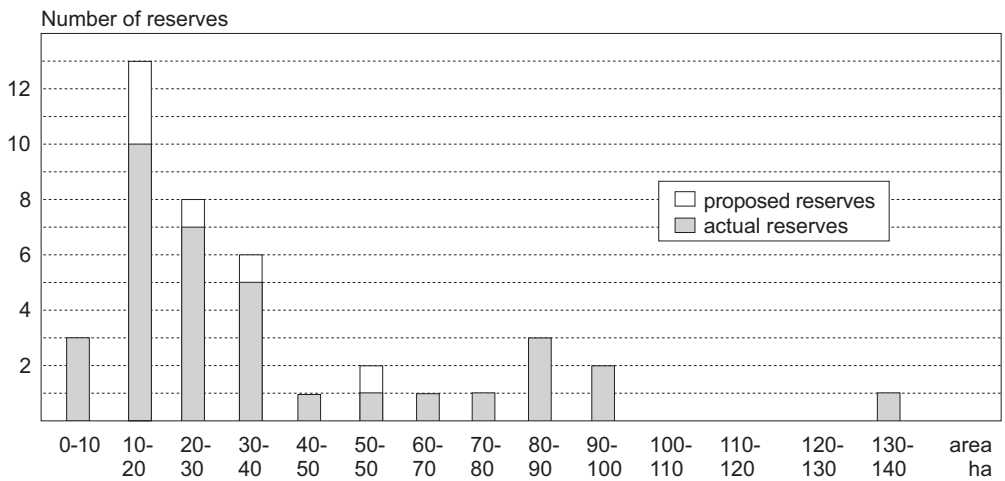


Figure 2. Forest reserves in Flanders by area-class divisions.

2.1. Integral and Directed reserves

In contrast with ‘Nature reserves’ the concept of ‘Forest reserves’ has no tradition in Flanders.Management initiatives are automatically linked with nature preservation activities. The original concept of forest reserves as is understood, especially in Central Europe, and represented by ‘strict reserves’ with specific scientific goals, is completely new to Flanders.

This explains why there is a distinction between ‘strict Forest reserves’ on the one hand, and ‘Forest reserves with special management’ was included in the ‘Implementation Order on Forest Reserves’. In addition, other regulations and selection criteria, typical for Nature reserves are included. Thus, the difference between Nature reserves and Forest reserves is very small and consequently, creates much confusion.

The basic criteria for ‘directed Forest reserves’ (with special management) and ‘integral Forest reserves’ (strict reserves) are listed in Table 2.

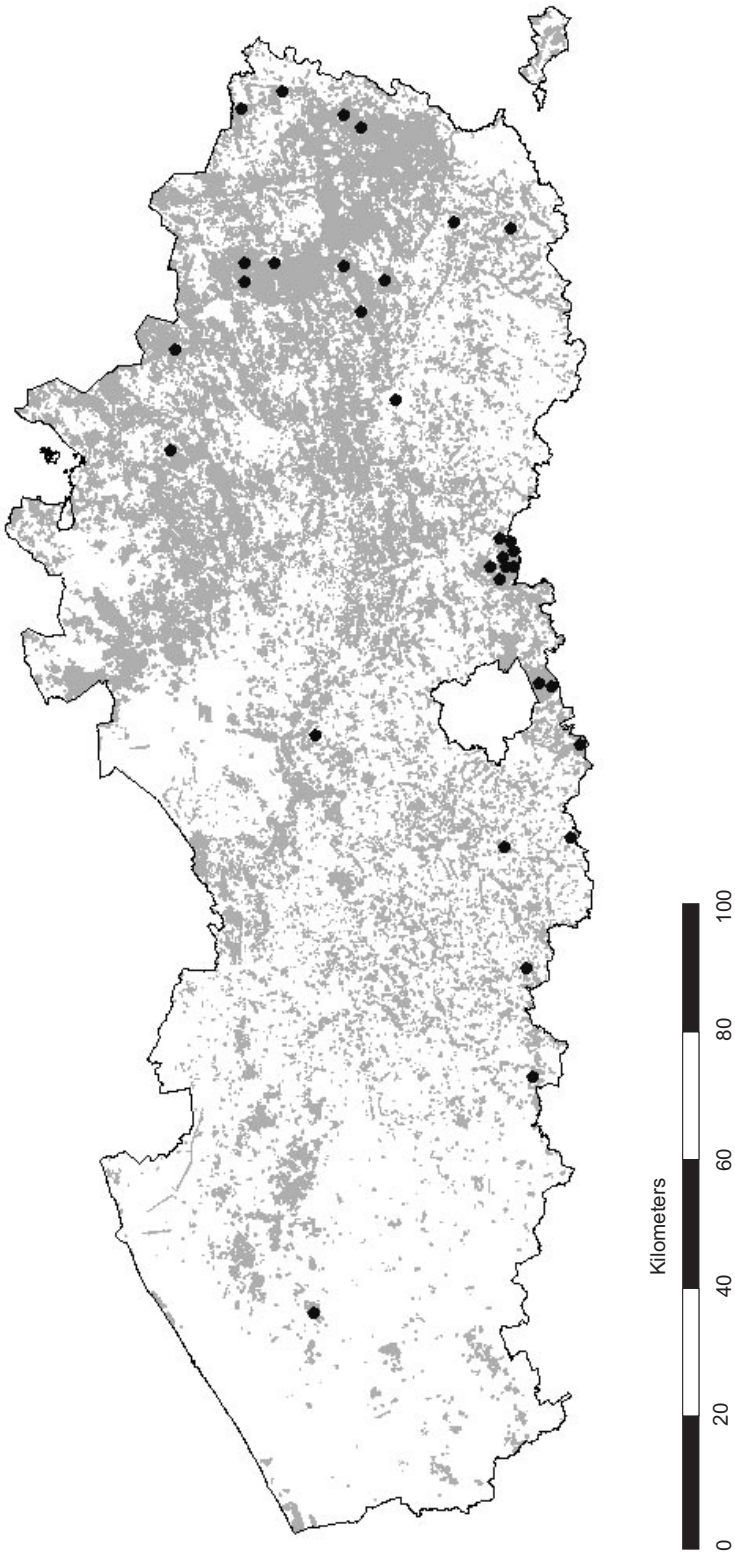


Figure 3. Distribution of forest reserves in the Flemish Region.

Table 5. Basic criteria for the two types of Forest reserves in Flanders.

	'Directed reserve'	'Integral reserve'
Goals	Special management directed towards enhancing the ecological value	Monitoring of spontaneous development
Principal criteria for selection	Actual natural value e.g.: • old coppice (with standards) • rare vegetation-type which requires special management	Development of a representative network of forests: 1. all forest types in the principal landscape units 2. minimum area (Minimum Structural Area)
Scientific research	Studies on of the effects of different management regimes	Monitoring of spontaneous processes -fundamental knowledge on forest ecology -application in forest management
	Vergleichsfläche (Hessen), Nature reserves, National parks, etc.	Strict Forest reserves in other European countries

For all Forest reserves a management plan must be made and a Management Commission subsequently outlines the required management prescription. At present, no definite decisions have been made on strict or managed reserves, although some options have already been proposed.

3. FOREST ECOLOGY RESEARCH

As the establishment of Forest reserves is a very recent development in Flanders, research has, up to recently, been very limited. Hence, this section has been broadened to include ecological research in forests as a whole. The following review endeavours to summarise some of the most important research completed to date on this topic, although the list is by no means complete. Although some of the research was done in unofficial Forest reserves, most of it was carried out outside Forest reserves. Nevertheless, it gives some guidance from past research experience as to what research can be implemented in Forest reserves currently.

In Belgium, forest research began as early as 1864, when a school for forestry was established in Bouillon. This school lasted for only 4 years and its programme was subsequently adopted by the agricultural institution of Gembloux and the University of Leuven.

In 1898, a course with a specialisation year in forestry was instigated at the institutes of Gembloux and Leuven. In 1919, a new agricultural institute was created in Ghent, which was later incorporated into the university of Ghent, and here too, a forestry department was created.

In the late 1960s, the University of Leuven was split into a Flemish and French-speaking institute in Louvin la Neuve. In total, this means that there are four different Universities providing an education in forestry. A considerable amount of important forestry research is carried out in these institutions.

In 1896, under the auspices of the forestry administration, the Research Station for Forest and Hydrobiological Research was established. This station was amalgamated with the Institute for Populiculture in Geraardsbergen in 1991, to form the Institute for Forestry and Game Management, the official scientific institute for forest research in Flanders.

The Institute for Nature Conservation is similar to the Flemish administration responsible for research in Nature Conservation. Although more emphasis is given to other ecosystems, some of their research is also carried out in forests.

In Wallonia, forestry research in Forestry is organised at the two universities and in the Forestry Department of the Institute for Agricultural Research in Gembloux. Further information on Wallonian forests is available on the Internet at http: // envagri.wallonie.be. In addition, a list of contact addresses is given at the end of this section.

3.1. Historical research: review of the most important topics

Up to the 1960s, forest research was very much oriented towards productivity and the potential of new, exotic species in Belgium. However, some research was done on forest ecology. Since the 1970s, increasingly more attention was paid to aspects of forest ecology, forest ecosystems, close-to-nature forestry and nature conservation in forests. Consequently, research on these aspects expanded enormously. The motivation and stimulus for focusing greater attention on such aspects came primarily from the research sector, especially at the universities.

At the Station for Forest and Hydrobiological Research in Groenendaal:

1950s and 1960s: compilation of Forest Ecological Maps.

- *Galoux A. & Reginster P. (1954). Cartographie écologique et forestrière du Domaine provincial de Mirwart.*
- *Rogister J.E. (1968). Cartographie écologique et forestrière de la Forêt Domaniale de Longues Virées*
- *Rogister J. & Galoux A. (1982). Forestry and ecological mapping in Belgium. IN: Jahn G. (ed.) Handbook of Vegetation Science, Part 12, 117-146; The Hague.*

1960s and 1970s: research on forest ecosystem ecology (gas-exchanges, energy fluxes, water balance,....)

- *Galoux A. et al. (1968-1973). Recherches sur l'écosystème forêt. La chênaie mélangée calcicole de Virelles-Blaimont. Proefstation van Waters en Bossen werken – reeks A, nr. 12-14*
- *Galoux A. (1974). Ecosystem, open thermodynamic system. The oak forest of Virelles-Blaimont.Göttinger Bodenkundliche Berichte, 30, 131-149.*
  also: Rad. and Environm. Biophys. 15, 113-130.

1970s and 1980s: phytosociological research and ecological classification of forest plants by ROGISTER

- *ROGISTER J.E. (1981). Contribution à la classification écologique des groupements forestiers dans la vallée de la Semois ardennaise. Proefstation van Waters en Bossen werken – reeks A, nr. 18.*
- *ROGISTER J.E. (1981). Het karakteriseren van bosplantengezelschappen met behulp van trofie- en hydrie-soortengroepen. Toepassing op gezelschappen op natte en vochtige groeiplaatsen. Proefstation van Waters en Bossen werken – reeks A, nr. 27.*
- *ROGISTER J.E. (1985). De belangrijkste bosplantengemeenschappen in Vlaanderen. roefstation van Waters en Bossen werken – reeks A, nr. 29.*
- *ROGISTER J.E. (1988). Invloed van de boomsoortenkeuze op de ontwikkeling en samenstelling van de kruidlaag. Proefstation van Waters en Bossen werken – reeks A, nr. 15.*

Research on forest structure in a proposed forest reserve at Liedekerke

- *De Cuyper B. (1993). An unmanaged forest – research strategy and structure and dynamics. IN: Broekmeyer M., Vos W. & Koop H.(eds.)(1993). European forest reserves, pp. 215-216. Proceedings of the European Forest reserves Workshop; 6-8 May 1992, Wageningen. IBN-DLO – Wageningen – Netherlands.*

At the Institute for Nature conservation

Testing the Dutch SILVI-STAR-methodology in three Forest Nature reserves.

- *Koop H., Leten M., Boddez P., Tielens T. & Hermy M. (1992). Bosstructuur en soortensamenstelling van het Rodebos; monitoring van bosstaatsnatuurreservaten in Vlaanderen. IBN-DLO – rapport 92/27.*
- *Bosstructuur en soortensamenstelling van het Walenbos; monitoring van bosstaatsnatuurreservaten in Vlaanderen. IBN-DLO – rapport 92/28.*
- *Bosstructuur en soortensamenstelling van het Hannecartbos; monitoring van bosstaatsnatuurreservaten in Vlaanderen. IBN-DLO – rapport 92/29.*

Research on relations between forest type and specific faunal groups (including: spiders, Carabids and birds.)

- *Gaspar C. et al (1989). Recherches sur l'écosystème forêt, Biocénose des Coléoptères.*
- *Comptes rendus du Symposium 'Invertébrés de Belgique'.*
- *Bulletin of the Royal Belgian Institute for Natural History.*
- *Reports of the Institute for Nature Conservation.*

At the University of Ghent

Analyses of the unofficial forest reserve in Zoniënwoud:

- *Van den Berge K., Maddelein D. & Muys B. (1993). Recent structural changes in the beech forest reserve of Groenendaal (Belgium) In: Broekmeyer M., Vos W. & Koop H.(eds.)(1993) European forest reserves; pp. 195-198. Proceedings of the European Forest reserves.*

Workshop; 6-8 May 1992, Wageningen. IBN-DLO – Wageningen – Netherlands.
- *Van den Berge K., Roskams P., Verlinden A., Quataert P., Muys B., Maddelein D. & Zwaenepoel J. (1990). Structure and dynamics of a 215-years old broad-leaved forest stand recently installed as a total forest reserve. Silva gandavensis 55, 113-152.*

Research on nutrient fluxes and relationships between soil and forest stand

- *MUYS B. (1990). N-excess in the forest: effects and possible measures. Silva Gandavensis 55, 35-42.*
- *MUYS, B. (1993). Synecologische evaluatie van regenwormactiviteit en strooiselafbraak in de bossen van het Vlaamse Gewest als bijdrage tot een duurzaam bosbeheer. doctoral theses – University of Ghent, 335 p.*
- *Maddelein D., Meyen S. & Lust N. (1991). Driving forces and limiting factors in long-term dynamics of forest ecosystems on sandy soil. University of Ghent, 223 p.*
- *Sioen G., Neirynck J., Maddelein D. & Muys B. (1993). Site-classification in relation with vegetation and humus characteristics in the forest of Halle (Belgium).*
- *IUFRO S1.02.06 Technical meeting on site classification and evaluation, Clermont-Ferrand, France, October 19-22, 1993.*

Other important research

Phytosociology and forest plant ecology:

- *NOIRFALISE A. (1984). Forëts et stations forestières en Belgique. Les presses agronomiques de Gembloux.*
- *HERMY M. (1985). Ecologie en fytosociologie van oude en jonge bossen in Binnen-Vlaanderen. Doctoral thesis, Faculty of Sciences, University of Ghent.*

CO_2-concentrations:

- *Effect of increased atmospheric CO_2-concentration on primary productivity and carbon allocation in typical Belgian forest ecosystems. – Final report. Laboratory of Plant ecology: University of Gent.*

Historical ecology of forests:

- *Tack G., Van Den Bremt P. & Hermy M. (1993). Bossen van Vlaanderen: een historische ecologie. Davidsfonds – Leuven.*
- *Hermy M., Van Den Bremt P. & Tack G. (1993). Effects of site history on woodland history. IN: Broekmeyer M., Vos W. & Koop H.(eds.)(1993). European forest reserves, pp. 219-232 Proceedings of the European Forest reserves Workshop; 6-8 May 1992, Wageningen – IBN-DLO – Wageningen – Netherlands.*

Ecological characteristics of tree species:

GROUPE INTERUNIVERSITAIRE F.S.A.Gx. – U.C.L. – U.L.B. – U.Lg. (1991). Le fichier écologique des essences, 1 en 2: définition de l'aptitude des stations forestières. Ministère de la région Wallonne. Nouvelle imprimerie Duculot, Gembloux.

3.2. Ongoing research – research institutions

University of Leuven:
- research on the ecology of old-forest-plants (Doctoral research by ir. Olivier Honnay; M. Hermy)
- geographic information system for Nature Conservation (an ACCESS-Arcview programme)
- research on Protection forests

Institute for Nature Conservation:
- research on relations between forest type and specific animal groups
- ecohydrological study in relation to the vegetation in the forest nature reserve 'Walenbos'
- realisation of 'red lists' and 'Biological Evaluation Maps of Flanders'

University of Gent:
- research on liming in forests
- research on nutrient cycling, carbon-cycle, transformation of homogeneous forest stands etc.

Institute for Forestry and Game Management:
- research on European level II-plots (forest health vitality network): nutrient cycles
- relation between soil condition and tree species:
- forest ecology monitoring towers (measurement of ozone-conc., radiation, wind velocity, etc.)
- methodology for quantification of forest biodiversity
- research on the relationship between soil- and soil-dwelling invertebrates and soil condition
- PNV-map of Flanders
- co-ordination of research in Forest reserves.

3.3. Research in official forest reserves: ongoing research and future tasks of the Institute for Forestry and Game Management

Current research is limited to the following topics
- basic inventory of Forest reserves (carried out by the Universities of Ghent and Leuven)
- methodology for the study of Forest reserves (carried out by the University of Ghent)

Future tasks of the Institute for Forestry and Game Management are summarised as follows:

1. Assistance and advise in realising a forest reserve network
   - list of selection criteria
   - follow-up of new proposals
   - time-table for completion of the network

2. International contacts

3. Follow up of proposals for management
   - choice between 'directed' and 'integral' reserves

4. Development of a monitoring methodology
   - analysis of foreign monitoring systems

5. Co-ordination, organisation and logistical support for scientific research in Forest-reserves
   - organisation of monitoring
   - centralisation of all data and research results in a central databank (using GPS, GIS, etc.)

4. LIST OF IMPORTANT CONTACT ADDRESSEES

In Flanders:

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kris.vandekerkhove@lin.vlaanderen.be

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fax: +32-2 657 96 82

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fax: +32-9 224 44 10

Laboratory for Forest, Nature and Landscape –
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fax: +32-16 230 607

Administration for Forestry:
Contact person on forest reserves:
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Graaf de Ferraris-gebouw
Emile Jacqmainlaan 156
1000 Brussels
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fax: +32-2 553 81 05

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1348 Louvain-la-Neuve

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1000 Brussels.
Internet: WWW: http: // envagri.wallonie.be

ir. Yvan Grollinger
Inspecteur général de la Nature et des Forêts
Avenue Prince de Liège 15
5100 Namur

Mr. Jacques STEIN
Ministère de la région Wallonne
Direction Générale des Ressources naturelles
et de l'environnement
Direction de la conservation de la Nature
et des Espaces verte
Avenue Prince de Liège 7
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tel: 081 32 12 77

Brussels Region:

Forestry Administration:
ir. X. Lejeune
Dir. Nature et Forêt
Gulledelle 100
1200 Brussels
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DENMARK

Jens Emborg

The Danish Forest and Landscape Research Institute
Hørsholm, Denmark

1. INTRODUCTION

Nature-oriented forestry has become widely accepted as a promising approach to meet the criteria for sustainable forest management. Nature-oriented forestry aims to achieve reasonable economic targets, while modifying forests as little as possible, from their natural condition. Natural forest ecosystems are used as a basic reference point in the silvicultural approach of mimicking natural forest structures, processes and dynamics, in commercial forestry. This, in combination with the need to protect biodiversity, has created an increasing interest in natural forests in the general public and among foresters in Denmark.

However, only few remnants of *natural forests* exist today in Denmark. The scientific base for nature-oriented forestry is weak and practical experience of nature-oriented forestry is rare in Denmark. The scarcity of natural forests is probably the main reason for our fragmentary knowledge on long-term forest ecosystem development, and on the structure and processes existing within natural forests. For all these reasons, extensive establishment of forest reserves occurred during the 1990s in Denmark.

2. SUMMARY OF DANISH FOREST HISTORY

Most of the landscape in Denmark has been cultivated extensively, and there are practically no inaccessible areas. Two hundred years ago the total forest area fell as low as 2-3% of the total area of Denmark, due to overexploitation of forest resources. As a result of an intensive reforestation effort, the forest area has now increased to about 11% of the total land area, which amounts to 445,000 ha.

Along with reforestation, systematic and organised forestry was introduced, which was accompanied by legislation specifically governing wood production. As a result, few forest areas have been left untouched and there are only small pockets of near-pristine woodland remaining. Mixed deciduous forest would have formed the natural

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vegetation in most parts of Denmark. Wind is considered as the most important natural disturbance factor, but during the last millennia at least, human impact has been the most important factor in shaping the countries forests.

Today, about 2/3 of the forest area is covered with conifers – mainly plantations – and 1/3 with broad-leaved tree species. In 1990 the total standing volume in Danish forests was estimated to be 55 million m^3 (57% conifers, 43% broadleaves). The mean annual

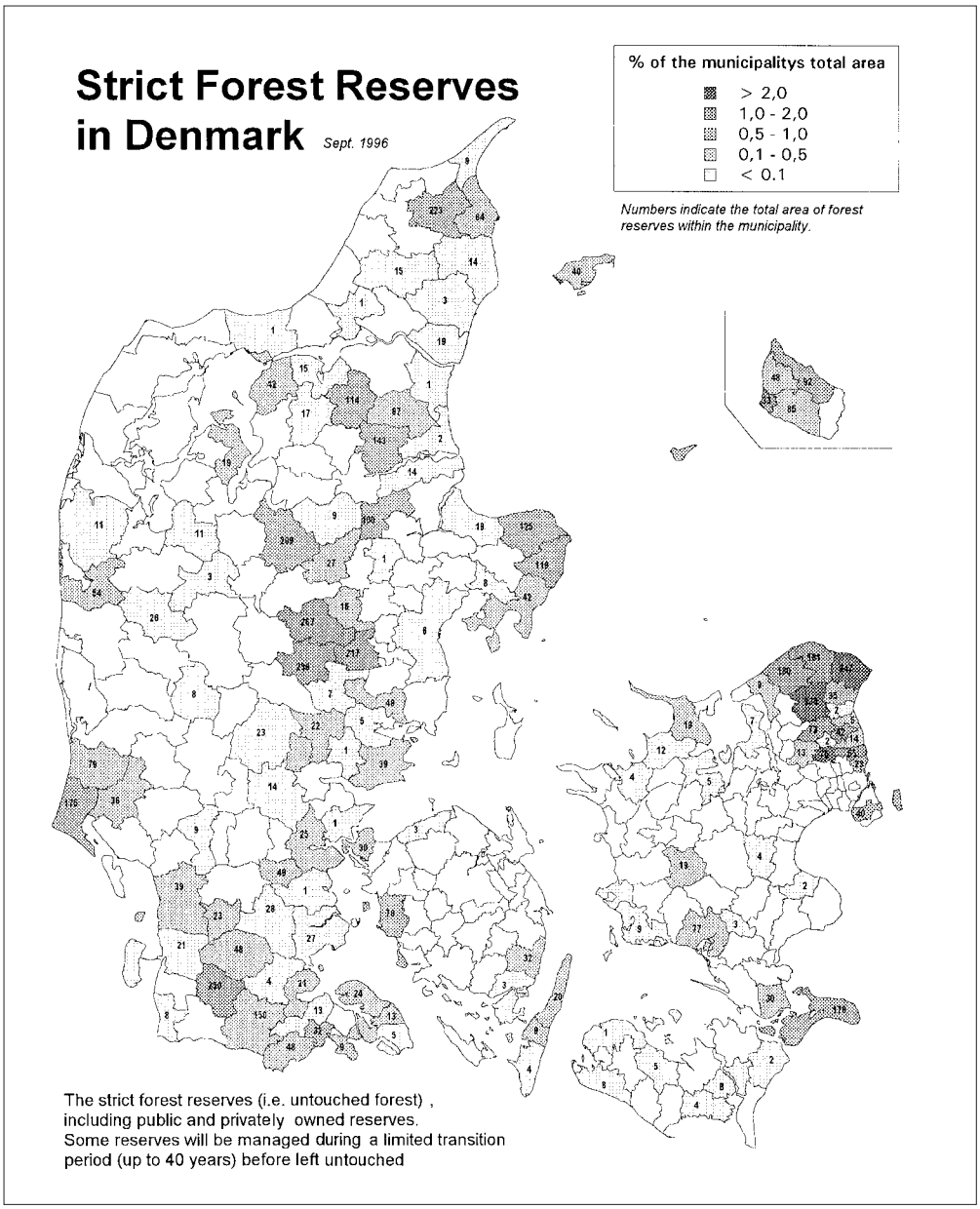

Figure 1. Strict forest reserves in Denmark.

increment is estimated to be around 3.2 million m^3 (70% conifers, 30% broadleaves), while the mean annual harvest is only 2.3 million m^3 (68% conifers, 32% broadleaves). This results in a considerable accumulation of standing volume in Danish forests. 1.9 million m^3 of the annual harvest is used as sawn wood and 0.4 million m^3 as firewood. The annual total harvest equals 4.8 m^3/ha/year on average. It is national to double the Danish forested area (to some 22%) over a 100-year period. National grants and other political measures are being used to increase reforestation in Denmark.

3. PRESERVATION OF NATURAL FORESTS

Only a few, relatively small forest reserves were established in Denmark prior to 1994. In most cases, such reserves resulted from informal, private initiatives or from formal, national preservation orders.

3.1. Danish strategy for natural forests

In 1994, the Danish national strategy for natural forests was published (Ministry of the Environment 1994). The strategy speeded up the establishment of natural forest reserves and the following principles and objectives were stated:

"The strategy is planned to cover a period of 50 years and should be seen as a continuation of the nature conservation efforts undertaken during the past few decades and as a follow-up of the 1989 Forest Act revision and the plans to double the woodland within a tree generation. Very intensive efforts in these areas will be made within the coming years.

Immediate measures to be taken are:

- protection of all natural State-owned forests.
- protection of oak coppices, pastoral forest, coppice forest, and Virgin-like forests in all state owned forests.

Measures to be taken up to the year 2000:

- protection of a least 5,000 ha of untouched forest, primarily in natural forests, but coniferous forest/mixed forest should also be represented.
- protection of at least 4,000 ha of traditional management systems, primarily in natural forest.
- as a component of a strategy for conserving genetic resources, forest trees and shrub areas will selected, and efforts will be undertaken to conserve local genetic resources, while minimising mixing native – with external genes.
- implementation of specific research programmes in order to improve the basis for conserving biodiversity in forests, and provide more basic knowledge on dynamics and development of forest ecosystems.
- more information will be provided to private forest owners, foresters and the general public about natural forests, untouched forest, and special forestry practices.

Measures to be implemented by the year 2040:

- it is aimed to secure an area of natural, untouched and traditionally managed forest totalling at least 40,000 ha, equivalent to 10% of Denmark's present forest area. A large proportion of natural forests will be managed according to traditional, multiple-use high forestry.
- establishment of additional areas of untouched forest and traditional management systems in pro-portion to the expansion of the total national forest area through afforestation.
- public afforestation will expand the natural forest by including areas where unrestricted natural regeneration will be allowed to occur.

Of the 5,000 ha of untouched forest which are to be protected before the year 2000, 4,000 ha must be located in deciduous forest, with the remainder occurring in coniferous forest or mixed forest."

The strategy will be revised in the year 2000 and the current results at that time will be reported. Improved understanding of natural forest though research and monitoring is expected to be available then, to enable future decisions to be made and enforced within this field. In particular, protection of large, compatible areas will be evaluated, and the need for establishing additional forest reserves will be considered.

3.2. Establishment and classification of forest reserves

The national strategy has been followed up by establishing a network of strict (untouched) forest reserves in Denmark (1996):

- Private forest: 46 reserves; total 1147 ha (0.5-166 ha, average 25 ha).
- Public owned forest: 246 reserves; total 3937 ha (0.5-250 ha, average 16 ha).
- Total: 292 reserves; total 5086 ha (0.5-250 ha, average 17 ha).

The reserves are distributed across Denmark as presented in Figure 1. A detailed report on the State-owned forest reserves has been published (Ministry of the Environment and Energy 1997). In Denmark, there are four categories of forest reserves:

- Legally protected areas: Public or private areas protected by a formal preservation order. These areas are very well protected; orders are very stringent and almost impossible to modify.
- Private reserves: Reserves established by private land owners and protected by internal (at estate level) management decisions (e.g. non-intervention or grazing forest). Decisions can be changed from day to day, but in practice, these areas are well protected in most cases.
- Permanent management agreements: Reserves established on private land with financial support from national grants. Establishment of non-intervention reserves are based on registered, permanent agreements between the State and the land owner. Such areas are very well protected; agreements are very stringent and almost impossible to modify or cancel.

- State forest reserves: Network of non-intervention reserves in State forests; status granted by ministerial order after careful selection of the most relevant and representative sites nationally. They are very well protected as long as stable political conditions persist; only war or similar events may affect their status.

4. RESEARCH IN NATURAL FORESTS

Denmark has a strong tradition of studying long term vegetation dynamics – during the glacial, interglacial and Holocene periods – through pollen analysis. Key researchers in this area include Knud Jessen, Johannes Iversen, Bent Aaby, Bent Odgaard and Svend Th. Andersen. However, there is no strong tradition in Denmark of studying natural forest dynamics, neither from a biological point of view (few relevant sites) nor from a forest management point of view (no strong tradition for nature-oriented silviculture).

The most intensively studied forest reserves in Denmark are Draved Skov in southern Jylland and Suserup Skov in central Sjælland. In Draved Skov, a considerable amount of pollen work has been carried out and published. Stand structure has been monitored since 1948 in long term permanent sampling plots, the results of which are currently being prepared for publication. Suserup Skov has been a relatively strict reserve since 1854. Some interventions have occurred, especially during the two World Wars. Since 1961, Suserup Skov has been maintained as a strict forest reserve (untouched forest). Some floristic research was carried out between 1960-1980, but as yet, none of this work has been published. A study on the structure, dynamics and light-conditions was carried out between 1990-1994 as part of a Ph.D. thesis and several scientific papers have been published.

4.1. Basic research programme on long term monitoring in Danish natural forests

A basic research and long term monitoring programme/strategy in natural forests has been formulated (The Forest and Nature Agency 1993). The strategy states that research and monitoring should be co-ordinated and concentrated in a limited number of (research) reserves. The need for long term monitoring and the requirement for a well documented reference base to serve nature-oriented forest management is emphasised. To stimulate the process a sum of about 1 million DKK has been invested annually, over a three-year period, to stimulate research within this field.

Financing long term research and monitoring is a major problem. A long term nature- and environment monitoring programme covering all Danish ecosystems, ranging from marine biotopes to freshwater systems to terrestrial biotopes, including forests, is in preparation. It is still not known what share of the programme forests, especially natural forests, will receive. The forest monitoring programme will be closely linked to the Helsinki criteria and indicators. A major discussion concerning the distinction between long-term monitoring and research in natural forests is ongoing, which will determine which relevant department foots the bill.

4.2. Ongoing research

The titles of the most important projects are listed below (addresses of the researchers are given in Chapter 7):

Long-term forest dynamics

- Mapping Danish forest development during the last 3000 years (Richard Bradshaw)
- Long-term monitoring of Danish non-intervention natural woodlands (Draved, Løvenholm)(Peter Friis Møller)
- Modelling forest dynamics during the last 1500 years in Draved Forest (Richard Bradshaw)

Forest structure, structural dynamics, regeneration and biogeochemistry

- Regeneration in natural forests and under nature-oriented forest management (Palle Madsen, Jens Emborg, Henrik Vejre, J. Bo Larsen).
- Pilot study to develop methodology for monitoring in permanent plots (Palle Madsen, Peter Friis Møller).
- Heath succession at Nørholm Hede (Torben Riis-Nielsen)
- A major programme: "Structures, processes and dynamics of natural forests – a reference for nature-oriented forestry" (Spy-Nat-Force) is now under development (Jens Emborg).

Biodiversity-related issues

- Indicators for nature quality (Michael Stoltze, Flemming Rune).
- Biodiversity patterns in natural versus managed forests (Flemming Rune).
- Riparian zones and biodiversity in forests (Nikolai Friberg).

5. SUMMARY OF THE PRESENT STATUS OF NATURAL FORESTS IN DENMARK

A lot of basic work has been carried out, for example, in the establishment of reserves, the development of a national strategy for natural forests and in the co-ordination and formulation of research programmes. There is a growing interest in research and monitoring of natural forest reserves, especially in untouched forest areas. It is likely that future research topics will include:

- Biodiversity patterns
- Nutrient cycles
- Regeneration patterns
- Natural forest as a reference for silvicultural management

There are a number of small-scale or pilot research activities currently ongoing. Medium-sized programmes are in preparation. The level of funding for research in natural forests is likely to increase in future. A considerable effort is being made to co-ordinate the various initiatives within this field.

6. PUBLISHED AND UNPUBLISHED LITERATURE ON NATURAL FOREST RESERVES IN DENMARK

Historical perspectives

Aaby, B. 1983. Forest development, soil genesis and human activity illustrated by pollen and hypha analysis of two neighbouring podsols in Draved Forest, Denmark. Danmarks Geologiske Undersøgelse 2, 114. 114 p.

Andersen, S.T. 1984. Forests at Løvenholm, Djursland, Denmark, at present and in the past. Den Kongelige Danske Videnskabernes Selskab Biologiske Skrifter 24:1. 208 p.

Bradshaw, R.H.W. and Holmqvist, B. (in prep.) Danish forest development during the last 3000 years reconstructed from regional pollen data. (under review by Ecography)

Fritzbøger, B. and Emborg, J. 1996. Landscape history of the deciduous forest Suserup Skov, Denmark, before 1925. Forest and Landscape Research 1: 291-309.

Iversen, J. 1973. The development of Denmark's nature since the last glacial. Danmarks Geologiske Undersøgelse V. Series No. 7-C. 126 p.

Møller, P.F. 1990. Naturskove i Danmark. En foreløbig opgørelse over danske naturskove udenfor statsskovene. Report for Skov- og Naturstyrelsen. 569 p.

Stand structure, gap dynamics, regeneration

Christensen, M., Heilmann-Clausen and Emborg, J. 1993. Suserup skov 1992, opmåling og strukturanalyse af en dansk naturskov. Miljøministeriet, Skov- og Naturstyrelsen, feltstationsrapport. 80 p.

Emborg, J., Christensen, M. and Heilmann-Clausen, J. 1996. The structure of Suserup Skov, a near-natural temperate deciduous forest in Denmark. Forest and Landscape Research 1: 311-333.

Emborg, J. 1998. Understorey light conditions and regeneration with respect to the structural dynamics of a near-natural temperate deciduous forest in Denmark. Forest Ecology and Management (in press).

Emborg, J. (in prep.). Suppression and release during canopy recruitment of Fagus sylvatica and Fraxinus excelsior. (Canadian Journal of Forest Research).

Biodiversity aspects

Bradshaw, R.H.W. and Vollbrecht, T. (in prep.) Estimating stand-scale forest biodiversity. (Under review by Biodiversity Letters).

Christensen, M. and Emborg, J. 1996. Biodiversity in natural versus managed forests in Denmark. Forest Ecology and Management 85: 47-51.

Møller, P.F. 1997. Biodiversity in Danish natural forests. A comparison between unmanaged and managed forests in East Denmark (in Danish with an English summary). Danmarks Geologiske Undersøgelse Rapport 1997/41. 209 p.

Soil and biogeochemical aspects

Vejre, H. and Emborg, J. 1996. Interactions between vegetation and soil in a near-natural temperate deciduous forest. Forest & Landscape Research 1: 335-347.

Political issues

Emborg, J. and Larsen, B. 1992. Naturskov er mere end blot genkonserves, debatindlæg om naturskovsstrategien. Skoven 24(3): 136-138.

Emborg, J. 1993. Skovbruget og naturskoven. Skoven 25(5): 210-212.

Emborg, J. 1993. Naturskovsforskning – med afkast til skovbruget. Skoven 25(11): 462-464.

Ministry of the Environment 1994. Strategy for natural forests and other forest types of high conservation value in Denmark. 48 p.

Skov- og Naturstyrelsen (Emborg, J.) 1994. Strategi for dansk naturskovsforskning. Skov- og Naturstyrelsen, 14 p.

7. KEY PERSONS INVOLVED IN RESEARCH AND MONITORING

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FINLAND

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1. INTRODUCTION

Ecological sustainability in forest management has been set as a general goal in several international expert meetings and agreements during the last few years. Even if present silvicultural and forest management methods are based on a long tradition of ecological and forestry research, there is a clear need for a more ecologically-based approach. Biodiversity in forest areas can be maintained through the protection of vulnerable, rare ecosystems, and through appropriate silvicultural management.

New, more ecologically based silvicultural methods need a reference point and it is generally agreed that natural forests should be used for this purpose. The findings from recent and current research projects in forest reserves allow us to compare natural and managed forests in all development phases. This yields valuable information for practical forest management. Research in natural forests will give answers, for example, to questions regarding the dynamics of forest development, natural forest regeneration, and sustainable long-term development of forest stock and forest soil. Results from such studies may be applied to solving problems like rotation length, methods of regeneration from harvested areas and thinning, and soil management in the development of silvicultural methods.

2. THE DEVELOPMENT OF FINNISH FORESTS AND FORESTRY

For centuries, Finland was a very sparsely inhabited country and consequently, the use of forests was minimal. The first settlers turned to the forest for game, berries and shelter and they made their houses from wood. Heating these houses consumed large volumes of wood. The first commercial use of Finnish forests was for tar distillation. It began in the 17th century and increased until the 1860s by which time the amount of

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exported tar was estimated to be 23 mill. litres, annually. Tar exportation was concentrated in coastal areas, whereas the main tar-producing region in the 19th century was Central Finland. Tar was not distilled in the northernmost parts of the country.

The spread of settlement in the country was accompanied by shifting cultivation, which greatly affected forest structure. This can still be seen in the most heavily cultivated areas in central Finland, where birch forests dominate. Heikinheimo's studies (1915) revealed that slash and burn cultivation in Finland was practised on over 4 million hectares per annum. By the beginning of this century, some 50-75 percent of Finland's forest area had been exploited in this manner. In the eastern part of Finland, shifting cultivation was practised for a longer time and was also more intensive than elsewhere in the country. As with tar distillation, shifting cultivation was not common in Lapland.

Forest fires have perhaps been the most influential factor in the development of Finnish forests up to the present century. Wildfires have occurred at 50-year intervals on dry sand and gravel soils and at 100-120 year intervals on the moist moraine soils in middle and eastern Finland. The interval between fires has become shorter since 4000-3000 BC. Using forest fire statistics and the average interval between fires, it can be estimated that most Finnish forest land has been burned over, at least once, during the past 400-500 years (Tolonen 1983). In the most humid areas of Lapland forest fires were rare. It has been estimated that fires occurred there at intervals of 400-500 years (Hyvärinen and Sepponen 1988). On the other hand, in the most heavily treated slash and burn cultivation areas in eastern Finland, forest fires set by man have sometimes occurred almost annually (Lehtonen 1997).

The Finnish saw milling industry began in the first half of the 19th century and it quickly became the most important user of Finnish forests. As a result of different uses and excessive exploitation of forests, concern grew about the insufficiency of timber resources. In 1850, C.W Gylden published the first map of Finnish forests, which indicated that the least forested areas were the coastal areas and also the south-eastern parts of the country where the pressure of shifting cultivation had been greatest. Abundant forest cover was only found in Lapland and in the most sparsely inhabited areas of Central Finland. E. v. Berg (1859) reported the condition of forests as being very poor and suggested many improvements to the structure of forestry and the use of forests.

The first systematic national forest inventory in Finland was carried out between 1921and 1924 (NFI1) (Ilvessalo 1929). Because of the decrease in land area following World War II, comparable data on forest resources can only be presented from the second national forest inventory (NFI2) onwards. According to seven successive inventories, from the NFI2 (1936-38) to the NFI8 (1986-94), the total forest area of Finland has remained almost constant (26.67-26.28 mill. ha) (Tomppo and Henttonen 1996). The total area of productive forest land (growth >1 m^3/ha) has increased from 17.09 to 20.03 mill. ha and the areas of scrub (growth 0.1-1 m^3/ha) and waste land (growth <0.1 m^3/ha) have decreased from 4.59 to 2.96 and from 5.00 to 3.13 mill ha respectively. The increase in productive forest land is mainly as a result of the drainage of formerly non-productive peatlands and, to some extent, of the afforestation of former agricultural fields. The total area of peatlands is estimated to be 8.92 mill. ha of which 4.70 mill ha have been drained. It is estimated that approximately 10% of the total

drainage operations have been unsuccessful as the original sites were too poor (Tomppo and Henttonen 1996).

Because of intensive treatment and regeneration of forests, the total volume has increased from 1370 to 1937 mill.m^3 (NFI2-NFI8) in sixty years. 46% of the total volume is now Scots pine (*Pinus sylvestris*), 36% Norway spruce (*Picea abies*), 15% birch (*Betula pendula* and *B. pubescens*) and 3% other broadleaved tree species, mainly aspen (*Popula tremula*) and black or grey alder (*Alnus glutinosa* and *A. incana*). The increase in the total volume has been mainly concentrated in southern Finland with conifers. The amount of pine dominated stands has increased from ca. 50% to 65% (Tomppo and Henttonen 1996).

The annual growth of forests has increased from 47.4 to 75.4 mill. m^3 (NFI2-NFI8). 15 mill. m^3 of this growth has occurred on ditched peatlands. The mean annual increment per ha is now 3.28 m^3 and the mean volume is 94 m^3/ha. The annual felling rate has been smaller than the growth rate since the 1960s. During the last decade, the total drain has been 55 mill. m^3 annually on average. It has been counted that a total drain of 2,310 mill. m^3 has been cut in the Finnish forests since the beginning of the 1950s (Tomppo and Henttonen 1996).

Approximately half of the regeneration felled areas (0.8% of the forest area annually) have been artificially regenerated since the 1950s. At present, a quarter of the forest land is regenerated by planting or direct sowing (5.14 mill. ha). The proportion between artificial regeneration and natural regeneration at present is 30% to 70%. Artificial regeneration has concentrated on pine planting (2.18 mill. ha) and direct seeding (1.73 mill. ha). Spruce planting has been used on over 1 mill. ha (Varmola 1996). Only a very small number of exotic tree species have been planted in Finland. Siberian larch (*Larix sibirica*) and lodgepole pine (*Pinus contorta*) have been the most promising tree species but the planting area of these species has only occurred on some thousands of hectares.

In southern Finland forests have become older on average and the age distribution is very even at present. The amount of forests over 100 years old was 4.6% in the NFI2 and is now 13.3% (NFI8). Spruce forests are, in general, older than pine forests. In northern Finland the amount of forests over 140 years has decreased from 29.8 to 19.3% and most of the oldest forests are located in the conservation areas. In addition, the overall ageing of forests can be seen in the amount of large trees presently. In the whole country the amount of trees larger than 30cm in BDH has increased from 155 mill. m^3 (NFI3) to 373 mill. m^3 (NFI8). The increase is concentrated in southern Finland (Tomppo and Henttonen 1996).

In conclusion it can be stated that Finnish forests have not changed to a large extent during the last century. The biggest changes have been the increase in the forest land area as a result of intensive drainage, the increase in Scots pine-dominated forests – it has been favoured in forest regeneration – and the lack of forest fires due to effective fire protection. In future, it seems that forests will be more even-aged in southern Finland because of the continuously diminishing amount of harvested timber. Due to the age structure the tending of young stands as well as the first commercial thinning will be the most demanding tasks for the future forest operations. In northern Finland harvesting will concentrate on relatively old forests and a corresponding management regime of young stands will not occur for decades.

3. HISTORY OF THE ESTABLISHMENT OF NATURE RESERVES IN FINLAND

In Finland, the idea of establishing nature reserves was muted as early as 1880. Several scientists wanted to preserve typical Finnish scenic landscapes for future generations, since the natural environment was continuously diminishing. This early promotion led to the establishment of nature reserves in both Finland and Sweden.

Since the beginning of the 20th century, numerous nature reserves have been set up in Finland; the first one was established in 1914. A law protecting nature reserves against human intervention was passed in 1923. A large number of strict nature reserves and national parks followed. The most protected areas in Finland are based on the Nature Conservation Act (71/1923), according to which protected areas can be established on both State and privately owned land. Since 1981, the number of nature conservation areas has rapidly increased; at present there are 32 national parks and 19 strict nature reserves, with a total area of 885,600 ha (Table 1). A new Act on nature conservation entered into force in 1997. The main aim of the Act is to protect valuable natural ecosystems as well as to protect endangered species.

Traditionally, forest areas in Finnish forest management have been divided into three categories according to the annual growth rate of the forest stock. These categories are forest land (growth > 1 m^3/ha), scrub land (0.1 m^3/ha < growth < 1 m^3/ha), and waste land (growth < 0.1 m^3/ha). Recently, in response to international practice, the two first categories of forest land areas have been combined, which increases the statistical size of protected forest land areas in Finland.

Today, the proportion of protected forest area of the total forest area is slightly over 10% (2.7 mill. ha). These protected forest areas are divided into different categories (c.f. strict nature reserves, national parks, wilderness areas, herb-rich forests, old forest reserves, peatland forest protection areas etc., see Chapter 3). Protection areas, which are legally binding, cover 1.3 mill. ha of forest land. In addition, the Finnish Forest Research Institute, the Finnish Forest and Park Service, and forest companies have conserved parts of their own forest areas independently. A further 1.4 mill. ha of forest land (5.4%) have restricted wood production management regimes. Together with the

Table 1. The number and total area of the protected areas in Finland divided into the four main categories.

Main category	Number of areas	Total area (ha)	Minimum (ha)	Maximum (ha)
Strict Nature Reserves	19	152 000	63	71 171
National parks	32	733 000	421	285 484
Wilderness areas	12	1 487 000	15 268	293 643
Other protected areas -	1 455	536 635		
peatland protection areas	173	414 000	5	51 812
herb-rich forest reserves	53	1 200	0.4	151
old-growth forest reserves	929	9 148	3	480
other State protected areas		183 000	0.4	10 825
privately protected areas	1 099	60 835		

protected forest areas, this totals over 15.5% of the total forest area. The majority of the present protection areas are concentrated in northern Finland (Appendix 1).

A proposal for new protection areas of old growth forests was prepared in 1996 and it has been approved by the government. The area of these old growth protection areas is approximately 294,000 ha. Most of these new reserves are located in northern Finland. The purpose of protecting old growth forests is to preserve biological diversity, and the level of conservation will correspond to that applied in the national parks.

The Green Belt-project has also in preparation for a considerable period. The idea of the project is to connect nature conservation areas in the easternmost part of Finland with the westernmost part of Russia. The present conservation areas on the Finnish side, for which official decisions have already been made, are included in the project. On the Russian side, decisions with respect to the conservation areas are well under way in the Republic of Karelia. The planned chain of protected areas would include five national parks in the Republic of Karelia, in addition to old-growth forest areas in the Murmansk and Leningrad regions. The total area of the Green Belt would cover some 970,000 ha of forests in Russia and some 950,000 ha in Finland.

4. THE CLASSIFICATION OF CONSERVATION AREAS IN FINLAND

Conservation areas can be divided into four main categories (Metsähallitus 1996) (Table 1.) A Strict Nature Reserve is a national state-owned reserve, which, owing to its exceptionally high scientific value, is permanently preserved by law, in its natural state and in an undisturbed condition. For this reason, public access, for example, is only allowed with special permission. Normally, the only permitted activity is research. However, exceptions can be enacted by a decree for the benefit of the ‘nomadic Same’ and nearby inhabitants in Lapland. A number of strict nature reserves also possess valuable biotopes and cultural heritage sites, the preservation of which entails constant management.

In terms of international classification, strict nature reserves in Finland take the form of IUCN’s Category I, Scientific Reserves.

A National Park is a reserve owned by the State: it has diversified natural features and landscape and cultural values, or otherwise, in terms of protection, is at least of national importance. It is preserved in perpetuity, free from economic activities affecting nature, and an effort is made to maintain or restore its natural state. It is, at the same time, a site of interest to which the public has a right of access. The most important function of a National Park is preservation in regard to abiotic and biotic components, but within the confines of protection. The functions of a National Park also include biological research, environmental education, and recreation. Therefore, the management plan of a National Park may include matters related to guidance, information, tourism and their practical arrangements in the National Park, traffic arrangements, hiking and skiing routes, other services and research. However, since the preservation objective has priority, other activities must be fitted in without compromising this objective.

Finland’s National Park practises mostly adhere to international recommendations (IUCN’s Category II, National Parks). Five National Parks, owing to their small dimensions or inadequate level of protection, have been omitted from the UN’s

National Parks list. In terms of the Finnish law, however, these areas are still National Parks and, as such, diversify our National Park grid.

Wilderness areas have been established on the basis of the Wilderness Act, with a view to preserve wilderness nature areas and the Same (Lapp) culture and their way of life, and to develop the diversified natural state and its pre-requisites. Wilderness areas must have an area radius of at least 8-km without a road network.

Other protected areas are special reserves established by act or decree, or they can be established as special reserves under the terms of the Nature Conservation Act. These protected areas may vary considerably in regard to their size, character, conservation objectives and management. They may be subject to strict preservation or contain habitats requiring constant management. The objectives of each reserve is decided separately depending on its specific requirements.

The primary aim of peatland protection areas is the protection of virgin peatland ecosystems. However, protection regulations are less severe than in National Parks and strict nature reserves. For example, limited exploitation of forestry on mineral soil may be permitted within protected peatland areas.

The purpose of the herb-rich forest reserves is to preserve some lush herb-rich forest habitats, which are rare in Finland. Old growth forest reserves aim at the preservation of old growth forests in an untouched state. Other State protected and privately protected areas vary in status from areas of the strict nature reserve type to old manors and their associated estates of cultural landscape value.

5. HISTORY OF RESEARCH IN NATURAL FORESTS IN FINLAND

A summary of research on natural forests in Finland has been published in Finnish in a review on ecological sustainability and silvicultural alternatives (Parviainen and Seppänen 1994).

Research on natural forests was an essential part of early forest research in Finland during the 1920s. In particular, the work of Ilvessalo, Cajander and Lönnroth formed the basis for knowledge on the dynamics of natural (nature normal) forests. Ilvessalo published growth and yield tables for natural forest data (Ilvessalo 1920) and later studied the relationship between crown diameter and the stem of trees (Ilvessalo 1950). Lönnroth examined the structure and development of natural forests as early as in the 1920s (Lönnroth 1926). During the past eight decades, a tradition deriving from A.K. Cajander has dominated forest vegetation research in Finland. The essential idea of the theory of forest types was previously expressed by Cajander in his pioneer paper of 1909 (Cajander 1909). Later, Cajander presented details of his theory of forest types, further developing it in several papers published in German (Cajander 1921, 1923, 1930; Cajander & Ilvessalo 1921), English (1926, 1949b) and Finnish (1916, 1925, 1949a). The essential idea was that all stands with identical floristic composition and ecological character with respect to the ground vegetation belong to the same forest type. Since the forest type mainly reflects the primary site factors, it might be possible to create a classification system, based on vegetation types, that could be used to indirectly indicate primary conditions of other corresponding sites.

Studies in the 1920s and later have been primarily aimed at having a silvicultural application (c.f. Heikinheimo 1947), but they also have provided information on the structure of natural forests, and on mortality and regeneration processes.

In early studies of natural forests the data was mostly collected from temporal sample plots and the results of tree data were given as averages. There were of course exceptions to this. For example, the oldest permanent sample plot network in natural forests was established by the Finnish Forest Research Institute in the strict nature forest reserve of Vesijako. Measurements of this sample plot network have been done at 10-year intervals since the 1920s. In general, however, the quality of the old data on forest dynamics is not good enough for present-day requirements. In the development work on nature-oriented silvicultural methods, there is a need for more detailed information about the structural heterogeneity and its variation within different temporal and spatial scales.

6. PRESENT STAGE OF FORESTRY RELATED RESEARCH IN NATURAL FORESTS IN FINLAND

Until recent times, there has been little research activity in natural forests in Finland. However, the results of studies in production forests have been compared, in several cases, to undisturbed forests. Today, the Finnish Forest Research Institute has about 6,000 permanent experiments going on in production forests (total area of 12,000 ha). Each experiment has an unmanaged reference sample plot. Reanalysing the relevant data of these experiments could provide important information on the dynamics of natural forests (Appendix 3)

Independent inventories of floral and faunal populations have been made in several conservation areas, but often, there has been no link between these inventories and forest structure, development phases and tree data from the same spot. This lack of information has obvious limitations in relation to the wider perspective of biodiversity overall, and the factors affecting it. However, this situation does not decrease the value of these studies. For example, in the Seitseminen National Park in southern Finland (founded in 1982), there have been several studies on forest structure, and the relationship between forest structure and different faunal populations (e.g. Haila et al. 1994; Punttila et al. 1996; 1994, Raivio 1992; Wollschläger 1996).

During recent years, the lack of information on natural forest dynamics has been recognised and several research programmes concerning natural forests have been established. The focus of the research has been on relationships between forest structure and specific floral and faunal populations, and more recently, on forest dynamics and features of natural forests. One important research area is fire ecology, a topic where very intensive studies are underway. In the following list only the main research programmes are described. In addition to this, there are several smaller research projects going on in Universities and other research organisations. The six research organisations responsible for the principal natural forest research programmes are: the Finnish Forest Research Institute, the Finnish Environment Institute, the Universities of Turku, Joensuu and Helsinki, and the University of Lapland, Rovaniemi. A large

number of the projects described are carried between these organisations in co-operation with one another. The research programmes are presented in a thematic-oriented order.

A. The structure and dynamics of natural forests

Monitoring Undisturbed Forests in Finland
Responsible researcher: Antti Isomäki, The Finnish Forest Research Institute
Aims:
i) To compare features of managed and undisturbed forests
ii) To develop terminology and indicators describing the state of naturalness
iii) To provide basic information for developing nature-oriented silvicultural methods
iv) To increase knowledge on natural forest dynamics

The research programme was established in 1993 and focuses on research of stand structure, natural regeneration, tree species dynamics, tree competition, spatial distribution of trees, rules of mortality, and the development of biomass (Välimäki 1996). By the end of 1997, 282 permanent sample plots were established in Finland (Appendix 2) and 17 in the Russian Federation (14 in the Republic of Karelia and 3 in the Republic of Komi).

Inventory of the old-growth forest areas and ecological research of their structure
Responsible researcher: Tapio Lindholm, The Finnish Environment Institute
Aims:
i) To monitor the amount and quality of ancient forests of Finland
ii) To study the history of forests and determine the crucial ecological features of natural forests

The structure of forest stock and its spatial variation, as well as the impact of forest stock and soil on the vegetation is studied in this project. In 1993, the Finnish Environment Institute established a large ‘umbrella’ research programme called ‘The Finnish National Biodiversity Research Programme (LUMO). The LUMO-research programme includes 69 research projects, which are connected to the research programme in various ways. The project ‘Inventory of old-growth forests’ has ended, but continues as an ad hoc protection programme of new inventoried old-growth forests.

The dynamics of boreal forests and remote sensing
Responsible researcher: Risto Kalliola, The University of Turku
Aims:
i) To compare the features of natural boreal forest areas with managed forests
ii) To provide recommendations for management of forests on a local and regional scale.

This research programme was established in 1990. In addition to the Finnish national parks, natural forests reference areas are located in unmanaged forest areas of the

Republic of Komi, in the Russian Federation. This project focuses on tree species dynamics and spatial variation of the forest mosaic in order to improve forest management and conservation of endangered species.

Research programme on forest ecology
Responsible researcher: Seppo Kellomäki, The University of Joensuu
Aims: i) To develop models for simulating the development of natural and productive forests with respect to regeneration-, growth- and mortality processes

The models are based on the gap-dynamics principle and the field layer vegetation is also included. Project ends in 2001.

Structure and dynamics of natural and managed boreal forest landscapes – linking landscape pattern, stand structure and species diversity
Responsible researcher: Timo Kuuluvainen, University of Helsinki
Aims: i) To compare the habitat, stand and landscape structures, and species diversity between a pristine forest area (northern Karelia in Russia) and managed areas (Kainuu, Finland)
ii) To model the links between forest structure and species occurrence at habitat, forest stand and landscape scales
iii) To examine disturbance dynamics in natural and managed forest landscapes using observations of current disturbances and reconstruction of past disturbance events
iv) To use a simulation model for forest landscape disturbance, succession and management as a tool to conduct experiments and to interpolate the obtained results over large spatial and temporal domains.

The project was launched 1997 as a part of the National Biodiversity Research Programme, FIBRE. The first phase of the programme ends at the end of 1999. The second phase of the programme will be conducted in 2000-2003.

B. Relationship between forest structure and flora- and fauna populations

Invertebrite diversity and bark beetle risk in mature managed, over-aged and old-growth spruce forests in southern Finland
Responsible researcher: Juha Siitonen, Finnish Forest Research Institute
Aims: i) To define how bark beetle diversity in old managed forests differs from that in natural old-growth forests

The research programme was established in 1994 and sampling of the insect data was done between 1994-1996. Sample plots in unmanaged forests are located in the area of the Republic of Karelia, Russian Federation.

Ecological research of the bufferzone between peatland and mineral soil forests
Responsible researcher: Petteri Tolvanen, The University of Helsinki
Aims: i) To determine typical features of the vegetation of the bufferzone between mires and mineral soil forests
ii) To determine roughly the variation in the width of the bufferzone

The project was launched in 1992. The field inventories were made in the same year.

The impact of the forest structure and forest management on the diversity of bark beetlefauna in northern forest border forests
Responsible researcher: Anna-Liisa Sippola, The University of Lapland, Rovaniemi
Aims: i) To develop silvicultural methods suitable for northern forest conditions in order to preserve forest biodiversity

The field inventories were made between 1992-1995. This project will end in 1998

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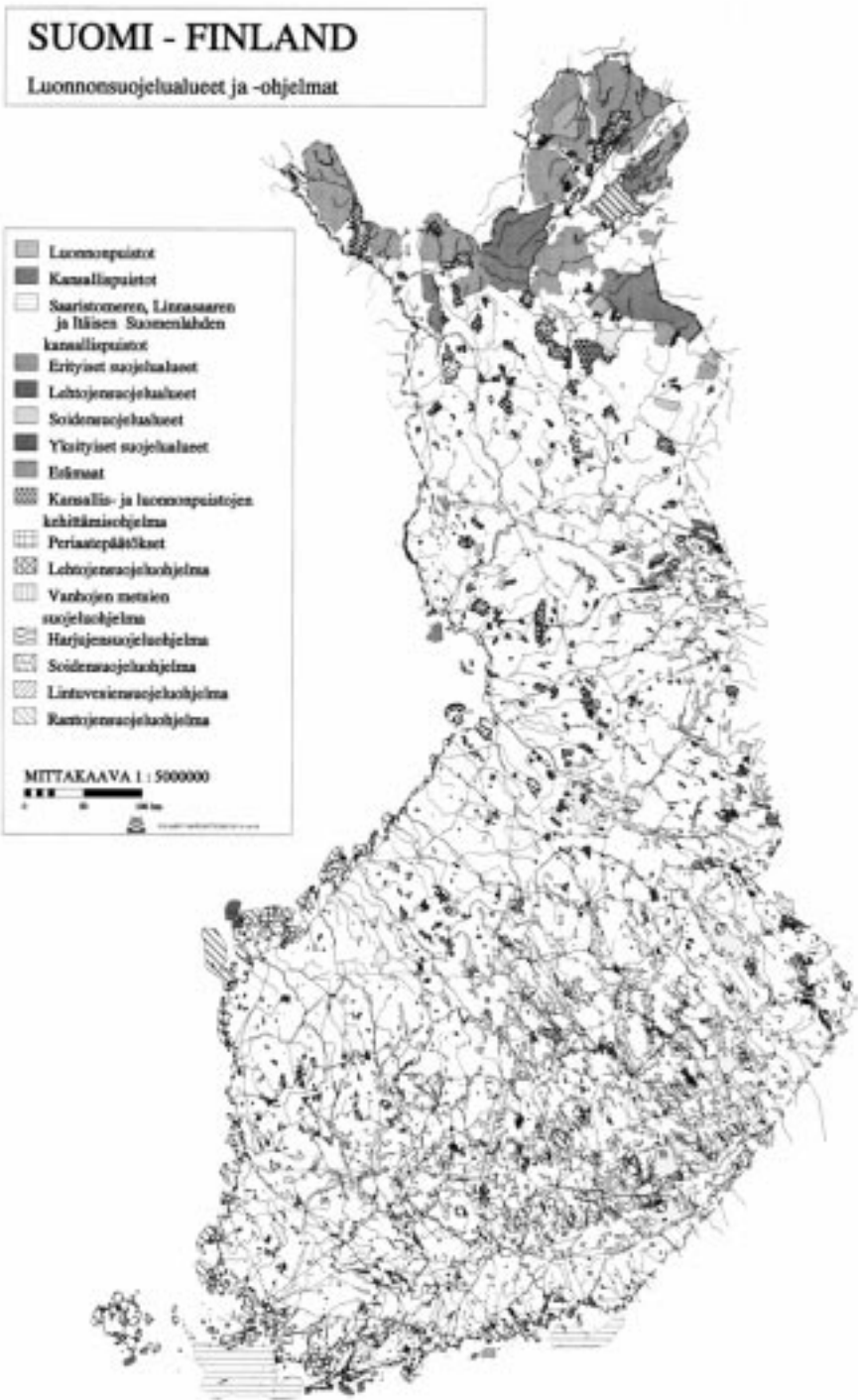
APPENDIX 1.

Existing nature reserves and prepared protection programmes in Finland. Explanations of the categories are as follows:

Luonnonpuistot	Strict Nature Reserves
Kansallispuistot	National Parks
Saaristomeren, Linnasaaren ja Itäisen Suomenlahden kansallispuistot	National Parks of Finnish archipelago (Saaristomeri, Linnasaari and Eastern Suomenlahti)
Erityiset suojelualueet	Special (other) state owned protection areas
Lehtojensuojelualueet	Protected areas of herb-rich forests
Soidensuojelualueet	Protected peatland areas
Yksityiset suojelualueet	Privately protected areas
Erämaat	Wilderness areas
Kansallis- ja luonnonpuistojen kehittämisohjelma	National Park and Strict Nature Reserve Programme
Periaatepäätökset	Principal decision of protection of Mikkeli Islands
Lehtojensuojeluohjelma	Herb-rich forest protection programme
Vanhojen metsien suojeluohjelma	Old forest protection programme, areas to be protected by law in 1996
Harjujen suojeluohjelma	Ridge protection programme
Soiden suojeluohjelma	Peatland protection programme
Lintuvesiensuojeluohjelma	Protection programme of protecting valuable areas for water birds
Rantojensuojeluohjelma	Protection programme of lake shores


SUOMI - FINLAND
Luonnonsuojelualueet ja -ohjelmat
Luonnonpuistot
Kansallispuistot
Saaristomeren, Linnasaaren ja Itäisen Suomenlahden kansallispuistot
Erityiset suojelualueet
Lehtojensuojelualueet
Soidensuojelualueet
Yksityiset suojelualueet
Eräsnaat
Kansallis- ja luonnonpuistojen kehittämisohjelma
Periaatepäätökset
Lehtojensuojeluohjelma
Vanhojen metsien suojeluohjelma
Harjujensuojeluohjelma
Soidensuojeluohjelma
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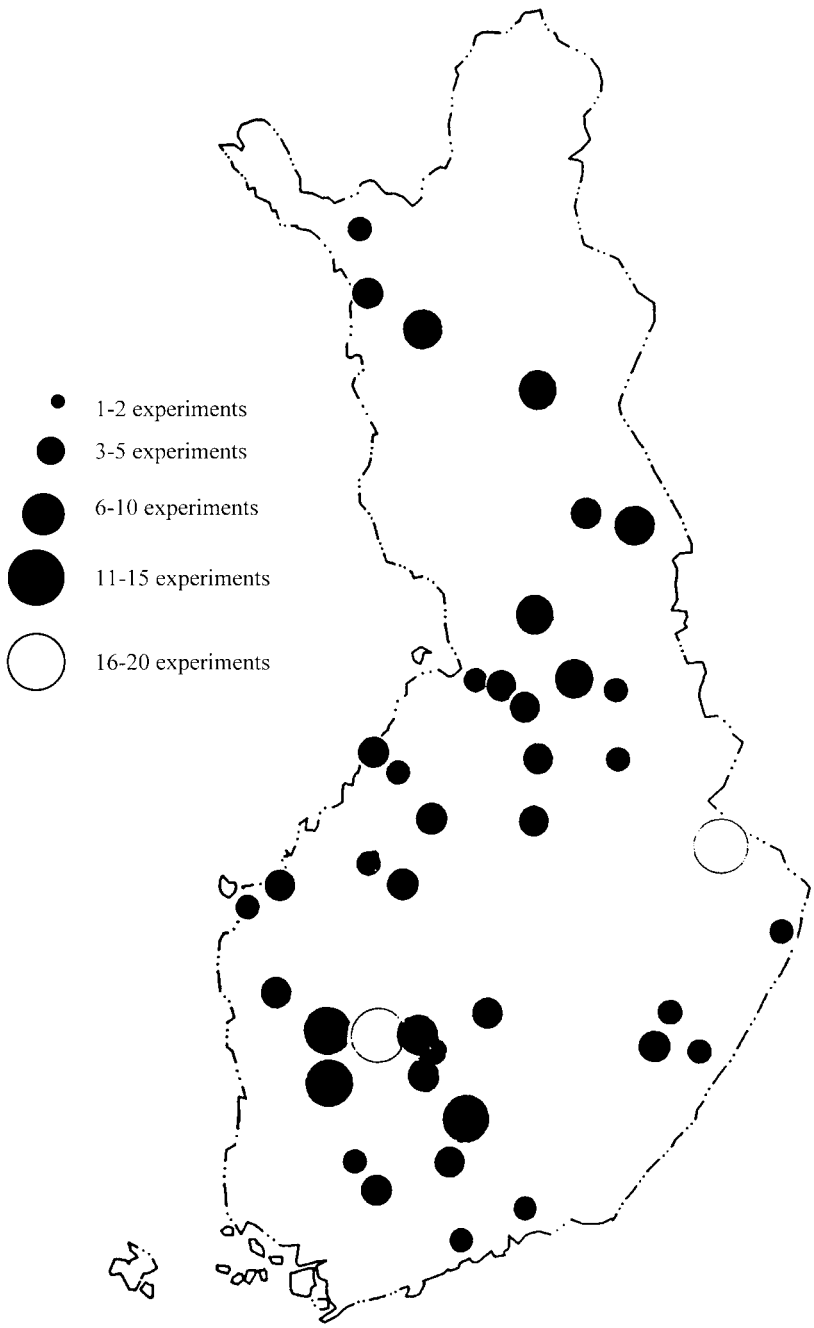
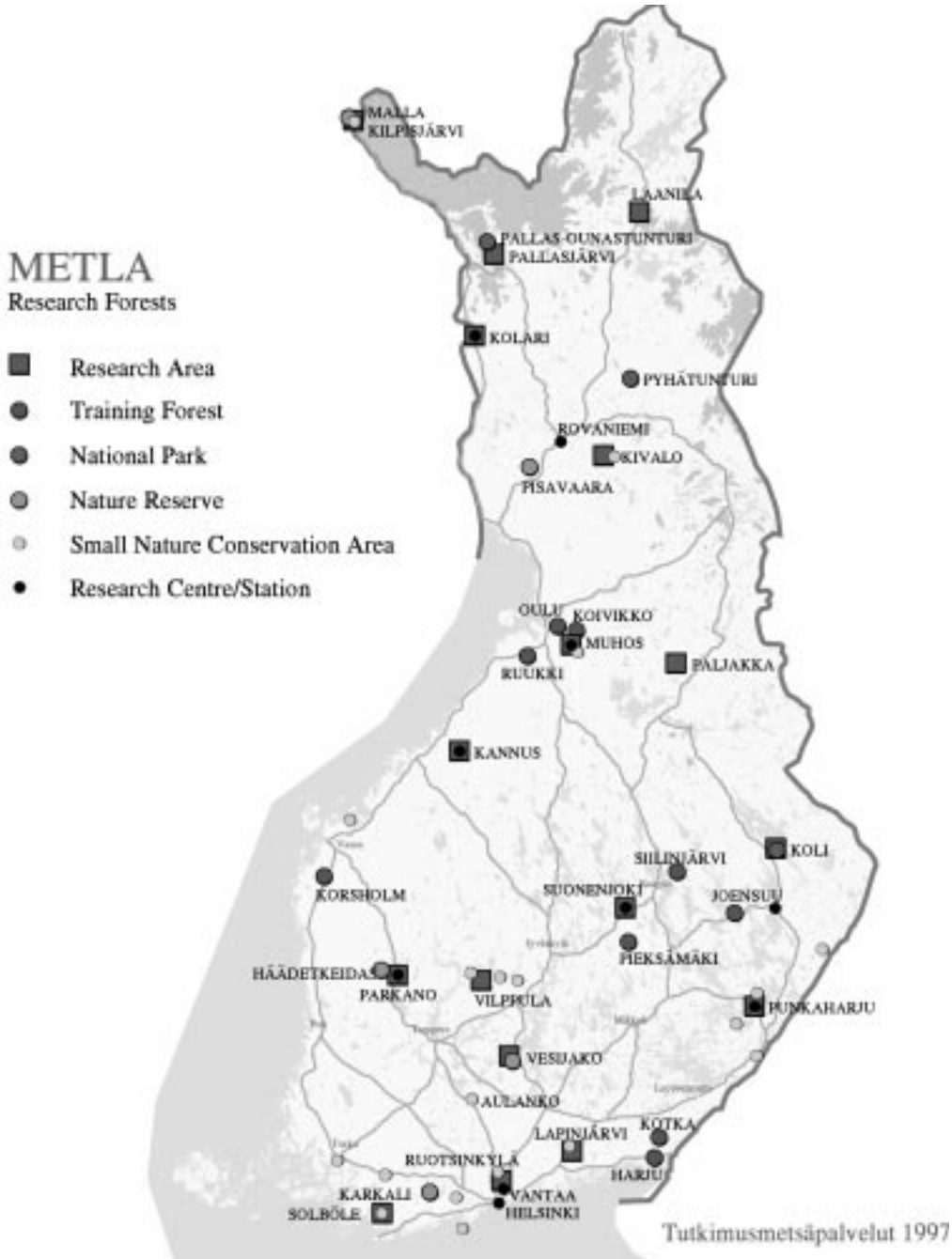
APPENDIX 2.

Spatial distribution of sample plots in programme ‘Monitoring Undisturbed Forests in Finland’. The size of the legends indicate the number of experiments as follows:



APPENDIX 3.

Research forests of the Finnish Forest Research Institute in 1997.



FRANCE

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1. DISTINCTIVE FEATURES OF FRENCH FORESTS

French metropolitan forests occupy 14,610,000 ha, including poplar plantations. Of the total land area, 26.4% is covered in forest, which is close to the European average. However, in relation to forestry, France is unique compared with its EU partners, especially in the three areas outlined below:

1. French forest ecosystems are particularly ecologically rich and diverse, both in terms of species number and silvicultural methods. The national forest inventory lists 89 different indigenous species, which is exceptional for a European country. This reflects the wide variety of soils, climate and terrain. Broadleaf species, especially oak, predominate, accounting for 64% of the forested area. In addition, it is worth noting that forests in the Landes region, are primarily made up of maritime pines, which occupy almost 1 million hectares. This is Europe's largest man-made forested area, established in the 19th century with State assistance. Essentially, the natural forest of the area at that time, which occurred on relatively poor sandy soils, was extended using indigenous species.
2. With the exception of Portugal, France has the largest proportion of privately owned forests, i.e. greater than 70%. Close to 3.8 million private owners posses a total of 10 mill. hectares of forest, with an average holding of 2.6 hectares. Three-quarters of the privately-owned forest sector belong to 400,000 owners, each owning forest parcels greater than 4 hectares in area. In mainland France, state-owned forests account for 1.8 million, i.e. 12% of the forested area. Approximately 11,000 local authorities own forest, i.e. nearly one community in three. These local, community-owned forest mainly occur in the East, South-East, the Massif Central and the Pyrénées regions.
3. In its overseas départements and territories, France has large tropical forests amounting to some 8,800,000 hectares, most of which are in French Guyana, i.e. 8,300,000 ha.

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EFI Proceedings No. 16, 1999

2. FORESTS OF THE PAST AND PRESENT

French metropolitan forests have been shaped by man throughout the last 15 centuries. This legacy can be seen in the extensive areas of coppice and coppice / high forest mixtures. Only 6 million hectares are high forests, a typical silvicultural treatment of natural and semi-natural forests in France.

Since the beginning of the 19th century, the forested area of France has doubled. Hence, there are many relatively new areas occupied by high forests: only a quarter of all high forests may be regarded as semi-natural old forests. This proportion is significantly higher in public forests, which contain the ancient royal forests.

There are now around 15 million hectares of forest in mainland France, which is about the same area that was forested at the end of the middle ages.

Since 1947, private forest owners and Communes have planted or replanted 2.2 million hectares of forest with financial aid from the State. The annual rate of afforestation is about 20,000 hectares a year. The proportion of softwoods in new plantations has been steadily falling over the past 20 years, and now stands at 55% of the total. This share, which is still considerable, is explained by the necessity for diversification in the production forests of France, two thirds of which are still made up of broad-leaf stands.

Natural forests in mainland France have virtually disappeared: 30,000 ha were identified in the inventory of 1994, most of which are concentrated in mountain regions. Natural forests are defined by the presence of high forest from time immemorial, consisting exclusively of local, native species, and free of human interference for at least 50 years.

Semi-natural old metropolitan forests, defined by the presence of high forest consisting exclusively of native species – established for at least 80 years and not emanating from plantations – occupy about 1.5 million hectares.

In 1997, standing timber stocks represented 1,954 million of m^3 (61% broadleaf species). Annual wood production is about 42.7 million of m^3 of hardwoods, 36.8 million of m^3 of softwoods and 1.1 million m^3 of poplar plantations. In 1994, log harvest reached 20,945,000 m^3 and industrial timber harvest was 11,494,000 of m^3.

3. FRENCH FOREST POLICY AND FOREST MANAGEMENT

”Economic, ecological and social forest development falls within the compass of State policy” (Article 1 of the Forest Code). It is defined, co-ordinated and implemented by the Ministry of Agriculture, which is responsible for forest policy, with the assistance of the Ministry of the Environment. The latter is also responsible for nature protection and hunting policies, which have important consequences for forest policy.

State- and community-owned forests are managed by the “Office National des Forêts” (ONF – National Forestry Board), with a strong forestry staff of 13,000 individuals that supervise and protect 4,400,000 hectares of public forest in metropolitan France, i.e. 8% of mainland France, and who are also responsible for public forests in the four overseas départements. They deal with financial management,

ecology, landscaping and tourism. In addition, they also provide public services such as fire prevention in forests, dune protection, prevention of erosion and avalanches in mountainous regions, public liaison, hunting, etc.

Public forests are managed on the basis of a management plan implemented for 10 to 20 year periods. Forest management is comprehensive and "integrated"; a set of subsidiary objectives are generally associated with the primary objective. Ecological imperatives and landscape quality are always taken in consideration. Biodiversity is safeguarded and all outstanding biological and landscape features are protected.

It is obligatory under forest law to have approved management plans in private forests greater than 25 hectares in area. Such plans are optional for forests between 10 and 25 hectares.

4. PROTECTION OF VULNERABLE AREAS

France has numerous legal procedures for protecting vulnerable areas, all of which are adapted to very specific contexts. Slightly more than 1% of metropolitan forests are governed by various statutory protection measures, specially dedicated to nature conservation, i.e. national parks, protected forests, nature reserves, national hunting and wildlife reserves, and bio-reserves in public forests. This chapter presents information based on Sustainable Forest Management in France – Indicators for the Sustainable Management of French Forests (Ministry of Agriculture 1994; ONF 1998).

4.1 National Parks

For most of the parks, unrestricted forestry activities occur, although with respect to the protective objectives and measures specific to each park. Decree's for the creation of National Parks generally insist that all forest planning documents, for both private and public forests, are presented for approval to the National Park Management. For any activity not covered in the planning document, the contractor must obtain authorisation prior to its execution. Any public or private work altering the character of the National Park is prohibited and activities liable to alter the state or appearance of the area are subject to prior authorisation.

Seven National Parks occupy 371,250 ha, i.e. 0,6% of the national territory, in central zones and 921,100 ha in buffer zones, which are categorised as follows;

- high mountains: Vanoise, Ecrins, Mercantour and Pyrénées;
- uplands: Cévennes;
- tropical forest: Guadeloupe;
- marine and island habitats: Port-Cros.

98,800 ha of forest, representing 27% of the total area listed as National Park central zones, are affected by the above-mentioned regulations.

4.2 Nature reserves

Their purpose is to conserve specific or representative features of the natural heritage, unique ecosystems, rare landscapes and biological areas of special interest, habitats of a particularly rare or endangered species, fossil deposits, etc. Unrestricted forestry activities are increasingly being supervised by specific management provisions, e.g. modifications of logging operations, the ceasing of all activities in certain sectors, etc. Forested represent about 15% of the total area of the 139 Nature reserves. There are 143,200 ha in Nature reserves in metropolitan France and 302,850 ha in the overseas départements.

4.3. Regional Nature Parks

An area with a rich natural and cultural heritage, and with a specific development project based on the conservation and improvement of the local heritage, may be classified as a Regional Nature Park by the Ministry in charge of Environment, for a period of 10 years and renewed if approved. This is usually done after it is proposed by the appropriate authorities in the various regions,

At present, there are 36 Regional Nature Parks, which occupy 10% of the national territory and include within their boundaries some 1,600,000 ha of forests.

4.4. Protected forests

This protection status currently constitutes the most effective legal tool of forest legislation for the protection of forests threatened by any factor. The principle effect of this status, pronounced by decree, is to prohibit land clearance, to subject forest management to specific technical rules, to monitor user rights and to control public access. Originally, this legal framework was limited to fighting erosion, avalanche protection, and water and sand encroachment, and was later extended in 1976 to protecting the ecological value of forest ecosystems and their populations. By 1998, 80,500 ha were covered by this protection category.

4.5. Bio-reserves

In public forests, when the determining objective is the protection of ecosystems or landscapes, distinct areas of ecological interest are defined in the managed forest.

Areas of ecological interest can be transformed into bio-reserves approved by the Ministry of Agriculture and the Ministry of Environment, which submits the project to the National Council of Nature Protection for approval. Bio-reserves in public forests are aimed either:

- at protecting outstanding natural environments characterised by the presence of rare or endangered species (Flora and Fauna) or exceptional ecotypes and rare or

endangered habitats; human activities are reckoned to be necessary to pursue the target set: special forest reserves; or
- to permit scientific observation of forest environments and dynamics where there are no ongoing silvicultural operations: strict forest reserves

It is planned to develop these networks so that it includes at least 30 000 ha by the end of the 20th century.

Table 1. Special forest reserves in public forests as of May 1998.

	State owned bio-reserves area (number of reserves)		Other public bio-reserves area (number of reserves)	
Metropolitan France	15 250 ha	(118)	1 000 ha	(11)
Overseas départements	5 150 ha	(1)	-	-

4.6 Biotope rulings

In France, these rulings, which numbered about 450 in 1997, are laid down by the Prefect of the département. The ruling then establishes the measures which are necessary for the conservation and future sustainability of habitats and the survival of protected species. This procedure, which can be implemented quickly, may not stipulate overly cumbersome restrictions, and no management is provided for within the context of the initial ruling.

5. DEVELOPMENT OF RESEARCH IN NATURAL FORESTS

Except for the numerous studies carried out in the forest of Fontainebleau, there are not many references to, and studies of, unmanaged forests elsewhere in France.

A research program on mountainous semi-natural forests was started in 1993; an inventory of semi-natural alpine forests was carried out using a method based on two criteria; the age of the oldest trees (stand's maturity) and the date of the last human intervention.

Three forests adjacent to natural forests have been studied in detail, i.e. the community-owned forests of Sixt (Haute-Savoie) and Moulinet (Alpes-maritimes), and the state-owned forest of Bois du Chapitre (Hautes-Alpes). The following topics were studied:

- historical study (carbon dating of charcoal and vegetation evolution);
- phytoecological and structural description;
- entomological and pathological inventories;
- forest stand dynamics;
- growth simulation of Norway Spruce in irregular stands (Sixt).

Permanent plots have been installed to monitor the natural evolution of the stands. Other studies are carried out on those sites to improve the knowledge base of semi-natural forests:

- influence of herbivorous on the ecosystem's dynamics;
- biodiversity in unmanaged forests (dead wood, saprophytic insects, etc.).

Research on semi-natural forests in mountainous regions are carried out by:

- CEMAGREF Grenoble (research centre of the Ministry of Agriculture): C.Chauvin – C.Thouvenin, J.F. Abgrall;
- University of Savoie: J. André, J.P. Faivre, S. Camaret;
- University of Nancy: J.C. Rameau;
- University of Aix – Marseille: M. Thinon.

A new programme is about to start in the Pyrénées, headed by the ONF and the university of Toulouse (F. Gauquelin). Semi-natural forest stands in Fontainebleau have been studied for many years (University of Paris – Orsay).

Many studies and descriptions of the natural vegetation dynamics have been completed, concerning alluvial forests, mainly in the Rhine valley by the University Louis Pasteur in Strasbourg (J.-M.N. Walter) and the University of Metz (laboratoire de phytoécologie – A. Schnitzler).

6. STRICT FOREST RESERVES IN METROPOLITAN FRANCE

6.1 Forests in strict forest reserves

There are about 14,000 ha of forests with a status of 'Strict forest reserves':

- National Parks: 700 ha;
- Nature reserves: 12,600 ha in different sites in numerous locations;

Examples:

- Nature reserve "Massif du Ventron" (Vosges): 390 ha;
- Nature reserve "Ile de Rhinau" (Alsace): about 250 ha;
- Nature reserve "Forêt d'Offendorf" (Alsace): 60 ha.
- bio-reserves: 700 ha.

6.2 Strict forest reserves in bio-reserves

6.2.1. Principles

The ONF is currently working on the design of a national network of strictly protected forest reserves covering a wide range of representative forest ecosystems. The selected forests have two main characteristics:

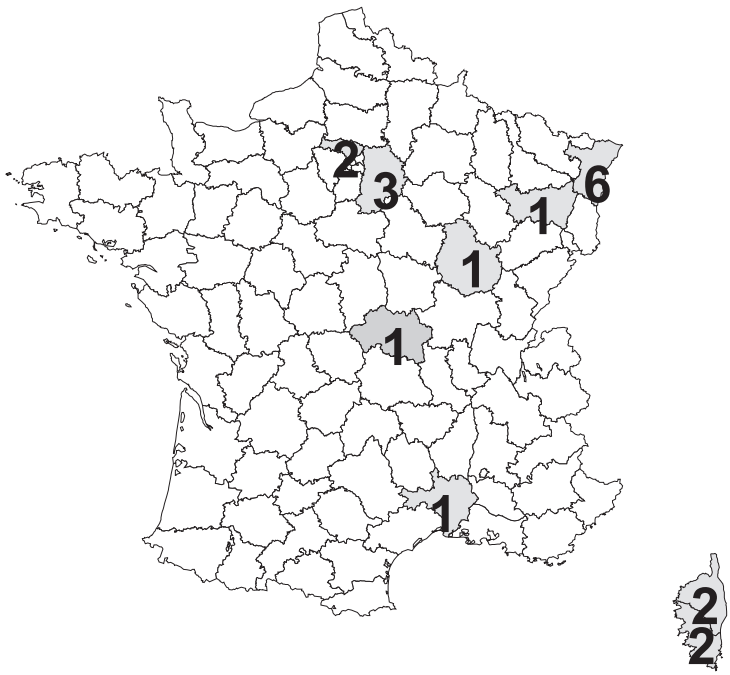

Figure 1. Strict forest reserves in bio-reserves – metropolitan France (number per department).

1. common, but representative of ecological diversity in France,
2. semi-natural forests:
   - forests composed of native species,
   - native species of local origin,
   - past forestry management: high forests, excluding plantations,
   - no significant impact on species composition and stand structure since World War II,
   - presence of dead wood and senescent trees in forest stands.

Silvicultural operations and harvesting are prohibited in strict forest reserves in order to preserve or restore natural forest dynamics. The size of each reserve varies greatly. However, a minimal area is necessary to study the forest stand's natural dynamics:

- 50 ha in plain regions,
- 100 ha in mountain regions.

Those minimum areas cannot are too small to study great perturbations such as storms and fires. In mountain regions, larger areas will be studied. Two or three large strict forest reserves are planned, i.e. in Fontainebleau (500 ha), the Alps and Corsica. As reserves are normally surrounded by public forests, buffer zones are generally useless; forestry policy protects biodiversity, species and habitats.

6.2.2. Management in strict forest reserves

The prohibition on harvesting does not mean that no other management procedures can occur. Any human intervention which is likely to modify the species composition or the stand structure is prohibited, i.e. no cleaning, no cutting and no silvicultural operation.

However strict forest reserves are still managed, e.g. monitoring, inventories, scientific studies and outlining the agenda for a specific management plan. In some cases, the scientific committee may decide to recreate natural disturbances if they do not occur presently, i.e. flooding of alluvial forests.

For each forest reserve the manager, aided by scientists and ecologists, draws up an action programme which is valid for between 10 and 20 years duration.

Table 2. Existing network.

Department	Owner	Name of forest	Name of reserve
Seine et Marne	State	Fontainebleau	les Hauteurs de la Solle
	State	Fontainebleau	le Gros Fouteau
	State	Fontainebleau	la Tillaie
Val d'Oise	State	Montmorency	Tourbière de la Cailleuse
	State	Montmorency	Tourbière du Nid d'Aigle
Vosges	State	Vologne	Tourbière des Hautes Pinasses et des Grandes Ronces
Bas-Rhin	State	Donon	Tourbière de la Maxe
	State	Nonnenhardt	Vallée du Srautbach
	State	Ingwiller	Vallons de l'Eickenbachthal
	State	Offendorf	Rossmoerder
	Community	Saverne	Stampfthal
	Community	Wantzenau	Wantzenau
Côte d'Or	State	Citeaux	Citeaux
Allier	Sate	Tronçais	Tronçais
Gard	State	Aigoual	Peyrebesse
Haute-Corse	State	Tavignano	Tavignano
	State	Fango	Malazanca
Corse du Sud	State	Punteniellu	Punteniellu
	State	Sabinetto	Sabinetto

N.B.: There are approximately 118,200 ha of strict forest reserves in the overseas *départements*, i.e. Guyana – 110,300 ha and La Réunion – 7900 ha.

A regional scientific committee gathers together all concerned parties, including the manager, the owner, scientists and ecologists. This consultative committee helps the manager with regard to inventories, studies and specific management guidelines for the reserve.

Human activities. The action programme details all operations recommended to improve the strict forest reserve, in addition to all prohibited actions.

- Civil engineering: new roads and tracks are prohibited. Maintenance operations are allowed, but with specific restrictions.
- Ecological engineering: derogation's may be permitted by the scientific committee. Materials are left on site (except rubbish).

Interest	Size (ha)	Buffer zone (ha)
old declining high forest of *Quercus petraea* and *Quercus robur* mixed with *Fagus sylvatica* on a sandstone chaos – plain	79,00	
old declining high forest of *Quercus petrae* (400 years old) on limestone and silt – plain	21,00	
old high forest of beech on limestone – plain	36,00	
peat bog	32,40	63,50
peat bog	9,40	53,10
peat bog	14,13	
peat bog	3,00	
very rare boreal species: *Lycopodium annotium* – plain	1,00	
peat bog (*Osmunda regalis*, *Sphagnum ssp.*, etc.)	1,00	
typical alluvial forest – Rhine	52,64	97,97
ash and maple stands in ravines, rare flora	2,00	1,36
protection of a unique ecosystem	7,79	
interest in various bird species (woodpeckers) Monitoring of old forest nesting birds	17,43	29,25
Old high forest of oaks	61,17	
natural evolution of a beech stand at high altitude	18,43	
natural evolution of *Pinus nigra subsp. laricio var. corsicana* – mountain	50,00	310,00
natural evolution of stands of *Quercus ilex* – mountain	77,90	
Abies alba with a very slow growth – Mediterranean forest	6,13	
natural evolution of maquis of *Quercus ilex* – mountain region, with maritime influence	210,00	

- Scientific research: non-destructive studies are allowed by the manager after consulting with the scientific committee.
- Hunting: controlled in the reserve, but not prohibited. Hunting prevents game from congregating; deer and wild boar populations can be greatly deleterious to vegetation dynamics if not frequently culled/regulated.
- Fishing: prohibited.
- Pasture: prohibited.
- Silvicultural operations: all are prohibited.
- Public access and pedagogy: they are not the main objectives of the strict forest reserves. Public access can be allowed, but it is necessary to channel people on pre-determined pathways and through delimited areas. Safety measures are taken to prevent accidents, e.g. dangerous branches or trees along trails are cut down and left on the ground. Interpreters explain the ecology of the forest reserve, its functions and interesting features.
- Alleviation of natural disturbances: as recommended by the scientific committee.

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GERMANY

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ABSTRACT

Forest cover in Germany amounts to about 10.74 mill. ha or one-third of the total land area. Forests are owned by the regional states and the federation (34%), by other public owners (20%), and by private owners (46%). The predominant tree species are beech (about 9% of forest area), oak (7%), other deciduous trees (7%), spruce (46%), white fir (1%), and pine (8%). Exotic tree species like Douglas fir (1%) or larch (2%) play only a minor role. Total standing biomass is estimated to be about 2.2 bill. m³; average biomass per ha 302 m³ and annual cuttings 40 m³ (Western states; BMELF 1990).

Under natural conditions, forest would cover more than 90% of the territory. Beech would predominate, regionally and locally, in mixtures with other tree species, covering about 70% (Figure 1). The other main forest types are naturally restricted to site conditions that reduce the competitive strength of beech. The natural distribution of spruce and pine has been artificially much expanded. On the other hand, many of the productive oak forests – apart from stands on very wet or very dry sites – are now also thought to be anthropogenic, having been preserved by pasture forest and coppice-with-standard management since the postglacial mixed oak forest period.

1. HISTORICAL PERSPECTIVE AND MILESTONES OF RESEARCH

Since the beginning of the 20th century, German scientists and foresters have recognised the importance of establishing forest reserves for the preservation of natural vegetation. The first reserves were established in 1911, while renewed efforts were made after the Second World War. In the eastern part of the country, the reserves were managed by the nature conservation authorities, in the western part by forestry administration. It must be borne in mind that the management of landscape in Germany is under the authority of the regional government of each ”state”, so that the history of the creation of forest reserves and the legal state of nature reserves varies between the

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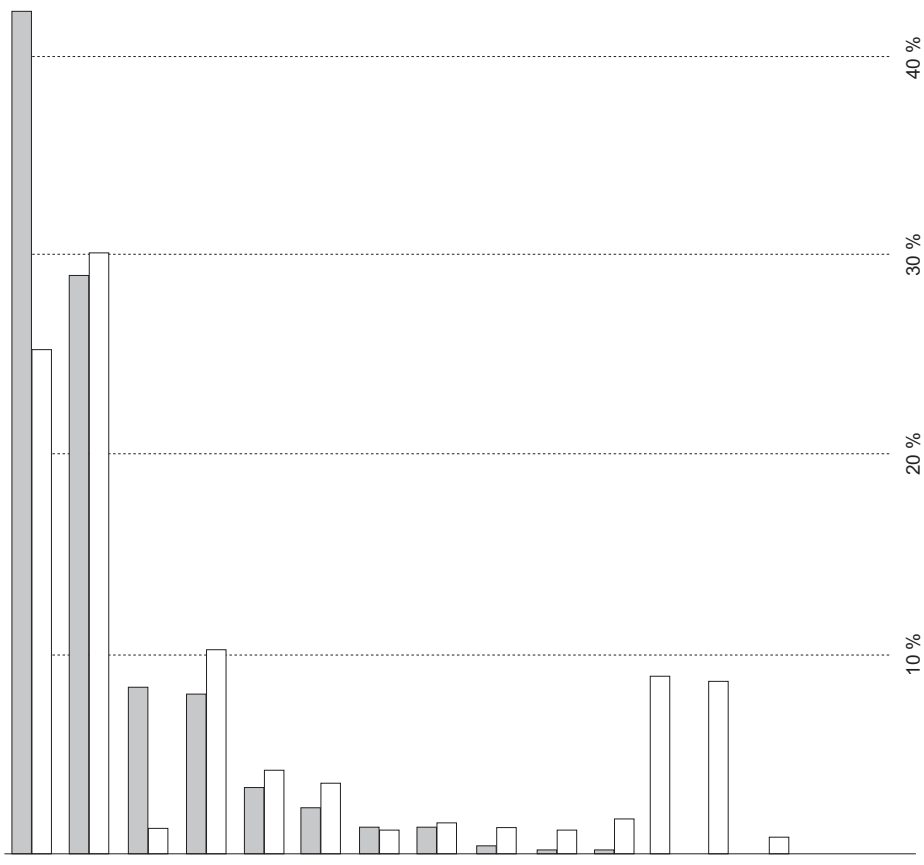

Figure 1. Potential area of forest types (gray bars) compared with actual area of these forest types within strict forest reserves (white bars). Only the most predominant forest types and only the western states are represented. From Wolf and Bohn 1991.

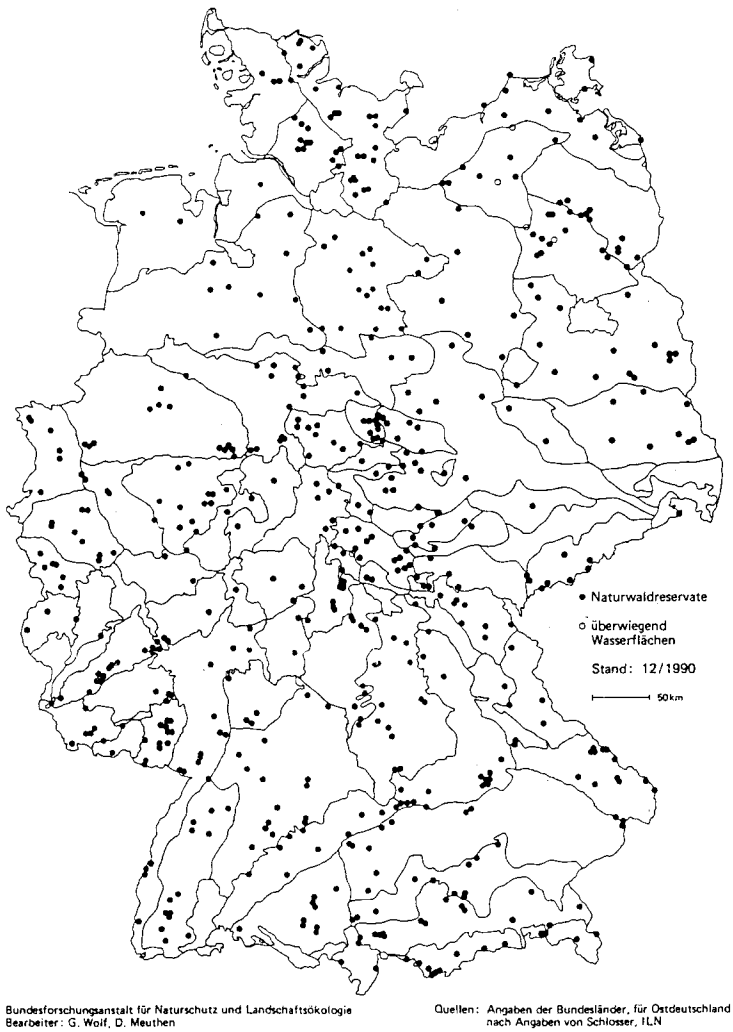

Figure 2. Distribution of strict forest nature reserves (●) in the forest growth regions of Germany. From Schriftenreihen Vegetationskunde 1991.

16 political subunits (states) of the Federal Republic of Germany. Statistics on forest reserves are presented in Table 1, and their current distribution pattern is mapped in Figure 2 (Wolf and Bohn 1991). The common objectives of strict forest reserves (Projektgruppe 1993) and other nature protection categories (BNatschG 1987) are summarised in Table 2.

Initially, the selection and establishment of forest reserves was based on scientific data on the vegetation and plant biogeography. Forest stands which are typical and representative of forest communities had to be legally protected, in order that their natural features and dynamics could be studied, free from the influence of management

Table 1. Number, area and proportion of natural forest reserves** (totally protected forest reserves)*** in Germany

Name of state* (“Bundesland”)	Size Classes (ha) <5	5-10	10-20	20-50	50-100	≥100	Medium Size (ha)	Total Number	Total Area (ha)	Total forest forest area (1000 ha)	Reserve proportion forest area (%)
Baden-Württemberg**	5	5	29	13	10	13	48,0	75	3600	1345	0,27
Bayern**	3	10	26	72	29	9	41,1	149	6124	2411	0,25
Berlin*										16	
Bremen*										1	
Brandenburg***	4	5	11	9	4	2	30,4	35	1064	1024	0,10
Hamburg**	0	2	1	1	0	0	12,8	4	51	3	1,70
Hessen**	0	2	4	19	2	3	40,9	30	1228	840	0,15
Mecklenburg-Vorpommern***	1	6	8	5	5	6	50,3	31	1559	497	0,31
Niedersachsen**	0	3	20	33	23	4	45,2	83	3753	984	0,38
Nordrhein-Westfalen**	4	14	34	14	3	1	18,6	70	1314	842	0,16
Rheinland-Pfalz**	6	12	6	14	5	2	28,2	45	1271	805	0,16
Saarland**	0	1	2	4	3	1	36,1	11	751	86	0,87
Sachsen***	1	3	3	3	3	1	35,1	14	494	485	0,10
Sachsen-Anhalt***	0	2	3	6	2	2	83,7	15	1255	434	0,29
Schleswig-Holstein**			preliminary installation				14,1	49	690	145	0,48
Thüringen***	9	10	16	7	4	2	22,2	48	1064	515	0,21
Federal Republic of Germany	33	75	163	200	93	46	36,7	659	24218	10433	0,23

* No reserves in the states Berlin and Bremen
** Western („old“) States by 06/1996
*** Eastern („new“) States by 02/1991 from Schriftenreihe Vegetationskunde 1991; partly realized. Areas have still to be checked in detail.
**** Statistical Yearbook for the Federal Republic of Germany 1996

Table 2. (Strict) Forest Reserves and other nature protection categories in Germany – Definitions and Objectives.

Common understanding of Strict Forest Reserves* (Projektgruppe 1993)

Strict Forest Reserves are areas that are from now on unmanaged.
They are reserved for natural processes (natural development).

Main Objectives

- Basic scientific research (fauna, flora, site, stand structure, ecosystem functioning)
- Applied research (silviculture, landscape, management, biotope management)
- Monitoring areas (ecosystem development; biological development; naturalness, reference sites for managed or polluted areas)
- Nature protection (rare and endangered species, genetic resources) and personal nature experience ("virgin forest of tomorrow")

Definitions of categories of nature protection areas in Germany (BNatSchG 1987)

Biosphere reserve (Biospärenreservat)	Combined natural and cultural landscapes including core areas, designed management areas, developmental areas and regeneration areas.
National park (Nationalpark)	Large-scale natural or near to nature ecosystems, ideally left to free succession. Commercial interests are no longer involved. Some management is permissible or even essential where the natural balance is deeply disturbed and should be restricted to buffer zones including core areas, developmental areas and designated management areas.
Nature protection area (Naturschutzgebiet)	Special protection of nature or landscape in its entirety or in individual areas a) in order to preserve biocoenoses or biotopes of wildlife and plants; b) for scientific, nature historical or cultural reasons and c) for rarity, specificity, or eminent beauty reasons.
Landscape protection area (Landschafts-schutzgebiet)	Special protection of nature and landscape a) to preserve and restore the nature balance or the use of natural goods; b) for variety, characteristic features and beauty reasons; c) for their particular implications to recreation.
Nature park (Naturpark)	Mostly protected areas, well suited for recreation. Dedicated to recreation and tourism, according to landscape plans.
Bird sanctuaries (Vogelschutzgebiete)	Bird protection areas according to different EU-guidelines; important bird areas; wet areas; European reserves; Europe Diploma reserves.

* Many regional names exist: Naturwald, Naturwaldreservat, Naturwald(par)zelle, Bannwald, Bestocktes Totalreservat

by humans. In general, mature forests (optimum phases) were chosen, as they were believed to be comparatively stable, and preservation of a relatively small area of a few hectares was thought to be sufficient for the representation of a specific forest community. The expansion of studies in phytosociology and site-specific forestry research broadened the range of vegetation types described, and highlighted the need for more reserves. It was considered more important to represent the complete range of forest communities than to designate only a small number of very large reserves.

Recently, the adequacy of representation of forest communities in forest reserves has been questioned. As Figure 1 shows, reserve areas are strongly biased when compared with the potential natural vegetation (Wolf and Bohn 1991). Forest reserves should not

only reflect the range of forest vegetation types, but also their relative presence in the landscape. They should not only depict rare and special biotopes, but normal manageable and productive sites. They are not static systems, but are rather areas in which all natural processes may occur. The percentage of the protected areas in relation to commercial forests is a matter for debate among forest owners, forest scientists, non-governmental groups, such as Greenpeace and WWF, and official nature conservation bodies. Continued progress in site and vegetation mapping of forest stands enables one to obtain a balanced assessment of site types from which the desired protection area can objectively be derived.

About half of the reserves in Germany are smaller than 20 ha (Table 1). From a scientific point of view, it can be demonstrated that these small reserves will not completely suffice to meet research and conservation demands. There is a need to distinguish between the larger, more representative reserves, which are more required for silvicultural research, and the smaller reserves which may play a role in nature conservation.

Apart from the forest reserves network, tens of thousands of hectares of unmanaged areas (BMELF 1997) are legally protected in nature protection reserves, in national parks (e.g. the Bavarian Forest National Park), in the biosphere reserves recently created in some parts of Germany, or are in reserves in private or public ownership, without legal protection (Table 3). The large-scale wilderness areas of national parks or biosphere reserves fulfil other demands to those of the forest reserves network. They

Table 3. Nature Protection Areas in Germany (Nature Reserves, Large Scale Reserves, Strict Forest Reserves)

	Open Land	Forest	Number of reserves	Area, ha	Percentage of area	
Germany	+	+		35 000 000		
Forest area		+		~ 10.740.000 ***	~ 31%	
Nature protection areas	+	+	~ 5000	~ 600.000	~1.8%	of total area
Large Scale reserves	+	+				
Biosphere reserves	+	+	~ 9	~ 600.000	~1.8%	
National parks*	+	+	~ 8	~ 160.000	~0.5%	
[Nature parks]**	+	+	~ 85	~ 7.000.000	~20%]	
Non intervention areas						of forest area
Within above categories,				~ 60.000 ***	~ 0.6%	
+ in other protection categories,						
+ reserves not legally protected		+				
Strict forest reserves			~ 650	~ 24.000	~ 0.2%	
(legally protected)		+				
In some states: Legally protected biotopes within forest management areas		+			5-10%	of forest area

* Terrestrial reserves only. In addition another 550,000 ha of marine ecosystems are protected.
** Chiefly tourism – and recreation – focused.
*** BMELF 1997. Very heterogeneous categories are included, not the whole area is strictly protected. The research is not the main objective of these reserves.

may be, for example, refuges for rare animal species with a large habitat range. As only a few large-scale reserves can be designated in a densely populated country like Germany, the range of sites and forest types represented in such reserves will be limited, and for this reason the validity of research results from these reserves to exploited forests is questionable. In addition, it is not possible to give exact data on the area of forests included in this network, as most categories overlap (e.g. biosphere reserve + national park + nature protection area + strict forest area).

2. RESEARCH APPROACHES

Most research activities have focused on vegetation studies: stand type, stand structure, vegetation mapping, and plant inventories. Correlations with regional forest history, individual stand history and local site factors (site and soil mapping) have been investigated. Research on stand dynamics, or the succession of forest phases, has been introduced with the installation of permanent plots, transects, and core areas (ranging in from small to several hectares), in which stand structure is repeatedly documented.

Over the past few years, faunistic studies have been initiated in several states. As can be expected, all findings are correlated and interpreted as far as possible, and the analysis of biodiversity is an important research approach. Research on disturbance in forests is also included – windthrow areas in several states were recently declared forest reserves. Episodes of disturbance, such as windthrow or beetle attacks, in the forest reserves are accepted as natural processes that are studied within the framework of permanent plot inventories. There are, however, still some phytosanitary restrictions due to the small size of many forest reserves.

The methodology of integrated long-term monitoring in forest reserves, based on many biological and ecosystem parameters, has been studied in a special paper, and a national monitoring program of unmanaged beech ecosystems has been recommended (Thomas et al. 1995).

3. THE MOST IMPORTANT RESEARCH REPORTS

As mentioned previously, there has to date been no national research activity. One problem in Germany is the coordination of research on a national scale, which can only be accomplished on a voluntary basis between the states. In the past, scientific coordination was organised by the National Office of Nature Conservancy (BfN, former BFANL; Trautmann 1969, 1976), who held several symposia. The proceedings of some of these symposia are published in several issues of ”Natur und Landschaft” (BFANL 1980, 1989) and in ”Schriftenreihe für Vegetationskunde” (BFANL 1991). In 1988, a working group called ”Natural Forest Reserves” (“Naturwaldreservate“) was formed by the forestry administrations in order to meet the need to harmonise management and research in German forest reserves (Projektgruppe 1993). Based on a thorough study of Albrecht (1990), which reviews management and research in forest reserves up to the

present day, some general recommendations at a minimum level were formulated. The situation is summed up in AFZ (1994) and in Bücking (1995, 1997). The Federal Agency of Nature Conservation has adopted responsibility for maintaining a bibliography of publications and reports concerning forest reserves and case studies (Meuthen and Wolf 1991), which is regularly updated. Most states have created their own publication series dealing with investigations in the different forest reserves.

The whole programme has involved lots of individual case studies, according to the numerous stand, forest, and site types, and it is difficult to generalise results in a few sentences. One general finding of silvicultural importance is that the concept of natural tree species composition has changed. It seems now that, in most parts of Germany, beech forests play a much more dominant role than was thought some decades ago under the concept of long-term managed forests.

Another point of general interest is that the understanding of forest phase cycles has been enhanced through the study of natural processes in forest reserves. It has been demonstrated that, besides pioneer and preforest stages, intermittent forest types may play a temporary role. Biodiversity indices change with phase cycling. An understanding of the importance of dead wood in the forest ecosystem was promoted, and it is now the standard even in commercial forests to leave a certain amount of dead wood behind in the stand. Biodiversity is strongly linked to dead wood structures and microhabitats, which are more plentiful in uneven-aged and irregular stands than in commercial forests.

4. COMPARISONS BETWEEN UNMANAGED FORESTS / MANAGED FORESTS / PRODUCTIVE FORESTS, APPLICATIONS TO SILVICULTURE

The primary point of interest in forest reserves may be different for nature conservationists and foresters, but it is generally accepted that one important aim is to derive from the study of forest reserves some lessons for silviculture in productive forests. Several studies deal with comparisons between unmanaged forests and managed forests. The state of Hessen parallels forest reserves with managed forests as a rule. It should be remembered that most of the state forest authorities have adopted a forest management which is as close as possible to natural development. The standards of their near-to-nature silviculture will have to be defined with regard to forest reserves.

5. THE MOST IMPORTANT ONGOING RESEARCH PROJECTS, RESEARCH GROUPS AND EMPHASIS IN RESEARCH

Ongoing research is predominantly concerned with carrying out standard surveys of permanent plots or core areas in forest reserves, as a continuing of earlier inventories. In future, research will focus on more representative forest reserves of a sufficient size. As it is not possible to study the larger forest reserves on the basis of single core areas, systematic grid designs for permanent circular plots will be adopted. Because of the

lack of funding for faunistic research, it will continue to be restricted to a selected choice of forest reserves and, within these forest reserves, to a small number of special biotopes and systematic groups of animals. There is a need to develop research which compares faunistic data between managed and unmanaged forests. In contrast with studies on vegetation science, there is an apparent lack of standardised methodology for faunistic research in forests (Dorow et al. 1992). A group of specialists is considering these problems in forests, and plans to recommend guidelines for long-term research in forest reserves (Winter in press). Research deficits in the broad area of conflict between nature conservantion and forest management are analysed in a special project (Ammer and Kuebler 1997; Feldmann et al. 1996).

Research groups are located in the Forest Research Institutes, the Universities, and the national and local Natural History Museums. It would be beneficial if scientific researchers could be involved in forest research at full capacity for the long term, but at the moment, this is almost unthinkable for most researchers and forest practitioners. The development of standardised methodologies with a high level of precision is required. It is even more important that the tasks of management and coordination be placed in the hands of research institutions, e.g. governmental Forest Research Institutes.

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GREECE

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1. GREEK FORESTS

The long and intensive use of Greek forests, in combination with frequent periods of war, foreign occupation and political and economic instability, have resulted in the extensive destruction of forest resources, as well as the severe degradation of mountain and sub-mountain landscapes due to soil erosion. This was exacerbated by the topography, which is steeply sloping, and the Mediterranean climate, characterised by heavy rains and prolonged dry, warm summers. It should also be mentioned that over the centuries, practically all potential arable area in Greece has been converted into agricultural land. In many cases, woodlands, even on the steepest of slopes, have been cleared for cultivation (olive trees, vineyards etc.).

All these factors have had a profound effect on forests, which have been eliminated in mountainous areas, with most of the remainder being unable to adequately fulfil their functions and satisfy social needs. Reforestation has not changed the landscape in Greece, although it has contributed enormously to erosion and flood control. The total area reforested in the last 70 years does not exceed 175,000 ha.

According to the results of a national forest inventory (1992), about 50% of the country's total area is forest. About 25% of this total consists of commercial forest (forests capable of producing more than 1 m^3/ha/year), while 24% is occupied by non-commercial forest (marginal land for grazing, fuel wood production and soil protection).

Table 1 shows that of the commercial forests, 22% consists of coniferous forests and 30% consists of broad-leaved forests, i.e. in total these sectors occupy 52% of the total forest area. The silvicultural systems used are not distinguished in the statistics mentioned above, but it is widely accepted that the ratio of coppice to high forests is about 55:45.

The crucial problem of the Greek forests is poor growing stock and hence, low annual increment. 46.6% of the commercial forests have basal areas below 10 m^2/ha and only 28.5% are over 30 m^2/ha. From Table 2, it is obvious, that even the commercial forests have a very poor mean growing stock, i.e. 85% of the total area has a growing stock of less than 100 m^3/ha.

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Table 1. Distribution of forest tree species in Greece

	Forest types	Area (ha)	%
Conifers	*Abies*	543 308	8.34
	Pinus halepensis – P. Brutia	567 731	8.72
	P. nigra	281 692	4.33
	P. silvestris	20 955	0.32
	P. leucodermis	8 300	0.13
	P. pinea	108	0.00
	Abies/P.nigra	4 762	0.07
	Spruce	2 754	0.04
	Total conifers	1 429 610	21.95
Broadleaves	*Fagus*	336 640	5.17
	Castanea	33 081	0.51
	Quercus	1 471 839	22.60
	Platanus	86 579	1.33
	Betula	1 437	0.02
	Total broadleaves	1 929 576	29.63
Total industrial forests		3 359 186	51.58
Non-industrial forests		3 153 882	48.42
Total forests		6 513 068	100.00

Greek forests are managed, more or less, according to the principles of natural silviculture. This means that forest managers do not alter species composition, natural regeneration is used for forest renewal, and uneven-aged structures are preferred to even-aged forests. Shelter-wood and selection systems are also preferred and are applied, where feasible.

Artificial silviculture, i.e. re-planting with exotics after the final cutting/harvest, is not applicable in most Greek forests for a variety of reasons. Reforestation is practised for protection purposes and also for production.

Plantation silviculture is applied in Greece in the lowlands, where there is fertile agricultural land and alluvial soils in large riparian areas. Poplars are cultivated very successfully in Northern Greece, while Eucalyptus is cultivated in the South. There are no opportunities for clonal forestry in Greece outside of fertile agricultural soils.

Coppice silviculture is a special treatment used in some Greek forests. Although indigenous species grow in such forests, stands are regenerated vegetatively and all conifer and broad leaf species with poor resprouting ability are eliminated. Short rotations, followed by sheep and goat grazing, destroy site productivity. Social and economic restrictions are the main obstacles to the rehabilitation of coppice forests, which implies conversion of these low output forests into high forests. In the past, a major proportion of beech forests were converted into high forests and currently, a significant proportion of oak forests are similarly under conversion.

Table 2. Area of Industrial Forests distinguished in growing stock classes and timber dimensions.

Growing stock	Total classes		Area with measurable trees / Timber dimension classes						Area with non-measurable trees			
			Saw wood DBH>30cm		pillars DBH:10-30cm		Pools wood DBH:5-10cm		Regeneration and sprouts DBH<5cm		Area without regeneration	
m^3/ha	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
0	563347	16.8	11690	2.1	35033	6.2	10636	1.9	138141	24.5	367847	65.3
1-100	2305610	68.6	484831	21.0	436528	18.9	100893	4.4	449822	19.5	833536	36.2
>100	490229	14.6	240457	49.1	145224	29.6	19195	3.9	30472	6.2	54881	11.2
Total	3359186	100	736978	21.9	616785	18.4	130724	3.9	618435	18.4	1256264	37.4

Finally, it should be stressed that Greece is of considerable interest to the whole of Europe where forest vegetation is concerned. Tree species encountered in Northern Europe have their southern limits in Greece (*Picea abies, Betula verrucosa, Pinus silvestris, Abies alba, Fagus silvatica*). In an area of only 131,957 km^2, there is a dramatic variation in climatic conditions and geomorphological characteristics. These combined with the geographical position of Greece, between the three continents of Europe, Asia and Africa, creates an impressive variety of vegetation types and interesting habitats. Greece probably possesses the most diverse flora in Europe and a floristic abundance that is unrivalled, when compared with all other Mediterranean countries of similar size. With more than 6,000 species, about 800 of which are endemic, Greece represents an immense range of genetic resources, ecosystems and natural beauty.

The systematic classification of vegetation in Greece is shown in Figure 1. Except for the *Astragalo-Acantholimonetalia* vegetation association, which consists of grasses and dwarf shrubs and is encountered beyond forest limits, all other vegetation types belong to tree and shrub communities.

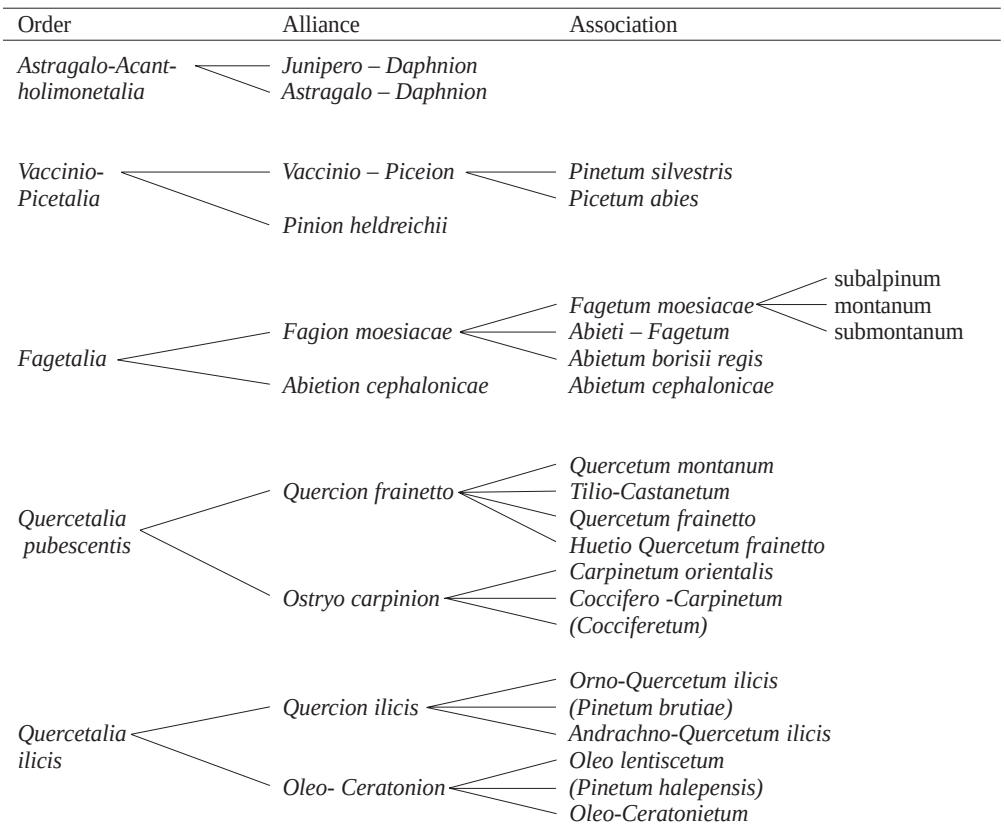

Figure 1. Systematic classification of Greek vegetation (Dafis 1976).

2. HISTORY OF FOREST RESEARCH

A prerequisite to the protection and appropriate management and utilisation of forest resources, is the acquisition of fundamental knowledge and information concerning the forest environment and its relation to natural vegetation. Its use as part of other forms of natural resources, i.e. scenic beauty/tourism, and its exploitation by any other means must also be accounted for.

Appreciation of all the above occurred only recently in Greece, as was also the State's expression of intent to organise the protection and rational management of forests and mountainous natural resources.

To deal with the country's silvicultural problems, which were growing continuously, the University School of Forestry in Athens was established in 1917, which subsequently became a department of the National Technical University. This school was transferred to the newly established Aristotelian University of Thessaloniki in 1926 and became a separate department of the School of Physics and Mathematics. The University School of Forestry, which is the only School in this field in Greece, has recently been renamed the 'University School of Forestry and Natural Environment', and functions today as part of the School of Geotechnical Sciences.

The first attempts at forest research were made in 1929 by the Forest Service, leading subsequently to the foundation of the Office for Forest Scientific Research at the Central Administration's General Directorate of Forests, which in Greece, is part of the Ministry of Agriculture. However, until 1946, only one or two foresters worked in this office.

In 1946, the Institute of Forest Research was established as part of the Forest Service, with its base in Athens and its staff consisted of a forest inspector, three foresters and a chemist. This institution started to employ its own specialised personnel soon after 1953. But as a research unit, it was not fully recognised until 1961, when relevant legislation provided for the establishment of five laboratories:

- Forest Soil Science and Forest Hydrology
- Forest Phytopathology and Entomology
- Forest Ecology, Silviculture and Genetics
- Forest Management
- Wood Technology

The foundation of four forest research stations, in Tripolis, Messologgi, Larissa and Thessaloniki was also provided for in the above legislation. Of these four stations, only the latter in Thessaloniki began operating in 1962, later forming the Forest Research Institute of Thessaloniki, which is still functioning today.

A decree in 1977, on the re-organisation of the Greek Ministry of Agriculture, led to the two above-mentioned forest research institutes having primary responsibility for carrying out forest research in Greece – these institutes are part of the Ministry's General Directorate of Forests and the Natural Environment. The same legislation also provided for the establishment of the Centre of Technology of Forest Products, which was planned to be located in Larissa, in addition to eight other forest research stations. These research units had not been established until very recently, except for a number

of forest research stations, which were periodically operational, but often without any definite work programme.

In 1989, with the establishment of the National Agricultural Research Foundation (NAGREF) under Law 1845/1989, both Institutes of Forest Research were transferred under the jurisdiction of NAGREF, which is the national body responsible for research and consultation activities in all aspects of agriculture, including forestry and rural development. NAGREF functions as a legal entity in the wider public sector, supervised by the Greek Ministry of Agriculture.

Under this new status, the forest institutes still remain the main national bodies of forest research, and are closely related to the respective policies of the General Directorate of Forests and the Natural Environment. Moreover, a great deal of research is also undertaken – occasionally in co-operation with the two forest research institutes – at the University School of Forestry and Natural Environment.

In recent years, especially since 1980, considerable efforts to initiate forest research have been made by the Departments of Forestry at the Technological and Educational Foundations in Drama, Karditsa and Karpenisi, established between 1975 and 1985.

3. STRUCTURE OF FOREST RESEARCH ORGANISATIONS

Today, forest research in Greece is carried out by the following organisations:

a) The two NAGREF forest research institutes in Athens and Thessaloniki:
   - Institute of Mediterranean Forest Ecosystems and Forest Products
   - Technology, based in Athens (IMFE & FPT or FRI-ATHENS)
   - Forest Research Institute based in Thessaloniki (FRI-THES)

b) The Department of Forestry and Natural Environment at the Aristotle University of Thessaloniki

c) The Departments of Forestry at the Technological and Educational Foundations of Drama, Karditsa and Karpenisi

d) The General Directorate of Forests and the Natural Environment of the Ministry of Agriculture

e) Various private organisations and other non Forestry Institutes and Faculties

The Forest Research Institutes (F.R.I.), which operate under existing regulations of the Ministry of Agriculture and with new status within NAGREF, are organised in the following eight divisions:

1. Forest Management and Economics
2. Silviculture and Forest Genetics
3. Forest Ecology
4. Landscape Architecture and Environment Development
5. Protection of Forests
6. Forest Hydrology
7. Forest Utilisation and Technology of Forest Products
8. Pasture and Wildlife Management

As a rule, the heads of all Forest Research Institutes are researchers (foresters) holding a PhD degree, and they all must speak at least one of the following languages: English, German, French or Italian.

In general, forest research carried out by the Forest Institutes, is applied research aimed at solving practical forestry problems. Research topics research projects are usually selected and designed by the researchers in compliance with general forest policy, after consultation with their colleagues at the relevant institutes.

An indication of the importance the Forest Service places on forest research is apparent by the budget allocated for forest research. This shows that real interest began to develop after 1965, and that generally funding has been limited to significant research projects.

The increase in personnel was analogous to increased funding and although their number is very limited, research personnel engaged in forest research today are considered to well-educated, with the potential to conduct a very high standard of research. Almost all researchers have received their University degrees in Greece. In addition to acquiring good academic experience (including postgraduate and post doctoral studies) in well-recognised educational institutions abroad, they all can speak at least one foreign language. National and international collaboration is being maintained by several researchers.

4. FOREST RESERVES AND PROTECTED AREAS

The idea of setting aside certain forest areas as special reserves to safeguard their natural characteristics, in addition to facilitating research was initiated in 1937 by the Greek Forest Service. At that time, a law (856/1937) that recommended the establishment of five national parks was enacted. The first of these was created in 1938 at Mount Olympus, the sacred residence of the twelve gods of Greek mythology.

In 1971, an amendment to the 1937 law (Law 996/1971) abandoned the limitation of five national parks and recognised two more categories of protected areas under forest legislation, known as “aesthetic forests” and ”protected natural monuments”. In principle, the Forest Service preserved these areas in the same way that national parks were preserved, but in practice, less effort and fewer resources were spent on their management.

Law 996/1971, which still applies today, also addresses faunal, floral and habitat protection. It regulates hunting and provides for the establishment of “game refuges“, “game breeding sites“, and “controlled hunting areas“, the first of which was established in 1939. Although these “hunting reserves” were set aside primarily to conserve birds and mammals for hunting, the Forest Service provides significant protection of flora, fauna, and the natural environment generally. Thus, these areas have also made an important contribution to nature conservation and they are also important locations for research purpose, as special types of forest reserves.

The four categories of protected areas – national parks, aesthetic forests, protected natural monuments and hunting reserves – consist mainly of natural vegetation and they are very important as strict forest reserves (Table 3).

Table 3. Protected areas.

Category of protected area	Number of areas	Aggregate area, ha
National Parks	10	95 000
Aesthetic Forests	19	33 000
Protected Natural Monuments	51	16 500
Hunting Reserves	7	10 500
Internationally Important Wetlands	10 +(1)	100 000
Other Areas	2	105 000
Total	99	360 000

*one wetland, i.e. lake Mikri Prespa, is also included as part of a national park.

The national parks, which are designated according to a presidential decree published in the official gazette, consist of a core area of at least 1,500 hectares, which is strictly protected, and a peripheral zone of a size at least equivalent to the core area. According to the relevant legislation, the core area is owned by the State, which has the power to buy all private rights, and there are strict prohibitions on any kind of development or exploitation. The activities prohibited include the excavation and exploitation of minerals, digging, erection of advertising billboards, industrial activities, housing and other constructions, as well as agricultural and forestry activities, pasturing, hunting, and fishing. In the peripheral zone all activities are controlled by the competent authority, so as not to produce any negative impacts which may effect the core area. The organisation, function, and management of each national park is governed by a regulation issued by the Minister of Agriculture.

The prohibitions appropriate to the core areas of national parks also apply to protected natural monuments. Aesthetic forests have functions and regulations similar to those in the peripheral zones of the national parks. These areas are also designated by a presidential decree or relevant decisions published in the official gazette.

Designated hunting reserves are also backed by special legislation (Law 177/1975 and P.D 453/1977) giving power to the forest service to take all appropriate measures not only to protect and multiply game for hunting purposes, but also to preserve the natural environment of these areas which function simultaneously as special reserves.

Research is an integral part of forest reserves and protected areas in Greece, although it has been, and still is, rather spontaneous. Moreover, it is unfortunate that there are no systematic data available on the type and volume of research carried out in national parks and other protected areas.

The most important locations for natural forest- and natural ecosystem- research generally, are the national parks, especially their core areas. They are the most important type of reserves in Greece where nature conservation efforts are best expressed. According to the relevant law (996/1971), national parks are defined as “mainly forested areas of special conservation interest on account of flora and fauna, geomorphology, subsoil, atmosphere, waters and generally their natural environment, the protection of which seems necessary; also on account of the need for the conservation and improvement of their constitution, form and natural beauty, to permit

aesthetic, psychological and healthy enjoyment and, moreover, they are areas for carrying on special research of any kind".

Ten national parks were designated between 1938 and 1974 containing some of the loveliest and most important landscapes in Greece and covering a wide range of ecosystems from the most northerly point south to the Libyan Sea and the Greek islands. One of the most important wetlands – Lake Mikri Prespa, with its surrounding, mainly forested land area – is also included in this category of protected areas.

In Greece, national parks occupy a total area of 95,000 hectares. Of this total, 35,000 hectares are in fully protected core zones. Of the remaining area, 34,000 hectares are in peripheral zones in five national parks, which have been especially delineated. Peripheral zones also exist in the remaining national parks, but they have not yet been formalised. An additional 26,000 hectares have been earmarked for protection in these 'yet-to-be-defined' peripheral zones.

Important protected areas have also been included among the 19 aesthetic forests designated between 1973 and 1980, occupying a total area of 33,000 hectares. This type of reserve, also established under Law 996/1971, contains "forests or natural landscapes, which have particular aesthetic, scenic and touristic significance and, which also possess such characteristics as demands the protection of their fauna, flora and natural beauty".

Areas or sites that possess important values for nature conservation, but do not have the size or diversity to be designated as national parks or aesthetic forests are classified as "protected natural monuments". These include areas that present a special paleontological, geomorphological, or historical significance; and trees, clumps of trees, or rare species of plants presenting special botanical, phytogeographical, aesthetic, or historical significance. There were 51 protected natural monuments designated between 1975 and 1985, fifteen of which comprise specific surface areas, amounting to a total of about 1,700 hectares. Some of these fifteen areas contain natural features of international importance. Included among them is the famous "Virgin Forest of Central Rodopi".

Numerous areas have also been specially designated as hunting reserves under hunting legislation. Very few of these areas, however, are really important for nature conservation, as the application of hunting legislation does play a fundamental role in the protection of important natural values. In addition, some of them have also been included in lists of other types of protected areas, including Ramsar sites and national parks, and receive their primary protection from those designations.

To complete the picture of reserves and protected areas in Greece, mention of some other areas, which are not forest reserves in the strictest sense, should be made; these areas are also important in the nation-wide system of protected areas. They are the Internationally Important Wetlands and other areas that have been, or are going to be, designated as marine parks. Moreover, these categories also contain land areas that, in most cases, consist of specially protected forest vegetation, which may be particularly useful for research, a principal aim of the designation of all protected areas in Greece.

The total area of parks and other reserves (land area) in Greece amounts to about 360,000 hectares. This represents 2.72% of the national land mass and an area of about 37 hectares per thousand people. The principal statistical characteristics of the system are given in the following "Synopsis of Parks and Protected Areas in Greece" and their locations are indicated in Figure 2.

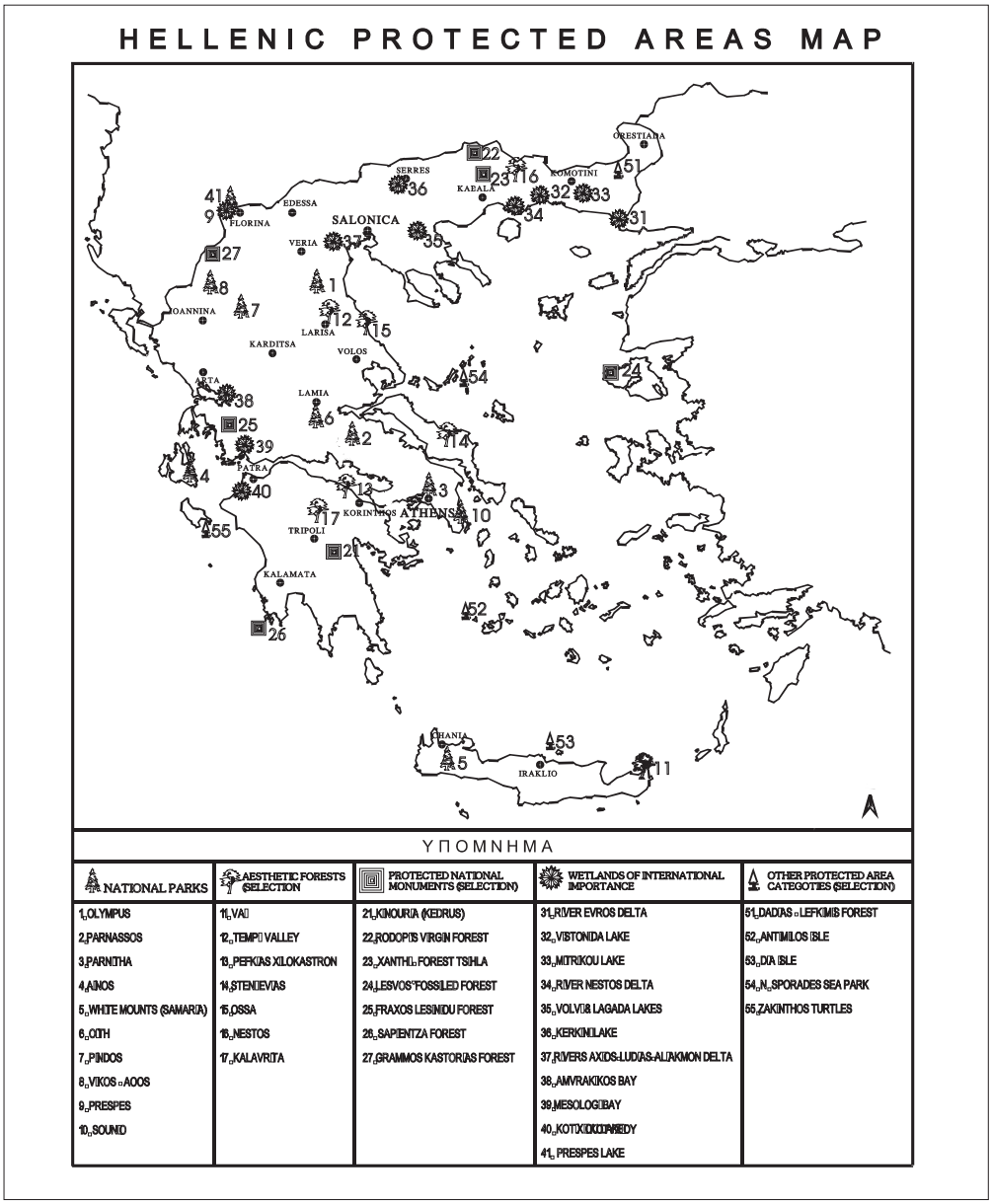

Figure 2. Hellenic protected areas map.

5. RESEARCH PROGRAMMES IN NATURAL FORESTS

Long term research in Forestry is the principal task of the two Forest Research Institutes (FRI) in Athens and Thessaloniki. Forest research is also carried out in the University of Thessaloniki as well as in the Technological and Educational Foundations.

The FRI Athens initiated an ambitious research project in the 1960s and established a considerable number of experimental plots all over the country (125 individual plots, with a mean size of about 0.5 ha each). Stand profiles were elaborated, soils and vegetation were analysed, and dendrometric characteristics are measured every five years. Silvicultural interventions, usually thinning, have been applied in order to discover their effects on stand growth and structure. The development of control plots can be studied, in addition to realising previous objectives. The majority of valuable tree species and forest types are represented in the experimental plots of the FRI-Athens.

The absence of young stands in the network of the FRI-Athens is accounted for through research activities initiated by the FRI-Thessaloniki, since the late 1980s. Using international experience on related research, the experiments of FRI-Thessaloniki are statistically designed, so as to provide better information on the effects of silvicultural treatments on the growth and structure of the stands.

The intensity of data and observations make it practically impossible to extend the networks of both Institutes to all the various age classes, sites, elevations, greater regions, ecotypes etc. Modern methods of research will fill the gaps in knowledge on the development of the forests in which human intervention is absent.

Recently, the idea of establishing a network of plots – using existing reserves and protected areas, supplemented by new areas so as to include all important vegetation types and forest ecosystems, where no intervention will take place – has been under discussion within the forest scientific community. Such a network of reserves would yield a lot of information to the natural forest research effort.

An example of the efforts made towards this end is a research project entitled: “Silvicultural research in natural forests of Greece”, which was undertaken by the Division of Silviculture of the Forest Research Institute of Thessaloniki in collaboration with the Department of Forestry at the Technological and Educational Foundation of Karditsa.

The aim of the project is to establish permanent experimental plots in as many undisturbed, naturally developing forests as possible. In future, these will be monitored as reserves. To date, the following plots have been established:

1. **Birch forest in Nevrokopi/Drama.** The southernmost limit of birch is in Northern Greece. Hence, the scientific and practical interest in this forest type is immense. A permanent experimental area, of about five hectares, has recently been installed. Within this plot various development stages (birch, birch/scotch pine, birch/scotch pine/spruce etc.) have been distinguished in the field and data have been collected in all of them. The succession pathways of the various stand types will be monitored in future, and useful results will soon be available for this species, which is still expanding southwards and to lower elevations of Northern Greece.

2. **Natural relict black pine forest in Sithonia/Chalkidiki.** This is an isolated relictic forest, where natural regeneration will be investigated. Additionally, all developmental stages will be analysed in order to establish succession models. To date, no data have been collected.

3. **Beech/fir/scots pine natural forest in Pindos.** Stand types that occur in the locality of Baitani have been distinguished. Stand characteristics, plant-sociological and soil analyses have been performed for the various mixtures that occur. Succession pathways are under study.

General research information about the specific categories of forest research and the importance given to each of them, the scientists involved, as well as important research reports, references etc., are unfortunately not readily available for Greece. It is also very difficult to fully describe all the relevant information related to methodological approach, research projects and results.

An effort to collect and analyse this information has been undertaken by the Institute of Mediterranean Forest Ecosystems and F.P.T. They have already finished the first phase of this project, which consists of an inventory of all the publications on forest research during the 70-year period, 1925 to 1995. These data, which are presented in

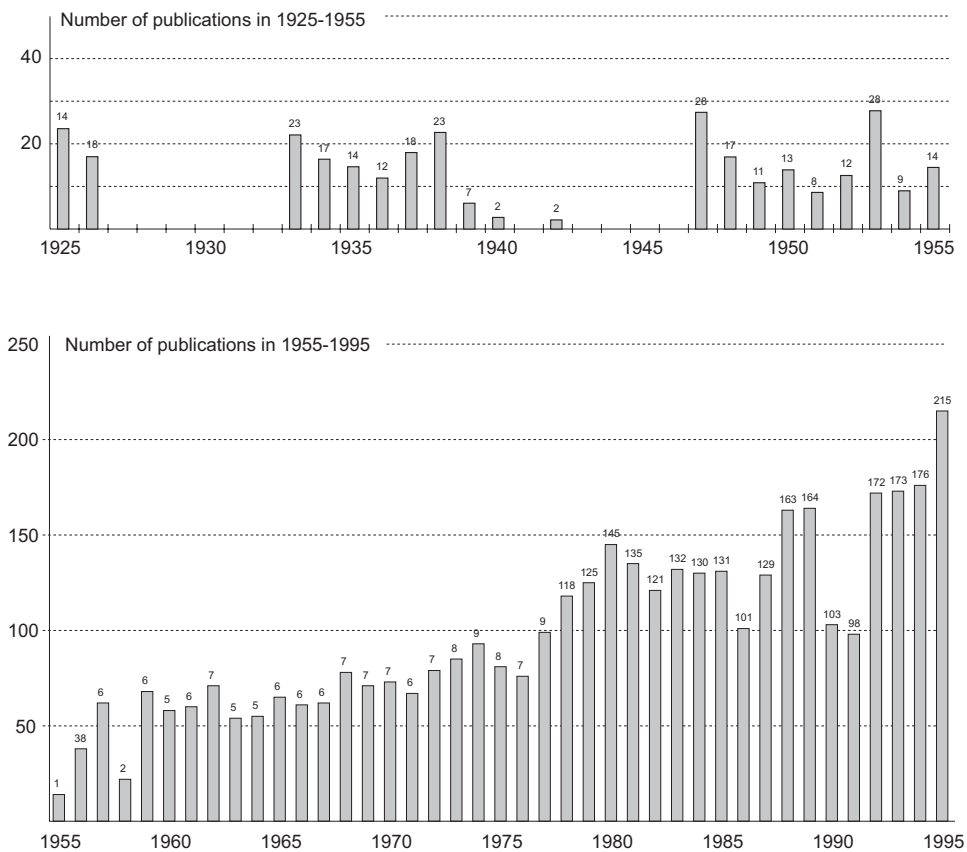

Figure 3. All Forest Research Publications in 1925-1955 and 1955-1995. Source: Institute of Mediterranean Forest Ecosystems & Forest Products Technology (Dr L. Boskos).

Fig. 3a and 3b (Total Forest Research Publications 1925-1995) and Fig. 4 (Publications in Different Forest Research Fields) of the appendix, give a reasonable indication on where the emphasis has been placed in forest research during this period, in addition to the relative importance of the various forest research fields.

Moreover, it is true that research publications are the justification of research itself, and give a good indication of the research carried out, as well as of the importance given to the various fields of forest research.

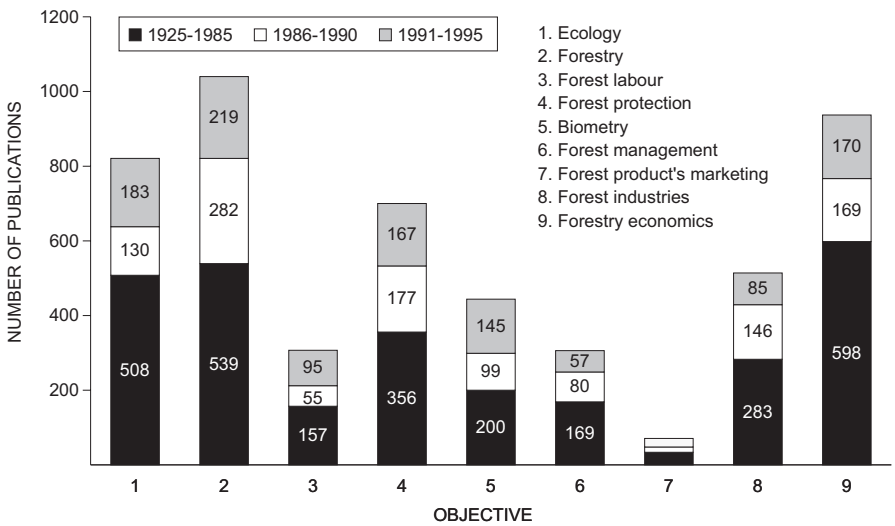

Figure 4. Publications in different Forest Research Fields Source: Institute of Mediterranean Forest Ecosystems and Forest Products Technology (Dr. L. Boskos).

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HUNGARY

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ABSTRACT

This report provides a brief overview of scientific research in semi-natural forests in Hungary. A short description of the main forest types is followed by basic information on forestry. Different types of legal protection are described. The present state of the Hungarian forest reserve network and ongoing scientific activities are discussed in detail.

1. BACKGROUND INFORMATION ON HUNGARIAN FORESTRY

1.1 Basic facts on forest vegetation

Total surface area:	9,303,000 ha	
Forested area:	1,712,000 ha;	18.4% of the country (in 1994)
Legally protected forests:	327,178 ha;	19.1% of the total forest area (in 1994)

Potentially, more than 80% of the land area of Hungary could be covered by forest vegetation. About half of the forest estate in Hungary is artificial (plantations of exotic species like black locust, black pine, poplar cultivars, and of extensive plantations of Scots pine). Potential and actual proportions of the main natural forest vegetation types are shown in Table 1.

As a result of intensive forest management in the past two centuries, there is no virgin forest remaining 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 would be extremely difficult (e.g. deep valleys, steep rocky slopes, military areas, former country border areas – “the iron curtain” – floodplain forests, etc.).

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Table 1. Potential and actual proportions (percent of the country's territory) of the principal natural forest vegetation types, based on Jakucs (1981).

Forest vegetation type	Potential share	Actual share	Natural occurrence
Open sandy pedunculate oak forest	6.5%	< 1.00%	lowland sandy duneland
Closed sandy pedunculate oak forest	8.0%	< 1.00%	lowland sandy duneland
Downy oak forest	4.0%	< 1.00%	southfacing scrub
Loess oak forest	9.0%	< 1.00%	zonal at 140-250 m
Turkey oak forest	19.5%	2.50%	zonal at 250-450 m
Sessile Oak-hornbeam forest	10.5%	2.40%	zonal at 400-600 m
Beech forest	4.0%	1.25%	zonal above 600 m
Scots pine forest	1.5%	< 1.00%	acidic nutrient poor sites
Acidophilous forest	1.0%	< 1.00%	acidic nutrient poor sites
Spruce forest	1.0% >	< 1.00%	cool and humid valleys
Swamps (alder, willow, birch)	4.0%	< 1.00%	former meanders
Gallery forest	18.5%	< 1.00%	large river floodplains

A substantial part of the forests in Hungary could be classified as semi-natural (sensu lato), given that it is not a prerequisite to exclude forests that have been clear-cut. In most parts of Hungary the standard practice has been to use clearcutting followed by either natural or artificial regeneration, so semi-natural forests – sensu Korpel – are rarely found among production forests.

1.2 Basic data on forestry and forest management

According to the most recent data (Halász and Szabó 1997) the forested area in Hungary is 1,737,800 ha, of which more than 110,000 ha represents felled areas and lots under regeneration. Total volume and annual increment growth are estimated to be 317.2 million gross m^3 and 11.5 million m^3, respectively. Annual cutting was 6,604,000 m^3 in 1996 (Dauner 1998) and during the same year 20,225 ha regenerated successfully. Due to current dynamics in relation to change of forest ownership, exact data can not be given. Approximately 60% of our forest is state owned, the rest is private.

In most Hungarian production forests clearcutting and regeneration has been the 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. Harvest, which is mainly through clearfelling, occurs subsequently. The timing and intensity of these operations are described in the authorised forest management plan (FMP), which is obligatory in Hungary. It describes the present status and the prescribed forest operations over ten-year periods for each forest management unit. FMP is derived from a special survey that is carried out by the staff of the Forest Management Planning Service of the Ministry of Agriculture and is based on site description and the actual state of individual forest stands. The tree mass, tree stand, habitat type are all recorded 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 get. 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 to the general public. Nevertheless, copies of aerial photographs depicting forest lands are available from the National Institute of Cartography.

2. CONSERVATION OF FORESTS IN HUNGARY

2.1 Protected forests in Hungary

The first legally protected areas were designated in the 1930s in Hungary. However, valuable areas (including forests) had been protected previously, especially within large holdings belonging to the nobility. Legally protected forested lands belong to one of the following categories (Act No. LIII/1996. on Nature Conservation in Hungary):

A national park (NP) is a large territory, exceptional and unique at the national and / or international scale, a considerable part of which is occupied by natural ecosystems or by areas only marginally affected by human activity. Its main purpose is to preserve flora, fauna and abiotic components, and to serve scientific and educational goals.

A Landscape Protection Area is a relatively large area, where natural values and human activities are in harmony, thereby creating a characteristic landscape. Its main purpose is to preserve landscapes and natural values.

A Nature Reserve is a small contiguous territory containing exceptional natural values and elements. Its main purpose is to preserve certain valuable natural components or the whole ecosystem.

Forest Reserve: (Article 29(3) Act No. LIII/1996): This is a new legal category in Hungary. This status can be attained by any forest area that serves the purposes of conservation of natural or near-natural forest communities, undisturbed natural forest dynamics and scientific research. Article 29(4) declares that by virtue of the Act, the core areas of forest reserves shall be declared strictly protected. In 1994, ca. 12,500 ha forest was set aside to be designated as forest reserves. These areas are for studying the natural, dynamic forest processes and to “learn” from nature for the benefit of a more nature-oriented silvicultural strategy. Forest reserves are divided into core areas (ca. 4000 ha) and buffer zones. Core areas are non-intervention areas = strict forest reserves. These zones are most important forest management has taken place even in most strictly protected areas of national parks, landscape protection areas and nature reserves. A moratorium on harvesting in strictly protected stands was declared in 1991. Legal protection of forest reserves is also safeguarded by Act No. LIV/1996 on Forests and the Protection of Forests. Paragraph 17(3) d declares that forest reserves, that serve the conservation of close-to-nature forest habitats and their research, qualify as protected

forest. Forest reserves belong to one of the above categories, i.e. national park, landscape protection area and Nature reserve.

The recent establishment of the forest reserve network does not imply that there has been no tradition of studying different aspects of forest communities. However, it provides the legal framework of studying natural processes in non-intervention stands, which is a relatively new concept in Hungary.

3. RESEARCH IN NATURAL FORESTS

3.1 A brief outline of research in natural forests

Scientific comprehension of our forests mainly originates from two sources. They are forestry science and biological sciences (botany, zoology, ecology), both with long but different traditions.

A common feature of forestry research has been the concentration on production forestry, most often on exotic species (black locust) or cultivars (poplars). The most important traditional approaches have been:

- distribution of tree and shrub species (works of Fekete, L., Blattny, T., Bartha, D. and Mátyás, Cs.)
- yield and growth studies on major tree species (works of Fekete, Z., Béky, A., Mendlik, G, Somogyi, Z. and others since the beginning of this century)
- site assessment (works of Magyar, P., Babos, I., Májer, A., Járó, Z., Szodfridt, I. and others since the 1930's)
- developing a system of forest types based on the results of phytosociology and site description (works of Májer)
- nutrient cycling research (works of Járó, Z., Führer, E., Manninger, M. and others since the 1960's)

There are two main centres of forestry research in Hungary, where detailed information can be obtained:

1. University of Sopron, Faculty of Forestry, P.O.Box 132 H-9401 Sopron, Hungary
2. Forest Research Institute, Frankel Leó u. 42-44., H-1023 Budapest, Hungary (Director Ernõ Führer, Department of Silviculture and Yield – Zoltán Somogyi, Department of Ecology – Miklós Manninger)

Research carried out by biologists in forests has traditionally followed alternative pathways. The oldest approach has been floristic (and faunistic) by definition. Floristic research has been carried out for 250 years or so. over the past eighty years, the most influential approach to forest vegetation research has been the Central European phytosociological school. It resulted in the detailed description of forest communities, with detailed vegetation maps of certain regions. The works of Soó, R., Zólyomi, B., Simon, T., Pócs, T., Jakucs, P., Fekete, G., Kovács, M., Borhidi, A. and others contain

valuable information on the composition and spatial distribution of different forest communities in Hungary.

Forest succession in managed oak woods has also been studied (e.g. by Csontos, P.). In addition, there are some projects set up in different forest communities which address other aspects of forest research. The “Síkfõkút Project”, which was initiated in 1972, is a complex ecological study of a turkey oak/sessile oak forest stand (c.f. works of Jakucs et al.). The “Rejtek Project” is a multi-disciplinary study of secondary succession after clearcutting of a beech stand. Investigations include permanent plot monitoring of vegetation change, and soil microbiological activities (works of Tóthmérész, B. Tóth, JA.). Small-scale patterns of forest vegetation and its relation to site properties and canopy characteristics have been studied in the “Völgyfõ Project”, which is taking place in a sessile oak stand (works of Standovár, T. and co-workers). A project aimed at studying canopy/understory relationships in beech woods has just been initiated by the same group. The main motive has been to search for those stand structural characteristics that are closely related to species richness of the forest floor. The institutions and contact personnel for these forest ecological projects are the following:

- Department of Plant Taxonomy and Ecology, L. Eötvös University, Ludovika tér 2., H-1083 Budapest, Hungary. Contact persons: Tibor Standovár, Péter Csontos
- Department of Ecology, Kossuth Lajos University, Egyetem tér 1., H-4010 Debrecen, Hungary. Contact persons: Pál Jakucs, Béla Tóthmérész.

3.2 State research in forest reserves

This section deals with forest reserves as described above. In 1991, the Hungarian Government decided to establish the Hungarian Forest Reserve Network. In 1992, the National Committee of the Forest Reserve Network was established to select suitable reserve areas and determine research priorities. In 1993, the National Committee of Forest Reserves presented final recommendations and the Hungarian Forest Reserve Network was established with 71 reserves during 1994. These areas have been excluded from all management activities. Initially, responsibility was shared, for a few years, by two ministries, i.e. the Ministry of Environment and Regional Policy, and the Ministry of Agriculture. The former has now full responsibility for all forest reserves since the enactment on January 1, 1997 of new acts on conservation and forests. ‘Forest Reserves’ has become a new legal category under the Act on the Protection of Nature No. LIII/1996. and under the Act on Forests and Forest Protection LIV. 1996. These Acts govern forest areas designated to the monitoring of natural dynamics of forest ecosystems, and prohibits any kind of intervention within the core area of a forest reserve.

Altogether 71 forest reserves were earmarked for the network. Table 3 and Figure 1 show those 65 reserves where agreement amongst their stakeholders was virtually copper-fastened by mid 1994. The final selection and negotiation, with legal declaration of the reserves (exact number and territory) has not been finalised. Table 2 shows brief statistics of the size of the reserves.

Table 2. Characteristics (mean, minimum, maximum) of Hungarian forest reserves (based on data of 69 possible reserves).

	Core area (ha)	Buffer zone (ha)	Total area (ha)
Mean	57.6	121.7	179.3
Minimum	3.4	0.0	9.3
Maximum	299.5	445.4	504.4
Total area at present	4100.0	9300.0	13400.0

Table 3. List of Forest Reserves in late 1994 (based on Temesi 1995)

Number	Name	Core area (ha)	Buffer zone (ha)	Total (ha)
1	Pilisoldal	44.9	114.5	159.4
2	Vadállókövek	42.7	59.8	102.5
3	Nagy Istrázsahegy	44.5	105.1	149.6
4	Pogány-Rózsás	90.3	286.4	376.7
5	Gerecse	50.8	164.7	215.5
6	Pusztavacs	28.0	146.0	174.0
7/1	Juhdöglõ-völgy	27.2	52.0	79.2
7/2	Meszes-völgy	49.0	72.3	121.3
8	Kisszénás	34.0	77.5	111.5
9	Ócsai Turján	22.6	44.7	67.3
11	Nagybugaci Õsborokás	75.8	161.1	236.9
13	Sasér	19.6	18.2	37.8
14	Maros Hullámtér	21.3	39.7	61.0
15	Kunpeszér Tiloserdõ	18.9	49.4	68.3
16	Közöserdõ	27.4	0.0	27.4
17	Guthi Erdõ	24.3	89.9	114.2
18	Farkassziget 2	7.8	33.7	41.5
19	Bockereki Erdõ	64.1	157.6	221.7
20	Dédai Erdõ	20.0	52.0	72.0
21	Fényi Erdõ	59.3	158.8	218.1
22	Tilos Erdõ	19.5	42.3	61.8
23	Rarkassziget 1	24.3	51.3	75.6
24	Baktai Erdõ	26.3	9.0	35.3
25	Nyírségi Erdõ	33.9	92.5	126.4
26	Ropolyi Erdõ	52.8	161.2	214.0
27	Dávodi Erdõ	46.9	64.3	111.2
28	Balátai-tavi Erdõ	92.1	317.7	409.8
29	Buvát Keszeges-tavi E.	75.2	178.0	253.2

It is likely that some of the planned reserves will be withdrawn from the network because of inappropriate species composition or poor condition.

Of the reserves agreed upon at this stage, there are a number of old-growth stands which have not been managed for several decades, e.g. Kékes Észak, Tátika, Vétyem, Õserdõ.

Table 3 (continued). List of Forest Reserves in late 1994 (based onTemesi 1995)

Number	Name	Core area (ha)	Buffer zone (ha)	Total (ha)
30	Dél Veránka Sasfok	54.2	127.1	181.3
31	Kádársziget	36.2	44.4	80.6
32	Vaskereszt	31.5	82.5	114.0
33	Bükkhát	36.2	154.7	190.9
34	Matty	30.2	0.0	30.2
35	Kõszegi Forrás	106.7	0.0	106.7
36	Vétyem	31.0	152.1	183.1
37	Remetekert	31.2	125.7	156.9
38	Csörnyeberek	25.1	80.3	105.4
39	Tátika	74.0	187.6	261.6
40	Tóth-árok	59.1	376.6	435.7
41	Somhegy	92.7	195.6	288.3
42	Burokvölgy	95.8	132.4	228.2
43	Virágoshegy	47.0	261.8	308.8
44	Fehér Sziklák	45.7	201.8	247.5
46	Hidegvízvölgy	20.3	37.0	57.3
47	Erebe Szigetek	11.4	46.5	57.9
48	Lóvári Erdõ	3.4	5.9	9.3
49	Dombos Ház	81.5	28.1	109.6
50	Bikafej Erdõ	56.5	207.0	263.5
51	Hosszúvölgy	38.4	107.0	145.4
52	Antal Liget	47.5	125.9	173.4
54	Pap Erdõ	20.4	19.3	39.7
55	Csörgõ völgy	51.2	77.5	128.7
56	Kékes Észak	71.5	26.8	98.3
57	Mórvölgy	75.4	314.7	390.1
58	Kecskés-Galya	86.4	49.8	136.2
59	Várhegy	93.1	83.7	176.8
60	Õserdõ	59.0	445.4	504.4
61	Leányvölgy	57.3	380.7	438.0
62	Paphárs-Kecskevár	57.8	92.2	150.0
63	Csókásvölgy	144.0	259.2	403.2
64	Nagy-Sertéshegy	65.7	361.3	427.0
65	Ördögvölgy	96.4	150.2	246.6
67	Pataj	65.0	171.0	236.0
68	Alsóhegy	100.7	0.0	100.7
69	Kelemér-Serényfalu	83.9	244.8	328.7
70	Haragistya-Lófej	299.5	0.0	299.5
71	Nagyoldal	229.8	0.0	229.8
Total		3856.2	8156.3	12012.5

Demarcation of the National Forest Reserve Network began in 1992 by the National Committee of Forest Reserve Network. Members of the committee included the University of Forestry, the Hungarian Academy of Sciences, the Ministry of Agriculture, the Ministry of Environment and Regional Policy, and specialists belonging to nature conservation groups (Czájlik 1994). Criteria for the selection of forests were:

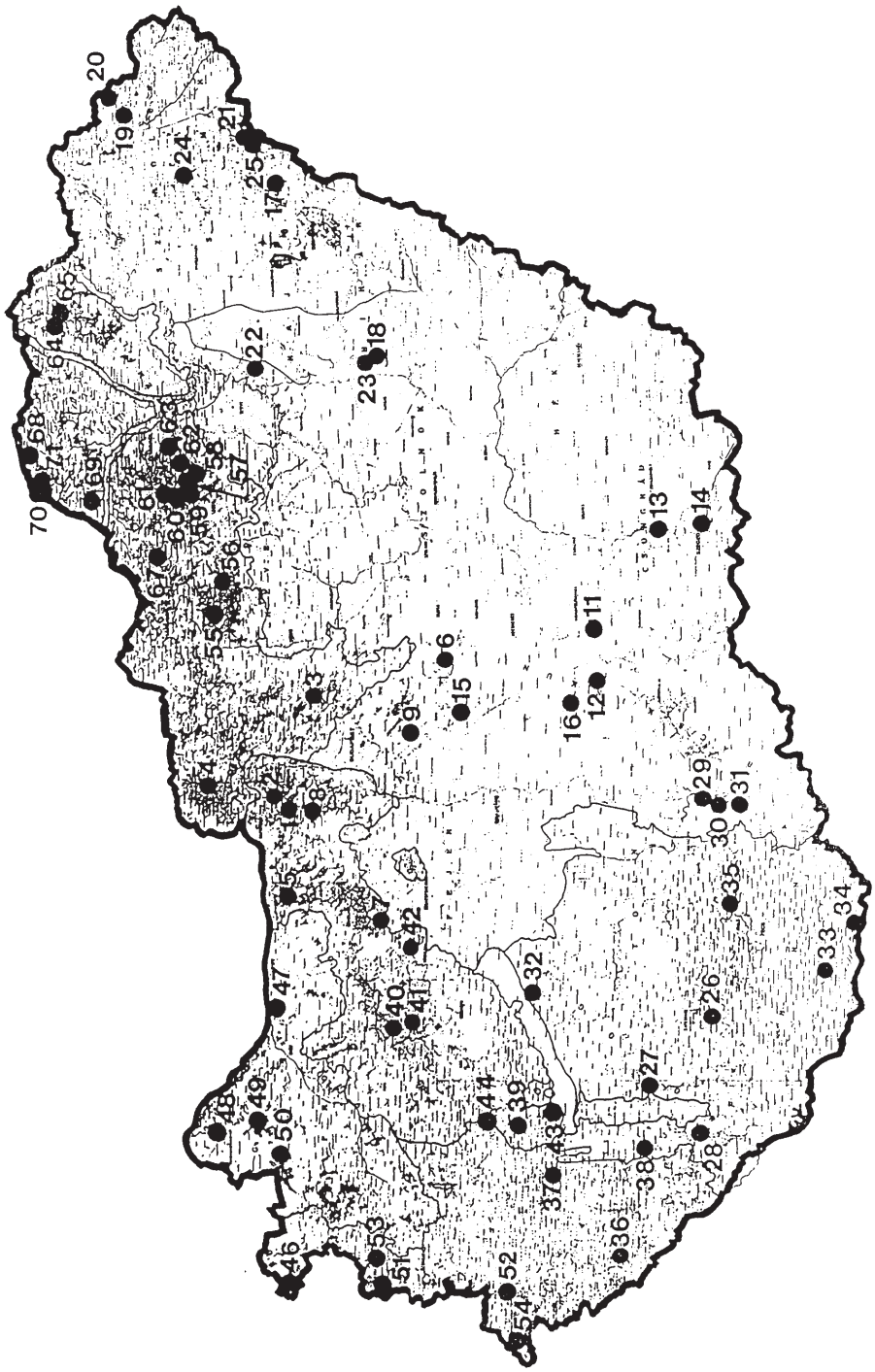

Figure 1. Fores reserves in Hungary. This map was prepared by Géza Temesi (deputy head, Department of Landscape Protection and Forestry, Ministry of Environment and Regional Policy).

- Network should include each forest type of Hungary;
- Network should cover each silvicultural landscape entity;
- On the basis of recent knowledge, it should represent all forest association types;
- Structure of the forests and species composition should be as close to the potential natural forest community as possible.

Many beech stands were well suited well to these criteria, since there was minimal silvicultural activity within selected areas. In contrast, not many sites were available in the oak zone; oak forests have been managed intensively for centuries, and natural processes will only occur after a regeneration period.

In March 1993 a scientific workshop was held to discuss potential studies and methods of forest reserve research. Some of the lectures presented were published (Czájlik 1994; Hahn and Standovár 1994; Somogyi 1994).

According to the information provided by the National Authority for Conservation in 1996-1997, the selection of approximately 10 reserves was well advanced. It is planned that these reserves will become prototype and model reserves, where a standard, fixed monitoring scheme will be applied, which will later be applied to all reserves, upon refinement. It is planned to include site description, vegetation mapping and stand structure description. Data will be stored in a central data bank under the auspices of the National Authority for Nature Conservation, who are the official governmental organisation in charge of conservation generally, and of the national forest reserve network. Their address is:

National Authority for Nature Conservation,
Ministry of Environment and Regional Policy
Költõ u. 21., H-1121 Budapest, Hungary
Phone: +36-1-1562133
Present head: János Tardy

They can answer any question regarding organisation, legal status and the forthcoming data bank on forest reserves.

In addition to the standard monitoring activities described above, the National Authority for Conservation also encourage and support detailed research on the structure and natural dynamics of selected reserves. In addition, they will publish a book on the methodical framework of the forest reserve programme. This book will be published in 1998 and about 15 experts, including the authors of this report, are involved in writing this volume.

Prior to official network activities, systematic research on forest dynamics began in 1986 in two of the reserves. These studies were initiated and conducted by the Vásárhelyi István Nature Conservation Group lead by Péter Czájlik in co-operation with the Dept. of Plant Taxonomy & Ecology, L. Eötvös University. The main study area for this group is the “Kékes North” Forest Reserve in the Mátra Hills, Northern Hungary, where research began in 1990. The same group conducted similar studies in the Csörgõ Valley Forest Reserve (Mátra Hills, Northern Hungary) between 1986 and 1989. Both areas are situated in the montaine beech zone, where due to their location, guarantees long continuity of these forests and the autochotony of genetic sources. Research includes:

- geological description
- vegetation mapping
- preliminary soil survey
- detection of relatively homogeneous patches within the reserve, according to forest associations and developmental phases,
- analyses of climatic data
- measurement of micro-climatic data
- marking and measurements of sample plots
- data collection on flora
- data collection on fauna
- mycological data collection
- inventory of natural values (protected species)
- general description of the reserve
- tree ring analysis of dead wood
- health / condition of the tree stand
- forest structure analyses of different developmental phases (optimal, ageing, collapsing and revival phase), includes: 1) Transect measurements: 20 m wide, each tree is mapped and numbered, measurements include: dbh, crown-top height, crown base height, canopy projection (in 4 directions); at present, more than 3 hectares have been covered by these transects and more than 4000 trees have been measured. 2) Systematic test circle sampling in 50X50 m network.

The Kékes North forest reserve was suitable to study the entire forest cycle, since the natural form of each developmental phase can be found here in a mosaic-like pattern (Czájlik 1991/a,b; Czájlik et al. 1993). Forest structure was analysed in each developmental phase and the results showed a strong correlation with Korpel's data from Slovakian beech forests. We concluded:

- Results help to model forest developmental processes in the beech forests in relation to habitat characteristics.
- Tree ring analysis of fallen trees is necessary to examine the naturalness of processes in beech forests.
- Transect sampling is an essential part for any complex, systematic examination (e.g. biodiversity), test circle sampling is appropriate for logging estimates only. (Czájlik 1996.)

More detailed information can be obtained from:
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Vásárhelyi István Nature Conservation Group
Kazinczy u. 18, H-1191, Budapest, HUNGARY
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E-mail: Magloczk@koki.hu

Similar, but less complex investigations have been carried out by the same group in the Aggtelek National Park, Zemplén Landscape Protection Area, and jointly with the Forestry Faculty, Sopron University, in the Tátika Forest Reserve.

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IRELAND

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ABSTRACT

Natural forest vegetation in Ireland was almost wiped out by human activity over thousands of years. The term "semi-natural" is generally used to refer to those stands which survive, and those which most resemble the potential natural vegetation, while the term "woodland" is generally preferred over "forest". Research on the semi-natural woodlands in Ireland has been sporadic, with, as yet, no national programme of research operating under any one authority. The research to date has been primarily concerned with ecological accounts and surveys; assessing the effects of herbivores and of invasive exotic species; history of vegetation development and disturbance; soils; monitoring of soil and ecological processes. (There is very little published research on stand structure and development.) Traditionally, projects of this kind have been funded by conservation bodies, but in latter years, forestry authorities have invested in research and monitoring of ecological processes.

Irish forestry is a relatively young industry, which was first developed in the early part of this century, and expanded dramatically during the 1980s and 1990s. Native stands play an insignificant role in commercial forestry. However, the planting of broadleaved species has become more commonplace in recent years. The establishment of a national programme of research on stand structure of native species would benefit the development of a national broadleaves programme, while evaluating the true potential role of native stands in the link between silviculture and conservation.

This report aims to provide an account of the current status of Ireland's natural forests and current research projects.

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1. HISTORICAL BACKGROUND

1.1 Development of the Natural Vegetation

It is known, through pollen analysis of lake sediments and peats, that Ireland was almost totally forest covered in the first half of the Post-glacial period, or Holocene, which opened around 10,000 years before present (B.P.). As temperatures increased, open grassland was quickly colonised by Juniper (*Juniperus*), Willows (*Salix*) and Birch (*Betula*). Pollen diagrams then indicate development of woodland dominated by Hazel (*Corylus*) and Scots Pine (*Pinus*). By 8,000 years B.P., mixed forests of Elm (*Ulmus*)-Oak (*Quercus*)-Ash (*Fraxinus*)-Hazel had developed on fertile soils, while Oak-Pine mixtures were more widespread on poorer soils and upland areas. The "climax phase" of Irish forests is thought to have lasted for the following 2,000 years (Mitchell & Ryan 1997), after which the influence of agricultural practices began to have a significant effect (Section 1.2).

A striking aspect of the native Irish flora is the fact that so many plant and animal species which could be expected to occur, based on their present-day natural distribution and ecology, are absent. Webb (1983), for example, estimates that there are 815 species of seed-plants (*Angiosperms* and *Gymnosperms*) native to Ireland – a figure which compares poorly with other European countries, even those which have comparable climates and are less varied topographically.

These "missing" species include some of the trees, shrubs and herbaceous plants associated with temperate forests elsewhere in Europe. For example, Beech (*Fagus sylvatica*), Lime (*Tilia* spp.) and Hornbeam (*Carpinus betulus*) are not native here, while taxa such as Goodyera, Paris, Trientalis and others, are not recorded in the ground flora of Irish woodlands. The reasons for this are not fully understood, although it is believed to be a natural phenomenon (Webb 1983; Mitchell & Ryan 1997), rather than a result of extinctions. This viewpoint is supported by the pollen evidence. In contrast, reviews of the Irish saproxylic invertebrate fauna by Speight (1988, 1989a) conclude that the limited number of species present is a result of anthropogenic forest clearance.

There has been one apparent tree species extinction from the Irish forests – Scots Pine (Pinus sylvestris) is believed to have finally disappeared some time during the past 1,000 years B.P. or so (Mitchell & Ryan 1997). The decline of Pine was probably caused by climatic change, exacerbated by the clearance of forests by humans (Bradshaw & Browne 1987). Elm was a dominant component of the early forests, but experienced a dramatic decline around 5,100 years B.P., probably due to an outbreak of disease (O'Connell et al. 1988). It is still present in the native flora, but remains a minor component of the native woodland vegetation and is still prone to periodic outbreaks of disease (i.e. Dutch Elm Disease, which is caused by the fungus *Ophiostoma ulmi*).

An account of the present-day native forest vegetation is given in Section 2.

1.2 The Influence of Humans

In Ireland, the practice of clearing land for agriculture developed after 6,000 years B.P. This, together with a shift to wetter climatic conditions, led to the onset of the depletion

of Irish forests, and to the spread of blanket bog over large areas, particularly in the western part of the country. Bronze Age prosperity in Ireland led to major, and largely permanent, woodland removal, due primarily to the increased sophistication of agricultural practices (Mitchell & Ryan 1997).

By the 18th century A.D., exploitation by humans had resulted in the reduction of forest cover to such low levels that concern arose among the private landowners and the Government of the time, who introduced measures to curb the decline (McCracken 1971). On many of the large estates, landowners initiated large-scale private tree-planting, but this did little to reverse the overall trend of reduction of native woodland cover. By the early part of this century, further exploitation of private woodlands led to a reduction in woodland cover to 0.5% (Kelly & Fuller 1988), which amounts to around 35,000 ha.

The 20th Century has seen a steady increase in the total forest cover in Ireland. By the end of 1995, the total forest cover was 8%, or 570,000 ha (DAFF, Department of Agriculture, Food and Forestry 1996). This is due to the successful development of the Irish forestry sector.

1.3 Commercial Forestry in the 20th Century

State Forestry began in 1903, with the acquisition of Avondale House, Co. Wicklow, as a forestry training centre. Purchase and planting of lands by the State continued over subsequent decades, and the strong involvement of the State in forestry is reflected in the fact that 70% of all forests today are State-owned. Since the 1940's, a major programme of afforestation has been undertaken by the State. Since the 1980's, this programme has been a national priority, and private planting has been actively encouraged (COFORD, The National Council for Forest Research and Development 1994). In the last few years, the area planted by private owners has exceeded that planted by the State. The forestry sector has expanded considerably – Ireland's annual timber production is currently 2.7 million m^3 (D. McAree, pers. comm.) – and Ireland currently has a very high rate of afforestation. In 1995, for example, the total area planted by public and private owners amounted to approx. 28,000 ha (DAFF 1996).

Commercial Irish forestry is based primarily on planting exotic conifers, in stands composed of one or two species. The dominant species in modern Irish forestry is Sitka Spruce (Picea sitchensis), which covers 58.8% of the total forest area, and accounts for 65% of current annual afforestation. The reason for this is that Irish conditions have been found to be extremely suited to the cultivation of this species – the average yield class for Sitka Spruce in this country is 16 (COFORD 1994). Other important coniferous species here include Lodgepole Pine (*Pinus contorta*), Norway Spruce (*Picea abies*), Larches (*Larix decidua, L. kaempferi, L. x marschlinsii*), Douglas Fir (*Pseudotsuga menziesii*) and Scots Pine. More recently, however, there has been an increased emphasis on planting broadleaved species, with the result that they currently account for 20% of annual afforestation (DAFF 1996). The broadleaved species and provenances used are predominantly non-native, but the use of native stock is encouraged where possible. The area of "Productive or Planted Forest" in Ireland is 464,000 ha (DAFF 1996) and just over half of these productive forests are less than 25 years of age (Fig. 1).

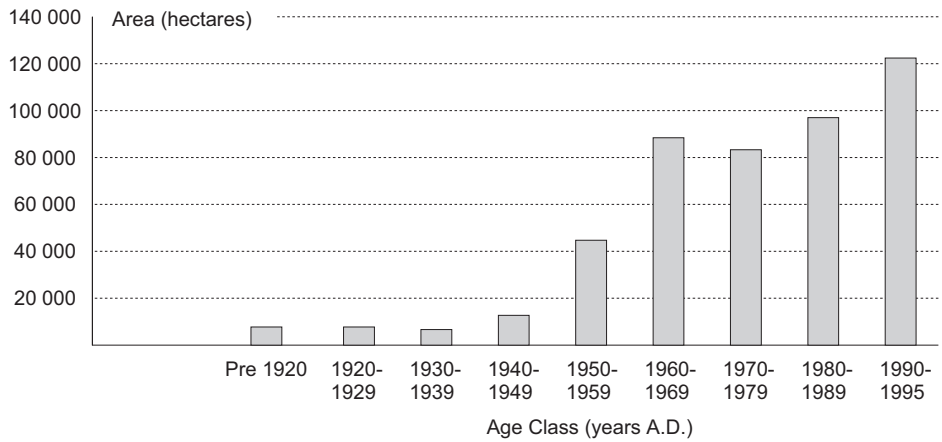

Figure 1. Age class distribution of "Productive or Planted" forests in Ireland (adapted from DAFF, 1996). Most of these forests are in public ownership and most are coniferous plantations.

2. IRISH NATIVE WOODLAND VEGETATION

Estimates of the area of semi-natural woodland present in this country vary (Neff 1974; Cross 1987a; RSPB 1994; DAFF 1996), but the area of broadleaved stands is unlikely to exceed 100,000 ha, or approx. 1.5% of land area. Most of these are in private ownership. Irish broadleaved woodlands can be broadly categorised as follows (slightly modified from Cross (1987a)):

1. Remnants of the wildwood (sensu Peterken 1981), largely confined to the poorest sites, greatly modified and abandoned silviculturally 100-180 years ago.
2. Plantations, most of which are 150-200 years old (but with some younger stands) on better sites, with some good quality timber. Exotic species, such as beech, are common and the native species may be of foreign provenance.
3. Secondary woodland on abandoned farmland, usually scrub-like with the better quality timber often selectively removed.

There has been some debate on the existence of "ancient" woodland in Ireland. The descriptions above reflect the fact that all of our woodlands have been greatly modified by human influence. Nonetheless, the current view is that some small pockets of woodland are "ancient" (Kelly & Fuller 1988; O'Sullivan 1991; Rackham 1995), sensu Peterken (1981), who defines such sites as having been continuously wooded since 1600 A.D. While candidates for "ancient" woodland are doubtless of major significance, national conservation efforts are aimed also at the "secondary" stands. The scarcity of semi-natural woodlands renders the entire resource of potential conservation

value. The use of the term “semi-natural“ defines stands which are considered to most resemble the potential natural vegetation.

A national inventory of forests (O’Flanagan 1973) differentiated between “high forest“ (probably 1 & 2, above) and “scrub“ (probably 3, above). Over half of the stands which constitute “high forest“ originate from before 1900 A.D. (Fig. 2). They tend to be rather small in size – few exceed 100 ha (Cross 1987a) – and most are not intensively managed. Yield classes have been calculated for four of the major species: for Oak and Beech, the yield class varies from 4 to 8, while for Ash and Sycamore, yield classes are in the range 8 to 12 (Fitzsimons 1987). From a conventional forestry point of view, these stands are of poor quality.

Table 1 shows the native woodland vegetation types which have been described in this country.

Table 1. Native woodland vegetation types which have been described in Ireland, with the corresponding nomenclature assigned under the Braun-Blanquet system (White & Doyle, 1982). Authors of the descriptions are cited in the text (Section 4.5). Summaries of Oak forests and Mixed Oak forests are from Cross (in press).

Vegetation Type	Phytosociology
Acidophilous Oak forests	*Blechno-Quercetum*
• Sessile Oak forests	Subassociation *typicum*
• Sessile Oak forests rich in bryophytes and lichens	Subassociation *scapanietosum*
• Mixed Oak woodlands with *Hyacinthoides non-scripta*	Subassociation *coryletosum*
Mixed Pedunculate Oak-Ash forests on base- and calcium-rich brown earths and rendzinas	*Corylo-Fraxinetum*
• Pedunculate Oak-Ash forests with *Corylus avellana*, *Circaea lutetiana*, *Brachypodium sylvaticum* and *Veronica montana*	Subassociations *veronicetosum* and *typicum*
• Hazel-Ash forests on shallow calcareous soils with *Sesleria caerulea* and *Asplenium trichomanes*, rich in bryophytes	Subassociation *neckeretosum*
• Ash-Pedunculate Oak-Hazel woodlands with *Filipendula ulmaria*	Subassociation *deschampsietosum caespitosae*
Wetland Woods	
• Riparian Woodland with *Salix* spp. and *Alnus glutinosa*	*Salicetum albo-fragilis*
• *Salix* Woodland of lakeshores and stagnant carr	*Osmundo-Salicetum atrocinereae*
• Alder-Ash woodland with *Carex remota*	*Carici-remotae-Fraxinetum*
• Birch woodland with Holly and Rowan, on deep peat well drained in upper layers.	*Betuletum pubescentis*
• Birch-Willow woodland with *Sphagnum* on waterlogged peats	*Sphagnum palustre-Betula pubescens* community

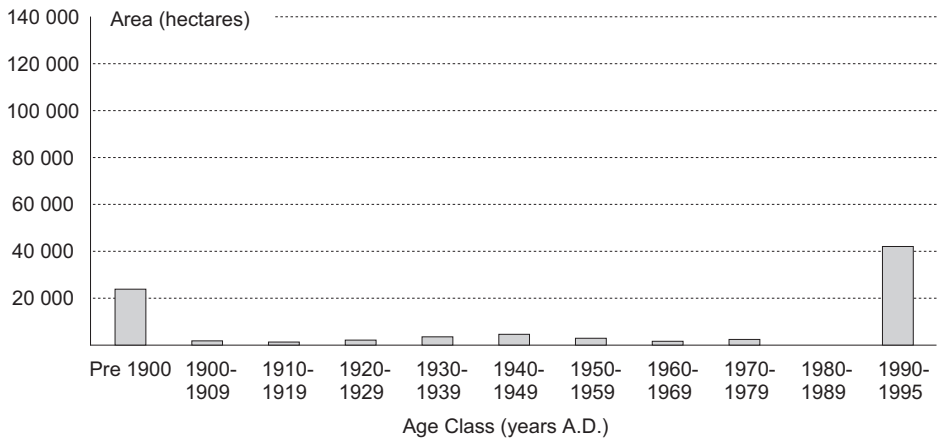

Figure 2. Age class distribution of broadleaved "high forest" in Ireland (adapted from Fitzsimons, 1987). Many stands of native species (e.g. "scrub", cf. Section 2) would have a higher representation of younger trees, but these are not included. Data for the 1980's and 1990's have been included to reflect the recent increase in planting of broadleaved species - the larger part of this area was planted after 1990 (Source: The Forest Service).

3. PROTECTION OF IRISH WOODLANDS

3.1 Legislation and Government Agencies

All forests in the State are also afforded some protection through a series of Forestry Acts (1946, 1956, 1988), which primarily regulate commercial forestry activity. Also of relevance to forestry are the Local Government (Planning and Development) Acts (1963-1992). Most of the controls on forestry relate to the felling of trees. The European Communities (Environmental Impact Assessment) Regulations (1989) require impact statements to be prepared for afforestation applications in certain cases.

The Wildlife Act (1976) was the first comprehensive conservation legislation introduced in this country. It paved the way for the designation of Nature Reserves, in which lands can be given protection for the preservation of ecosystems and species of flora and fauna. At that time, the provisions of the Wildlife Act were very much linked to forest management, and the Forest Service assumed many of the responsibilities for wildlife management and conservation, thereby becoming the Forest and Wildlife Service.

For the purposes of clarification, mention is made here of the administrative changes that have since occurred. In 1989, the Forest and Wildlife Service split into its constituent parts:

1. The commercial element of State forestry became a semi-state company called Coillte Teoranta ("Coillte" is the Irish word for woods or forests). Coillte Teoranta has responsibility for planting and managing the State's commercial forests.

2. The Forest Service retains overall responsibility for Ireland's forests, i.e. promotion of forestry, forestry research and forest protection; awarding and controlling grant applications and licences; administration of the Forestry legislation.
3. The Wildlife Service joined the Office of Public Works and became the National Parks and Wildlife Service. This organisation has responsibility for Nature Reserves, National Parks and conservation of the wider countryside, under the provisions of the Wildlife Act.

In 1997, the Forest Service was transferred from the Department of Agriculture & Food to the Department of Marine and Natural Resources. Meanwhile, the National Parks and Wildlife Service became part of Dúchas The Heritage Service, and within that Service is referred to as National Parks and Wildlife (NPW).

3.2 Woodlands Protected for Conservation

This report focuses mostly on National Parks and Nature Reserves, since it is in these areas that most of the State-funded monitoring and research on semi-natural woodlands has been undertaken.

Of the estimated 100,000 ha of Ireland's broadleaved woodland, not more than 6,000 ha are protected for conservation through ownership and/or legislation (Table 2) in National Parks and Nature Reserves. At present, there are 5 National Parks in Ireland (Department of Arts, Heritage, Gaeltacht and the Islands 1998). One of these, Killarney National Park, contains the largest areas of native oakwood in the country (circa 1,000 ha), as well 25 ha of woodland dominated by Yew (Taxus baccata), 155 ha of wet woodland, and considerable stands of mixed woodland, which originated as amenity plantations (Kelly 1981; OPW 1990). Of the 78 designated Nature Reserves, 32 contain woodland of conservation value (Fig. 3). There are important semi-natural woodlands which lie outside Parks and Reserves. Examples are St. John's Wood (Co. Roscommon), Abbeyleix Wood (Co. Laois), Charleville Wood (Co. Offaly) and Pontoon Woods (Co. Mayo). Some of these are partly in State ownership, while others are privately-owned. Fig. 3, therefore, shows a subset of Irish woodlands of conservation value.

Table 2. Area of woodland (hectares) protected in Irish National Parks and Nature Reserves, showing the proportions acquired/designated over decades past.

	Pre-1980	1980-89	1990-98	Total
National Parks	Majority *			2,860
Nature Reserves **	None	2,275	353	2,335 †
Other‡				541
Total				5,736

* Most of the Parks woodlands were acquired before 1980, but there have been some important additions since then, e.g. Ullauns oakwood (Killarney).
** These figures are derived from the designation dates of Reserves.
† Total excludes 2 Nature Reserves which lie within National Parks.
‡ Lands acquired for conservation, but which lie outside National Parks and Nature Reserves, i.e. not yet designated.

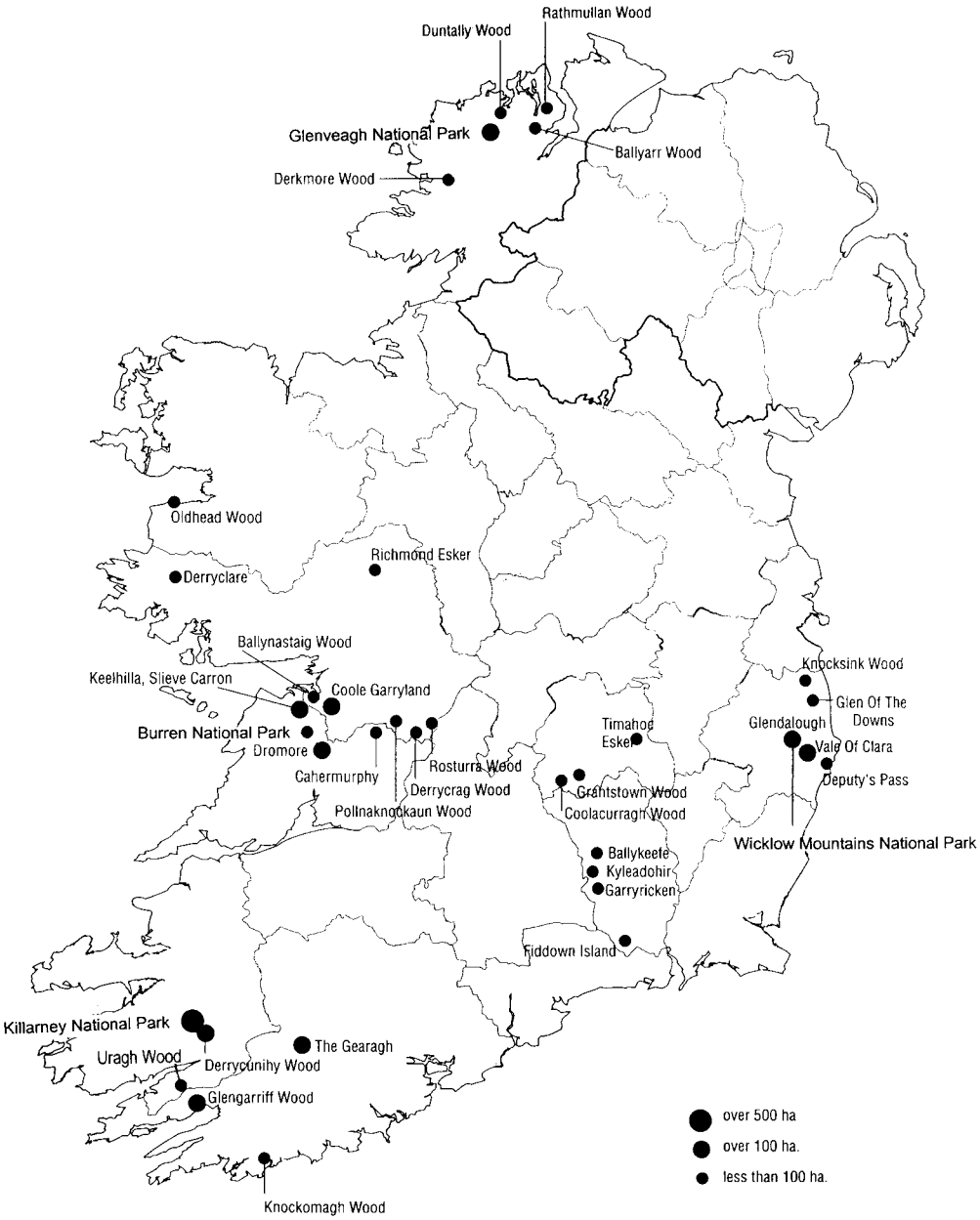

Figure 3. Location of Nature Reserves and National Parks with forests of scientific/conservation value in Ireland, with an indication of the area of woodland protected at each site. (Map adapted from Hickie, 1997; Data from NPW).

The process of designating lands for conservation is very active in Ireland at present. Since 1992, two designations are being introduced, namely Natural Heritage Areas (NHAs) and Special Areas of Conservation (SACs). These represent a major new development, in that most of the land in NHAs and SACs is privately-owned. NHAs will be covered by national legislation which has not yet been introduced. In the meantime, NHA lands are given special consideration by planning authorities and other public bodies. SACs are proposed under the European Habitats Directive, which was passed into Irish law in 1997. It is envisaged that about 590,000 ha will be designated as SAC (Department of Arts, Heritage, Gaeltacht and the Islands 1998), while the NHA network will comprise an even greater area, incorporating SACs and other lands.

The development of the proposed NHA/SAC network is of major significance, as it greatly expands the area of protected semi-natural woodland in this country. The area of woodland included within the network has not yet been fully quantified, but figures are being prepared by NPW.

The dominant woodland types represented in the Parks and Reserves are the oakwoods (Fig. 4). Oakwoods are listed on Annex I of the European Habitats Directive (Romao 1997), but some other woodland types which occur in this country are recognised on the Directive as being of critical conservation value, i.e. Yew Woods, certain categories of Wet Woodland ("Alluvial Forests") and Bog Woodland (Cross 1987b). [Note: minor amendments to some of the definitions were made in 1997.]

3.3 History of Establishment of Parks and Reserves

Ireland's first National Park was established in 1932, with the donation to the State of lands at Killarney. The four other Parks have been established and enlarged during the 1980's and 1990's (Hickie 1997).

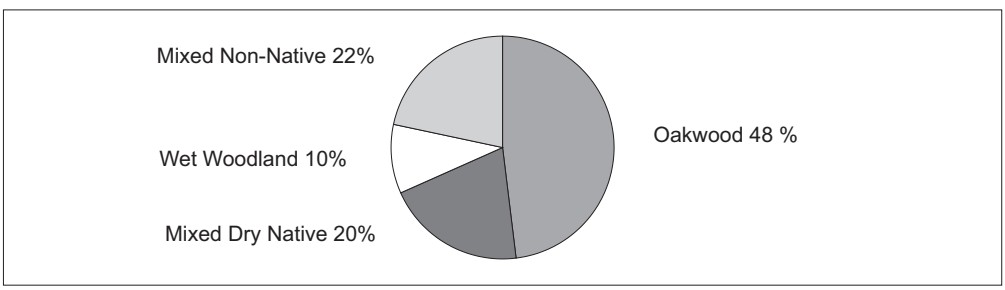

Figure 4. The proportion of woodland types represented in protected areas (National Parks and Nature Reserves) in Ireland. "Oakwood" includes a number of vegetation types, all dominated by *Quercus petraea* or *Q. robur*. "Mixed Dry Native" includes stands of ash/oak, hazel, yew, etc. "Mixed Non-Native" stands include those with beech and coniferous species. This Figure is compiled from estimated values.

The first Nature Reserves were designated in 1980 (Table 2), and all of these were semi-natural woodlands, because of the early link between the conservation authority and the Forest Service. Since that time, Nature Reserves have been established on raised bogs and coastal habitats (Hickie 1997). Acquisition of land which is conservation value is an ongoing process in NPW, although realistically, this body can only ever hope to own a small proportion of the total resource. Broadleaved woodlands are targeted as part of the process of land acquisition.

3.4 Ownership and Management

For the most part, the lands in National Parks and Nature Reserves are owned and managed by the State. There are some Nature Reserves which are owned either by private individuals, State bodies other than NPW, or NGOs, and which operate under management agreements with NPW. All but one of the woodlands in Parks and Reserves are State-owned (Hickie 1997).

In protected Irish woodlands, it is general policy to implement management practices which are directed at conservation of the native habitat. This is particularly so in cases where survival of the stand is threatened by the direct and indirect pressures resulting from human activities. For this reason, Irish Nature Reserves are assigned Category IV in the IUCN (1990) definitions of protected areas, while Irish National Parks are assigned IUCN Category II (Department of Arts, Heritage, Gaeltacht and the Islands 1998).

Management of woodland in the Parks and Reserves is primarily aimed at the following:

1. Control of grazing. Overgrazing by sheep and/or deer is a significant problem in many Irish woodlands. Japanese Sika Deer (*Cervus nippon nippon*) were introduced during the 1860s, and have naturalised in many parts of the country, as have Fallow Deer (*Dama dama*). Their numbers have since increased to a level where they are inhibiting the natural development of tree/shrub regeneration and ground flora. It is important to establish control of grazers in woodland management (Hester et al., in press), which may mean fencing the stand to exclude them. Deer culling programmes are in operation in some of the National Parks.

2. Control of exotic plant species. Another 19th century introduction, Rhododendron ponticum, is a major threat to semi-natural woodlands, particularly those on acid soils (Cross 1981). Although present since the 1800s, there is evidence (in Killarney) that the extensive dense infestations which we see today only developed in this century, from around 1940 (Kelly 1981). The current aim is to clear R. ponticum from protected woodlands, with a view to restoring conditions which allow the natural development of the vegetation. There is also a general policy of removing coniferous and other exotic tree and shrub species. Other invasive shrubs in native woodland stands include Red-osier Dogwood (*Cornus sericea*) (Kelly 1990) and Cherry Laurel (*Prunus laurocerasus*).

4. RESEARCH IN NATURAL WOODLANDS

4.1 Stand Monitoring and Research in Stand Structure and Woodland Dynamics

During the 1970s, a number of research projects were begun, which were concerned with various aspects of oakwood ecology. As part of two of these projects, exclosures were set up in oakwoods in Killarney National Park, Co. Kerry (Kelly 1975) and Glenveagh National Park, Co. Donegal (Telford 1977), with the primary objective of researching woodland dynamics in the absence of the damaging effects of grazing (Section 3.3). Both of these projects have been continued to the present day (Hayes et al. 1991; Van Doorslaer & O'Sullivan 1987; Bleasdale & Conaghan 1996). The most comprehensive programme is in Killarney and is co-ordinated by Daniel Kelly, with assistance from students of the Botany Dept. at Trinity College, Dublin, and staff of the National Park, and with financial support from NPW (Appendix 1).

In all of these projects, there has been a major emphasis on vegetation description, and the assessment of regeneration of trees, shrubs and ground flora species. The dimensions of individual trees have also been recorded. There is a general scarcity of published stand structure data for Irish woodlands, with only two examples to hand (both from Killarney): Turner & Watt (1939), on oakwoods; and Iremonger (1990), on wet woodlands. Wilmanns & Brun-Hool (1992) examined the structure and composition of woodland margins. It is hoped that the expansion of stand structure research will be encouraged through participation in this COST Action.

A comprehensive programme of monitoring and scientific research is being undertaken in a semi-natural oakwood at Brackloon, Co. Mayo. This oakwood will be the flagship site of the Irish Ecological Monitoring Network (D. Little, pers. comm.). Forest health has been monitored at Brackloon since 1991 by the Forest Ecosystem Research Group (FERG), at University College, Dublin (Appendix 1). The forest health programme monitors nutrient inputs from precipitation, soil water, foliage and forest litter (Boyle et al. 1997). Additional financial support from COFORD has allowed the scope of monitoring to be broadened to include radioisotopes, soil fauna, flora, birds, bats and other mammals. A core plot has been established in Brackloon, to begin the process of researching stand dynamics. This will be developed with reference to the recommendations of COST Action E4. Research on the elucidation of ecosystem processes and site history is ongoing at Brackloon, and should provide a basis for the effective evaluation of monitoring data. It is intended that the prototype site should provide an example of best monitoring practice, which can be used as a guide in the development of other monitoring programmes.

During the 1970s, staff of the Forest and Wildlife Service instigated monitoring experiments in oakwoods around the country. Vegetation data and stand descriptions are available from these plots (M. Neff, pers. comm.), but are unpublished.

In the late 1980s, the Forest Service initiated a national programme to monitor forest structure and forest health, in co-operation with a wider European project. As in other countries, this programme consists of a network of permanent plots which are monitored annually by staff of Coillte Teo. and the Forest Service. The main focus of this work is an assessment of the health of trees in commercial plantations. Parameters which are measured include defoliation, die-back, disease, infection and an assessment

of overall forest vitality. Since 1995, the network has been expanded to include monitoring of certain ecological parameters, e.g. ground flora assessment and soil analyses (M. Delaney, pers. comm.). Brackloon Wood (above) is part of this monitoring network.

4.2 Palynological Research and Soils Research

Palynological research was introduced to Ireland by Knud Jessen, the prominent Danish researcher, in the 1930s. Early research availed of the profusion of lakes and bogs in the Irish landscape, and contributed much to our understanding of the development and decline of the natural forests (Mitchell & Ryan 1997).

During the 1980s, a new approach was introduced to Ireland by Richard Bradshaw, which relies on the analysis of pollen and charcoal preserved in organic deposits from small hollows in the woodland floor. The high representation of pollen from "local" sources allows interpretation of woodland dynamics at the scale of the individual stand (Bradshaw 1988; Mitchell in press). The technique has proved useful, for example in Killarney, where the response of tree species to disturbance and human activity has been described in some detail (Mitchell 1988, 1990a, 1990b; O'Sullivan 1991). Active research in this field is ongoing, primarily by Fraser Mitchell, Trinity College, Dublin (Appendix 1).

Many of the western Irish oakwoods occur on acidic soils, or podzols (Little 1997). Research in University College, Dublin, has compared the processes in soils (podzols) under oakwoods with those in open areas (Little 1994), and has derived some evidence that historical removal of woodland cover resulted in acceleration of the rate of soil acidification (Little et al. 1997). Cultivation periods, which frequently followed woodland removal, led to further alteration of soil structure (Little & Collins 1995).

When used together, the techniques of soil research and palynology allow examination of soil development and the dynamics of woodland vegetation in parallel (Little et al. 1996). Joint research of this nature is ongoing also at Brackloon Wood, (Section 4.1) and at Uragh Wood, Co. Kerry (Fig. 3, F. Mitchell and D. Cunningham, pers. comm.).

4.3 Forest Inventory

A national inventory of State-owned and private forests was carried out by the State Forestry Division between 1966 and 1973 primarily with a view to assessing the status of the national forest resource and its commercial potential (O'Flanagan 1973; Purcell 1979). The information collected was used to classify stand types, to quantify their extent throughout the country and to describe the stands in relation to yield class, volume of timber, age class, size class, etc. Broadleaved stands were included in the inventory, with a lower level of recorded detail. Coillte Teo. have continued to carry out inventories of the State-owned forests since the 1970s.

A new national inventory is currently under way, under the direction of the Forest Service. This is a major national project, which aims to map all forest stands greater than 1 hectare in extent. Aerial photography is providing the basis for mapping stand locations, while satellite imagery will be used to derive a broad-scale map of a range of stand types. Stands will then be visited on the ground, and features such as species composition, age class, yield class, stocking levels and site conditions will be recorded, from sample plots located within each stand type. The inventory will include both coniferous and broadleaved stands, and will provide important, up-to-date information on the status of woodlands of all types (G. Gallagher, pers. comm.).

4.4 Silvicultural Aspects of Broadleaved Stands

Broadleaves are not a major element in Irish forestry, although this is changing, with the provision, in recent years, of increased financial incentives to encourage broadleaved species in new plantations. There has been some research on the silviculture of both native and exotic broadleaved species, which is carried out primarily by the State forestry organisations (Hendrick & Ryan 1996; COFORD in press). Much of the available evidence was brought together in a new publication providing advice on the cultivation of Ash, Sycamore, Wild Cherry, Beech and Oak in Ireland (Joyce 1998). Preliminary research on the silviculture of Birch was carried out by Coillte (Doyle 1996), and is being continued now by Teagasc, The Agriculture and Food Development Authority (N. O'Dowd, pers. comm.). The silviculture of Willow is investigated in a Northern Ireland study by Dawson (1995, and ongoing).

4.5 Research on the Flora and Fauna of Native Woodlands

The systematic classification of Irish natural woodland vegetation is not yet complete. Early descriptions were made by Tansley (1939), Turner & Watt (1939) and Braun-Blanquet & Tuxen (1952). A general overview was subsequently provided by White & Doyle (1982). More detailed descriptions and classifications have been devised for acidophilous woodland vegetation (Kelly & Moore 1975; Kelly 1981), hazel/ash and oak/hazel mixtures on calcareous soils (Ivimey-Cook & Proctor 1966; Kelly & Kirby 1982; Cross 1992) and wet woodlands (Kelly & Iremonger 1997).

The literature on ecological studies of the invertebrate fauna of Irish woodlands and forests is in need of systematic review. Research on the status and ecology of saproxylic invertebrates is of particular relevance here, and has been reviewed and discussed in a European context by Speight (1989b).

There are a number of studies on the bird communities of broadleaved woodlands (Wilson 1977; Carruthers 1993), while more recent research examines the usage by bird species of conifer plantations, and the relationship between bird communities and stand management (Hendrick & Ryan 1994; COFORD in press).

5. CONCLUSION

This is a time of rapid change and development in Irish forestry. Ireland has traditionally had an agriculturally-based rural economy. However, there is a European move towards reducing agricultural production, to bring it into line with EU requirements, and forestry has been identified as the most feasible alternative land use practice. Thus, the Irish Government intends that the total land area under forests in this country is to be increased from its current 8% to 18% by the year 2050 (DAFF, 1996). The challenge in terms of our natural forests is to achieve a balance in this new phase of afforestation, to develop forests which are not only of commercial benefit, but which will protect and expand the area of native woodland. At present, the true potential of this natural resource is little appreciated. It is hoped that the authorities involved (i.e. The Forest Service, Coillte Teoranta, National Parks and Wildlife, Department of Agriculture, Teagasc), together with private landowners and the various research institutions, can co-operate to meet this challenge. The development of a co-ordinated network of research sites, which is aimed at improving our understanding of the structure, function and dynamics of native woodlands, will have an important role in this process. This is the relevance of this COST Action to modern Irish Forestry.

6. ACKNOWLEDGEMENTS

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APPENDIX 1: RELEVANT RESEARCH AND STATUTORY ORGANISATIONS

Botany Department, Trinity College, Dublin 2.

- Dr Daniel L. Kelly: woodland ecology, Killarney exclosures, vegetation classification
- Dr Fraser J.G. Mitchell: palynology, woodland history, grazing and management

Forest Ecosystem Research Group, Department of Environmental Resource Management, University College Dublin, Belfield, Dublin 4.

- Prof. E.P. Farrell: Project leader, forest monitoring and ecosystem processes
- Dr Declan J. Little: Brackloon woodland project, Irish Ecological Monitoring Network, woodland soils

Department of Zoology and Animal Ecology, University College, Cork.

- Dr John O'Halloran, Dr Paul Giller: biodiversity studies in forests

Department of Zoology, University College Dublin, Belfield, Dublin 4.

- Dr Tom Hayden, Dr Tom Bolger: mammal and invertebrate ecology.

The National Council for Forest Research and Development (COFORD), Agriculture Building, University College Dublin, Belfield, Dublin 4.

- Mr Fergal Mulloy & Mr Eugene Hendrick: co-ordination and funding of Irish forestry research, database of forestry research projects.

Coillte Teoranta, The Irish Forestry Board, Research and Development Section, Newtownmountkennedy, Co. Wicklow.

- Mr Michael Doyle, Dr Michael Keane: silviculture of broadleaved species.

Dúchas, The Heritage Service, National Parks and Wildlife, 51 St. Stephens Green, Dublin 2.

- Mr Michael Neff, Dr John R. Cross, Dr Aileen O'Sullivan: vegetation, conservation
- J. Wilson, T. Carruthers: bird censuses

The Forest Service, Department of the Marine and Natural Resources, Leeson Lane, Dublin 2.

- Mr Diarmuid McAree: forestry policy, forest protection
- Mr Enda Cullinan, Dr Gerhardt Gallagher: national forest inventory

ITALY

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1. FORESTRY-RELATED RESEARCH IN THE ITALIAN FOREST RESERVES

1.1 Introduction

Since the early 1900s, the importance of preserving natural forest resources, especially because of their 'natural' evolvement, has been recognised. Botanists, biologists and foresters use information from the research carried out within protected areas to improve management in natural forest ecosystems and to direct forest dynamics by means of silvicultural treatments. This information may be even more useful when applied to ecosystems which are artificial in origin, to improve sustainability over time.

Very large reafforestation programmes were carried out by the Italian Forest Service between the early 1920s and the late 1970s. The areas most affected by reafforestation were located along coasts, especially Mediterranean areas, and in the Apennines, where environmental restoration as well as soil protection were the primary goals.

At present new, extensive programmes for the establishment of fast growing hardwood and conifer plantations financed by the EU require a sound scientific basis supported by improved and reliable data from natural ecosystems. Even if the recently established artificial ecosystems, which were created for wood production, are only temporary, the need for them to be self-sustainable is critical. Information concerning hardwood populations, in terms of ecology, genetic structure and dynamics must be developed and improved. The Mediterranean regions, in particular, can benefit greatly from the implementation of results obtained from this increased knowledge. Here, local environmental variation is generally relatively high and ecological limiting factors, which play a fundamental role in forest dynamics, are numerous and create very complex interactions and influences.

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1.2 General information

The total area of Italy is 30,127,761 ha. The number of inhabitants was 57,746,000 (190/km^2) in 1991. The population density within forested lands was estimated to be about 6.7 people/ha.

The extent of the forest area is about 8,7 million ha (28.8%). This area is mainly located in hill and mountain ranges – the bulk of the human population is concentrated on the plains (15 % of the total area).

Because forests occur over a large geographic area, wide variation exists from both the microclimatical and environmental perspectives and several systems of ecological classification of forest areas have been suggested by botanists and foresters. Phytoecological classifications seem to be most efficient for description at local level, while on a regional basis, a general system of classification is required.

Different forest associations can be found overlapping one another on a small or large scale. In the Alps, pure or mixed conifer stands are predominate forests, while in the peninsular region of Italy, *Quercion ilicis* associations generally dominate, especially the Mediterranean range in western and southern Italy. *Quercion pubescentis – petraeae* is often dominant in central northern Italy. In southern latitudes these dominant oak species are progressively substituted by Mediterranean deciduous oaks.

At higher elevation *Fagion* or *Abietis – Fagion* are present with numerous variants according to the associated species present e.g. *Ilex aquifolium*, *Taxus baccata*, *Luzula* sp., *Asperula* sp., etc.

From the practical point of view, the phyto-climatic system proposed by Pavari in 1916, is still used in Italy because of its simplicity and ease of application generally. The following ranges were described:

- *Alpinetum* (high mountain forest vegetation),
- *Picetum* (corresponding to the Picea abies or mixed alpine conifer forest range),
- *Fagetum* (beech - silver fir forests or mixed hardwoods range),
- *Castanetum* (deciduous oak range),
- *Lauretum* (Mediterranean forests).

Within each division sub-divisions characterised by particular climatic parameters are included. In general, the wide bio-geographical divisions proposed in the framework of Natura 2000 Project are also acceptable. This system describes three primary regions:

1. Alpine region (almost the Alps),
2. Continental region (the Po Valley sensu lato, including the Adriatic slopes of the Appenines up to where they meet the Marche region).
3. Mediterranean region (the remaining part of Italy, including the Tyrrenian slopes, the southern Appenines and marine islands) including the following sub-divisions:
   3.1 thermo-mediterranean (Olea, Ceratonia and med. Conifers),
   3.2 meso-mediterranean (evergreen oaks),
   3.3 supra-mediterranean (deciduous oaks),
   3.4 mountain-mediterraean (Conifers and hardwoods),
   3.5 oro-mediterraean.

1.3 Forest resources

Deciduous tree species account for about 80% of the forest area, conifers occupy 16 % and 4% supports mixed stands. The forest area is distributed according to the types shown in Table 1.

The average volume per hectare in high forest is 211 m^3 (stands exceeding 5 m in height) and 115 m^3 in coppice forests.

The average current increment in high forest is 7.9 m^3. 36% of the current increment is felled each year. The average area felled annually in coppice forest is about 72,000 ha, i.e. 2 % of the total coppice area.

With regard to ownership, 66% of the total forest area is private and 34 % is public (almost all in municipalities).

Because of its particular geographic and orographic situation and its glacial and post-glacial history, Italy has got greater biodiversity compared to more northern regions. The number of species in Italy was recently estimated to be 5,464, with 712 of them regarded as endemic (Falinski and Mortimer 1996).

In Alpine regions, the above-mentioned principal natural forest associations are represented by mixed or pure high forest stands of spruce (*Picea abies*, 305,948 ha), silver fir (*Abies alba*, 64,000 ha), larch (*Larix decidua*, 136,033 ha) and mountain pines (*Pinus silvestris, P. nigra, P. cembra, P. mugo*, total area 182,140 ha).

At lower elevations, in the sub-Alpine and Appeninian ranges, forests are dominated by deciduous oaks (*Quercus petraea, Q. robur* and *Q. cerris* and other hardwood species, i.e. 419,188 ha in total). Pure beech or mixed beech/silver fir and beech/mountain pines ecosystems, the latter at higher altitudes and represented by *P. laricio* and *P. heldreichii*, occupy 239,642 ha.

In the Mediterranean range pine and oak associations are dominant. Pines, i.e. *P. halepensis, P. pinea* and *P. pinaster*, occupy 66,345 ha, while ever-green oaks, mainly *Quercus ilex*, occupy ca. 121,230 including 64,800 ha of Q. suber. In addition, deciduous oak, such as *Q. cerris* and *Q. pubescens*, alone or in mixtures, occupy 76 400 ha. Until 30 to 40 years ago, chestnut (*Castanea sativa*) fruit orchards occurred widely, but nowadays are estimated to occupy only about 90 000 ha.

The total coppice area is very important in Italy and it is represented especially by beech (166,365 ha), sweet chestnut (63,505 ha), deciduous oaks (113,957),

Table 1. Data from the National Forest Inventory (1985).

Type of forest	Area (ha)	Volume (m^3)
High forest	2,178,900	405,720,472
Coppice	3,673,800	323,391,713
Plantations for wood and non-wood production (mainly poplar, eucalypts and conifers and cork oak)	288,900	11,148,402
Bushland/maquis, riparian forests and rock-wood area	2,160,900	
Other forest areas without woody – vegetation	372,600	
Total	8,675,100	740,260,587

mediterranean oaks (45,357 ha), hornbeam (*Ostrya carpinifolia*, 62,211 ha) and other hardwood mixed species (92,656 ha). Coppices conifer standards also exist (18,558 ha).

2. HISTORY OF NATURAL RESERVES AND PROTECTED AREAS IN ITALY

In Italy, the latitudinal range (from 37° N to 47°) and the presence of the Alps and the Apennines, with altitudes of up to 3000 m, there exists a wide range of ecological conditions that strongly influence forest composition and their distribution. This situation is especially relevant to foresters working on biodiversity management and conservation because Italy is a glacial refuge for many species (and ecosystems that they belong to), which have had time to develop a variety of ecotypes, sub-species or species. Therefore, the significance of protected areas for conservation and the study of biodiversity and of genetic resources is especially great in Italy (National Academy of Sciences, unpublished data).

In 1922, the first natural park – the National Park of Gran Paradiso – was created in the western Alps. It was followed by the National Parks of Abruzzo (1933, central Apennines), Stelvio (1935, central eastern Alps) and Circeo (south of Rome on the coast belt). The National Park of Calabria was created in 1968. Since the creation of these "historical" parks, many others were created in the early 1990s by the State and by several regional administrations (Touring Club… 1982).

In 1971 and 1979 the Botanical Society of Italy and the State Forest Administration published two lists of the most important "biotopes". These represent the more interesting vegetal ecosystems, the majority of them being forest areas. They need to be strictly conserved due to their biological significance and/or the presence of peculiar endemic species and /or ecotypes. The network of biotopes has been a useful basis for the subsequent establishment of an extensive network of parks, in addition to State and Regional reserves. In total biotope areas occupies 1,113,150 ha.

Until recently, each park had its own specific laws, however, since the enactment in 1991 of the Law n. 394, all legislation concerning protected areas has been brought together under one umbrella, so to speak.

In 1994, the National Committee on Protected Natural Areas published the official list of protected areas, including 508 national parks, State nature reserves, regional parks and regional reserves.

Today, protected area reaches account for 2,106,225 ha, i.e. 6.99% of the national territory (Table 2). Most of these areas include a strict reserve core zone, where access is only allowed for scientific purposes.

The basic IUCN classification of protected areas was adopted in Italy, with modifications (Lucas 1995, La Marca et. al. 1995), and the following categories, defined by law (N° 394/1991) are, at present, defined for Italy:

I National park
II State nature reserve
III Regional natural reserve
IV Regional and/or inter-regional natural park

Table 2. Primary data on protected areas in Italy (Official list of protected natural areas, updating 1.1.1997).

Type and number of protected area	Surface (ha)	% of the national territory	and of the total protected area	Mean area (ha)
National parks, (18)	1,250,954 (71,812*)	4.15	59.39	69,497
State nature reserves, (154)	55,689 (88,392*)	0.18	2.64	362
Regional parks, (75)	617,859	2.05	28.76	8,238
Regional nature reserves, (171)	71,280	0.27	3.38	417
Humid areas "Ramsar", and other nat areas (94)	28,202	0.09	1.34	300
Total protected area (508),	2,106,225	6.99	100	

*marine areas.

V Wetland of international importance (in accordance with the Ramsar agreement)
VI Other protected natural areas

Furthermore, several other terms are used locally and regionally, i.e. biotope, natural monument, etc.

Another important network in Italy is outlined in the National Book of Forest seed Stands. This network was established in 1973 (Law 269/1973; Morandini et al. 1975), and covers about 22,800 ha of forests. The book lists approximately 160 seed stands, which constitutes the basic genetic material used in Italian forestry. Hence, these stands are the main sources of biodiversity in the country. They are mostly located within protected areas and managed using specific criteria for in situ genetic conservation.

2.1 A network of permanent plots for forest research

The evolution of artificial forest ecosystems established during the reafforestation programmes over the last seventy years or so, demonstrated the need to develop additional knowledge for their long-term management. Management techniques need to change in the traditionally managed natural forests too, i.e. coppices and productive high forest, they need to be managed using low intensity, minimum intervention techniques.

In 1952, the Experimental Station of Silviculture, now the Forest Research Institute of Arezzo, established a research programme (Pavari and Morandini, unpublished data) in order to establish a network of forest areas of especial interest. Forest ecosystems with the following dominant tree species were considered: beech (*Fagus sylvatica*), oak (*Quercus cerris*, *Q. suber* and *Q. ilex*), mixed forests dominated by *Pinus cembra*, *Larix decidua*, *Picea abies* and/or *Abies alba*. *Pinus laricio*, Mediterranean mixed forests, Castanea sativa were also included. Within these areas, all human activities (harvesting, use of dead wood, grazing, etc.) were immediately ceased so that information on the

Figure 1. Map of he National and Regional Park network in Italy (Source: Ministry for the Environment, 1996-1997, modified from the map published on Linea Ecologica 1997).

evolutive trends within the main forest ecosystems could be gleaned and learned from. Today, 24 permanent plots still remain, covering an area of 84 ha (Guidi et al. 1994; Figure 1). These areas are 1 to 6 ha wide and are included in parks or State nature reserves. Six of them are located in the Alps, 2 in the central Apennines, 7 in the southern Apennines and on marine islands and 9 occur within the Mediterranean region.

This is the oldest forest research network in Italy, where studies occur within protected areas. In recent times, other research institutions have established study areas within several parks or are working in the afore-mentioned network in collaboration with the ISSA.

3. HISTORY OF RESEARCH IN NATURAL FORESTS IN ITALY

Excluding the long tradition of botanical studies, forest research focused on the dynamics of natural forest ecosystems when Pavari (1916) introduced his phytoclimatical classification. Today, phytosociological methods are being used to classify forest ecosystems in order to characterise their dynamic trends.

The Forestry Institute (established. in 1869 and later became the Forestry Faculty in 1939), under the direction of Pavari and De Philippis, studied aspects of forest management related to silviculture in the Apennine forests, especially artificial stands and genetics. Later, when Pavari joined the Forest Research Institute (Issa, established. in 1922), field studies and research programmes were initiated, which included silviculture, ecology and genetic resource conservation and improvement. Issa is today, the Institution responsible for all research covering the national territory.

In the field of autoecology, a strong research tradition has developed in the Forestry Faculty of Padova (established in 1965), primarily concerns itself with the nature-oriented silviculture in the Alpine region. This school was established by L. Susmel and such research is ongoing.

The Institute for Forest Management and Planning, based in Trento (established. in 1970), concentrates its research effort in the Dolomites region. This Institute is also responsible for the National Forest Inventory and is currently carrying out studies and research on the impact of recreational activities on protected areas. The pressure on protected areas in Italy is very significant: over 170 million tourists/year visit our national parks and reserves, equivalent to 4 times the current Italian population.

The creation of numerous Forestry Faculties has allowed basic research to be carried out within the regional areas of each Faculty.

3.1 Current projects and a provisional list of teams working on forestry-related research in protected areas

The following list reports the main researches being carried out by several forest research Institutes within protected areas. Note that bibliographic references related to the activity of each Institute can be found in the attached list.

Table 3. Main researches being carried out by several forest research Institutes within protected areas

Project / Institute and team (contact point underlined)	Aims of the research actions	Localisation / Note
Monitoring of natural evolution in forests		
Istituto Sperimentale per la Selvicoltura – Forest Research Institute, Sect. of Biology, viale S. Margherita 80, 52100 Arezzo Amorini E. Cutini A. Fabbio G. Guidi G. Manetti C. tel. 0039 575 353021 fax 0039 575 353490 issar@ats.it	Evaluation of the development and definition of evolutive patterns of undisturbed forests in order to develop sound options for the management of forest types concerned. Definition of sustainable models of silvi-cultural treatment able to preserve biodiversity and to maintain the productive function	• Forest MAB "Collemeluccio Montedimezzo" Central southern Apennines (protected since 1954). / State nature reserve *Fagus sylvatica* and *Quercus cerris* mixed forest. • Forest Umbra, Puglia (protected since 1954) / National park. *F. sylvatica* with *Ilex aquifolium* forest • Natural strict reserve Sassofratino northern Apennines (protected since 1939) / National park *F. sylvatica* and *Abies alba* mixed forest • Macchia Magona Medit. Tuscany coast (protected since 1954) / Community forest reserve. Mediterranean mixed maquis • Pineta Alberese, Tuscany coast (protected since 1975) / Regional natural park uneven-aged *Pinus pinea* forest • Forest Campigna and Mt Falterona, northern - Apennines (protected since 1980) / National park. *Abies alba* forest and Beech coppice being converted to high forest
Evaluating and monitoring the genetics of the inherent population - studies on structure of forest populations made up of several species to obtain reference models for silviculture - planting and management of genetic resources in situ		
Mercurio R. Univ. of Reggio Calabria Sect. Ecology and forest resources protection, viale S.Margherita 80 52100 Arezzo	Use of biochemical markers to evaluate the genetic structure of long-term, undisturbed populations within strict forest reserves. Floristic and structure survey to characterise	• Madonie Range, northern Sicily (protected since 1968) / Regional strict reserve of Vallone Madonna degli Angeli, Madonie Regional Park. *Abies nebrodensis* relic population (30 trees remaining) National park • Strict reserve Sassofratino, Tuscan Apennines (protected since 1959). / Mixed hardwood and *A. alba* forest *Prunus avium* populations

De Rogatis A. Ducci F. Proietti R. Tocci A. t. 0039 575 353021 f. 0039 575 353490 ducci.fulvio@krenet.it	the evolutive stage of the ecosystem.	• Several sites of the Po Valley, northern Italy / Regional and private parks, Q. robur and Q. petraea high forests
Monitoring of natural forests		
Università degli Studi di Firenze Ist. di Selvicoltura, via S. Bonaventura, 13 50145 Firenze Piussi P. tel 0039 55 30231247 fax 0039 55307263 piussi@Cesit1.unifi.it	Dendroecology and structural, evolutive dynamics (most started in 1994).	• Monti Uccellina, Tuscany coast (protected since 1975) / Regional park Mediterranean mixed maquis • Boschi di Carega, northern slope of northern Apennines / Mixed oak forest (*Q. robur* and *Q. petraea*) • Paneveggio Forest, Dolomites / Regional natural park *Picea abies* pure stands and mixed forest with *Larix decidua, P. abies, Pinus cembra*.
Study of beech and silver fir natural regeneration mechanisms, with peculiar reference to the gap dynamics		
Paci M. Salbitano F. fax 0039 55 307263 paci@Cesit1.unifi.it	Gap analysis and structure, light (IR), spatial distribution of natural regeneration.	National Park of Casentino Forests, eastern Tuscany / Strict reserve Sassofratino. Mixed stands of beech and silver fir
Monitoring of natural forest using permanent plots		
Università degli Studi di Torino Dept. Agroselviter, via L da Vinci 44,	Dendroecology and structural evolutive dynamics. Dendro-chronology and dendroclimatology	• Paneveggio forest, Dolomites / Regional natural park *Picea abies* pure stands and mixed forest with *Larix decidua, P. abies, Pinus cembra* • Valle Pesio and Tanaro, Maritime Alps / *Abies alba* natural seed stand

Table 3 (continued). Main researches being carried out by several forest research Institutes within protected areas

Project / Institute and team (contact point underlined)	Aims of the research actions	Localisation / Note
10095 Grugliasco, Torino Motta R. tel 0039 11 4115270 fax 0039 11 4113487 motta.selv@iol.it	on sub-alpine forests and on the timber line	• Alevé forest, western Alps / *Pinus cembra* forest and *P. cembra, L. decidua* mixed forest • Alpe Devero forest, western Alps / *L. decidua* forest
Monitoring of evolutive dynamics from the structural and floristic point of view within forests managed under different silvicultural treatments. Multiple use capability		
Università degli Studi di Firenze. Ist. Assestamento e Tecnologia Forestale via S. Bonaventura, 13 50145 Firenze La Marca O. Marziliano P. tel 0039 55 30231219 fax 0039 55 319179	Productivity and sustainable management	• Forest Inversa di Spigno, Gargano -Puglia / National park of Gargano *Quercus ilex* coppices • Forest Bosco Quarto, Gargano - Puglia / *Quercus cerris* high forest • Forest of Monte Barone, Gargano - Puglia / *Pinus halepensis*, evaluation of forest fire risk in unman. pine forest • Forest of Bosco Cavolecchia, Gargano / *Q. cerris* aged coppice
Monitoring of dynamic changes in forests developing under natural evolution processes (in protected areas and reserves)		
University of Camerino (Macerata) Dept. of Botany and Ecology Lab of Plant Population Ecology	Analysis of stand dynamics by repeated inventories of forest structure. Similar analysis of the herbaceous and shrubby (0 - m	• Natural Reserve Torricchio Mt. Central Appenines, Marche. (protected since 1970). / High forests undisturbed for long periods or old coppice in central Appenines. Beech and silver fir mixed stands. 1 permanent plot

via Pontoni, 5 62032 Camerino MC	height) layer. Population structure within a sub-grid.	
Canullo R. Campetella G. Nola P. Venanzoni R. tel 0039 737 632527 fax 0039 737 40528 botanica@camserv.unicam.it	Analysis of stand dynamics by repeated inventories of the forest structure Analysis of stand dynamics by repeated inventories of forest structure. Similar analysis on the herbaceous population structure within a sub-grid.	• Natural Reserve "Abbadia di Fiastra", Marche (protected since 1984) / Mixed hardwood old coppice with standards in the past (*Q.cerris* with *Carpinus orientalis, Fraxinus ornus* etc.). 3 permanent plots • Forest of Gariglione / National Park of Calabria, Sila Piccola (protected since 1982). / Beech forest with Abies alba in the dominated storey. 1 permanent plot

Research on the impact of recreational activities on the environment within protected areas

Istituto Sperimentale per l'Assestamento Forestale e l'Alpicoltura P.za Nicolini, 6 38050 Villazzano (TN) Bianchi M. Scrinzi G. Tabacchi G. Tosi Vittorio tel 0039 461 381116 fax 0039 461 381131 isafa.biofor@tqs.it Sartori G. Parco regionale della Foresta di Paneveggio (TN)	Establishing methods of evaluation Estimation of such impact on the Alpine reserves environment General inquiry on protected area agreement by tourists Use and integration of GIS with expert system for the evaluation of tourist and recreation potential of natural resources in a watershed of the Dolomites area Study using an expert system concerning the naturalistic quality of vegetation. Biodiversity and spatial diversity assessment as indicators for multifunctional management modelling	• Natural Park of Sesto Dolomites, Bolzano / High altitude ecosystems • National protected area network / Dolomites • Gardena Valley, Dolomites conifer forests and high altitude ecosystems

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THE NETHERLANDS

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SUMMARY

The Dutch Forest Reserves Programme officially started in 1983, when the first forest reserves were designated. So far, 48 forest reserves have been established. Each forest reserve represents a specific forest and site type. At the end of this millennium 60 forest reserves will be selected. Two-thirds of these will be administered by the National Forest Service, the remainder by nature conservation organisations and local authorities, mainly municipalities. The Research Programme is financed by the Ministry of Agriculture, Nature Management and Fisheries. Research is carried out by institutes of the Agricultural Research Department, belonging to the afore-mentioned Ministry. Forest reserves are strict reserves, where an integrated research programme with a ten-year monitoring cycle has been developed. The study mainly concentrates on forest dynamics and vegetation development.

1. INTRODUCTION

In the Netherlands, 9.8% of the land area is covered with forest, e.g. 334,026 ha. Forested areas containing virgin forest do not exist in The Netherlands. Exploitation and deforestation since Roman times (cattle and sheep grazing, fire-wood utilisation, timber and arable land) drastically reduced the forested area, so that only 4% of the total land area remained under forestry at the end of the 19th century (Al 1995). Large areas of heathland and drift sands developed. The last virgin forest, the “Beekber-gerwoud”, was felled in 1869, even though it had been managed to some extent. However, a few old planted woodlands have been protected and well-managed for several centuries. Approximately 10% of the total forest area consists of forests which were in existence in 1800. Afforestation of heathland and drift sands started during the 19th century. At present forest, which either established spontaneously (64,573 ha, 19% of the total

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Table 1. Forested area and ownership in The Netherlands, specifically in relation to nature preservation areas.

Forested area Ownership	Total area in ha and % of total forested area in The Netherlands		Main objective of nature preservation in ha and % of total area of the ownership	
State	104 323	31%	24 200	23%
Private	136 385	41%	31 900	23%
Municipalities	50 258	15%	10 200	20%
Nature conservation organisations	37 486	11%	30 100	80%
Others	4 826	2%	2 000	42%
Total	334 026		98 500	

forest area) or was planted, accounts for 10% of the total area. Of this total, a forest-complex of 73,000 ha is situated on the Veluwe Hills (CBS 1985; CBS 1991).

The ownership of forest in The Netherlands is almost equally divided between the State, private individuals and others (Table 1). Nature conservation is the main management goal in 30% (98,500 ha) of these forests, although in many cases other functions are also considered (e.g. recreation, landscape and low level wood production). Part of the forest area is protected as nature reserves, by national or local government or by private nature conservation organisations. Policy for these nature reserves aim to conserve the flora and fauna of the forest area: 18,500 ha are set aside for nature conservation purposes only.

2. MOTIVES

At the end of the 1970s there was much discussion about the “naturalness” of Dutch forests and especially on whether it was desirable to permit naturally-occurring processes to be studied. The general consensus was that little was known about spontaneous processes in forest-ecosystems. The main reasons were:

- most of the Dutch forests sites were reafforested during the last century so that the resultant stands were even-aged and were of either first or second generation;
- almost all forests have been managed intensively, e.g. afforested with exotic tree species; some of the soils have been tilled and fertilised; there has been intensive felling;
- the few forests that have developed spontaneously have not been monitored.

However, some of the primary goals of the Dutch National Long-term Forestry Plan (Meerjarenplan Bosbouw 1986) are:

- increased timber harvest from existing forests and from newly planted forests;

- 8% of the total forested area will be designated exclusively for nature conservation;
- virtually all forests should become more attractive for outdoor recreation;
- most forests should be multi-functional in future, which implies the development and maintenance of naturalness in forests;
- in some areas silviculture will focus on converting even-aged, monotonous stands into mixed stands with an improved vertical structure.

Because of insufficient knowledge regarding the forest ecosystem, many questions (e.g. on tree regeneration, species competition, structural development etc.) arose, as to the implementation of these plans into forest management practice. Current research on forest structure and dynamics has solved only some of these problems: most studies were concerned with only a number of the various factors that play a role in the forest ecosystem.

Furthermore, most research had been done in intensively managed forests and was short term in nature. Until then, long-term monitoring of the forest consisted only of trees and stands e.g. forest statistics and lately forest vitality, and other aspects of the ecosystem were ignored (Table 2). The main conclusion at the end of the 1970s was that there was a clear lack of knowledge about the forest ecosystem. Basic information on forest types of and on individual tree species was available, but it was not known how these forests would develop in time. It was concluded that long term monitoring of the various factors, which determine ecosystem development in undisturbed forests, would provide, at least some of the required, essential information and knowledge.

Table 2. Long term monitoring programmes in forests in The Netherlands.

Programme	Main goal	Number of plots	Frequency	Started in
Forest statistics	Inventory of a.o. · forest types · tree-species · height/diameter · types of rejuvenation · types of forest history	All forested areas > 0.5 ha	app. once per 20 years	1938
Forest vitality, phase 1	Development of vitality of the forest	3000 plots, equally divided over all forest types and sites	yearly	1984
Forest vitality, phase 2	Cause of changes in forest vitality	200 plots, only on forest sites of sandy soils	once per five years	1995
Forest reserves	Study of natural processes in undisturbed forest-ecosystems	60 plots, equally divided over all forest types and sites	once per 10-20 years	1983

3. DEFINITION AND AIMS OF FOREST RESERVES

In response to these motives, the Minister for Agriculture, Nature Management and Fisheries decided that forest reserves should be established. Their primary aim is to improve the understanding of spontaneous processes in forest ecosystems, through research and monitoring. Forest reserves are selected areas of forest where no management can take place, other than protection them against external disturbing, e.g. sensu strict reserves (Broekmeyer and Szabo 1993; Broekmeyer 1995).

If forest managers know more about natural forest dynamics, a more realistic approach towards flexible management policies can be adopted. Furthermore, if it is known how managed forests differ from natural forests, a better appreciation of the benefits and disadvantages of management will develop. Due to very low timber prices obtained on the international market, wood production is becoming a less important management objective. Nowadays, many Dutch forest owners prefer, and are encouraged by the government, to focus on other than wood production functions. Small-scale wood production, spontaneous regeneration and nature restoration management are considered to be less expensive and to have lower risks for the manager. Wood production is still important to many forest owners, but under present circumstances, they tend to favour more nature-oriented forests in order to reduce management costs. The Forest Reserves Programme has become an important knowledge source concerning the forest ecosystem, especially in separating fact from myths in relation to forest management. Hence, forest reserves are like outdoor laboratories for the study of natural processes in undisturbed ecosystems, although the research that is carried out concentrates on monitoring and describes spontaneous processes by systematic observations as opposed to experiments. Thus, their primary aim is scientific by definition. However, the definition of ‘forest reserves’ is still very confused.

Within this programme forest reserves are non-intervention forests; all sites are not managed or exploited. The nature conservation component does not play a role in this definition. The Dutch forest reserves programme includes forests, which as a result of their tree species composition and stand structure, represent the original state of the vegetation particularly well, as well as planted forests composed of exotic tree species. In addition, the aims and applications of forest reserves are manifold. Increasingly, during the last decade, new visions on (active) nature development, the importance conserving biodiversity, the relevance of strict reserves for the preservation of genetic variability, etc., have been developed. Researchers, as well as politicians and policy-makers, have stated their view that forest reserves, especially the most natural and oldest ones, could play an important role in realising these visions (Table 3; Koop and Siebel 1993; Bosbeleidsplan 1993).

4. SELECTION OF FOREST RESERVES

Because the natural processes that occur in forests differ in various forest types, forest reserves have to be selected in such a way that they will be representative of all Dutch

Table 3. Main aims and applications of the Dutch Forest Reserves Programme (between brackets: main tasks required for their proper application).

Main aims of forest reserves:	
1	area for scientific research of natural processes
2	area for nature conservation, including preservation of species, preservation of undisturbed forest soils
3	reference area for study of the effect of forest management
4	reference area for valuation of nature e.g. 'eco-certification'
5	long-term monitoring area, which is safeguarded against direct human influences
Main applications of results	
a	restoration and conservation of old-growth and semi-natural forests (1,2,4)
b	natural (integrated) forest management (1,3)
c	conversion management (1,3)
d	classification of forest soils and humus profiles (2,5)
e	management measures against acidification, pollution, 'drought-suffering' (3,5)
f	afforestation (2,3)
g	governmental forest policies e.g. state-aided measures and forests (3,4)
h	predicting forest development (modelling) (1)

forest areas and types. The main factors that determine forest type are: site type, species composition and forest history. These three factors form the primary selection criteria for reserves and have been implemented using the following classification systems (Broekmeyer and Hilgen 1991):

- Site type is reflected in a site classification system that differentiates between geological and general soil features, resulting in 13 site regions;
- Species composition is reflected in a typology based on the potential natural vegetation. The PNV describes the composition of the vegetation after 100-200 years of undisturbed development. This resulted in 33 forest vegetation types in The Netherlands;
- Forest history is reflected in a typology based on land use before afforestation and forest age. This typology contains 13 types.

A combination of these three typologies resulted in approximately 50 characteristic forest types. Within any such forest type planted, as well as spontaneous forest, could occur, as is often the case in The Netherlands. Planted forest stands often consists of monotonous even-aged mono-cultures, mostly Pinus sylvestris. The more natural forests have developed spontaneously on abandoned fields or areas unsuitable for cultivation. They are often used for predicting forest development (modelling) (1) and mostly consist of secondary or young primary forest, with a species combination corresponding to the PNV. If the species composition of the herb layer corresponds to the potential natural vegetation, it is called 'floristically characteristic', otherwise it is called 'floristically non-characteristic'. If both types are found on a site type, they are both

designated as forest reserves. Therefore, both floristically characteristic and floristically non-characteristic sites are included in the Dutch forest reserves programme. In addition, the fact that forests with exotic tree species may be selected, is unique in Europe. At the beginning of the next millennium 60 forest reserves should be established. Their area varies from 5 to 500 ha. Up to now 48 reserves have been created (Table 4; Figure 1).

Figure 1. Location of the Dutch forest reserves (for reserve names see Table 4).

5. MANAGEMENT OF FOREST RESERVES

Forest reserves have an official status since they are designated by the Minister. The Minister recommends the forest owner to designate and manage the area concerned as a forest reserve. Nevertheless, for judicial reasons, no direct, compulsory legal status can be applied to forest reserves. Once a forested area has been designated as a forest reserve, a document outlining the rules of forest management is drawn up with the forest owner and the local administrator. In general, forest reserves are strict reserves where no management operations are allowed. The ownership status should be as stable as possible to safeguard the reserve. If a forest is selected, a guarantee must be given, that in principal, it will not be disturbed for at least 50 years. However, for practical reasons, forest reserves owned by private individuals and nature conservation organisations, may become part of the programme if a guarantee of at least 10 years is provided.

The borders of the forest reserve are occasionally clearly demarcated so that visitors know they are entering a forest reserve. It is, of course, forbidden to disturb or harvest anything in the forest, but as most reserves are already designated as protected conservation areas, there is generally no need for any additional demarcation of the reserves. Recreational activities are neither prohibited nor encouraged. Facilities like picnic-tables, bridle-ways etc., are removed. Roadways and footpaths are not kept open or maintained unless required for fire-breaks or surveillance. The forest reserve is surrounded by a buffer zone, the width of which is approximately twice the height of the canopy. Management in this zone has to be adjusted to suit the maintenance of the forest reserve. For example, measures required to combat insects and seed-producing exotic trees may be carried out in this zone.

6. RESEARCH PROGRAMME

6.1 Purpose

The study of forest reserves implies and involves monitoring spontaneous processes in permanent plots. Permanent plots are most advantageous in that they enable detailed observations of succession to be directly made. On the one hand, there is the limitation that you have to wait for succession to take place, so that the most interesting results will not emerge for several decades. Therefore, conversion management will sometimes take place in a selected forest area, before it will be officially designated as a reserve. In floristically non-characteristic reserves, in particular, this could accelerate forest dynamics. On the other hand, the analysis of data from sites where the inventory has recently been repeated, indicates that, even within a decade, several trends and processes of natural can be seen and elucidated, respectively (Clerkx et al. 1995-1; Broekmeyer et al. 1995; Clerkx et al. 1995-2). The forest reserves programme has three main goals:

1. inventory of spontaneous processes (inventory);
2. analysis and interpretation of these processes and associated factors (research);
3. analysis of the importance of these processes for forest ecosystem dynamics (management);

Table 4. Review of some characteristics of the present Dutch forest reserves (September 1996; a total of 48 reserves).

	Name forest reserve	Potential Natural Vegetation Area	
1	Starnumansbos	*Betulo-Quercetum*	53 ha
2	Lheebroek	*Betulo-Quercetum*	39 ha
3	Galgenberg	*Fago-Quercetum*	48 ha
4	Tussen de Goren	*Betulo-Quercetum*	40 ha
5	Vijlnerbos	*Luzulo-Fagetum*	15 ha
6	Vechtlanden	*Carici elongatae-Alnetum*	12 ha
7	Zeesserveld	*Betulo-Quercetum*	17 ha
8	Meerdijk	*Lysimachio-Quercetum*	20 ha
9	Pijpebrandje	*Fago-Quercetum*	36 ha
10	Nieuw-Milligen	*Betulo-Quercetum*	50 ha
11	Drieduin 1	*Empetro-Pinetum*	25 ha
12	Drieduin 2	*Empetro-Betuletum*	20 ha
13	Drieduin 3	*Betulo-Quercetum*	28 ha
14	Het Leesten	*Fago-Quercetum*	42 ha
15	‘t Quin	*Betulo-Quercetum*	29 ha
16	‘t Sang	*Carici-elongatae-Alnetum*	15 ha
17	Grootvenbos	*Alno-Betuletum*	40 ha
18	Schoonloerveld	*Fago-Quercetum*	28 ha
19	Oosteresch	*Betulo-Quercetum*	35 ha
20	Roodaam	*Convallario-Quercetum*	35 ha
21	Riemstruiken	*Fago-Quercetum*	22 ha
22	Zwarte Bulten	*Fago-Quercetum*	45 ha
23	Leenderbos	*Betulo-Quercetum*	28 ha
24	De Schone Grub	*Milio-Fagetum*	15 ha
25	Dieverzand	*Empetro-Pinetum/Betulet-Quercetum*	31 ha
26	Keizersdijk	*Fraxino-Ulmetum*	32 ha
27	Kloosterkooi	*Alno-Betuletum*	28 ha
28	Wilgenreservaat	*Fraxino-Ulmetum*	50 ha
29	Molenven	*Betulo-Quercetum*	42 ha
30	Beerenplaat	*Salicetum-albae*	20 ha
31	Tongerense Hei	*Betulo-Quercetum*	40 ha
32	Houtribbos	*Fraxino-Ulmetum*	20 ha
33	Hollandse Hout	*Fraxino-Ulmetum*	40 ha
34	Kijfhoek	*Crataego-Betuletum*	30 ha
35	De Geelders	*Stellario-Carpinetum*	15 ha
36	Berkenvallei	*Empetro-Betuletum*	50 ha
37	Slikken van Flakkee	*Fraxino-Ulmetum*	700 ha
38	Pilotenbos	*Fraxino-Ulmetum*	15 ha
39	Smoddebos-Duivelshof	*Stellario-Carpinetum*	15 ha
40	Duurse Waarden	*Salicetum albae*	20 ha
41	Millingerwaard	*Salicetum albae*	80 ha
42	Bekendelle	*Pruno-Fraxinetum*	4 ha
43	Weenderbos	*Fago-Quercetum*	20 ha
44	Het Rot	*Fago-Quercetum*	20 ha
45	Kremboong	*Betulo-Quercetum*	31 ha
46	Norgerholt	*Fago-Quercetum*	25 ha

Table 4, continued. Review of some characteristics of the present Dutch forest reserves (September 1996; a total of 48 reserves).

Name forest reserve	Potential Natural Vegetation Area	
47 De Stille Eenzaamheid	*Leucobryo-Pinetum/Betulo-Quercetum*	100 ha
48 De Horsten	*Filipendulo-Alnetum*	33 ha
49 Mattemburgh	*Fago-Quercetum*	100 ha
50 Kampina	*Betulo-Quercetum*	40 ha
51 Smalbroeken	*Lysimachio-Quercetum*	80 ha
52 Herkenbosscher Heide	*Fago-Quercetum*	40 ha
53 Bunderbos	*Milio-Fagetum*	10 ha
54 Heloma- en Bleekerspolder	*Filipendulo-Alnetum*	80 ha
55		
56		
57 Grote Weiland	*Fraxino-Ulmetum*	30 ha
58 Oude Kat	*Fraxino-Ulmetum*	30 ha
59 Achter de Voort	*Stellario-Carpinetum*	9 ha
60		

6.2 Lay-out of the research programme

To assist the research effort in all forest reserves, they have been mapped according to a pre-set sampling scheme. Three different scales of study are used (Figure 2):

1. the entire forest reserve (15-500 ha.) with 50-70 sample points (Figure 3) situated on a 50 × 50 m grid (small reserves) or situated along several transects, transverse to the most important gradient (larger reserves).
2. a core area (1 hectare block, 70 × 140 m, Figure 4)
3. a herb-layer transect (in the middle of the central transect, 2 × 100 m.)

A 50 × 50 m grid or several transects are established for the entire forest reserve. Approximately, 50-70 points per reserve are selected as sample plots. Analyses of the data obtained focuses on describing changes in structure and composition of the forest stands over time, and the attendant dynamics of different tree and shrub populations. Data from the sample plots is also used to map forest structure of entire reserves in conjunction with aerial photography. Also soil- and humus samples are collected at the sample plots and vegetation relevés are made within this area.

The core area represents the most characteristic part of the forest reserve. It is situated in a homogeneous part of the reserve and is oriented north-south. It is subdivided into seven transect strips of 10 × 140 m. Part of the central strip forms a strip transect, in the middle of which, there is a transect for studying the herb layer, and consists of 50, 2 × 2 m quadrates. The analyses of the data obtained in these areas is focused mainly on forest structure and the vegetation development.

6.3 Research methods

Within the Dutch forest reserves programme an integrated, descriptive study approach is carried out (Stuurman and Clement 1993; Kemmers et al. 1993; Koop and Bijlsma 1993; Veerkamp and Kuyper 1993; see Table 5). The study is partly based on the Silvi-Star method (Koop 1989; Figure 5-7). Spontaneous processes are studied from numerous perspectives. Attention is paid to:

1. site (soil, humus profiles, hydrology)
2. forest dynamics (population development, forest regeneration, stand succession)
3. forest structure (tree position, dead wood, vitality, crown projection)
4. forest vegetation (vegetation types and maps, vegetation succession, species composition and dispersion, PNV's). In future, the following aspects will possibly be studied in some of the reserves. The mycoflora of 16 reserves has already been studied.
5. avifauna (frequency and dispersion of breeding birds)
6. mycoflora (fungal species composition)
7. biogeochemical study of the humus profile (element contents, % organic matter, C/N ratio's, etc.)

The inventory of the above-mentioned parameters is split into two programmes: the initial programme and the basic programme. The main aim of the initial programme is to record the condition of the forest reserve at the time of designation. As part of this

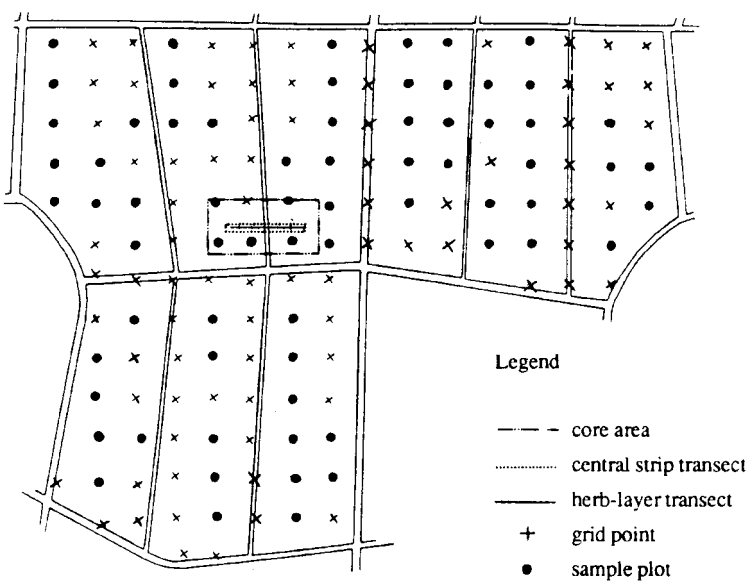

Figure 2. Lay-out of the entire forest reserve

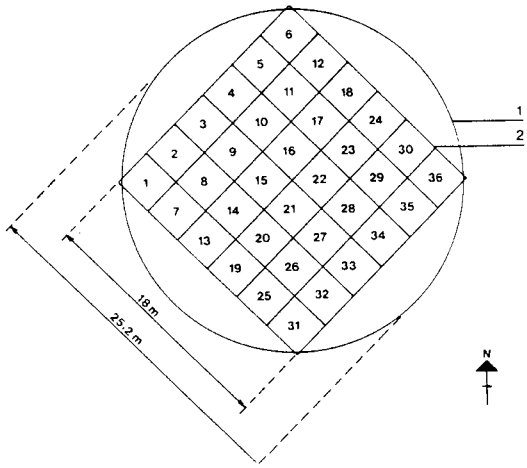

Figure 3. Lay-out of a sample plot

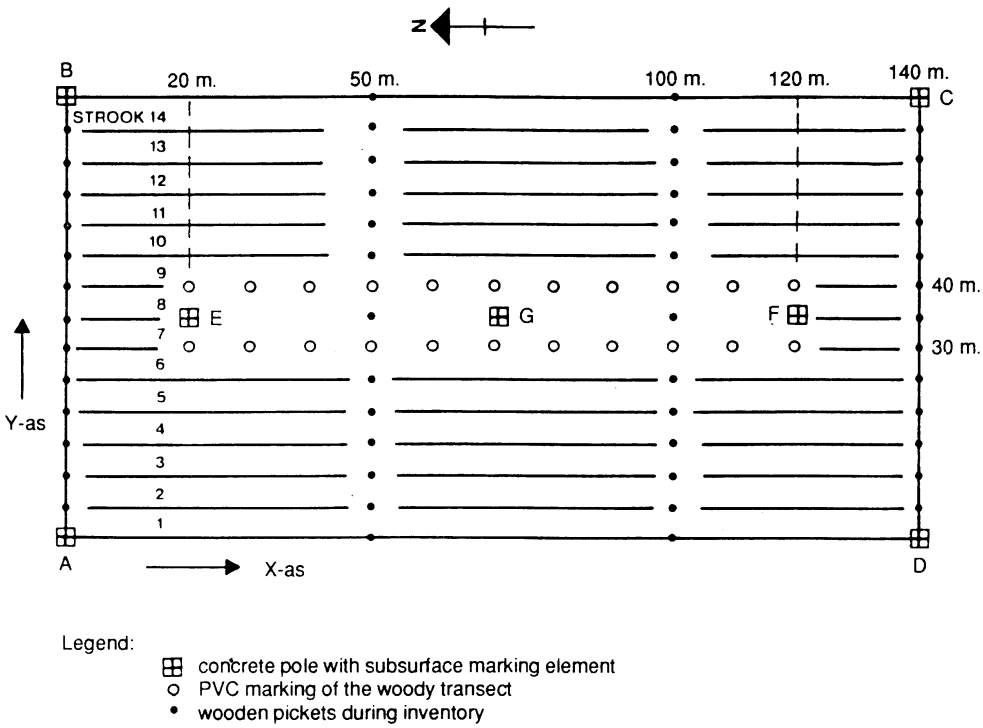

Figure 4. Lay-out of the core area

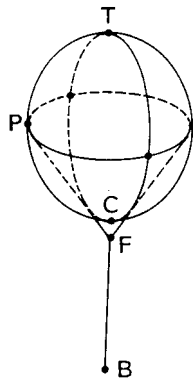

Figure 5. The three-dimensional tree model. T top of the tree; P periphery point; C crown base; F fork; B stembase

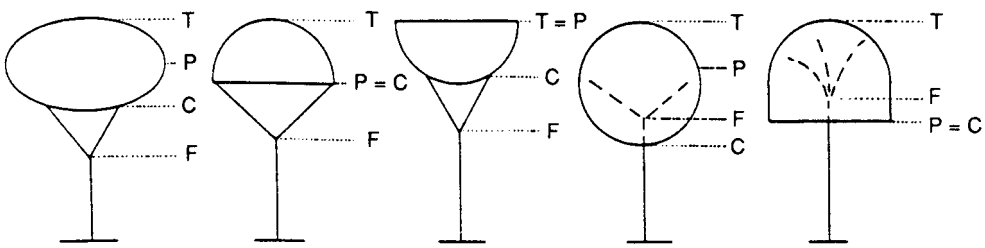

Figure 6. Different tree forms with the measured parameters.

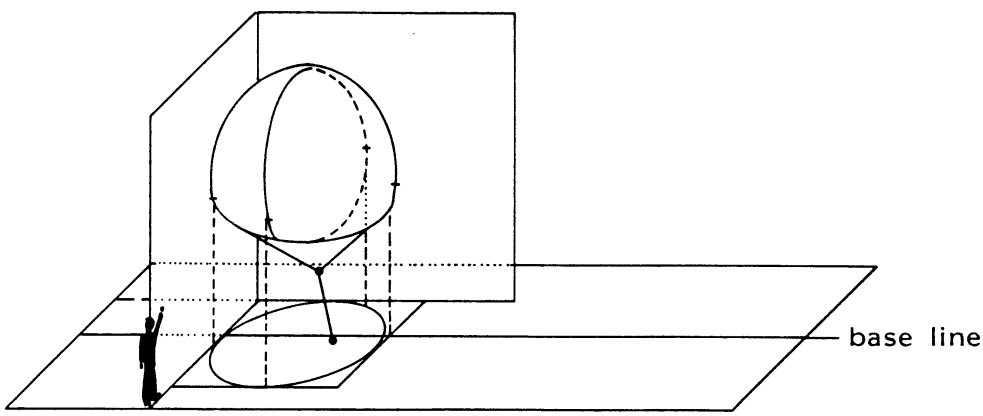

Figure 7. Measuring crown projections.

initial programme primary site factors are recorded, such as macroclimate, topography, parent material and groundwater. It is carried out once, almost immediately after designation. The basic inventory is designed to monitor secondary site factors, such as humus profiles, groundwater fluctuations, plant communities and other slow-changing variables, in addition to recording forest-dynamics and forest structure. The emphasis is on methodical observation of spontaneous developments of biotic factors in the forest ecosystem. This is done by means of repeated sampling at ten-year intervals. However, some aspects are monitored more frequently (Table 5).

6.4 Research results

Research results consist of several basic information types such as:

- data-files (vegetation relevés, soil profiles, forest structure of the core area of the sample plots)
- maps (entire reserve: geological map, soil map, vegetation map, forest structure map; core area: vegetation map, crown-area/species map, stem position and tree map, map of the light-climate, etc.)
- aerial photographs (CIR photos, scale 1:5000 and 1:10.000)
- groundphotos (about 10 photos on fixed points in the core area of the herb and tree layers).

All this basic information is published in several reports, which serve as back-ground documents for further research. There are three main reports for each forest reserve:

1. General information on the reserve;
2. Geological and soil reports;
3. Reports on forest structure and vegetation for the entire reserve and the core area. Since 1988, the basic reports for each forest reserve have been published and this is ongoing for newly established forest reserves.

A phase of scientifically analysing the data began recently. The first repeat inventories (every 10 years) have recently been made, which makes it possible to analyse forest dynamics in situ. Various computer programmes have been developed which can, for example, simulate the light climate based on the inventoried data of forest structure in the core area. These results can be combined with vegetation maps, tree-species rejuvenation maps, etc. Therefore specific procedures have been developed to link the data file with a geographical information system. Since 1995, progress has been made with the onset of a more interdisciplinary approach: results of various subjects are combined and analysed for specific site types. For example, the rejuvenation of Scots pine on sandy soils in 8 reserves has been studied in relation to abiotic conditions like soil type. In the near future, forest dynamics of the *Fago-Quercetum* will be studied in a sequence of artificial to natural forest types. These results have been published in institutional reports, but they will also be published soon in scientific magazines, as well being made accessible to forest managers.

Table 5. Overview of the research programme in Dutch forest reserves.

Level	Forest reserve	Core area	Strip transect
Surface	15-500 ha	70 × 140 m (1 ha)	2 × 100 m
Inventory	1) inventory of 50-70 soil profiles 2) geological map 3) soil map 4) aerial photography 1:10.000 and 1:5.000 5) app. 15 vegetation relevés 10x10 m 6) 50-70 sample plots of 500 m^2 inventory of all trees >5 cm dbh* and dead trees >10 cm 7) 50-70 sample plots of 324 m^2 counting of all trees < 5 cm dbh and height > 0.5 m# 7) vegetation map 8) crown projection map 9) forest structure map	1) inventory of entire forest structure 2) mapping of vegetation types including specific forest species 3) mapping of living trees > 5 cm dbh (stem base position, crown projection)% 4) mapping of dead trees > 10 cm, including uprootings 5) terrestrial photography at fixed points. appr. 10-20 up (tree layer) and down (herb layer)	1) inventory of 20 relev,s 2 × 2 m - species composition - species cover for moss-layer, herb-layer, shrub layer up till 5 cm dbh.
Scale	1:2500	1:200	
Frequency	10 years (with the exception of 1-3) and dead trees 3 years	10 years; update of broken stems	3 years
Data processing	A set of computer programmes is available for processing of data files. A selection: -ARBODIGI: digitising of maps -ARBOPLOT: plotting of ground plan from standard files -ARBSELEC: selection of records on tree variables -ARBSTRIP: selection of a strip transect from the core area in any given direction and length -ARBOSUM: computes crown area, crown volume, timber volume and basal area for a single tree -CANOSCAPE: computes view of crown-layer for species with relation to tree height -FOREYE: simulating fish-eye photographs allowing analysis of light patterns -NEWTREE: projecting stem bases of new trees over other e.g. vegetation maps		
Data analysing	With the help of the above mentioned computer programmes and statistical analysis together with a Geographical Information System, for example the following analysis could be done: - growth and decay of individual trees - study of population dynamics	- forest succession (development of forest phases and gap-dynamics) - vegetation succession	
Parameters monitored for forest structure in entire reserves and core area, divided over different subjects (resp. *, # and % signed in the table):			
	- stem base position: * % - tree species: * # % - diameter at 1.30 m breast heigt (dbh): * # % - height of the crown top: * # %	- height of the stem base: * # % - 4 perifery points of the crown: % - crown base: * % - first large living branche: %	- internal crown cover: % - social position: % - vitality: * % - damage (cause and intensity): * %

7. ORGANISATION OF THE FOREST RESERVES PROGRAMME

Several departments in the Ministry of Agriculture, Nature Management and Fisheries have been partners in this programme since its initiation. All partners are represented in a special working group, which is concerned with the co-ordination of research. At a higher level, a Steering Committee deals with financial and policy aspects. The main participants are listed below, including their tasks and contact-personnel.

1) forest reserve selection and establishment

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3) research of soil and humus profiles

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4) mycofloral research

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Working Group Co-ordination of Research in Forest Reserves
Chairman: H. Koop, Institute for Forestry and Nature Research, IBN-DLO
Secretary: M.E.A. Broekmeyer, Institute for Forestry and Nature Research, IBN-DLO

Steering Committee Forest Reserves
Chairman: J.J. Bakker, Ministry of Agriculture, Nature Management and Fisheries, Department of Nature Management
Secretary: J.L. van der Jagt, National Reference Centre for Nature Management, IKC-N

A set of computer programmes is available for processing data files. A selection:

- ARBODIGI: digitising of maps
- ARBOPLOT: plotting of ground plan from standard files
- ARBSELEC: selection of records on tree variables
- ARBSTRIP: selection of a strip transect from the core area in any given direction and length
- ARBOSUM: computes crown area, crown volume, timber volume and basal area for a single tree
- CANOSCAPE: computes crown-layer views of species in relation to tree height
- FOREYE: simulating fish-eye photographs, allowing analyses of light patterns
- NEWTREE: projecting stem bases of new trees over other trees, e.g. vegetation maps

For example, with the help of these computer programmes and statistical analysis, together with a Geographical Information System, the following analysis may be done:

- growth and decay of individual trees
- study of population dynamics
- forest succession (development of forest phases and gap-dynamics)
- vegetation succession

Parameters monitored for forest structure in entire reserves and core areas, divided into different subjects (resp. *, # and % signed in the table):

- stem base position: * %
- tree species: * # %
- diameter at 1.3 m breast height (dbh): * # %
- height of the crown top: * # %
- height of the stem base: * # %
- 4 periphery points of the crown: %
- crown base: * %
- first large living branch: %
- internal crown cover: %
- social position: %
- vitality: * %
- damage (cause and intensity): * %

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NORWAY

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1. FORESTS AND PROTECTED FORESTS IN NORWAY.

Norway experiences a wide range of climatic conditions and covers a large altitudinal range. The range of conditions which prevail is further extended by the heterogeneity of its landscape, with its fjords, valleys and mountains. Of the total land area of 323,000 km², 37% is covered by forest. The productive forest area is calculated to be 22%. Of this 22%, 76% is dominated by conifer forests and 24% by deciduous forests. The annual harvest is approximately 10-11 mill. m³ from the annual growth of 17 mill m³.

Data on forest resources are obtained from the National Forest Inventory, which was initiated in 1920. The approach and methodologies adopted in this inventory have evolved over time. Today, re-survey of permanent plots, every 5 years, is the most important part of the programme. Vegetation type, age structure of the trees, forest structure, and dead wood are surveyed, in addition to forest resource parameters. The data are analysed to obtain information on the status and development of forests on county and country levels.

From both a short-term and long-term perspective, there is a clear need to conserve biological diversity in Norway. This requires scientific justification, as well as public support and effective organisation for nature conservation and management. The pioneers in Norwegian nature conservation were scientists in the fields of geography and biology. In more recent times, there has been important popular support for protected areas, through environmental organisations. Since 1898, selected species and areas have been legally protected, and three Nature Conservation Acts (1910, 1953 and 1970) have been produced.

The Nature Conservation Act states as its outset that the "protection of nature means the management of the natural resources based on acknowledgement of the close interrelationship of man and nature, and on the preservation of the quality of nature for the future". The political and administrative process of designating and establishing protected natural areas is a long process with eight defined steps. These include documentation and study of the natural state of the areas to be protected, planning, the active participation of landowners, the local community and interested organisations and others, eventually cul-

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EFI Proceedings No. 16, 1999

Table 1. Areas protected under the Nature Conservation Act, as of 31 December, 1994.

Classification	Number	Area (km^2)	Percentage of Norwegian Mainland*
National parks	18	13 788	4.25
Nature reserves	1 172	2 155	0.67
Landscape protected areas	76	4 656	1.43
Natural monuments (Geological)	86[1]	2	0.00
Other protected areas	72[2]	107	0.03
Total	1 424	20 708	6.38

*) Mainland excl. Svalbard (protected areas on Svalbard is established after the act of Svalbard of 1925)
1) In addition there are about 180 trees/groups of trees per protected batanical Natural Monuments
2) Protection of species without protection of the biotop may found on some localities

minating in a resolution of the Norwegian government establishing the protected area. After the scientific work, the process of protecting natural areas is continued by gathering information, and through co-operation, consultation and political support.

By January 1, 1995, there were 18 National Parks, 76 Landscape Protected Areas and 1172 Nature Reserves in Norway. The largest portion of protected areas consists of National Parks, while Nature Reserves comprise 10.4% of the total area under protection. An overview of protected areas is presented in Table 1. Note the followinf definitions: (i) **National Parks** cover large unspoiled, or essentially unspoiled, or distinctive or beautiful natural areas, where the aim is to protect the natural environment. The landscape with its flora, fauna and natural and cultural monuments shall be protected against development, construction, pollution and other encroachments. (ii) A **Nature Reserve** is an area where nature is unspoiled or virtually unspoiled, or which consists of distinctive biota, and which is of special scientific or pedagogical significance, or which stands out by virtue of its distinctive features. Nature Reserves have the highest level of protection under the Nature Conservation Act. (iii) The function of a **Landscape Protected Area** is to preserve distinctive or beautiful natural or cultural landscapes. In a Protected Landscape Area, no activity may be undertaken which can substantially alter the nature or the character of the landscape. (iv) **Natural Monuments** are protected as geological, botanical and zoological features which are of scientific or historical interest, or which are of distinctive character.

2. BACKGROUND TO FOREST RESERVES

The first forest reserves in productive forest areas were established early this century. Additional forest areas were selected for protection in the 1970s, when the National Parks were created. Most of the National Parks in Norway are located in alpine areas. In broadleaved deciduous forests and conifer forests, there have been separate action plans to create a network of forest reserves. In 1977, 160 forest reserves of broadleaved deciduous forest were established, and early in the 1990s, the planned establishment of 280 km^2 of reserves in productive conifer forest was fulfilled.

Table 2. Overview of forest protected as nature reserve, national park or administratively protected of owner

Total forest area	1 995 km²	1.68% of all forest
Conifer forest	795 km²	1.20% of all conifer forest
Deciduous forest	1 200 km²	2.28% of all deciduous forest
Productive forest	600 km²	0.86% of productive forest
Productive conifer forest*	449 km²	0.84% of productive conifer forest

* The Norwegian government decided in1995 to increase the area of productive conifer forest in reserves by 120 km² before the year 2000. Then, 1.06% of the productive conifer forest will be protected in forest reserves.

The forest reserves are classified into three groups. (i) Type areas, (ii) Special areas and (iii) Supplement areas. Type areas are the "heart" of the reserve system, and these conserve the typical conifer mosaic in the different regions of Norway. The Special areas aim to protect the rare and threatened elements, while the aim of the Supplement areas is to include part of the mosaic, thereby extending the Type area network.

The background to the process of establishing a reserve is a partial inventory, which is not a complete study of all aspects of the stand biodiversity, but is instead a review of the vegetation, with some emphasis on special features of interest.

The biological rationale for establishing protected areas has changed somewhat over time. Initially, the aim was to conserve wilderness areas, or those which typified a particular vegetation type. In the last decade, there has been more emphasis on conservation of biodiversity, i.e. by including the more productive areas in lowland parts of Norway. Figure 2 illustrates some of the points considered during the development of the last plan (1995), which proposes to include a further 120 km² of productive conifer forest in reserves.

3. RESEARCH IN NATURAL FORESTS AND RESERVES

Research projects that are restricted only to Nature Reserves are rather few. The reason for this is that the forest reserves represent only a small part of the total forest area in Norway, and that the whole resource is, to some extent, of scientific interest. However, there have been many studies on more or less natural forest and managed forest. These include projects on forest history (history of both use and disturbance) and the structure and dynamics of forests. Experimental research has investigated, inter alia, the effects on forests of fragmentation, combination of multiple use with production, conservation and biodiversity aspects. Research in landscape ecology and landscape planning in forestry is expanding.

3.1 Red List and special key habitats

A search for Red List species in forests is ongoing, and the data collected will contribute to updating the national Red Lists. There is also in progress an inventory of key habitats for biodiversity. These areas can be inside or outside protected areas.

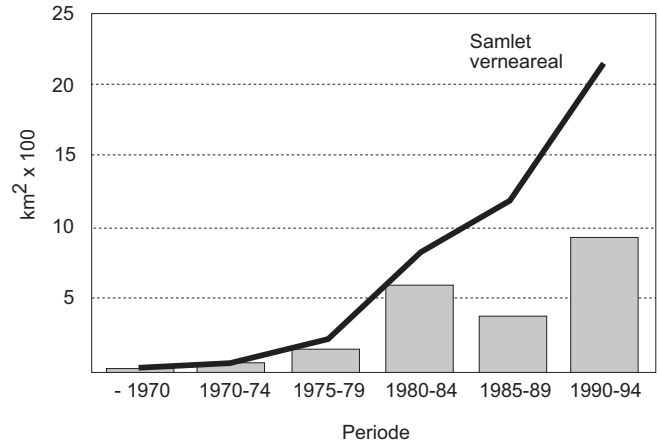

Figure 1a. Areas protected as Nature Reserves.

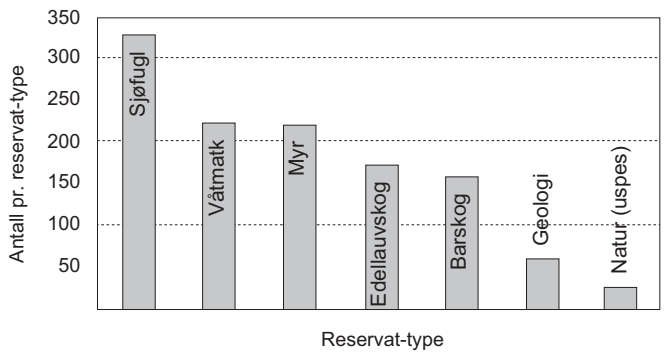

Figure 1b. Number of types of Nature Reserves in Norway.

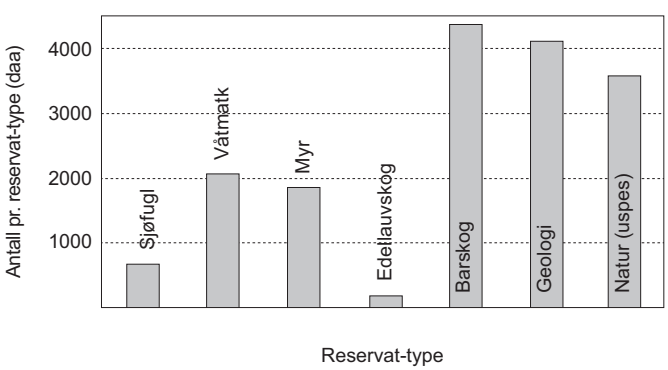

Figure 1c. Area per reserve for types of Nature reserves in Norway.

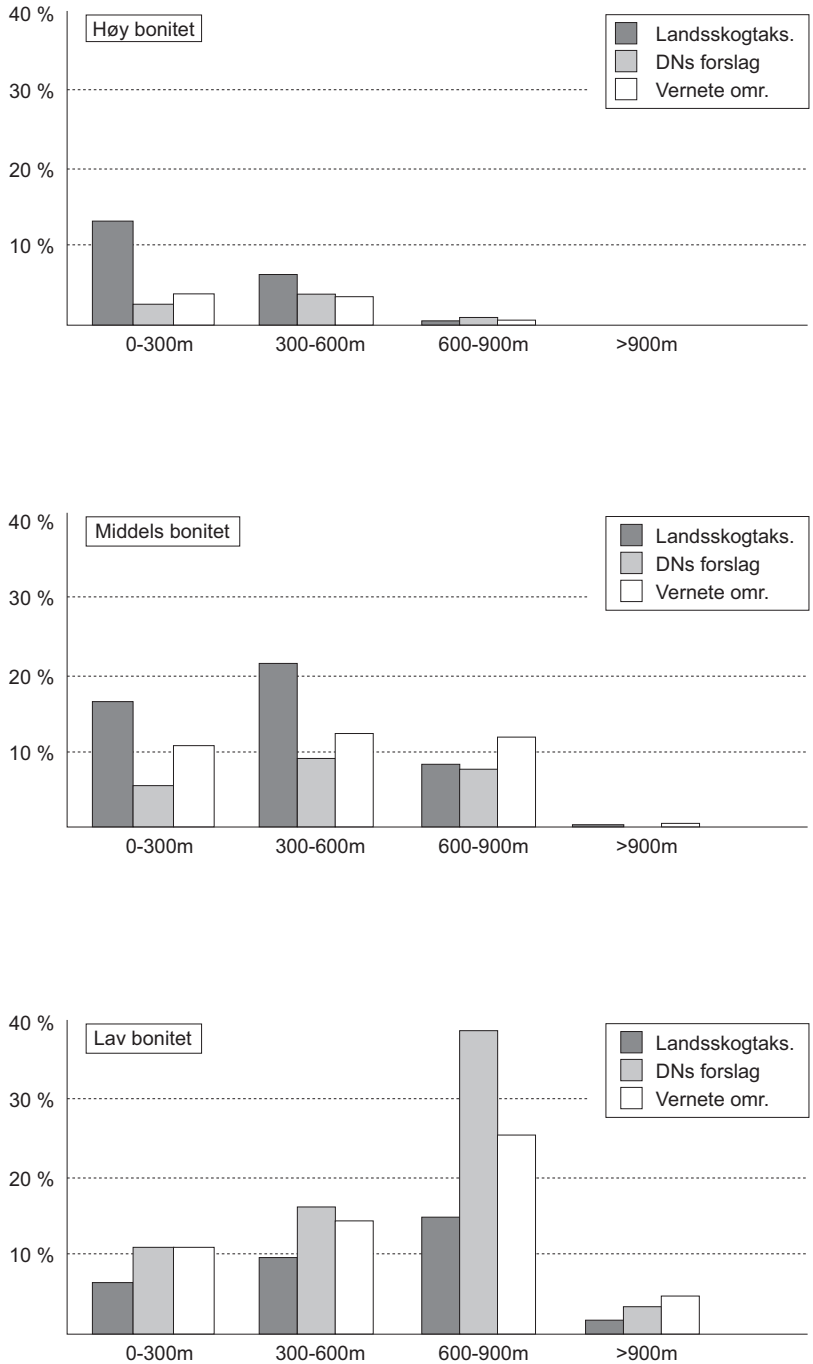

Figure 2. Relative distribution of productive conifer forest by productivity classes for protected sites at various altitude levels in eastern Norway. The distribution of protected sites is compared to the material from the Norwegian forest survey (Landsskogtaks.) and the sites proposed by the Norwegian Directorate for Nature Management (DN).

3.2 Programmes in forest reserves and National Parks

In Norway, there is no national research programme dedicated to forest reserves, but many institutions (Universities and research institutes) are involved in nationally funded programmes for forest research in a broad sense. The government has developed a national plan for monitoring biodiversity in Norway. (Note: This includes the forest areas in which the forest resources have been monitored since about 1920.) It is intended that protected areas will be important reference areas for the new monitoring programme, and several sampling sites will probably be placed in forest reserves.

There are plans to initiate research on management of forest reserves, and methods for the identification and selection of small-scale areas, for biodiversity conservation in managed forests, are under evaluation.

Deposition of long-distance airborne pollutants has caused acidification in northern European forest ecosystems in recent decades, and this has been an important topic of forest research in Norway. In this context, several monitoring programmes are financed by the Norwegian government. In 1989, the "Monitoring Programme for Terrestrial Ecosystems" was begun in boreal birch forests. Several of the monitoring sites are now located in National Parks or in Landscape Protected Areas, and in these, flora, fauna and soils are investigated. The Norwegian Institute for Nature Research (NINA) is responsible for the botanical and zoological studies, and the Norwegian Forest Research Institute (NISK) for soil studies. Other monitoring programmes, mostly in non-protected boreal coniferous forests, are performed by NISK (i.e. ICP FOREST UN programme), by the Norwegian Institute for Land Inventory (NIJOS) and by the University of Oslo.

The Norwegian Ministry of Agriculture initiated, in 1996, a rather comprehensive programme to investigate biodiversity and cultural heritage associated with forests. Stand structure and biodiversity are assessed – the latter by recording vascular plants, lichens, mosses, birds, some mammals and insect groups. This programme includes mainly natural forest, of both deciduous and coniferous types, but it is restricted to forests that lie outside the Nature Reserves. This kind of approach will probably be the most important in future research on the Norwegian forests. NISK has the leading role in the programme, with contributions from NINA, several Universities and other institutions.

The Norwegian Research Council funds an ongoing research programme of forest research in a broad sense, which is concerned with the use and conservation of forest resources.

4. INSTITUTIONS INVOLVED IN RESEARCH RELEVANT TO NATURAL FORESTS

- Data on forest resources and some environmental parameters in forest areas (mainly productive) is provided by Norwegian Institute of Land Inventory (NIJOS).
- Norwegian Institute for Nature Research (NINA)
- Norwegian Forest Research Institute (NISK)
- Agricultural University, Ås
- Universities in Oslo, Bergen, Trondheim and Tromsø
- Several Regional Colleges and occasionally other Institutes.

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PORTUGAL

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1. INTRODUCTION

In Portugal, native forests consisted mainly of *Querci*, roughly distributed in the country according to a north-south division, bounded by the river Tagus, and a moisture gradient. In northern regions which are colder and more humid being influenced by the Atlantic ocean, there was *Quercus robur*, followed by *Q. pyrenaica* as moisture decreased, and in even more xeric and continental conditions, *Q. suber* and *Q. rotundifolia*. Higher mountains were covered by *Taxus baccata, Betula celtiberica* and *Juniperus communis*, while *Ulmus* spp., *Fraxinus* spp., *Salix* spp. and *Alnus* spp. bordered the riversides.

Quercus suber dominated the southern region, giving place to *Q. rotundifolia* and *Q. coccifera* as humidity decreased. In Mediterranean locations *Q. faginea s.l.*was also found.

However, by the beginning of the 16th century, Portugal was already importing wood from Italy and France to continue the ship construction program for the Discoveries (Braudel 1984).

Very little of those *Querci* forests remain nowadays. Since the beginning of the 18th century, agricultural practices and animal grazing have become increasingly intensive and the forested area has drastically diminished. Only about a third of the country is currently forested, but the species composition has changed and today *Pinus pinaster* and *Eucalyptus globulus* dominante.

Most of the forests (about 80%) are privately owned, and there is a large property fragmentation, which makes it very difficult to establish any sound management plans, for instance for forest sustainability.

Table 1 presents the main species, their area and evolution for the period of 1982-1995 according to the Forest Inventory data (Direcção Geral das Florestas 1997).

Afforestation of marginal or uncultivated agricultural lands, as well as reforestation, are being encouraged by the Government, so in this period of time (1982-1995) there has been an increase of 200x10^3 ha in the total forested area.

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Table 1. Main species, area (%) and evolution (1982-1995).

Main species	Area (ha) x 10^3	Evolution (1982-1995)
Pinus pinaster	1029.2	- 17%
Eucalyptus globulus	695.1	+ 80%
Quercus suber	720.7	+ 9%
Q. rotundifolia	475.7	+ 2%
Other oaks	134.0	+ 20%
Castanea sativa	40.9	+ 32%
Other broadleaves	103.4	+ 13%
Pinus pinea	78.5	+ 40%
Other coniferous	28.6	- 43%
Total	3306.1	

About half of the existing forests are used for wood production (mainly *Pinus pinaster* and other pines), while hardwoods like *Quercus suber* and *Q. rotundifolia, Castanea sativa* and *Eucalyptus* spp. are exploited for other products like cork, fruits (acorn, chestnut), and pulp.

Forest fires remain, no doubt, the major forest destruction factor. Every year, an average of 50 000 ha burns, mostly of pines, but of course there are also other species, even some relics forests. As a direct consequence, the eucalyptus and acacia area are increasing, and a striking characteristic of Table 1 is the increment of an exotic – *Eucalyptus globulus*.

2. PROTECTED FOREST AREAS IN PORTUGAL

However, in the 1930s Portugal was already aware of the need to protect natural ecosystems, as one may see by the constituting of the reserves of Arrábida, Cambarinho and Medos National Forest, consigned by the Forest Plan of that time. A specific legislation establishing the definitions of National Park and Natural Reserve followed in 1970, expressing a concern about the protection of our most significant ecosystems.

In 1993, a complete package of environmental laws established the following categories of protected areas:

- National park
- Natural park
- Natural reserve
- Natural monument
- Protected landscape
- Biological interest site
- Integral reserve

Protected areas of national interest, as the National and Natural parks and Natural reserves, can be defined as follows:

A **National park** is intended to protect one or several ecosystems, undisturbed or little disturbed by human intervention, integrating representative samples of natural regions, natural humanised landscapes, flora and fauna and their habitats, having ecological, scientific and educational interest, and regulating exploitation of natural resources.

Natural parks ensure the adoption of measures to maintain natural or almost natural landscapes of national interest, integrating harmoniously human activities, nature, and ecological biodiversity.

A **Natural reserve** provides the necessary conditions to the protection of species, groups of species, biotic communities or physical environment features, when human intervention is needed for their perpetuation.

All these areas have their own management plan and regulation. Their Organic Structure includes representatives of the Ministry of Environment, the Nature Conservation Institute and the municipalities. The Nature Conservation Institute is responsible for the management of these areas of national interest. Local municipalities manage areas with local or regional interest, as Protected landscapes.

In protected areas, special zones can be established, called Integral reserves. They are intended to keep natural processes totally undisturbed, leaving them to their natural evolution, therefore preserving ecologically representative examples. Human presence is only allowed for scientific research or environmental monitoring reasons.

However, we can still find very small areas keeping some old forests characteristics, that are located in zones having difficult access and, most of the time, no protection at all.

At this moment, we have the following protected areas (Table 2). Appendix 1 presents a showing these areas and Appendix 2 lists the different categories of protected areas, with the corresponding national terms and definitions.

The total protected areas cover 566 307 ha, representing about 6% of the area of Continental Portugal (8 878 946 ha).

Some of these zones are also included in international Biogenetic Reserves (European Council), Ramsar Convention and Biosphere Reserves (Unesco), as summarised in Table 3.

Portugal also participates in NATURA 2000 Network, and an important part of the chosen sites have included semi-natural forest “habitats” of the 43/92/EEC Directive.

3. FOREST RESEARCH IN PORTUGAL

Forest research is, as a rule, undertaken by the National Forest Research Station, as well as by several Universities and Polytechnic Institutes. There is no special program or research project concerning protected areas, so it tends to reflect general concerns and problems of all Portuguese forests, as well as an opportunity to study some situations and ecosystems little disturbed.

Vegetation studies are still perhaps the more frequent in these zones: plant inventories, vegetation dynamics, phytosociology etc. (Braun-Blanquet 1956; Pedro 1997; Rego et al. 1995; Vasconcellos and Franco 1958.)

Table 2. Protected areas.

Protected Areas	Size (ha)	% of Total area	Year of Establish.
National Park (1)			
1 Peneda-Gerês	70 290	0.79	1971
Natural Parks (10)			
2 Alvão	7 220		1983
3 Arrábida	10 821		1976
4 Montezinho	74 800		1979
5 Ria Formosa	18 400		1987
6 Serra da Estrela	101 060		1976
7 Serra de S. Mamede	31 750		1989
8 Serra de Aire e Candeeiros	38 846		1979
9 Sintra-Cascais	14 583		1994
10 SW Alentejano e Costa Vicentina	60 630		1995
11 Vale do Guadiana	69 773.5		1995
Total	427 883.5	4.82	
Natural Reserves (8)			
12 Berlenga	78		1981
13 Dunas de S. Jacinto	666		1979
14 Estuário do Sado	23 160		1980
15 Estuário do Tejo	14 560		1976
16 Paul de Arzila	535		1988
17 Paul de Boquilobo	530		1980
18 Serra de Castro-Marim	2 089		1975
19 Serra da Malcata	21 760		1981
Total	63 378	0.71	
Protected landscapes (3)			
20 Arriba Fóssil da Costa de Caparica	1 588		1984
21 Litoral de Esponsende	440		1987
22 Serra do Açor	346		1982
Total	2 374	0.03	
Classified Sites (10)			
23 Açude da Agolada	270		1980
24 Açude do Monte Barca	880		1980
25 Campo de lapiás Granja dos Serrões	51		1991
26 Campo de lapiás de Negrais	28		1991
27 Centro Histórico de Coruche			1979
28 Fonte Benémola	392		1991
29 Gruta do Zambujal	2.5		1979
30 Montes Santa Olaia e Ferrestelo	8		1991
31 Monte S. Bartolomeu	32		1979
32 Rocha da Pena	637		1991
Total	2 300.5	0.03	
Natural monument (1)			
33 Dinosaur footprints	81		1996

Table 3. Biogenetic Reserves, Ramsar Convention and Biosphere Reserves.

Biogenetic Reserves	Year of establish	Size (ha)
Gerês – Palheiros-Albergaria	1989	1650
Arrábida	1988	10 882
Serra da Estrela – Central plateau	1991	5 645
Berlenga	1989	Terrest. 78
		Marit 941.2
Paúl de Arzila	1991	535
Serra da Malcata	1988	21 759
Sw. Alentejano – Ponta de Sagres	1989	134
Ramsar Convention		
Ria Formosa	1978	16 000
Estuário do Tejo	1976	14 563
Biosphere Reserve		
Paúl de Boquilobo	1981	395

Since forest fires are still one of our major threats, there have been many research projects with results dealing with different aspects of this situation, and some of them directly intended for protected zones. For instance, at the Natural park of Arrábida, with a plant cover unique in Western Mediterranean Region, a fire prevention research project has been implemented, (Forest Fire Prevention in Arrábida Natural Park, Almeida 1993), with results regarding subjects such as establishing local fuel models, fire prediction fuel photo series, vegetation mapping, local climatic characteristics and fire statistics.

This subject is also closely related to vegetation and vegetation recover after fire, and there is also much research done on this issue for protected areas, for instance establishing phytosociological thypologies, biomass and aerial structure characteristics of some shrubs, woody species recover after fire, testing prescribed fire etc.

Faunistic studies are also being implemented, leading to the active protection of rare or endangered species by local populations, as it happened, for example, with eagles (Palma 1995), black storks and, to a certain extent, wolves. Most wetlands and freshwater ecosystems are also protected as natural reserves, therefore trying to avoid destruction.

A concerted and systematic research regarding representative parameters of protected areas would provide sound information to these zones future planning and management.

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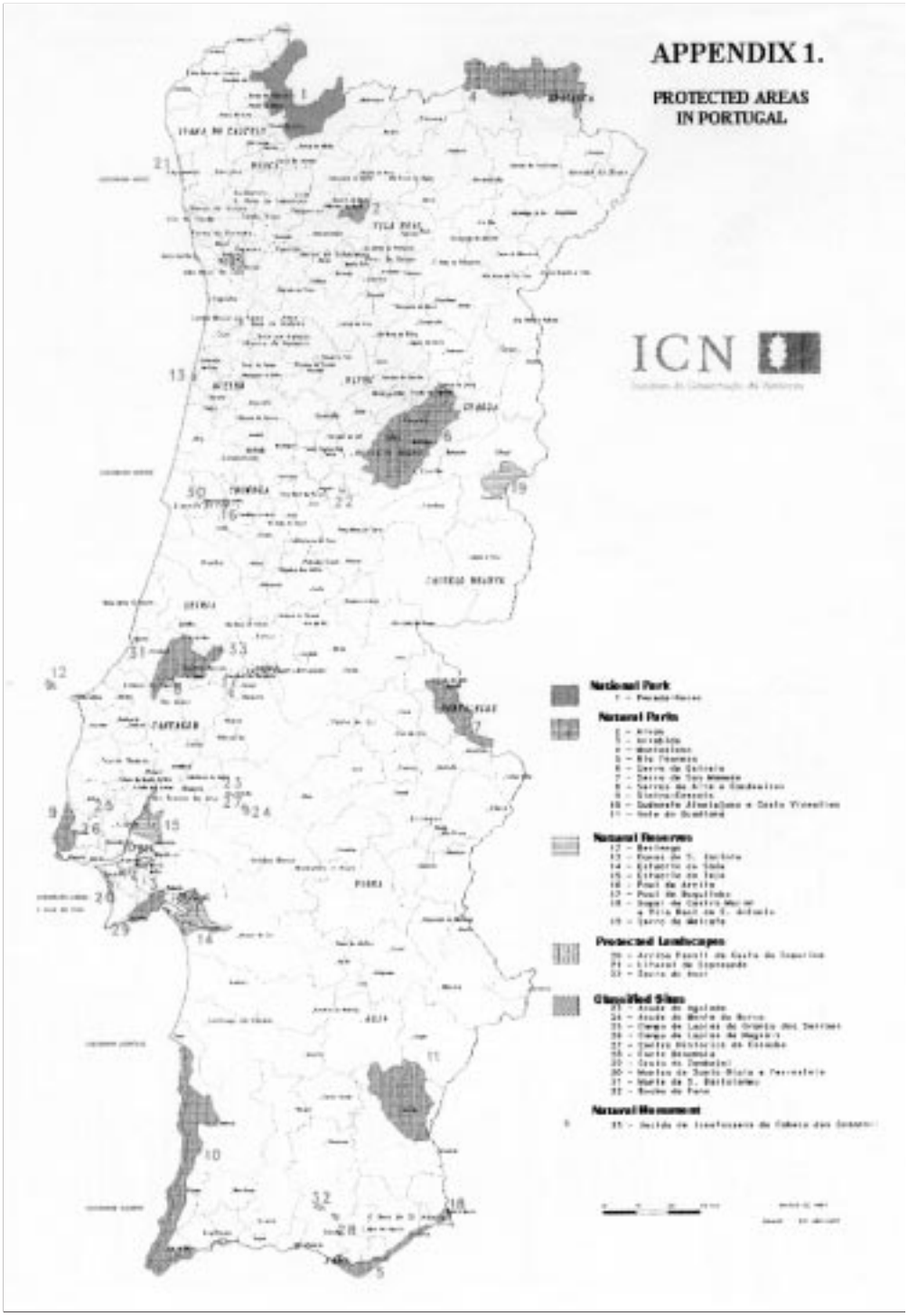
APPENDIX I: PROTECTED AREAS IN PORTUGAL



Appendix 2. Different categories of protected areas with the corresponding national terms and definitions.

Categories/English terms	Categories/National terms	Definitions
National park	Parque nacional	A National park is intended to protect one or several ecosystems, undisturbed or minimally disturbed by human intervention, integrating representative samples of natural regions, natural humanised landscapes, flora and fauna and their habitats, having ecological, scientific and educational interest, and preventing exploitation of natural resources.
Protected under law.		
Natural park	Parque natural	Natural parks ensure the adoption of measures to maintain natural or almost natural landscapes of national interest, harmoniously integrating human activities, nature, and ecological biodiversity.
Protected under law.		
Natural reserve	Reserva natural	A Natural reserve provides the necessary conditions for the protection of species, groups of species, biotic communities or physical environment features, when human intervention is needed for their perpetuation.
Protected under law.		
Natural monument	Monumento natural	Natural feature whose singularity, rarity or representativity in ecological, aesthetic, scientific or cultural terms demand its conservation and the maintenance of its integrity.
Protected under law.		
Protected landscape	Paisagem protegida	A protected landscape is defined as an area with natural or semi-natural and humanised landscapes, of regional or of local interest, with high aesthetic or natural value.
Protected under law.		
Biological interest site	Sítio de interesse biológico	Private protected area upon request by the owner, intending to protect fauna and flora species and their natural habitats.
Protected under law.		
Strict reserve	Reserva integral	May be established in protected areas to maintain natural evolution. Human presence is only allowed for research or monitoring purposes.
Protected under law.		
Biogenetic reserve, Ramsar Convention Reserva biogenética	Biosphere reserve Convenção de Ramsar Reserva da Biosfera	These are internationalcategories, in which some Portuguese protected areas are included

SLOVAKIA

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1. INTRODUCTION

Forest occupies approximately 2 million hectares, i.e. 40%, of the total land area of Slovakia and forest management planning guidelines emphasise multipurpose forest management. Slovakian forests are divided into three categories according to their primary functions. The commercial forest estate, with sustainable wood production as its predominant function, occupies 1,241,382 ha (69.29%) of the total forest area. The protection forests category, where protection, conservation and ecological functions are the main objectives, occupies 280,835 ha (15.23%). The category known as the 'special purpose forests' occupies 297,065 ha (16.11%), and occur particularly in watershed and emission areas. Another 215,292 ha, i.e. 1.37% of the total, are agricultural lands intended for afforestation and categorised as 'forest land'. Such areas will be registered as forest land only after they are afforested.

The total area of forest in Slovakia is 1,920,000 hectares. The total area administered by the Ministry of Land Management, i.e. excluding military forests, represent 1,944,473 ha (December 31, 1996). In relation to individual categories, protection forests are divided into 4 sub-categories:

- forest on extremely difficult sites such as rock mantle, ravines, ridges, deep peatlands (7.53%)
- high elevation forests just below the treeline (2.67%)
- the sub-alpine zone of dwarf pine (1.05%)
- soil protection/erosion control forests (3.98%)

Special purpose forests are divided into 8 sub-categories. Forests affected by air pollution are the most abundant in this category and represent 8.69% of the total forest area.

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2. HISTORY OF NATURE RESERVE ESTABLISHMENT IN SLOVAKIA

From the point of view of nature conservation, Slovakia, due to its inherant natural attributes, is a very interesting country. The establishment of a network of protected areas has been very successful and Slovakia compares very favourably with the most advanced countries in Europe in this area.

Forests are valuable national treasures. They are the principal component of the countries magnificent and colourful landscape, which makes Slovakia one of the most beautiful places on the planet. Therefore, it is to be expected that the majority of valuable protected areas, representing the biological and ecological diversity of Slovakian nature, are located in forest areas.

History notes that foresters were first to apply principles of nature conservation in their profession long before the official establishment of nature conservation institutions. Thanks to the stability of forest ecosystems, denaturation processes were impeded and areas of nature, which have been almost untouched by human activities, were preserved; these areas support many original species of fauna and flora, which died out elsewhere in Europe and are thus, important refuges.

The first protected area in Slovakia was officially sanctioned as early as the end of the last century. The establishment of preserved natural areas intensified in the late 1940s. After the establishment of the first Tatra National Park in the High Tatras in 1949, and subsequent to the enactment of the nature conservation law in 1955, protected landscape areas and other national parks were created.

Today, there are five national parks in the Slovak Republic: Tatra National Park, National Park of Pieniny, Low Tatras National Park, Fatra National Park and Slovak Paradise National Park with a total area of 200,000 ha, all of which together represent 4% of the national territory. A further 16 protected landscape areas have been established, covering an area of 660,500 ha (13.5% of the national territory), in addition to 448 State nature reserves with an area of 91,500 ha. Of the latter, 104 are protected semi-natural areas, while 228 are untouched areas.

The total area of protected areas and their protection zones account for 28% of the national territory of Slovakia, the majority of which represent the most valuable and well preserved natural areas, as well as the inherent biological and ecological diversity of Slovakian nature, most of which occurs in forests. Of the 270 forest reserves – occupying an area of 70,000 ha – 73 are close-to-virgin or virgin-like forest. Of all forest reserves, 11% are dominated by oak, 9% by beech, 45% by beech/fir/spruce, 20% by spruce, 14% by dwarf pine and 1.5% by alder, birch and willow forest communities. Many forest reserves are protected within national parks, biosphere reserves and protected landscape areas.

In Slovakia, there are four Biosphere reserves, which were established between 1972 and 1992, occupying a total area of 202,505 ha. These four reserves are: Slovak Paradise (86,165 ha), Tatras (105,660 ha), Polana (20,079 ha) and Eastern Carpathians (40,602 ha). All four are dominated by forest, which vary in extent between 56% and 90% of their total area. Multidisciplinary research with a strong emphasis on nature, environmental protection, optimal/sustainable forest management and land-use strategies are carried out in these areas.

3. TREE SPECIES COMPOSITION OF FORESTS

Distribution of tree species in forests is correlated closely with macro-relief. In the lowlands and hill territories of southern and eastern Slovakia, broad-leaved species are typical; in the mountains of middle and northern Slovakia, mixed forests prevail, with coniferous species dominating. The original tree species mix has been altered by centuries of management. The proportion of spruce and pine has increased substantially with a consequent appreciable decline in the distribution of fir, beech and oak. This trend in recent decades is well illustrated when the tree species composition in 1920 is compared with that which pertains today. This trend is characterised by an increase in spruce, an appreciable reduction in silver fir, which was the most productive tree species until recently.

Much attention has been paid to the attainment of a desirable (target) tree species composition of in Slovakian forests. This 'target composition' policy is based on basic principles of forest management, i.e. on the principle of maximum, continuous, safe and effective performance of forest functions in the public interest compatible with production decisions. Forest management takes fully into account the decisions and principles described above. From an ecological point of view, the following principles are applied in the attainment of target composition:

- biodiversity protection, i.e. the principle of cultivating mixed species stands;
- cultivation of tree species suitable to the site, i.e. the right trees in the right place;

Table 1. Original, actual and target distribution of coniferous in Slovakian forests. Distribution in %.

Species	Original	Real	Target
Spruce	7.7	27.5	27.0
Fir	14.1	4.6	8.0
Pine	0.9	7.7	9.0
Larch and other coniferous	0.9	2.0	3.0
Total	23.6	41.8	47.0

Table 2. Original, actual and target distribution of broadleaved species in Slovakian forests. Distribution, in %.

Species	Original	Real	Target
Beech	46.3	30.4	30.0
Oak	21.6	13.9	15.0
Hornbeam	3.9	5.5	1.0
Valuable broad-leaved species	3.9	7.4	5.0
Other broad-leaved species	0.9	1.0	2.0
Total	76.4	58.2	53.0

- alleviation of pollution impacts and other harmful impact, by using more resistant tree species;
- elimination of monocultures by altering the proportion of highly productive tree species through the addition of biological tree species in order to enhance sustainable development.

From the point of view of economic considerations, the following principles are applied:

- where site conditions allow, the proportion of commercial tree species are increased, i.e. spruce, larch, oak and other valuable broad-leaved species;
- silviculture is aimed at increasing tree species quality and increasing stem dimensions (in southern Europe, broadleaved species have been devastated, while in northern Europe small-dimensioned coniferous species prevail),
- wood production is orientated to the utilisation of wood for specific purposes, i.e. it is produced for mechanical, and, to a lesser extent, for chemical production treatments.

Today, the primary objectives are to preserve fir on convenient sites, to increase the share of larch and of valuable broadleaved species and to increase resistance to the impacts of pollution.

4. CLASSIFICATION OF FOREST PROTECTION AREAS

The total number and areas of virgin and natural forest reserves are presented in Table 3. Data from the inventory of virgin, natural and semi-natural forests in Slovakia, in addition to the number of forest reserves containing virgin forest and natural forest in Slovakia, their name, area and category (degree of origin according vegetation classification) and altitude are shown in Table 4.

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, 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.

Of all forest reserves with virgin forest or natural forest character, the oak vegetation category contains 580 ha (i.e. 3.8%), the beech-oak and oak-beech category, 383 ha (i.e. 2.5%), the beech category, 2,110 ha (i.e. 13.8%), the fir-beech category, 2,110 ha (i.e. 13.8%), the spruce-beech-fir vegetation category 3,410 (i.e. 22.3%) and the spruce vegetation category, 6,830 ha (i.e. 44.4%)

The dominant tree species in virgin and natural forests of Slovakia are as follows: spruce 52,3%, beech 23.6%, fir 7.2%, maple 3.4%, oak 3.1%, larch 1.9%, pine 1.6% alder 1.6%, rowan 2.4% and all other species accounting for the remaining 3.9%. When the present tree species composition of Slovakian forests is examined, it is apparent that virgin and natural forests contain more spruce and fir. Virgin forests contain more

Table 3. Number and proportions of virgin and natural forest reserves in Slovakia according size.

Area	Total number	% of total number	Total area	% of total area
< 50 ha	22	28.9	555 ha	3.6
50-100 ha	24	31.6	1,683 ha	10.9
100-500 ha	21	27.6	4,232 ha	25.0
500-1000 ha	6	7.9	3,858 ha	25.0
1000-5000 ha	3	4.0	5,100 ha	33.0
5000-10000 ha	-	-	-	-
10000-50000 ha	-	-	-	-
Total	76	100.0	15428	100.0

coniferous species than the national average and the national forest estate contains more beech, pine and oak compared to virgin forests. In comparison with the Slovak mean, coniferous tree species have a higher, i.e. 21%, and broadleaves a lower, i.e. 21%, occurrence in virgin forests.

Of the protection forests (approx. 270,000 ha), 20% (i.e. 54,000 ha) have the minimum character requirements of both virgin forest categories (I.A and I.B) and an additional 20% possess the character of the natural forest (category II). Approximately 60% of all protection forests are dominated by the 6th (spruce-beech-fir) and 7th (spruce) vegetation categories. Access to protection forests is undesirable for a variety of reasons. For these forests, specific selective silvicultural systems are proposed; sanitary cutting only is recommended (dispersed individual cutting).

In Slovakia, there are no untouched forest areas larger than 5,000 ha. The characterisation of forest reserves in Slovakia according to age or age structure is problematic. More than 80% of reserves are uneven aged. To express forests in terms of average age or to define age classes for them without concrete data from trees age analyses, leads to considerable error. Using typical forest management methods, forest stands in the nature reserves of Slovakia are generally included in the V. to VII. age classes, being generally greater than 90 years of age. Research of Slovakian virgin forests indicates that there are various age classes depending on ecosystem type. In beech virgin forests, for example, the average age is between 80-110 (trees measured had a dbh greater than 7 cm) and that natural mortality occurred between 220-240 years. In coniferous virgin forests, i.e. fir and spruce, the average age is 160-190 years, with a natural lifespan of 350-430 years.

All forest reserves in Slovakia are located in virgin, natural or semi-natural forests, i.e. in the first four categories devised by M. Broekmeyer). Forest reserves have not been established in secondary forests or plantations. More which 90% of forest reserve stands originate from natural regeneration. A few old stands of introduced tree species (e.g. *Castanea sativa*, *Carya alba*, *Quercus robur* ssp. *slavonica*) have been included in the protected study areas category, however the total area these is less than 200 ha.

It is envisaged that in the near future at least, the current area of natural forests will not change significantly. Where a reduction occurs, this will be due to harvesting in virgin-like forests which are still subject to some commercial management, especially in

Table 4. Virgin or natural forest reserves in Slovakia.

No	Forest Reserve (geographical unit) Objects not protected according of the nature Protectin Act	Size ha	Degree of origin	Degree of danger	Altitude (m)	Veg. level
1.	Istragov (Podunajská nízina)	14.00	B(C)	b(c)	120	1
2.	Kováèovské kopce	120.00	C(B)	b(c)	110-268	1+2
3.	Stinska (Bukovské vrchy)	90.78	A(B)	b(a)		4+5
4.	Palárikovská bazantnica (Podunajská nízina)	38.00	B(C)	b	150-160	1
5.	Rašelinisko bôl (Východoslovenská rovina)	11.77	B(C)	b(c)	103	1
6.	Šúr (Podunajská nízina)	350.00	B(C)	b(c)	130-140	1
7.	Velký Lél (Podunajská nízina)	12.20	A(B)	b(c)	110	1
8.	Boky (Kremnické vrchy)	176.49	A(B)	b(c)	180-589	1+3
9.	Bujanov (Èierna hora)	88.17	B(C)	a(c)	530-765	1+3
10.	Kašivárová (Štiavnické vrchy)	19.46	B(C)	b	475-600	2+3
11.	Kokošovská dubina (Slánske vrchy)	20.00	B(C)	b	470-520	2+3
12.	Lesná (Štiavnické vrchy)	6.11	B	b(c)	550-600	2
13.	Malé Brdo (Slánske vrchy)	55.56	B(C)	b	550-615	2+3
14.	Sitno (Štiavnické vrchy)	45.49	A(B)	b(a)	750-1011	3+4
15.	Kocúrová (Slovenské rudohorie)	16.72	B(A)	b	510-600	3+4
16.	Šivec (Slovenské rudohorie)	57.78	B(A)	a	480-784	3+4
17.	Dranec (Nízke Beskydy)	34.22	A(C)	b	330-515	4
18.	Harmanec (Velká Fatra)	45.00	B(C)	b(c)	750-900	4+5
19.	Havešová (Bukovské vrchy)	171.32	A	a	550-650	4
20.	Komárnik (Nízke Beskydy)	23.65	A(B)	a	515-572	4+5
21.	Kyjov (Vihorlat)	53.40	A	a	700-820	4
22.	Magura (Nízke Beskydy)	76.64	B(A)	a(b)	650-900	4+5
23.	Malý Milièe (Slánske vrchy)	14.95	B(A)	a(b)	725-780	3+4
24.	Maroèká Hola (Slánske vrchy)	50.23	B(A)	a(b)	590-635	4
25.	Oblík (Slánske vrchy)	89.58	A (B)	a	620-930	3+4+5
26.	Pl'aša (Bukovské vrchy)	118.64	A(B)	a	880-1163	4 +5
27.	Raštún (Malé Karpaty)	18.00	B(C)	b	310-748	3+4
28.	Jarabá Skala (Bukovské vrchy)	359,94	A(B)	a	1050-1199	4+5
29.	Rozok (Bukovské vrchy)	67,13	A	a	520-796	4+5
30.	Šimonka (Slánske vrchy)	55,03	A(B)	a	830-1092	4+5+6
31.	Velký Milièe (Slánske vrchy)	67,81	B(A)	b	660-820	3+4
32.	Vozárka (Slovenské rudohorie)	76,63	C(B)	b	500-738	4+5
33.	Badínsky prales (Kremnické vrchy)	30,70	A(B)	b	710-770	4+5
34.	Èierna Lutiša (Kysucká vrchovina)	27,06	B(C)	b	665-904	4+5
35.	Klak (Malá Fatra)	85,71	B(A)	a(b)	1050-1350	4+5
36.	Mokrá (Stratenská hornatina)	60,20	B(C)	a	950-1188	4+5
37.	Kysel (Stratenská hornatina)	21,00	B(A;C)	a	493-1000	4+5
38.	Sokol (Stratenská hornatina)	240,00	A(B)	a	610-1138	4+5
39.	Dobroèský prales (Slov. Rudohorie)	101,82	A(B)	a	700-1000	4+5+6
40.	Stuzica (Bukovské vrchy)	761,49	A	a	650-1220	4+5+6
41.	Vel'ký Javorník (Javorníky)	13,95	B	S(b)	1000-077	5
42.	Hronèokov Grúò (Polana)	55,22	A(B)	a	659-950	5+6
43.	Juráòova dolina (Záp. Tatry)	120,00	B(A,C)	a(b)	750-1300	5+6+7
44.	Klenovský Vepor (Slov. Rudohorie)	129, 94	A(B)	a(b)	1100-1339	5+6+7
45.	Korbelka (Velká Fatra)	86,10	A(B)	a	625-1000	5+6
46.	Korniezová (Velká Fatra)	84,05	A(B)	a	908-1254	5+6
47.	Kundraèka (Velká Fatra)	115,79	B(A)	a	900-1280	5+6
48.	Lipová (Velká Fatra)	31,27	A(B)	a	950-1260	5+6

Table 4, continued. Virgin or natural forest reserves in Slovakia.

No	Forest Reserve (geographical unit) Objects not protected according of the nature Protectin Act	Size ha	Degree of origin	Degree of danger	Altitude (m)	Veg. level
49.	Lubietovský Vepor (Polana)	124,60	A(B)	a	950-1277	5+6
50.	Malá Stozka (Muráòska Platina)	59,61	B(A)	a	805-1204	4+5
51.	Padva (Velká Fatra)	325,46	A(B)	a	850-1440	6+7
52.	Pod Latiborskou holou (Nízke Tatry)	88,27	A(B)	a	830-1280	5+6
53.	Chleb (Malá Fatra)	222,77	A(B)	a(b)	710-1350	5+6+7
54.	Rozsutec (Malá Fatra)	650,00	B(A)	a(b)	800-1610	5+6+7
55.	Rumbáre (Velká Fatra)	51,59	A(B)	a	825-1125	5+6
56.	Šrámková (Malá Fatra)	99,27	B(A)	a	700-1280	5+6
57.	Turková (Nízke Tatry)	107,00	A(B)	a(b)	600-900	4+5+6
58.	Velká Bránica (Malá Fatra)	184,68	B(A)	a(b)	720-1300	5+6
59.	Velká Stozka (Muráòska planina)	209,55	A(B)	a	875-1342	5+6
60.	Vtáènik (Vtáènik)	195,97	A(B)	a	1250-1345	5+6
61.	Bacušska jelšina (Slovenské Rudohorie)	4,26	B	b(c)	561	6
62.	Èierny Kameò (Velká Fatra)	34,40	A(B)	a(b)	1200-1480	7
63.	Ïumbier (Nízke Tatry)	650,00	A(B)	a(b)	1200-2043	6+7
64.	Jánošíkova kolkáreò (Velká Fatra)	45,81	A(B)	a	1175-1489	5+6+7
65.	Javorina (Vysoké Tatry)	1700,00	B(A)	b(a)	100-2206	6+7
66.	Babia Hora (Západné Beskydy)	530,33	A(B)	a	1100-1440	6+7
67.	Kotlov zlab (Západné Tatry)	46,94	A(B)	b	1250-1550	6+7
68.	Ohnište (Nízke Tatry)	420,00	A(C)	a(b)	900-1530	6+7
69.	Osobitá (Západné Tatry)	230,00	A(B)	b	1180-1680	6+7
70.	Pilsko (Západné Beskydy)	580,00	A(B)	a	1050-1557	6+7
71.	Podbanské (Vysoké Tatry)	1800,00	A,C(B)	a(b)	980-2496	6+7
72.	Polana (Polana)	685,84	A(B)	a(b)	554-1456	5+6+7
73.	Skalná Alpa (Velká Fatra)	67,46	A(B)	a(b)	1070-1420	6+7
74.	Vyšné Hágy (Vysoké Tatry)	1600,00	A(B)	b(a)	970-1898	6+7
75.	Udava (Bukovské vrchy)	52,09	B(A)	a(b)		5
76.	Chopok – Kosodrevina (Nízke Tatry)	65,00	A(B)	a	1380-1430	7

Degree of origin:

A. Very well protected – original, virgin state with no evidence of human influence (category IA)
B. Well protected – original state with minor human influence (cutting of individual trees) or recently damaged by natural catastrophes (category IB)
C. Natural forest which could have been influenced by human activity long ago or with evidence of human influence, damaged by larger natural catastrophes (category II)

Degree of danger:

a. Virgin forest or State nature reserves not endangered by human influence
b. Virgin forest or State nature reserve partially endangered due to human impact. If protection of these forest reserves is not improved they will decline (Korpel', 1989).

Vegetation category:

1. oak, 2. beech-oak, 3 oak-beech, 4 beech 5 fir-beech, 6-spruce-beech-fir and 7 spruce forest

eastern Slovakia. They are considered overmature, unproductive forests and hence, will be subject to increased exploitation in order to transform them into normal (systematically) managed forests. Only those which belong in the category of strict reserve areas (national parks or national natural reserves) will be preserved in the near future.

Virtually all forest reserves established in Slovakia prior to 1950 were instigated by the State and most forest reserves were established after 1950, i.e. in the time when all forests of Slovakia were still State-owned. At present, approximately 15% of all forest reserves are privately-owned, as a result of recent political developments. In private forest reserves, restrictive silvicultural practices are initiated by the owner. In mountain forest reserves the primary threat to them emanates from pollution in various forms, and from insects (especially Ips typographus).

5. FOREST CHARACTERISTICS

Forest management is governed by State enterprises, whose founder was the Ministry of Ground management. The second largest sector of the forestry industry (non-State) is made up of newly constituted private companies and individuals. The average area of State forest enterprises is 400,000 ha. The average area of the non-State sector is dependant on ownership status and is as follows: private forests – 5 ha, consortium forests – 120 ha, municipal and urban forests 600 ha.

The private owners union, which is operated through regional branches, represents the interests of private, community and municipal forest owners in the Slovak Republic. Land-uses in the Slovak Republic

- Agricultural land 49.9%
- Other areas 5%
- Built-up areas 2.6%
- Water bodies 1.9%
- Forest land 40.6%

Table 5. Development of forest land resources in 1950-1995, in mill. ha.

	1950	1960	1970	1980	1990	1995
Timberland	1,49	1,74	1,78	1,82	1,88	1,89
Forest land resources	1,5	1,75	1,8	1,85	1,95	1,896

Table 6. Development of forest categories in Slovakia in 1970-1995, stand areas in th. ha.

	1970	1990	1995
Commercial	1423	1367	1330
Special- purpose	163	224	273
Protection	210	250	261

Table 7. Changes in forest composition in Slovakia in 1970-1990, in mill. m^3.

	1970	1980	1990
Conifers	153.8	168.6	180.7
Broadleaves	129.9	150.1	177.2
Total	293.7	318.7	358.1

Table 8. Percentage age structural development of forests in Slovakia in 1950-1993.

	1-20	21-40	41-60	61-80	81-100	101-120	120+
1950	25	23	22	14	9	7	0
1970	19	23	22	18	10	6	2
1980	16	21	21	20	10	6	5
1990	17	15	22	21	14	6	5
1993	17	14	22	21	15	6	5

Table 9. Volume of harvested timber in Slovakian forests (mill. m^3) in 1950-1990.

Year	Restorative	Cultivation
1950	3,37	0,54
1960	3,27	0,74
1970	3,47	1,45
1980	3,83	1,49
1990	3,97	1,19

Table 10. Average annual volume of harvested timber. (mill. m^3).

Year	Regular	Iregular	Total
1961-70	3,60	1,67	5,27
1971-80	4,42	1,12	5,54
1981-90	3,74	1,90	5,64
1991-92	2,39	1,83	4,24

A. Tables 5-10 outline the framework within which research is conducted.

B. Long-term research objectives

1. Structure and development of forest stands – number of trees, standing stock/tree species mix
2. Growth and yield potential of tree species
3. Regeneration processes
4. Elucidation of the life cycle of virgin forest

Table 11. The structure of detailed investigations of selected virgin forests in Slovakia.

Name of the virgin forest	Area (ha)	Vegetation zone proportion by area in %	Degree of preservation of the original state	Lasting of research since the year	Number of permannt experimental plots/total area
1. Jurský Šúr	350	1.(100 %)	B(C)	1972	3/1.5 ha
2. Boky	176.39	1.(35%), 2.(55%),	A(B)	1974	3/1.5 ha
3. Kašivárová	19.46	3.(10%)	B(C)	1966	3/1.5 ha
4. Sitno	45.49	2.(65%), 3.(35%)	A(B)	1979	3/1.5 ha
5. Havešová	81.51	3.(75%), 4.(25%)	A	1979	3/1.5 ha
6. Kyjov	53.40	4.(100%)	A	1963	4/2.0 ha
7. Raštúò	109.01	4.(100%)	B(C)	1975	2/1.0 ha
8. Rozok	67.13	3.(75%), 4.(25%)	A	1970	3/1.5 ha
9. Badínsky prales	30.70	4.(85%), 5.(15%)	A(B)	1957	4/2.0 ha
10. Dobroèský prales	101.82	4.(70%), 5.(30%)	A(B)	1958	6/3.0 ha
11. Stuzica	659.40	4.(30%), 5.(50%),	A	1971	8/3.0 ha
12. Hronèokový grúò	55.22	6.(20%)	A(B)	1962	3/1.5 ha
13. Ïumbier (Kosod.)	650.00	4.(30%), 5.(40%),	A(B)	1976	3/1.5 ha
14. Kotlina pod Babiou horou	530.33	6.(30%)	A(B)	1976	4/2.0 ha
15. Kotlov zlab	46.93	5.(55%), 6.(45%)	A(B)	1968	3/1.5 ha
16. Pilsko	809.33	6.(15%), 7.(85%)	A	1977	4/2.0 ha
17. Polana	685.84	6.(15%), 7.(85%)	A(B)	1974	3/1.5 ha
18. Skalná Alpa	67.46	6.(10%), 7.(90%)	A(B)	1981	4/2.0 ha
19. Vysoké Tatry (Nefcerka)	1800.00	6.(25%), 7.(75%)	A,C(B)	1958/59	2/2.0 ha
		5.(15%), 6.(50%), 7.(35%)			
		6.(30%), 7.(70%)			
		6.(15%), 7.(85%)			

A = forest which has been continuously preserved in an original, virgin state without any traces or evidence of anthropogenic influence. **B** = well-preserved original state with some traces of the anthropogenic influences on parts of the reserve. Recently affected by a small-scale natural calamity. **C** = virgin forest possibly affected by human activities in the past, or with evidence of more recent appreciable anthropogenic influences. Affected by a large-scale natural calamity.

C. Measured and evaluated biometric traits

Permanent experimental plot located outside transects plus analyses of all trees on the plot with DBH of all trees greater than 8 cm. Measured traits:

- diameter at breast height (d 1.3) (cm)
- height (h) (m)
- sociological class
  1 predominant
  2 co-dominant
  3 suppressed intermediate
  4 suppressed
- stem quality (A, B, C, R following Priesol 1973)
- crown quality and length (1, 2, 3)
  1 – good, length of 1/2 to 1/3 of the tree height
  2 – medium, length of 1/3 to 1/4 of the tree height
  3 – short, length less than 1/4 of the tree height
- degree of sucker formation (for oak, eventually beech, hornbeam)
  1 – low (1 to 2 suckers per 1 m of the stem length)
  2 – medium (3 to 5 suckers per 1 m of the stem length)
  3 – high (6 and more suckers per 1 m of the stem length)
- stem damage (forking, cancer, frost break, rot, broken leader, bare leader, mechanical damage, browsing)

Transect measurements

- stability of trees using two co-ordinates (x, y)
- tree height
- height where crown development begins
- crown radius (x1 to x4)
- diameter at breast height (d1,3) of all trees greater than 1 cm
- regeneration processes: noting of individuals originating from natural regeneration according to tree species and using the following height classes:

1. height up to 20 cm
2. 21 to 50 cm
3. 51 to 100 cm
4. 101 to 200 cm

Individuals with DBH of 1 to 7 cm (diameter classes of 1 cm) are assessed. In all permanent experimental plots, lying and standing dead trees are noted (necromass). For trees lying on the ground, the following classification system is used (KorpeL' 1989)

a) recently fallen trees, the wood is sound with intact bark; tree species can be easily determined
b) the wood is rotted, bark is crumbling, tree species can still be determined
c) advanced decay, tree species cannot be determined

For determining the tree volume, Huber's formula is used:

$$V = \frac{\pi}{4} \bullet d^2_{(1/2 \cdot l)} \bullet l$$

where $d_{(1/2 \bullet l)}$ is the diameter of the fallen stem in the middle of the length, l is the stem length. The interval of measurement will generally be 10 years.

New research goals:

1. Investigation of the regeneration processes in spruce virgin forests (Babia hora, Pilsko, Kotlov zlab, Polana) under different pollution stress. Interval of measurements one year (1997, 1998, 1999).
2. Changes in soil chemical composition during the 20-year period in spruce virgin forests under a strong pollution stress (Babia hora, Pilsko).
3. Physiolgical processes in spruce virgin forests (Babia hora, Pilsko) as evaluated by the methods of potential acidity, dry-mass extracts and conductivity of dry-mass extracts (1995, 1997, 1998)

The Principal, most relevant research teams

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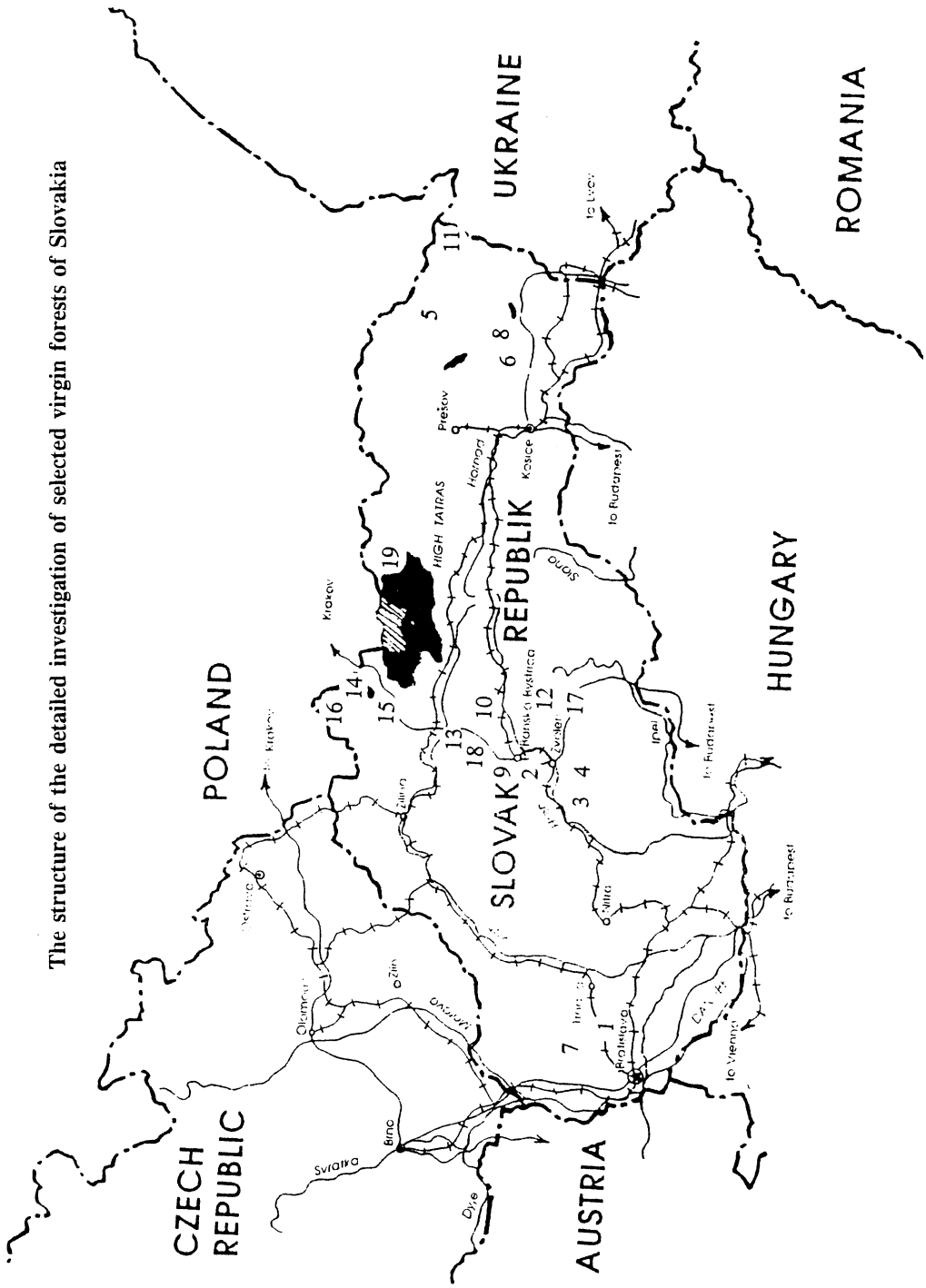
APPENDIX I: THE STRUCTURE OF THE DETAILED INVESTIGATION OF SELECTED VIRGIN FORESTS OF SLOVAKIA



The structure of the detailed investigation of selected virgin forests of Slovakia

SLOVENIA

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1. INTRODUCTION

1.1 Historical perspective

There is a long tradition of organised forest protection in Slovenia. The first forest reserves were established between the years 1887 and 1894 in the extensive intact forest area of Rog, located in the southern part of Slovenia. By 1973, a total of 343 hectares of old-growth forests were protected and excluded from utilisation.

During the 1970s, it became apparent that the existing forest reserves network was not large enough, because it did not cover the range of different Slovenian forest types. At that time, a comprehensive project, aimed at expansion of the existing forest reserves network, was launched by Professor Mlinšek. The following factors were considered in the formation of the reserves network:

1. future long-term research goals, including research on human impact on forest ecosystems and its natural ways of regeneration (succession pathways);
2. phytogeographical division of Slovenia;
3. distribution of important forest sites in Slovenia;
4. untouched forest sites and stands, except for special research goals;
5. size (a minimum area of 20 ha was decided).

As a result of the project, a network of 173 forest reserves, covering an area of 9,040 ha and including all the important Slovenian forest sites, was organised and protected by the government. Also, a database including all important basic data about forest reserves was created and published.

By 1995, the forest reserves network had been expanded to include 10,420 ha and a total of 186 forest reserves, which is approximately 1% of the Slovenian forest area (Fig. 1). Together with protective forest, forest with subordinate productive functions and ecocells, the forest reserves represent an important network of relatively

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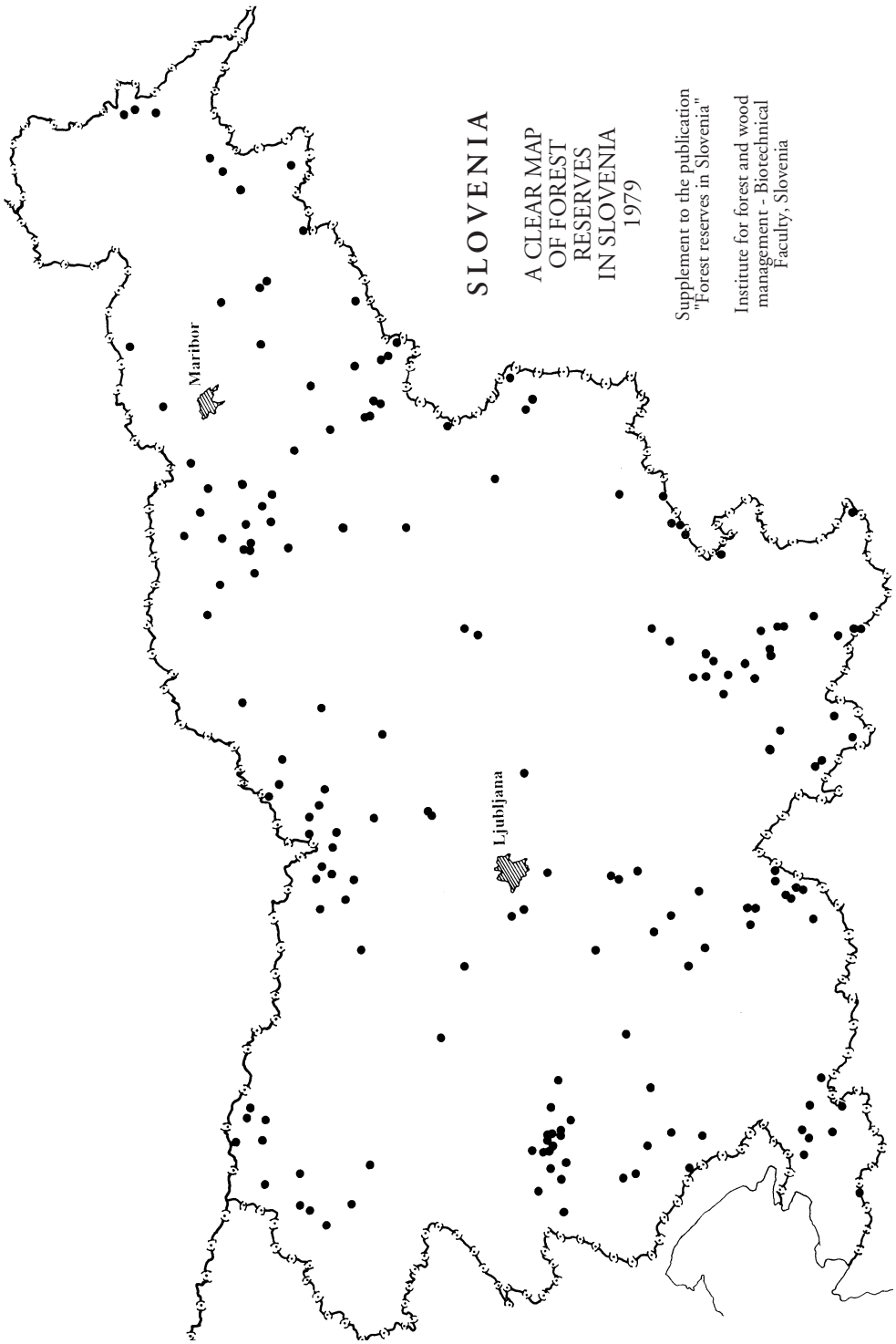

Figure 1. Map of forest reserves in Slovenia.

undisturbed natural systems and provide an important basis for the development of close-to-nature silviculture. The forest reserves in Slovenia have the status of "total reserves", which means that they are totally secured and protected by State law.

1.2 Ownership

After the conclusion of the recent process of denationalisation, the majority of the forest reserves will remain as State property, and for the rest there will be appropriate compensation under the Forest Act.

1.3 The purpose of forest reserves

Forest reserves in Slovenia are intended to serve as areas for research purposes and nature conservation. In addition to the study of undisturbed nature, the research in its broader sense also includes a study of human impact on forest ecosystems with pathways of natural regeneration, and the transfer of new research findings into practice, education and society.

1.4 Research approaches

Forestry research concerning mainly stand structure and stand dynamics was characteristic for the first research period (1882-1950). Full inventory methods were usually applied.

During the second period (1951-1980), long-term research on stand structure continued and a new network of permanent sample plots was established. In addition to forestry research, other groups of scientists, including phytocoenologists, zoologists (especially ornithologists) and mycologists, showed coniderable interest, although their research was not linked to forestry.

In the third and most recent research period, there is an emphasis on interdisciplinary and comparative research into forest reserves and managed forests on similar sites.

2. APPLYING RESEARCH RESULTS INTO SILVICULTURE

2.1 How does it work?

Transfer of research results into practice is obtained by tight co-operation between research, practice and education. This is primarily achieved through a network of workshops in Slovenia. Workshop preparatory teams always consist of faculty staff and field foresters.

2.2 What are the results?

- more than a hundred workshops, meetings and conferences
- an increase in the self-education abilities among the forestry staff
- close-to-nature managed multipurpose forest in Slovenia

2.3 Some examples

- integration of natural succession patterns in a conversion strategy of lower forests which are developing on abandoned agricultural land
- research into the structure and dynamics of dead biomass in old growth forests and development of guidance for managed forests
- comparative research into the patterns of natural disturbances and regeneration in old growth and managed forests

3. MOST IMPORTANT ONGOING RESEARCH INSTITUTIONS, RESEARCH GROUPS, PROJECTS

3.1 Research institutions:

I Biotechnical Faculty
Department for forestry
Unit for Silviculture
Vecna pot 83
1000 Ljubljana
Slovenia

II Slovenian Forestry Institute
Vecna pot 2
1000 Ljubljana
Slovenia

3.2 Research groups:

I/1. Prof. dr. D. Mlinšek
Prof. dr. S. Horvat-Marolt
Dr. J. Diaci
mag. D. Robi
mag. A. Boncina
M. Debeljak

I/2. Prof. dr. M. Adamic
II/1. dr. H. Kraigher

3.3 Ongoing research projects:

Research group I/1:

- Research into the structure and dynamics of old-growth forests in Slovenia (long-term research).

- Comparative research into the patterns of natural disturbance and regeneration in old-growth and close-to-nature managed forests.
- Responses of beech (*Fagus sylvatica* L.) to stress: research on homeostatic characteristic of beech trees and beech stands.
- New growth of virgin forest Pecka: research on the dynamic process within the new growth of silver fir (*Abies alba* L.) and beech (*Fagus sylvatica* L.)
- Entropy of forest, particularly entropy of natural (virgin) forest ecosystem: research of the flows of entropy, exergy and emergy through the virgin forest ecosystem.

Research group I/2:

- International project about protection of brown bear in Europe with BOKU Vienna, Forestry Faculty of the University in Munich.

4. MAINTENANCE OF FOREST RESERVES

Forest reserves are equipped, managed and maintained by the Slovenian Forest Service and are supervised in co-operation with the Biotechnical Faculty in Ljubljana. The reserves, like other forests, are inspected by corresponding inspection services, as well as by the Institute for Nature Conservation of Slovenia (Fig. 2).

Any exploitation, recreation, research and other activities, which would in any way change the natural situation and influence natural development in the future, are prohibited in the reserves. In the case of natural disturbances, no intervention is allowed

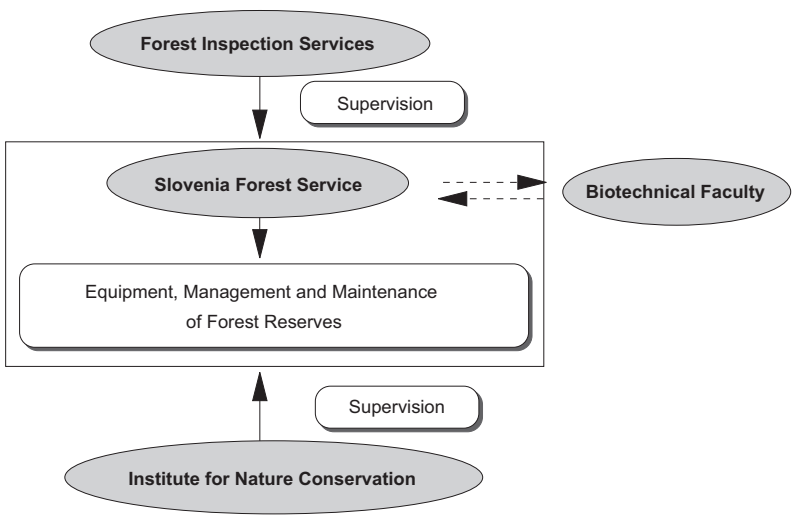

Figure 2. Maintenance of forest reserves in Slovenia.

in the reserves. Each forest reserve is surrounded by a protective zone, the height of which equals at least the height of a mature stand, not less than 30 meters. All the research methods employed must be undestructive. The co-ordination of research work is performed by the Biotechnical Faculty, Chair for Silviculture in Ljubljana.

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SPAIN

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ABSTRACT

Forests cover approximately 25% of Spain, but the majority of them have been severely impacted by human activities. Natural forests possessing the main features and functions of original forests are extremely rare. A substantial number of protected areas (approx. 500) have been stabilised in the past 15 years. The area concerned is approximately 3 million hectares or 5.75% of the whole country. Of these, 175 are protected forests and 87 are Forest Reserves.

Specific research and monitoring programmes in natural forests are very few. Research efforts are centred on fire ecology, silviculture, nutrient cycling or physiological studies.

1. FORESTS OF SPAIN

Biogeographic factors confer a high diversity of potential natural forests in Spain due to the influences from the Mediterranean, Euroriberian and Macaronesian regions. As a

Table 1. Number of phytosociological associations associated with natural forests in Spain. Distribution by biogeographic regions and bioclimatic zones.

Euroriberian Region		Mediterranean Region		Macaronesian Region	
Subalpine	4	Oromediterranean	4	Mesocanarian	9
Montane	22	Supramediterranean	24	Termocanarian	4
Coline	5	Mesomediterranean	13		
Total	31	Total	41	Total	13

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result, Spain has 72% of the priority habitats listed in the European Union Habitats Directive. According to Rivas Martínez (1987) there are 84 zonal phytosociological associations associated with natural forests throughout the State.

The natural environment has been extensively transformed and severely degraded by man; our present landscapes are largely the product of human intervention. Thousands of years of grazing, fire, cultivation and exploitation of forest resources have influenced whole territories to varying degrees.

According to the results of the first National Forest Inventory, ICONA (1974), about 51% of the total land area is not classified as agricultural or "monte" in Spanish. This concept includes pastures, shrublands and forests – the latter two occupying around 23% of the land area – including coppice forests, "dehesas", forest plantations and high forests (most of them being young secondary forest and managed forests). There are extreme regional differences in the extent of forest cover, ranging from 53.9% in the Bask country to 14.1% in the Canary Islands. Natural forests that contain most of the features and functions of pristine forests are very rare. On the other hand, although degradation has been severe and extensive, with around 18% of the land affected severe erosion, many forests, as well as shrublands and pastures, are of high value in terms of nature conservation, due to underutilisation, i.e. low level of human impact.

High forests only occupy 8.6% of the land area. This is relatively low and broadleaves represent only 26% of this total. There is a dominance of low-density forests: only 3.6% are dense forests with a stocking rate over 70%; 81.8% are open forests with less than 40% coverage.

Coppice forests occupy approximately 27% of the total forest area and represent 50% of all broadleaves. Some are being converted to high forests, others have been abandoned and the remainder is still managed using traditional methods.

Dehesas is the name given to open silvi-pastoral, manmade ecosystems with scattered trees occupying between 10-40% of the area, most of which is used as pasture. This type of anthropogenic ecosystem is very well suited to Mediterranean conditions, where the natural environment favours vegetative structures more suitable for firewood production and forage than for timber. This ecosystem contains around 27% of broadleaves, most of it being *Quercus ilex*.

Alluvial forests are scarce, fragmented and modified but their ecological importance in Mediterranean countries is very significant because of their unique character in a landscape where drought is a limiting factor. Alluvial forests are also important as natural corridors, as well as providing a protective function for river margins.

Artificial plantations represent a significant proportion of tree cover, i.e. approx. 21%. Roughly 85% of these are conifers, the balance is composed of eucalypts and poplars. The vast majority of these plantations are commercially oriented for wood production and for the restoration/protection of degraded and eroded land. Such plantations are often highly criticised for environmental reasons: species selection frequently excludes natural species. However, extensive soil degradation limits opportunities for species diversification; dense conifer plantations have low species diversity and are prone to forest fires. Frequently used establishment methods, such as terracing, produce high environmental impacts. Most of these plantations were established during the period 1950 to 1970. Data on forest types and principal tree species are displayed in Table 2.

Table 2. Forest area by species and forest types (ha). % 1: percentage of total national land area. % 2: percentage of total forest area.

Especies arbóreas	High forest	Coppice with standards	Alluvial forest	Dehesa	Coppice	Plantation	Total	% 1	% 2
Pinus pinaster	649,478	765				610,410	1,260,653	2.5	10.7
Pinus halepensis	804.946					334,518	1,139,464	2.3	9.7
Pinus sylvestris	436,722	1,011				342,074	779,807	1.5	6.6
Pinus nigra	382,137	384				161,765	544,236	1.1	4.6
Pinus pinea	178,285					106,046	284,331	0.6	2.4
Pinus insignis	4,375					239,221	241,596	0.5	2.0
Juniperus spp.	123,684						123,684	0.2	1.0
Pinus uncinata	58,504					6,556	65,060	0.1	0.6
Pinus canariensis	51,886					11,835	63,721	0.1	0.5
Abies spp.	6,291						6,291	<0.1	<0.1
Larix spp.						4,372	4,372	<0.1	<0.1
Other conifers	359,643	256,234	865			231,216	847,958	1.7	7.2
Total conífers	3,055,951	258,394	865			2,048,513	5,363,723	10.6	45.5
Quercus ilex	120,377	39,382		1,290,699	1,438,883		2,889,341	5.7	24.5
Quercus pyrenaica	100,494	56,693		58,913	368,657	640	585,397	1.2	5.0
Quercus suber	12,361	758		114,748	238,676	304	365.847	0.7	3.1
Quercus faginea	57,561	14,355		27,652	181,826		281,394	0.6	2.4
Fagus sylvatica	254,836	11,554		141	8,914	642	276,137	0.6	2.3
Eucaliptus spp.						225,234	0.4	1.9	
Quercus robur+Petraea	105,212	8,904		1,125	31,854		147,095	0.3	1.2
Castanea sylvatica	83,291	40,158	36	9,474	23,533	66	126,558	0.3	1.1
Populus spp.	128		30,492			35,357	65,977	0.1	0.6
Olea spp.	2,388	62		178	35,337		37,965	<0.1	0.2
Laurisilva spp.	18,850						18,850	<0.1	0.2
Betula spp.	4,944	1,715	72		662	149	7,542	<0.1	<0.1
Other broadleaves	342,987	163,415	128,789	131,093	340,289	20,801	1,127,374	2.2	9.6
Total broadleaves	1,103,479	306,996	159,389	1,633,023	2,668,631	283,193	6,154,711	12.2	52.2
Mixtures (conífers+broadleaves)	162,718	27,675				82,771	273,164	0.5	2.3
Total forest area	4,322,148	593,065	160,254	1,633,023	2,668,631	2,414,477	11,791,598	23.3	100
% forest surface	36.7	5	1.3	13.9	22.6	20.5	=100		
% total national area	8.6	1.2	0.3	3.1	5.3	4.8	=23.3		

Source: National Forest Inventory 1974, ICONA

Strict natural forests that retain features and characteristics of original forests are very rare. They are often located in inaccessible or marginal areas and in many cases, are still without effective protection and are subject to degrading actions and pressures. Perhaps the best ancient forests are non-Mediterranean; they are found in the Pyrinees, Cantabric, Northwest mountains and in the Canaries. Examples of seminatural forests are old growth forests of fir (*Abies alba*) at the Vall d'Aran and Vall d'Aneu in Catalonia and *Pinus uncinata* at some locations in the Pyrenees; pinsapo fir (*Abies pinsapo*) in Sierra de Grazalema; *Juniperus thurifera* in the Iberian range; *Pinus nigra sp. salzmanii* in the Cazorla and Segura sierras; *Pinus sylvestris* in Guadarrama Sierra; *Pinus canariensis* and *laurisilva* in different areas of the Canary Islands mountains; oaks (*Quercus robur*) in the Cantabric and northwestern areas (for instance Eume valley and Muniellos, Ancares and Caurel sierras); Beech (*Fagus sylvatica*) in the Cantabrian and Pyrinees ranges (Somiedo, Irati, Ordesa). Mediterranean-type forests of *Quercus ilex, Quercus suber, Pinus halepensis*, etc. occupy important forest areas but are usually disturbed and degraded. Nevertheless, some good examples of Mediterranean forest remain (Cabañeros National Park, los Alcornocales Natural Park, Sierra Madrona etc.).

Although there are no definitive records for these natural or near natural ecosystems, it can be said that strict natural forests do not amount to more than 30,000 hectares in Spain. Hence, these natural formations could be considered as relicts.

The present lack of reliable statistical data does not imply that further information could not be readily obtained. Although there are no specific nation-wide inventories to evaluate natural forest, as in other countries, exploring existing, more general inventories could easily provide a better evaluation of the current situation.

Thus, the Spanish forest map which was published at a scale of 1:200.000, but created at a scale of 1:50.000, and which is included in a digitised national nature data bank, could easily provide further information on this subject. In this inventory each "tesela" – that is, the smallest area of homogeneous forest cover – is described in a structural/climatic vegetation system subdivided into types characterised by the composition of dominant species or groups of species in the main stratum. The different successional stages, which to some degree can be a measure of naturalness, are also taken into account. Although the utilisation this system for the evaluation of natural forests presents some difficulties, it is undoubtedly a potentially useful instrument.

Other useful information may be provided by the second National Forest Inventory, which was carried out on a sampling intensity of one sample per 100 hectares and which provides useful information, such as forest status development, crown cover, types of human activities, legal conservation status of the area, and different structural forest measurements such as density, diameter classes, volume, etc.

Table 3. Standing volume and increment.

	Conifers	Broadleaves	Total
Total (m^3)	271,656,043	185,064,992	456,721,035
Annual increment (m^3/year)	21,714,783	9,622,268	31,337,051
Volume m^3/ha	50.6	30.1	38.7

Table 4. Evaluation of naturalness of Spanish forests.

Area of forests (ha)	11,791,598
Forests in relation to the total land area (%)	23%
Natural forests	< 30,000 ha
Seminatural forests (%)	3.0%
Moderately altered forests (%)	10%
Altered forests (%)	65%
Reforestation or plantations with exotic species (%)	21%

Another instrument of evaluation that will soon be available, is the inventory of habitats as defined by Annex I of the Habitats Directive 92/43/CEE. Although is not specifically intended for forest evaluation, it uses phytosociological associations to characterise habitats as well as a naturalness index to characterise conservation status. This will provide information on the most important remnants of natural forests and will presumably be the planning instrument used to create a network of strict natural forest reserves in the country. Despite the present information gaps a rough estimation of 'naturalness' in Spanish forests is provided in Table 4.

As an economic activity the importance of forestry is modest, its contribution to PIB being less than 1%. Annual timber extraction at the end of the eighties was almost 15 million cubic meters, whereas growth is estimated at 30 million cubic metres. Most production, i.e. 81%, is obtained from fast growing species, i.e. *Pinus insignis*, *Pinus pinaster* and Eucalyptus, although such species occupy only 18% of the total forest cover. This implies that most forests are of low productivity due to the prevalent dry Mediterranean climate, which in many cases renders other uses or products such as grazing, fuel, mushrooms, hunting, etc. more important than timber. In spite of the modest economic role of forestry in Spain, forests are of immense importance as refuges of biodiversity, playing an indispensable role in hydrological regulation, water production, erosion control, etc. Due to these factors, multipurpose objectives and low impact silvi-pastoral management in these fragile ecosystems should predominate.

2. HISTORY OF FOREST CONSERVATION AND PROTECTED AREAS

Deforestation and degradation of the forest resource has been severe and widespread. In Spanish history, the regulation of forest use was, until the 19th century, mainly focused on assuring an adequate wood supply for warship construction (Ordenanza para la conservación y aumento de los Montes de Marina, 1748). This resulted in certain limitations on other activities and imposed measures related to forest fire prevention. However, there was a lack of technical knowledge about forest practices required to ensure regeneration. The Ordenanzas were rigid and induced apathy among private forest owners. This was largely criticised by liberal politicians, but official attitudes did not change until much later when, in 1833 with the Ordenanzas Generales de Montes, all forests regulations were modified. In the 19th century, the liberal government

ordered the privatisation of most State, church and communal forests in what was called Desamortización. This resulted in intensive felling with catastrophic consequences, resulting in a low percentage of public forests remaining: today 1.2% are estate forests, 27.6% are municipal and communal forests and 71.2% are private forests.

In reaction to these events, a Catalogue of public forests to be conserved was created by the first State-employed foresters, which was approved and published in 1859. Several forest laws were approved in 1863, 1877 and 1957, and a State forest administration has been in operation since 1856.

Large scale forest planning and reforestation projects for conservation purposes were already in place by the end of the XIX century. Later, a huge reforestation program, which began in the 1940s, resulted in approximately two million hectares of reforested land, mainly composed of conifers and eucalyptus. In the seventies, due to natural and social reasons (rural crisis, etc.), an era marked by an increase in the occurrence of forest fires began. In contrast, rural abandonment has resulted in natural forest expansion.

Although the first National Parks were created in 1918, the establishment of nature reserves was relatively slow until the period 1987-1991 when a boom in the creation of protected areas occurred. Nowadays there are 489 protected areas, occupying 2,907,489 hectares, that is 5.75% of the whole country. Table 5 provides information about types, numbers and areas of protected areas according to the State Inventory of protected areas.

About 175 protected areas have forest conservation as one of their main objectives. 87 of these are Forest Reserves and they occupy 32,644 hectares. The figures given above are approximations, and can be contradictory due to problems of interpretation and normalisation caused by the profusion of protection categories that are difficult to standardise; it should be pointed out that protected areas are under the responsibility of autonomous Regions and that sufficient co-ordination measures have not yet been put into place.

The distribution of protected forest areas is not well balanced between biogeographical regions; representation in the Euroriberian region, especially in the colino belt, and in the oro and supramediterranean regions is very limited. Its must also be added that the number and extent of protected forest areas is still insufficient. Many

Table 5. Types, number and area of protected zones.

	Number	Area (ha)
Natural Park	101	2.086.970
National Park	10	132.478
Reserve	95	28.417
Reserve area	109	177.436
Protected landscape	5	4.629
Natural monument	4	2.247
Natural place	109	110.749
Others	56	361.563
Total	489	2.904.489

important small, near-natural forests are not legally protected and the impression given is that harvesting and other destructive impacts are still occurring in natural forests.

3. CONCEPTS OF NATURE RESERVES AND OTHER PROTECTED AREAS

The Spanish Law on Nature Protection (Ley de Conservación de los Espacios Naturales y de la Flora y Fauna silvestres), establishes four general categories for nature protection areas but autonomous Communities can create new ones. Within these four categories the terminology 'Forest Reserve' is not employed, but rather a more general concept of 'Nature Reserve' is used. Table 6 presents the definitions for these four national categories as well as other categories of protected areas defined by autonomic laws.

An analysis of Spanish conservation legislation reveals that there is no legal requirement to manage natural forests using non-intervention methods, nor any obligation to carry out research or monitoring, even though both objectives are practised in some protected areas. Efforts should be made to establish a legal framework for both these objectives, as well as providing for better co-ordination at national level of all natural forest conservation activities.

4. FOREST RESEARCH

Spain has a long tradition in the scientific study of forestry, dating back to the 18th century. This tradition was consolidated in the middle of the 19th century, when the School of Forestry was formed. However, forest research has been relatively modest until recent times. The activities of forest engineers have, in general, been related to management rather than research. Nevertheless, engineers and academic scientists have done excellent work in some areas. This includes botanical research and floral community inventory and description, but some aspects relevant to the understanding of ecological processes in natural or seminatural forests have received little attention, except in some Mediterranean evergreen oak and pine forests. The following is a brief review of the historical evolution of forest research in Spain. Emphasis is also placed on certain aspects of current research, which is considered relevant to the study of ancient forests.

Scientific knowledge on forestry increased when the works of Duhamel de Monceau were translated into Spanish, between 1751 and 1805. Spanish papers on forest science were first published in botanical and agricultural journals at the end of the 18th century. The Real Jardín Botanico de Madrid played an important role at this time. As a result of an increasing interest in science and technology, the Escuela de Ingenieros de Montes (Forestry School) was established in 1848. Political instability and personal conflicts within the school resulted in a lower level of scientific production than had been expected. However, the centre never quite disappeared and some important works were published in subsequent years. The School has, in fact, been the main centre of forestry

Table 6. Categories of Spanish nature reserves and other protected areas.

1. National categories

Parks / Parques
- Are natural areas, little affected by human impact, as a result of their landscape scenic value, the representivity of its ecosystems or the uniqueness of its flora, fauna or geomorphological formations, present ecological, aesthetical, educative, scientific values, whose conservation merits priority attention.
- Natural resources utilisation may be restricted, being forbidden, in all cases, if incompatible with the conservation objectives.
- Access is provided with certain necessary limitations to guarantee protection

Nature reserves / Reservas Naturales
- Are natural areas created to protect ecosystems, communities, or biological elements that because of their rarity, fragility, importance or uniqueness, deserve special status and attention.
- Exploitation of natural resources is restricted, except where compatible with the conservation of its integrity. Collection of biological or geological material is forbidden, except for education or research purposes, in which case pertinent, administrativeauthorisation is needed.

Natural monuments / Monumentos naturales
- Are areas, natural elements or formations of notorious uniqueness, rareness or beauty that deserve special protection.
- It can be considered as Natural Monuments, geological formations, paleontological deposits and other elements of the sea that are of special interest because of their uniqueness or importance in relation to scientific, cultural or landscape values.
- Natural monuments are not concerned with the protection of natural forests.

National Parks / Parques Nacionales
- Are areas, which have sufficient value to warrant conservation for the general public and for the Nation; such areas may become Parks under State Law.
- The area must represent one of the main natural ecosystems in the country.

Protected landscapes / Paisajes protegidos
- Are areas that because of its aesthetics or cultural values, deserve special protection.

2. Other categories

Strict reserve / Reserva estricta
Partial nature reserve / Reserva natural parcial
Natural reserve of wild fauna / Reserva natural de fauna silvestre
Natural Park / Parque natural
Regional Park / Parque regional
Protected natural area / Area natural protegida
Natural site / Area natura
Protection forest / Bosque protector

- The previous four categories fall within Nature conservation National law. Many other categories have been declared by the Autonomies from which a short list is provided of the most representative

learning in Spain, with respect to the large number of topics studied. A considerable effort was made by the engineers from the School to develop forest cartography (Comision del Mapa Forestal de Espña, created in 1868 and disbanded in 1887), but practically nothing was published, even though some documents were exhibited in the Barcelona International Exhibition of 1898. Unfortunately, the original documents seem to have disappeared when the Forest School building was bombed during in the Civil War (1936). The most important work remaining from this period was the Flora Forestal (1883 and 1890) by Maximo Laguna. In 1868, the journals Revista forestal and Economica y Agricola appeared, the latter existing until 1875. In 1877, the journal Revista de Montes – still published today – was published for the first time.

During the second half of the 19th century, significant efforts to improve botanical knowledge were made. These efforts were largely driven by M. Willkomm, a German botanist who analysed Spain's flora and vegetation, gave a good description of forest regions in the Iberian Peninsula and published a Prodomus Florae Hispanicae, which was the most complete botanical work carried out in Spain until recent times (the modern Flora Iberica is now published by the Consejo Superior de Investigaciones Científicas).

Bureaucratic changes resulted in less scientific activity and favoured management after the turn of the century. The most relevant effort to rebuild forest science in Spain was the creation of the Instituto Forestal de Investigaciones y Experiencias (IFIE) in 1928, with a modern approach to forest research, which included phytopathology, forest fauna, limnology and forest experimentation. However, the most prolific period of the IFIE only lasted a few years. Scientific production declined after 1932 and the consequences of the Civil War on the entire scientific effort made its recovery impossible. The IFIE survived for only a few years under Franco's dictatorship. Forest research has been transferred to the Instituto Nacional de Investigaciones Agraria (INIA), where agricultural topics are more important than forestry. However, some centres have continued to do relevant forest research within the INIA, or in institutes transferred from INIA to regional governments after 1978 (in particular, in Galicia and Catalonia), especially in topics such as timber production, wood technology, forest fires, tree pathology, etc.

Developments in edaphology and phytosociology during the present century has contributed to forest knowledge. Both disciplines have had a large number of practitioners at the Universities and at the Consejo Superior de Investigaciones Cientificas (CSIC) and have opened the door to an ecological perspective on forest functions.

At the Universities, the Madrid Forestry School, now called Escuela Técnica Superior de Ingenieros de Montes and other forestry schools in other Spanish universities develop research on a variety of forestry topics, whereas the faculties of Biology or Sciences have research teams, which are mostly concerned with naturalistic subjects (forest flora and fauna, ecology, biogeography, etc.).

The first large research effort on functional ecological processes began in 1979, with a study in the forests of Montseny and Prades sierras (Catalonia, Northeast Spain). The Montseny study area is included in the Montseny Biosphere Reserve, whereas the Prades site is within a State forest. The project was a co-operative effort, with researchers from the Universitat Autonoma de Barcelona, Universitat de Barcelona and

Universitat d'Alacant and Yale University. The objective was to analyse hydrology and biogeochemical cycles using small watersheds in areas covered by dense, homogeneous holm oak (*Quercus ilex ssp. ilex*) forests. Budgets for water, nitrogen, phosphorus, calcium, sodium, potassium and magnesium at watershed and plot levels have been established with considerable detail and primary production has been evaluated in both areas during the first phase.

A large number of other studies have been conducted in these sites by researchers of the three above mentioned Spanish universities and the Centre for Ecological and Forestry Research (CREAF), created in 1987 by the regional government of Catalonia. These include, for instance, studies on soil gas exchange, litter decomposition, ecophysiological behaviour of holm oak, forest responses to fertilisation and irrigation, in order to determine the limiting factors affecting production; root dynamics, using the minirhizotron technique, bird and insect communities, etc., some of which are still in progress.

Other functional studies include those on fire disturbance effects in holm oak forests and on forest dynamics, especially the relationship between holm oak and Aleppo pine (Pinus halepensis). However, these are not really old forests, even if Montseny, in particular, is relatively natural compared with most holm oak forests in Spain. However, the information obtained and its comparison with other sites in other countries can be useful to elucidate ecological functions in this type of Mediterranean forest.

Other studies in Spain have looked at forests from a biogeochemical point of view. The most relevant groups are a CSIC group at Salamanca, which has worked on nutrient cycles and litter decomposition in deciduous oak forests. They have also participated in some European projects. In addition, an INIA group in Madrid has worked on hydrological balances, nutrient circulation, gas exchange, and nutrient deficiency in Pinus sylvestris forests. Furthermore, a University group in la Laguna is studying laurisilva ecophysiology, etc.

With respect to general inventories and research work at National level, it should be mentioned that two detailed forest maps were made in the 1960s and 1990s, i.e. during the first and second national forest inventories, an inventory of habitats for Annex I of the Habitats Directive was carried out, and a national network of Level I and II plots as part of the European monitoring network of Forest Health observation plots was created, in addition to a detailed phytosociological map of potential vegetation communities for the whole country.

In spite of this, structural dynamic and functional studies on natural forests are still very few and far between and long term monitoring strategies with permanent plots are almost non-existent. Only the National Forest Inventory and a few inventories made for specific forest entities – mainly productive coniferous forests in the mountain ranges – are subject to forest management as in the Central European forest tradition. Silvicultural management is not practised in some of these forests because of protection needs or/and they have permanent plots, where structural and quantitative compositional information, as well as information on growth and dynamics, is obtained. A tendency in these studies is to broaden the spectrum of ecological parameters assessed, as has happened in the Catalonian Forest and Ecological Inventory.

In spite of the more obvious limitations, some monitoring programmes are beginning to work in some protected areas. Thus, the Spanish National Parks network is concerned

that research and monitoring should play a key role in conservation management. One initiative in this field is the monitoring programme of ecosystem dynamics in Garajonay National Park, which is a pilot study that will be extended to the whole National Park network in future.

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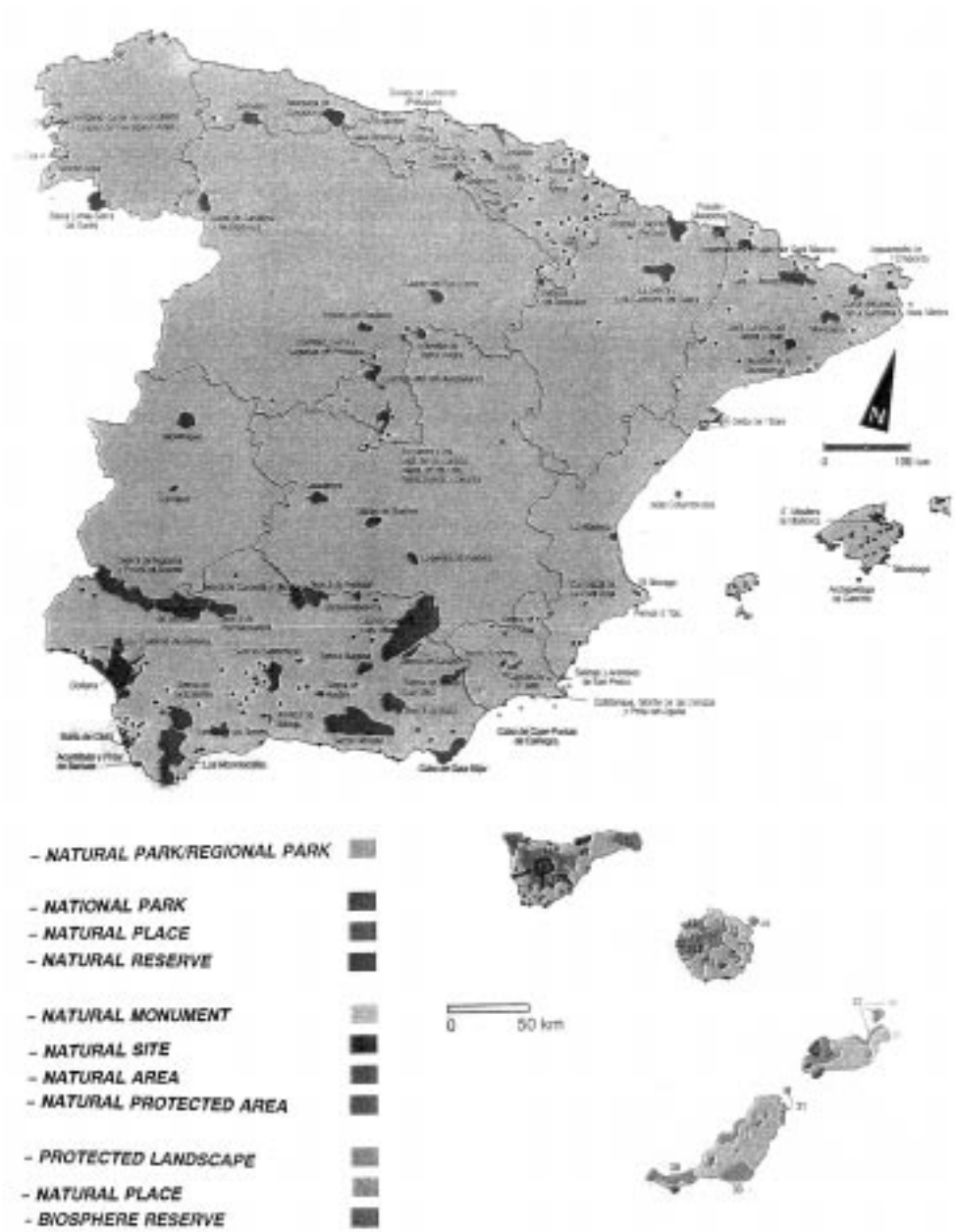
APPENDIX 1. MAP OF SPANISH PROTECTED AREAS



SWEDEN

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1. THE SWEDISH FOREST

Forests in Sweden occupy 24.4 million ha, which accounts for more than 25% of the EU total (National Board of Forestry 1996). Swedish forests have been of great importance for the welfare of the nation and its people for a considerable period of time. It was recognised at an early stage that knowledge of the forests is an essential prerequisite for their optimal utilisation. This knowledge has been obtained, to a large extent, from forest inventories. For the whole of Sweden, National Forest Inventories (NFIs) have been performed since the early 1920s. Over the years, survey methods have been changed and adapted to new conditions and demands. The most appropriate type of inventory to use depends on the forest type and the requirement for specific data for efficient decision-making.

The owner structure of Swedish forests today is as follows; 50% of the forest area is privately owned (e.g. forest farmers), 37% by companies (5 dominant ones) and the remaining 13% is owned by the public and State. The general types of forestry in Sweden can be categorised by the following keywords; multiple use, sustainable forests, and intensive management. This requires an inventory amenable to continuous change and which is trend-oriented; information from field experiments is especially relevant to the inventory. In spite of a vibrant forestry industry, annual growth is vastly under-utilised. The average standing volume of the Swedish forest estate is 119 m^3sk/ha and mean annual increment 4.4 m^3sk/ha.

Establishment of Nature Reserves

At the end of 1997, Sweden had 1,963 Nature Reserves and 25 National Parks. National Parks have been established under a law enacted in 1909. At that time it was stated that a major objective of National Parks was to enable scientific research in large areas of pristine nature to be carried out, an objective, incidentally, that has not been achieved

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to any great extent (cf. the sections on research below). A revised National Park system is in the process of being created, encompassing 33 existing, revised or new Parks (Naturvårdsverket 1989). In the new Park system, the 10 parks in the northern artic-alpine-mountain region are of less interest in the forestry context, while at least 14 Parks in other regions are more or less dominated by forests that are in, or will develop into a natural state.

The policy of establishing Nature Reserves has evolved gradually (Naturvårdsverket 1997). Up to 1964, when the first modern Law of Nature Conservation was created, most forest reserves were established by the State Forest Service without affording legal protection.

During the period 1964-72 a number of nature types were protected as Nature reserves, e.g. archipelagos, mountain areas, recreational areas, cultural landscape elements etc. A more strategic approach was introduced during the period 1972-85, which introduced nature-related inventories and conservation planning.

The first nation-wide strategic inventory of valuable forest was performed between 1978 and 1982 by a consortium which included the Environmental Protection Agency, the Regional Boards of Administration and the Forest Agency (including the Regional Boards of Forestry). A number of valuable forest areas, of varying quality, were identified and a very intense debate concerning the protection of forests followed. Conflicts between conservation interests and foresters was especially great regarding mountain forests, but many other areas elsewhere Sweden proved controversial. The resources provided for protection were insufficient, but the ongoing debate resulted in 1984, in an agreement between the State Forest Service and the Environmental Protection Agency not to perform any forestry operations in most of the identified valuable forests. In 1985 the state budget for buying land for nature protection was doubled to 40 MSEK, to 100 MSEK in 1989 and to 140 MSEK in 1991. By 1992 most of the identified forests were protected in law.

Since 1992 activities related to the creation of further Forest Reserves have continued as a result of new scientific information and an important Governmental Decision on Forest Policy of 1993. A major programme has thus been running during the period 1992 to 1996, systematically protecting valuable forests, using ca 90% of the available budget for buying land for nature protection (694 MSEK in total).

Forest protection areas and major types

The areas (in hectares) of three categories of protected forests are presented below; Nature Reserves NR, National Parks NP, State Forest Reserves and areas bought, but as of now are not yet legally protected, OTH on productive forest land (mean annual growth >1 m3) (Naturvårdsverket 1997).

The mountain forests along the Scandes are the last sizeable, (almost) pristine coniferous forests remaining in Western Europe. The Swedish mountain forests are generally in a natural, or near-natural state all along the 1000 km mountain ridge. In addition, it forms the border between Sweden and Norway. Together with lakes, mires, and bare mountains, the landscape here provides unique demands and possibilities for

	NR	NP	OTH	Total	% of productive forest land
Mountain forests	486 300	4 100	169 300	659 700	43.0
Other forests	66 500	32 210	73 910	172 670	0.8
Total	552 850	36 310	243 210	832 370	3.7

the preservation of its ecosystems. Scots pine, *P. sylvestris*, and Norway spruce, *Picea abies*, dominate together with mountain birch, *Betula pubescens* ssp. *tortuosa* – the latter forming the tree-line high in the mountains. The mountain forests are not at all uniform; low productive pine forest dominate in the southern and northern-most parts, while spruce forests are frequent in more maritime areas. At favourable sites, stands of up to 30 m in height, with high productivity occur. Frequent forest fires are rare due to the montaine climate; stands of long continuity dominate, characterised by gap dynamics due to snow and windthrows.

Boreal forests, which occur at lower altitude than forests in the mountain region, and occupy the northern half of Sweden, are generally subject to intense forestry activities. The above mentioned coniferous species dominate together with aspen, *Populus tremula* and birches, *Betula pubescens* and *B. verrucosa*. Fires, which today are more or less completely suppressed, are characteristic of this forest region. Natural, or near natural, forests that remain, exist mainly on sites where timber harvesting is difficult for various reasons, or where productivity is too low to make forestry worthwhile. In addition, regeneration must also occur for commercial forestry to be viable. Most productive and non-productive stands have been protected and the majority of forests in these reserves in this area are in the latter stages of succession. Only in exceptional circumstances have fire dynamics been reintroduced, especially in deciduous forest reserves, as well as in a few recently created burned areas.

In southern Sweden, coniferous forests occur – which do not differ greatly from boreal forest – while on richer soils, deciduous forests are the norm. A certain number of reserves have been created in coniferous forests, partly for recreational purposes. Rich hemiboreal deciduous forests in southern Sweden have generally been antropogenically influenced or even established originally as part of the old agricultural system. Although of limited area, some southern deciduous stands (elm, *Ulmus glabra*, oak, *Quercus robur*, beech, *Fagus silvatica*, ash, *Fraxinus excelsior* etc.) are considered as biodiversity hot-spots and are thus protected. The few protected deciduous forests in this region have identifiable natural features, which have persisted under long periods of human influence; such features include long continuity and gap dynamics.

The principal objective of management in Swedish forest reserves is to protect forests and allow them to develop freely. However, in practice, forest fire is controlled by the responsible authorities. The occurrence of exotic species in protected forests is negligible. The public has free access to all protected forest areas, except some small bird protection areas, and facilities for the public such as trails and information spots are frequently provided. (Naturvårdsverket 1997; Hansson 1992, 1997)

2. MONITORING AND RESEARCH ACTIVITIES

2.1 The National Forest Inventory (NFI)

The first NFI of Sweden began in 1923 and was carried out county by county utilising a strip survey. In 1953, the so-called tract-system was introduced and thereafter, all of Sweden has been assessed every year using this method. The tracts consist of clusters of plots, with each individual plot located equidistantly along the perimeter of a square. To improve monitoring of changes and trends, the design was changed in 1983 to include both temporary and permanent plots. Today, the NFI consists of an equal number of temporary and permanent tracts.

The permanent plots were established during 1983-1987 and re-measured every 5 years. Thus, those established in 1983 were re-measured in 1988, those established in 1984 were re-measured in 1989 and so on. The second re-measurement phase started in 1993. However, one of the limitations of the NFI was that forests in nature reserves and national parks were not inventoried. In order to compare protected forests and managed forests, permanent tracts were also established in nature reserves during 1994. It is intended to re-measure these tracts every 5 to 10 years.

2.2 Integrated environmental monitoring

A national network of “integrated monitoring” plots was established by SEPA during the late 1970s (Bernes et al. 1986). Integrated monitoring means measurement of a wide spectrum of ecosystem variables in small catchment areas. The network consist of 18 reference areas, evenly spread over the whole country. Natural or near natural forest is the principal Biotope in at least 15 of these monitoring areas; three are located in National Parks and the remainder in Nature reserves.

2.3 Experimental Forests of the Swedish University of Agricultural Sciences

Experimental Forests are mainly utilised by researchers based at the Faculty of Forestry at the Swedish University of Agricultural Sciences. The forests are also open for researchers from other universities, as resources allow. Personnel are stationed at the forests throughout the year and each Experimental Forest has a scientific leader.

When the first Experimental Forests were established, it was decided to encourage a broad range of activities. Considerable resources were put into inventories of geology, soils, vegetation, forest stands, etc. and meteorological stations were also established. Over the years, hundreds of field experiments have been established. Some of the research plots have been studied for close to 70 years. This continuity in studying forest stands makes the Swedish Experimental Forests unique in a global context. A wide variety of field experiments can be provided for by the forest staff in each location. They are also responsible for the establishment, management and inventory of research plots. Changes in factors concerning vegetation, forest stands, soil, water and climate are monitored as part of long-term research programmes.

The Experimental Forests were established at the following locations and in the following order:

- Siljansfors 1921
- Svartberget and Kulbäcksliden (Vindeln) 1923
- Tönnersjöheden 1923
- Ätnarova 1961
- Jädraås 1979
- Asa 1988
- Skarhult 1989

Below follows a brief description of the different Experimental Forests. The total area of Siljansfors Experimental Forest is 1520 hectares, of which 1390 is fertile forest land. The field experiments are directed towards the study of stand development and influence on the forest environment when using:

- alternative spacing of stems at cleaning and thinning
- different cleaning and thinning methods
- single tree selection
- different tree species
- pruning
- different provenance's
- fertilisation
- shelters
- alternative regeneration methods
  Climate, water quality and vegetation are all studied in long-term programmes.

The area of Svartberget and Kulbäcksliden Experimental Forests is 2531 hectares, of which 2093 hectares is fertile forest land. The first experimental plots were laid out in 1909. Current activities include applied, as well as basic research. The field experiments are directed towards the study of:

- pollution effects on trees
- pollution effects on ground and surface water
- occurrence of caesium in plants and animals
- climate in forest lands
- different regeneration methods
- yield and environmental effects of different tree species
- yield and viability of alternative plant provenance's
- fertilisation effects
- Climate, hydrochemical budgets and alternative methods for measuring environmental quality are studied in long-term programmes.

The total area of Tönnersjöheden Experimental Forest is 1143 hectares, of which 979 hectares is fertile forest land. The Experimental Forest was established in 1923 to endeavour to improve the productivity of Calluna heathland areas and poorly productive broad-leaved forest stands. The field experiments today are directed towards the study of:

- yield from different Swedish tree species subjected to alternative treatments
- yield from alternative exotic tree species
- alternative regeneration methods
- damage from different insects and fungus
- air pollution effects on soil and forest stands
- effects of different kinds of impregnation chemicals.

The total area of Ätnarova Experimental Forest is 3560 hectares, of which 2400 hectares is fertile forest land. The field experiments are oriented to the study of:

- micro-climatic change after clear-cutting
- climate influence on seedlings and trees
- yield and environmental effects of alternative tree species
- yield and quality of timber with different stem spacings
- effects on seedlings and the environment from alternative scarification methods
- planting using shelter
- single tree selection
- influence of genetics and environment on yield and quality

The total area of Jädraås Experimental Forest is 360 hectares, of which 275 hectares is fertile forest land. Today, the following activities predominate:

- preparing, measuring and weighing biomass samples
- chemical analysis of needles
- climate measurements
- chemical analysis of air and precipitation
- fertilisation and irrigation experiments
- measurement of organic debris
- peatland biomass forestry for energy.

The total land area of Asa Experimental Forest is 1110 hectares, of which 908 hectares is fertile forest land. The field experiments are oriented towards the study of:

- fertilisation and irrigation of forest land
- seedlings, insects, vegetation, and climate in shelterwood and clear-cut areas
- alternative scarification methods
- alternative seedling types
- regeneration on birch on arable land
- growth from different clones
- thinning
- studies of water, vegetation, and forest growth after liming
- alternative methods of measuring environmental quality

The total area of Skarhult Experimental Forest is 180 hectares, of which 176 hectares is fertile forest land. The forest stand is dominated by oak, beech and ash and the intention is to study management and ecology of broad-leaved deciduous forest.

Research on stand dynamics

Research on forest stand dynamics include studies on tree growth and mortality, and regeneration/re-growth of new trees, in both uneven-aged and even-aged stands. Ongoing research also include studies on the effects of shelterwood systems, i.e. both pine and spruce, studies on single-tree selection in spruce forests, selective harvesting in various forest types, enrichment planting without scarification, and modelling of stand development and tree growth. Several of the studied systems/methods may provide applicable material with respect to maintaining biodiversity in managed forests. In this regard, they are of considerable interest as alternatives to traditional silvicultural methods.

Nature conservation research

It is regrettable that scientific research has not been systematically applied in the Swedish National Parks. One notable exception is the Abisko National Park, which is an alpine park; the Royal Academy of Sciences manages a very well equipped scientific station adjacent to this park. Furthermore, study plots on forest fire sites have been established and analysed in Muddus NP. A permanent monitoring system consisting of 1143 plots was described in 1994-95, with respect to forest data, dead wood, forest fire indicators, food availability and grazing pressure due to moose and reindeer, etc. (cf. e.g. Engelmark 1984).

Several approaches to nature conservation research-related studies on natural forests can be found, ranging from inventories to experimental and functional studies. The Swedish Environmental Protection Agency (Swedish EPA) have conducted two research programmes:

“The importance of remnant biotopes for fauna and flora 1984-1995”, (Ericson et al. 1990). This programme, managed by the Swedish EPA, was primarily designed to complement ongoing conservation research focusing on individual, threatened species. A major emphasis was put on the fragmentation of natural forests and processes associated with edge effects (changes in predation or herbivory, climate effects, etc.). Event-based processes such as dispersal and metapopulation dynamics were addressed. Here, studies on the conservation of plant genetics has been a major contributor to the national research programme on genetic conservation and biological research. The results of this research programme and other related projects are presented in Hansson (1992). This research programme, which is relatively well-funded, could afford to carry out basic research, in addition to applied research. Subsequently, an international evaluation on the quality of the programme was thus, very favourable (Harris et al. 1989) and the impact of the expertise derived from it on, for example, Swedish forestry policy is very apparent.

“Indicators of biodiversity in the forest landscape” was a follow-up programme financed by the Swedish EPA in 1996-1998 (Hansson et al. 1996). The primary objective of this programme is to establish a set of indicators of forest biodiversity for

environmental monitoring and nature conservation planning. More precisely, the research shall test the effectiveness of different species and/or habitat structures in reflecting the state of biological diversity of the landscape. A number of long-term research projects, partly established under the Swedish EPA research programmes should additionally be mentioned:

- Epiphytic lichens in coniferous forests as environmental indicators
- Responsible scientist: Per-Anders Esseen, Umea University, Dept. of Ecological Botany
- Plots have been established in the following areas of natural forest (including Nature Reserves): County of Västerbotten: Kulbäcksliden and Svartberget Experimental Forest,
- Alpliden, Stenbithöjden, Gardfjället, Kirjesålandet NR County of Norrbotten: Luottåive, Granlandet NR.
- Landscape structures in boreal forests: importance for epiphytic lichen dispersal
- Responsible scientist: Per-Anders Esseen, Umea University, Dept. of Ecological Botany
- Plots have been established in the following areas of natural forest (including nature reserves and one National Park): County of Västerbotten: Alpliden NR, County of Norrbotten: Muddus NP, Jelka-area, Reivo NR, Sördöttern NR, Serri NR.
- Long-term change in a standing crop of a threatened forest lichen, Usnea longissima
- Responsible scientist: Per-Anders Esseen, Umea University, Dept. of Ecological Botany
- Plots have been established in the following areas of natural forest (including Nature Reserves and one National Park): County of Västernorrland: Malungsfluggen NR, Storberget NR, Skedviksbodarna NR, Skuleskogen NP

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RUSSIA

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1. INTRODUCTION

The current focus of forest management has undergone a shift away from the traditional approach, i.e. increasing forest productivity, to ecologically and environmentally-oriented forestry. This change of emphasis requires a new scientific basis in forestry. Because of this new ecological approach, sustainable forest management must focus on natural, old growth and unevenaged forests. Therefore, research in natural forests – both protected and managed – is of great importance in identifying the practical tools for sustainable forestry. This creates a new challenge for research goals and programme development in Russia's natural boreal and temperate forests. However, at present, Russian forestry is not sensitive to new ideas and approaches, due to the current transitional economic situation.

2. HISTORY OF FOREST RESERVES IN RUSSIA

The first serious attempt at forest protection in Russia was the so-called Trans-Oka Defence Barrier (Zaokskie Zaseki), which was established south of Moscow during the 1520. It was a 700 km long and 2 to 5 km wide dense, broad-leaved forest area, which prevented attacks from the steppe nomadic tribes. It had special wooden barriers on the southern forest border. Tree harvesting, haymaking, and even forest recreation were banned. By the 1670s, Zaokskije Zaseki had lost its military importance, but it continued to have some protective status as part of the Emperor's Forests (Kazennyje lesa) until the turn of them 18th century. Now a remnant of the former forest barrier is all that remains. An area of "virgin", unevenaged forest where no felling or cutting has taken place for at least 600 years, occurs in this forest remnant of the Kaluga region and a State Reserve "Kaluzhskie Zaseki" has been established there. Peter the Great installed a network of protected forests in the 18th century. It is important to point out

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that forest exploitation in Northern Russia consisted of low intensity selective felling. However, the removal of mostly large Scots pines until the middle of the 19th century, i.e. greater than 44cm DBH and later greater than 28 cm DBH, made a considerable impact up to the beginning of the 20th century. This practice encouraged the development of an unevenaged structure in taiga forests, which can be found today in remote locations in Karelia and Komi Republics, Murmansk, Arkhangelsk, Vologda, Kostroma, Perm and Kirov regions and even east of St. Petersburg. Extensive clear felling began in the 1930s, consequently there are a lot of secondary deciduous and mixed stands in Russian forests today.

The first State reserves in Russia were established at the beginning of the 20th century and since then the network of reserves and other protected territories has been intensively developed. The total number of Russian forest reserves and other protected territories is very large at present. More detailed information on State reserves and other protected land areas can be found in Appendix 1. Forest reserves occupy 1.4% of the total area of Russia. The goal is to increase the area of Russian forest reserves in the near future. However, under Russian forest legislation, there is a category of protected forests (Forests of 1st Group), which allows for a special regime of forest management, excepting clear felling. This category includes the northernmost pre-tundra forests, southernmost forest-steppe forests, protective belts along rivers, “green zones“ around settlements and towns, research and educational forests belonging to institutes and universities, and resort forests. The total area of this category in Russian European forests is 29.9%.

3. HISTORY OF RESEARCH IN NATURAL FORESTS IN RUSSIA

Natural forest is a forest ecosystem impacted by natural disturbances, forest fires and clear felling (without any thinning regimes), fertilisation, and drainage and pesticide control. However, natural forests in Russian State Reserves have developed under a natural disturbance regime only. Consequently, practically all forest research in the Russian taiga zone has been carried out in natural forests with different disturbance regimes. The initial results of forestry investigations during the last century were of a very general nature (Arnold 1880; Rudzskij 1899). More intensive research of natural forests was carried out at the beginning of 20th century; extensive information on forest resources was collected and Krüdener (1916) created a classification system of forest types. Subsequently, Ukrainian foresters further developed it. In addition, the general models of Russian silviculture were formulated during that period (Morozov 1926). A comprehensive study of forest vegetation was conducted by Sukachev and other forest botanists (Alekhin 1936; Korchagin 1954; Glushkov et al. 1948; Sukachev 1975; Vegetation Cover 1956) upon the creation of the so-called ‘North school of Forest Typology’.

During the same period a number of permanent sample plot experiments in taiga and broad-leaved forests were established. Parts of these plots remain today and they are a very valuable source of information (Sennov 1984). Forest institutions, universities and forest inventory enterprises have made a great effort to establish temporal sample plots,

in order to solve applied silvicultural problems. However, the majority of these plots subsequently disappeared and their number continues to decrease.

4. PRESENT STAGE OF RESEARCH IN RUSSIAN NATURAL FORESTS

At present there is very extensive research in Russian natural forests, covering all fields of silviculture, biology, ecology and environmental science. To begin with, State Forest Reserves and National Parks carry out their own scientific research. Research programmes include flora and fauna inventory; forest dynamics, regeneration, and forest health. Research on nutrient cycling and energy flows, ecophysiology, vegetation succession, air pollution, etc., is carried out in some reserves. Long-term studies are also conducted on permanent sample plots and "ecological stations". In addition, there is a "Chronicle of Nature" in the reserves, which allows for the continual collection of information, even though modern ecological monitoring is still not standardised, but is incorporated in the reserves' activities. Secondly, a network of Russian forest and biological institutions (about 20 forest and biological faculties, and 17 research institutes in European Russia) are carrying out very intensive studies in taiga natural forests. Generally speaking, the following branches of forest science, silviculture and related sciences have been developed during recent decades:

- theory on Forest Biogeocoenology (Sukachev 1975);
- comprehensive studies of biological cycles in taiga forests and ecosystem functioning (Rodin and Bazilevich 1964; Kazimirov and Morozova 1973; Kazimirov et al. 1977, 1978);
- studies of forest dynamics, forest site/type classifications and landscape science (Armand 1975; Razumovsky 1981; Chertov 1981; Skvortsova et al. 1983; Dyrenkov 1984; Isachenko 1991; Smirnova 1994; Popadyuk et al. 1995; Vasenov, Targulian 1995; Fedorchuk et al. 1996);
- studies on forest plants, population structure and biodiversity (Smirnova et al. 1988, 1989, 1995);
- ecological impacts of forest management (Karpachevsky 1981; Sannikov 1983; Sennov 1984; Gromtsev 1993);
- industrial pollution effects (Alekseev 1990).

A lot of other research is also being done in natural forests. However, there are many gaps in our knowledge and understanding of the mechanisms and quantification parameters of natural forest dynamics. At present, Russian scientific bodies in State Reserves, especially in natural boreal forests have initiated intensive studies on forest biodiversity and effects of climate change. A joint Russian-American study on carbon pools and flows in the forest ecosystems of Russia and US Pacific Northwest are ongoing presently. The first estimates of the total carbon pools in Russian forest and swamp ecosystems are already available and considerably more relevant data is expected from this project. Data on the General Land Survey and Inventory (Generalnoye Mezhevaniye 1770-1850), which became available only recently,

provides unique and specific information for the analysis of natural forest vegetation all over European Russia.

There are a large number of ongoing projects on natural forests in Russia, supported by the Ministry of Science and New Technologies, Russian Academy of Science, State Committee of Nature Protection, governments of the republics and regional administrations. However, only the support given by the State Committee of Nature Protection and a number of local sources is adequate.

For example, the State Committee of Nature Protection supports the programme for establishing the computer software and database for the "Chronicle of Nature". This is the Research Project known as "Organisation and Formation of the Information System of Russian State Reserves", which has the following goals: elaboration of the basic principles of the system; production of methodological manuals on inserting State reserves on the Internet, preparation and dissemination of information on the reserves activities, development of a software package for the "Chronicle of Nature," using the IRIS system for biodiversity studies. The IRIS automatically produces high-quality thematic maps with statistical data selected by the user (Andrienko and Andrienko 1995). The system applies an object-oriented knowledge representation language. Unlike other GIS packages, IRIS produces thematic maps automatically.

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APPENDIX 1

Additional information on Russian forest protected territories

The organisations responsible the establishment of Special Protected Nature Territories (forest reserve sensu lato) are:

- Federal Government,
- Republic Government,
- Regional Administration [“oblast“],
- Local Administration [“rayon“].

The legal status of the forest reserves falls under the Federal Law “On Specially Protected Nature Territories” (15 February, 1995), which has the following definition: Specially Protected Nature Territories with terrestrial, water and air space, where natural complexes and elements are located. These elements have exclusive, important environmental, scientific, cultural, aesthetic, recreational and health-related significance. These territories are excluded (completely or partly) from all economic uses by the Government and are regulated according to the rules and regime of special protection, which has been established by statute.

The Law defines a number of categories of Specially Protected Nature Territories. They are:

a) State Nature Reserve (Federal status),
b) National Park, (Federal status)
c) Nature Park, (Republic and regional status)
d) State Nature Refugium or “Zakaznik“, (all status levels)
e) Nature Monument, (all status levels)
f) Dendrological and Botanical Garden, (all status levels)
g) Medicinal Areas and Health Resort. (all status levels)

The legal definition of a State Nature Reserve is: “a nature protection, ecological and educational entity. Its goals are conservation and investigation of natural processes, conservation of the gene pools of plants and animals, and conservation of species and communities of common or unique ecosystems. Special protected nature complexes and objects (soil, water, flora and fauna) are excluded from economic use in the Reserve territory. They are examples of environmental, scientific, ecological, and educational importance and represent the natural environment, common or unique landscapes, or are refuges for gene pool conservation”. The regime of special protection for State Nature Reserves consists of:

- Prohibition of any activity contradictory to the objectives and status of the reserve. Introduction of new species is also prohibited.
- In the reserve the only activities allowed are those that support:
  - maintenance of natural environmental conditions, regeneration and protection of ecosystems from human impacts;

- maintenance of the conditions which allow sanitary protection and fire control;
- prevention of natural catastrophes;
- environmental monitoring;
- scientific goals;
- ecological and educational targets;
- supervisory functions.

Fully protected areas are usually established in the Reserve. Any human impacts on natural processes are forbidden in these areas. Their size is determined by the necessity to protect the nature complex and biodiversity as a whole. Activities supporting the viabil-

List of forest reserves in European Russia

Name	Year of establishment	Area, ha	Latitude	Longitude
“Denezskin Kamen”	1991	78192	-	-
Chernye zemli	1990	125000	–	-
Privolzskayalesostep	1989	8200	-	-
Orenburg	1989	21600	-	-
“Bryansky Les”	1987	11800	51°29’	33°52’
Dagestan	1987	18700	–	-
Shulgan-Tash	1986	22500	50°55’	56°48’
Kostomuksha	1983	47500	63°31’	30°25‘
“Basegy”	1982	19400	53°09’	58°36’
Nyzsny-Svir	1980	41400	59°18’	33°04’
Les na Vorskle	1979	100	45°05’	35°39’
Yuzsno-Uralsky	1978	254000	–	-
Kabarda	1976	74100	40°59’	43°16’
Pinega	1974	41200	65°24’	45°23’
Visim	1971	13500	54°36’	59°38’
Severo-Osetinsky	1967	29000	41°14’	44°01’
Volga-Kama	1960	8000	52°06’	48°48’
Darvin	1945	112600	57°22’	37°38’
Mordva	1936	32100	53°12’	43°20’
Teberda	1936	84900	42°41’	41°43’
Khoper	1935	16178	48°48’	41°42’
Kandalaksha	1932	58100	66°28’	33°13’
“Kivach”	1931	10600	63°42’	33°58’
Bashkirian	1930	49600	50°36’	57°59’
Zavidovo	1929	125400	52°05’	39°27’
Zsiguly	1927	23100	50°36’	49°40’
Ilmen	1920	30300	52°56’	60°12’
Central-Chernozemny	1935	4874	44°28’	36°05’
Prioksko-Terrasny	1935	4945	53°06’	37°39’
Oka	1935	22911	53°15’	40°49’
Central-Lesnoy	1931	21380	55°28’	32°56’
Lapland	1930	268436	67°10’	32°16’
Pechora-Ilych	1930	721322	–	58°42’
Voronezs	1927	31053	30°05’	50°18’
Caucas	1924	263277	40°13’	40°22’
Astrakhan	1919	63400	42°04’	48°28’

ity of reserves and local populations outside or adjacent the fully protected areas may be permitted.

The legal definition of a National Park is as follows: A National Park is an ecological, educational and research entity. Its territory includes natural complexes with special environmental, historical and aesthetic values. The territory may be used for nature protection, education, scientific and cultural objectives, and for tourism under controlled circumstances. The total number of Reserves in European Russia is 35.

Additional information on some forest reserves

Astrakhan State Reserve (biospheric). Total area 66800 ha, forest lands – 3000 ha (coniferous 2800 ha).

State Reserve "Basegy" (Perm region). Total area – 19400 ha, forest lands 17800 ha (coniferous 16300 ha).

Bashkirian State Reserve (Republic Bashkortostan). Total area – 49600 ha, forest lands 43200 (coniferous 27500 ha).

State Reserve "Bolshaya Kokshaga" (Republic Mary El). Total area – 21400 ha, forest lands – 20400 ha (coniferous 7600 ha).

State Reserve "Bryansky Les" (Bryansk region). Total area – 12200 ha, forest lands – 10800 ha (coniferous 4100 ha).

Visim State Reserve (Sverdlovsk region). Total area – 13500 ha, forest lands – 13000 ha (coniferous 8200 ha).

Voronezs State Reserve (Vorovezs region). Total area – 31000 ha, forest lands – 28600 ha (coniferous 10000 ha).

Vishera State reserve (Perm region). Total area – 241200 ha, forest lands – 181500 ha (coniferous 165200 ha).

Volga-Kama State Reserve (Republic Tatarstan). Total area – 8000 ha, forest lands – 7100 ha (coniferous 3300 ha).

Darvin State Reserve (Vologda & Yaroslavl region). Total area – 67200 ha, forest lands – 46200 ha (coniferous 36300 ha).

State Reserve "Denezskin Kamen" (Sverdlovsk region). Total area – 78200 ha, forest lands – 70200 ha (coniferous 64000 ha).

Zsiguly State Resrve (Samara region). Total area – 23100 ha, forest lands – 21700 ha (coniferous 1800 ha).

Caucaz State Reserve (biospheric) (Krasnodar Kraj & Republic Adygeya). Total area – 280400 ha, forest lands – 171600 ha (coniferous 80600 ha).

State Reserve "Kaluzskiye zaseky" (Kaluga region). Total area – 18500 ha,, forest lands – 18000 ha (coniferous – absent).

Kandalaksha State Reserve (Murmansk region). Total area – 58100 ha, forest lands – 11200 ha (coniferous 8500 ha).

State Reserve "Kivach" (Republic Karelia). Total area – 10900 ha, forest lands – 9200 ha (coniferous 7200 ha).

Kostomuksha State Reserve (republic Karelia). Total area – 47400 ha, forest lands – 29300 ha (coniferous 29200 ha)

Lapland State Reserve (Murmansk region). Total area – 278400 ha, forest lands – 153800 ha (coniferous 117800 ha).

Mordva State reserve (Republik Mordovia). Total area – 32100 ha, forest lands – 30900 ha (coniferous 18500 ha).

Nyzsny-Svir State Reserve (Leningrad region). Total area – 36400 ha, forest lands – 20300 ha (coniferous 0 ha).

Oka State reserve (Ryzan region). Total area – 55700 ha, forest lands – 48600 ha (coniferous 22200 ha).

State Reserve “Pasvik” (Murmansk region). Total area – 14600 ha, forest lands – 6500 ha (coniferous 5600 ha).

Pechora-Ilych State reserve (Komy Republic). Total area – 721300 ha, forest lands – 524600 ha (coniferous 550000 ha).

Pinega State reserve (Arkhangelsk region). Total area – 41200 ha, forest lands – 36900 ha (coniferous 34200 ha).

State Reserve “Privolzskaya lesostep” (Pensa region). Total area – 7300 ha, forest lands – 6500 ha (coniferous 5400 ha).

Prioksko-Terrasny State Reserve (biospheric) (Moscow region). Total area – 4900 ha, forest lands – 4600 ha (coniferous 2100 ha).

Severo-Osetinsky State Reserve (Republic Severnaya Osetia). Total area – 29000 ha, forest lands – 6400 ha (coniferous 1300 ha).

Teberda State Reserve (Republic Karachyevo-Cherkesia). Total area – 85000 ha, forest lands – 27400 ha (coniferous 16400 ha).

Khoper State Reserve (Voronezs region). Total area – 16200 ha, forest lands – 12500 ha (coniferous 1100 ha).

Central-Lesnoy State Reserve (biospheric) (Tver region). Total area – 24400 ha, forest lands – 22700 ha (coniferous 11300 ha).

Central-Chernozemny State Reserve (Belgorod &Kursk regions). Total area – 4900 ha, forest lands – 1700 ha (coniferous 0 ha).

“Les na Vorskle” State Reserve is the smallest reserve (100 ha); Pechora-Ilych State is the largest reserve (721322 ha). The average forest reserve size of is 76585 ha.

The objectives of the State Nature Reserves network are:

- protection of natural territories for conservation of biodiversity and maintaining the natural state of protected entities;
- scientific investigations, which include the “Chronicle of the Nature”;
- ecological monitoring in order to contribute towards the Federal System of Environmental Monitoring;
- ecological education;
- participation in the State’s ecological projects and schemes; locating potential industrial features;
- providing assistance in the scientific training of environmental specialists.

The objectives of National Parks are:

- conservation of the nature complexes, and unique and representative natural habitats or features;
- conservation of historic-cultural features;
- ecological education of the local population;
- facilitating controlled tourism;
- development and use of scientific methods of nature conservation;
- ecological monitoring;
- restoration of disturbed natural or historic-cultural features.

List of Russian European National Parks subordinated to Russian Federal Forest Service

No	Name	Location	Year of establism.	Area, 1000 ha
1	Sochinsky	Krasnodar Kray	1983	190
2	Samarskaya Luka	Samara region	1984	134
3	Marij Chodra	Republic Marij-El	1985	36.6
4	Bashkiria	Republic Bashkortostan	1986	98.4
5	Prielbrusje	Kabardino-Balkar Republic	1986	100.4
6	Kurshskaya Kosa	Kaliningrad region	1987	6.6
7	Valdajsky	Novgorod region	1990	158.5
8	Vodlozersky	Republic Karelia & Arkhangelsk region	1991	404.7
9	Nizsnyaya Kama	Republic Tatarstan	1991	26.1
10	Kenozersky	Arkhangelsk region	1991	139.2
11	Russkij Sever	Vologoda region	1992	166.4
12	Meshchera	Vladimir region	1992	118.8
13	Meshchersky	Ryazan region	1992	103
14	Smolenskoje Poozerje	Smolensk region	1992	146.2
15	Paanajarvi	Republic Karelia	1992	103.3
16	Chavash Varmane	Republic Chuvashia	1993	25.3
17	Orlovskoje Polesje	Orel region	1994	77.7
18	Yugyd va	Komi Republic	1994	1891.7
19	Khvalynsky	Saratov region	1994	25.5
20	Smolny	Mordva Republic	1995	36.5
21	Sebezsky	Pskov region	1996	50
22	Ugra	Kaluga region	1996	no data

The objectives of Natural Parks are:

- conservation of natural environments, or natural landscapes;
- development and maintenance of the resources for recreation;
- development and use of effective conservation methods and maintenance of ecological equilibria subject to recreation stresses.

The objectives of State Nature Protected Areas are:

- conservation and restoration of natural landscapes;
- conservation and restoration of endangered or rare species;
- conservation of fossil remnants;
- conservation and restoration of valuable water bodies or ecosystems;
- conservation of geological features.

List of personnel responsible for scientific activities in forest reserves

Dr. Alexey K. Blagovidov, Deputy Director of Reserves' Dept of State Committee on Nature Protection, Moscow. Responsible for all scientific research in State Reserves.

Dr. Roman V. Popadyuk, Senior Scientist, Centre of Forest Ecology and Productivity of Russian Acad. Sci., Moscow. Forest scientist working in almost all forest reserves in Russia and Ukraine.

Dr. Alexander S. Komarov, Head, Lab. Ecological Modelling of Institute Soil Sci. & Photosynthesis, Russian Acad. Sci., Pushchino on Oka, Moscow Region. Responsible for problems related to data bank establishment and current information collection in State Reserves.

Dr. Marina S. Botch, Senior Scientist, Komarov Botanical Institute of Russian Acad. Sci., St. Petersburg. Organiser of protective areas networks in Northwest Russia.

Dr. George A. Noskov, Head, Lab. Ornitology, Biol. Res. Inst. of St. Petersburg State University. Organiser of research in protected territories in Northwest Russia.

Dr. Oleg G. Chertov, Prof. Forest Sci., Faculty of Forestry, St. Petersburg Forest Technical Academy. Long-term experience in research in natural and protected forests and personal experience as former Deputy Director of State Reserves.

APPENDIX 2

Contents of Smirnova, O. and Shaposhnikov, E. (Eds.) 1996. Successive Processes and Biodiversity Conservation in Russian State Reserves. In press (In Russian).

UNITED KINGDOM

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1. FOREST COVER

About 7,000 years ago, most (c. 80%) of Great Britain (GB) was forested, but subsequent clearance reduced this to about 25% by 1100 AD and to about 5% at the beginning of the twentieth century (Rackham 1993). Afforestation this century has increased the area under forests to about 10% (Forestry Commission 1984). Similar processes operated in Northern Ireland (see also chapter by Aileen O'Sullivan). None of this current woodland cover is truly virgin – in all cases some forest management, grazing or burning has taken place, but some sites may have had a continuity of woodland cover back to the period of the "wildwood". It is impossible to prove such continuity and so the term "ancient woodland" is adopted for those sites where there is evidence for continuous woodland cover back to 1600 AD, when good records and maps start to become available (Spencer and Kirby 1992; Roberts et al. 1992; Marren 1992). Many ancient woods were formerly managed by coppicing or as wood-pasture. These practices have largely died out and between 1930 and 1985 many sites were replanted with introduced coniferous species. Woods in Britain are further classified therefore according to whether they are "semi-natural", that is composed predominantly of species native to the site, naturally regenerated or grown-up from stumps e. g. after coppicing; or plantations, usually of species that are not native to Britain (or to that particular region of Britain) (Table 1).

The areas of greatest value for nature conservation are semi-natural stands on ancient sites (Figure 1). The breakdown of all woodland by main tree species is shown in Figure 2, with the predominance of introduced species and young crops (Figure 3). The species composition of semi-natural woodland (both ancient and recent) can be described using the National Vegetation Classification (Rodwell 1991, Table 2) and varies according to soils and climate across the country (Figure 5). Recent work on an Ecological Site

Most of the statistics presented are for Great Britain, that is England, Wales and Scotland, but excluding Northern Ireland. The same general principles apply however (and see report for Ireland for forest history). Where data is included for Northern Ireland as well this has been noted.

Jari Parviainen et al. (eds.)
Research in Forest Reserves and Natural Forests in European Countries
EFI Proceedings No. 16, 1999

Classification (ESC) is helping to define these soil and climate parameters more precisely (Pyatt and Suarez 1997). Differences in the composition of the zones in terms of the National Vegetation Classification are shown in Appendix 1. The majority of ancient sites are small (Figure 4), but some recent plantations extend to thousands of hectares. (Figure 4 shows data for ancient woodland in England and Wales: the pattern for Scotland is similar.)

2. CONSERVATION IN BRITISH WOODLAND

Modern nature conservation in Britain began in the second half of the nineteenth century. Important conservation charities were founded then such as the National Trust and Royal Society for the Protection of Birds and Epping Forest was acquired by the City of London specifically to conserve it for its natural beauty and as a recreational area. The early twentieth century saw the founding of the British Ecological Society and the state forest service, although the conservation remit of the Forestry Commission was very weak until the mid-eighties compared to its production and strategic timber reserve objectives (Sheail 1976; 1987). National Parks and a wildlife service (initially called the Nature Conservancy) were formed as a result of an Act passed in 1949. This allowed for the identification of the most important sites for nature conservation as Sites of Special Scientific Interest (SSSI) or as National Nature Reserves. These were frequently privately-owned and the legislation did not prevent many of them being destroyed or badly damaged (including by inappropriate forestry operations) over the following 30 years. Much stronger protection was therefore introduced in 1981 (the Wildlife and Countryside Act) which, together with more sympathetic land management policies, has greatly reduced the rate of damage to these important areas. In 1991 the government agencies for nature conservation were divided along country lines into English Nature, Scottish Natural Heritage and the Countryside Council for Wales: Northern Ireland is covered by the Department of Environment, Northern Ireland.

Woodland, particularly ancient semi-natural woodland is protected via a variety of mechanisms including designation as Sites of Special Scientific Interest, ownership/ management by conservation organisations, local or national bodies sympathetic to nature conservation and to some degree through general land use policies (Thomas et al. 1997; Table 3). About 20% of ancient semi-natural woods and smaller amounts of the other categories in Figure 1 are covered by the statutory SSSI designation. They have been selected to represent the range of British woodland types, conserve rare species and to conserve the range of British woodland species (NCC 1989). These include National Nature Reserves which are owned or managed by the statutory nature conservation agencies (or by another body approved by the statutory bodies). The European Habitats Directive has led to the identification of woodland as potential Special Areas of Conservation (SACs). These are all in the first instance SSSIs and many are also nature reserves.

Management of protected sites. The fragmented state of ancient woodland in Britain and its long history of management, mean that strict forest reserves – usually referred

Table 1. Definition of terms relevant to British Conditions

Ancient woodland:
sites which appear, from documentary, ecological and topographic evidence, to have been continuously wooded since at least 1600AD. Many may be primary woodland sites. The tree cover may have been altered by felling, coppicing or recently by planting: the key point is that the site has remained woodland during this period.

Recent woodland:
sites where there is clear evidence that they were open ground (heathland, grassland, moor, bog etc) within the last 400 years, although most recent woodland has developed this century.

Semi-natural woods/stands:
woods or stands that are composed predominantly of trees and shrubs native to a site and which have not obviously been planted. They originated from seed, suckers, coppice regrowth or old pollards etc. Semi-natural stands may be on either ancient or recent woodland sites.

Plantations:
stands that have clearly developed as a result of planting and which contain few of the characteristics of semi-natural stands. Most are composed of species that are not native to Britain or to the sites in which they occur.

Table 2. List of woodland communities in Great Britain (Rodwell 1991)

W1	*Salix cinerea – Galium palustre* woodland
W2	*Salix cinerea – Betula pubescens – Phragmites australis* woodland
W3	*Salix pentandra – Carex rostrata* woodland
W4	*Betula pubescens – Molinia caerulea* woodland
W5	*Alnus glutinosa – Carex paniculata* woodland
W6	*Alnus glutinosa – Urtica dioica* woodland
W7	*Alnus glutinosa – Fraxinus excelsior – Lysimachia nemorum* woodland
W8	*Fraxinus excelsior – Acer campestre – Mercurialis perennis* woodland
W9	*Fraxinus excelsior – Sorbus aucuparia – Mercurialis perennis* woodland
W10	*Quercus robur – Pteridium aquilinum – Rubus fruticosus* woodland
W11	*Quercus petraea – Betula pubescens – Oxalis acetosella* woodland
W12	*Fagus sylvatica – Mercurialis perennis* woodland
W13	*Taxus baccata* woodland
W14	*Fagus sylvatica – Rubus fruticosus* woodland
W15	*Fagus sylvatica – Deschampsia flexuosa* woodland
W16	*Quercus* spp. *– Betula* spp. *– Deschampsia flexuosa* woodland
W17	*Quercus petraea – Betula pubescens – Dicranium majus* woodland
W18	*Pinus sylvestris – Hylocomium splendens* woodland
W19	*Juniperus communis* ssp. *communis – Oxalis acetosella* woodland
W20	*Salix lapponum – Luzula sylvatica* scrub
W21	*Crataegus monogyna – Hedera helix* scrub
W22	*Prunus spinosa – Rubus fruticosus* scrub
W23	*Ulex europaeus – Rubus fruticosus* scrub
W24	*Rubus fruticosus – Holcus lanatus* underscrub
W25	*Pteridium aquilinum – Rubus fruticosus* underscrub

Table 3. Major conservation categories and definitions that apply in Britain

a National forestry policy states:

- woodland that is broadleaved is expected to remain as such, i. e. there is a presumption against conversion to other land uses or a major change in its composition;
- the special characteristics of ancient semi-natural woodland should be retained.

b Wildlife and Countryside Act 1981 (as amended) can further conservation of woodland species and sites through:

- designation of woodland areas as Sites of Special Scientific Interest which then requires that the land-owners and managers consult and agree management of the woods with the statutory nature conservation agencies (English Nature, Scottish Natural Heritage, Countryside Council for Wales); National Nature Reserves are a sub-set of the SSSI series managed usually by the conservation agencies themselves;
- protected status being given to particular species, both plants and animals, making it an offence to damage, disturb or destroy them or their immediate habitat.

c Landscape and other designations operated by local planning authorities which include:

- "National Parks" and Areas of Outstanding Natural Beauty (AONB) in England and Wales, and similar designations in Scotland; the bulk of the land in such areas is privately owned and farmed; there is usually some additional protection for woodland (through local planning policies and procedures) but they are not the equivalent of National Parks elsewhere in the world;
- Tree Preservation Orders which may be imposed on areas of woodland, as well as individual trees, which prevent most felling of trees without prior agreement from the local authority.

d Ownership by bodies (other than the statutory conservation agencies who are willing to manage woodland (often Sites of Special Scientific Interest) sympathetically for nature conservation, of whom the most significant area:

- Forest Enterprise (the land-owning branch of the state forest service, the Forestry Commission);
- non-governmental conservation organisations (National Trusts, Royal Society for the Protection of Birds, Woodland Trust, the County Wildlife Trusts);
- local authorities.

These different categories and mechanisms may overlap for any particular wood making it difficult to define precisely the total area of woodland that has some degree of protection.

to as minimum intervention areas in Britain – would not be the best option for nature conservation in many protected woodland sites (Rackham 1980; Peterken 1996). Where the sites are privately-owned there is also the need, under the legislation, to consider the owner's objectives for the wood which may include maintaining landscape, recreation or wood production values. Therefore the aims for SSSIs and other protected sites are to treat them as coppice, managed high forest, wood-pasture or minimum intervention according to the particular characteristics of the site and the treatment of the surrounding area.

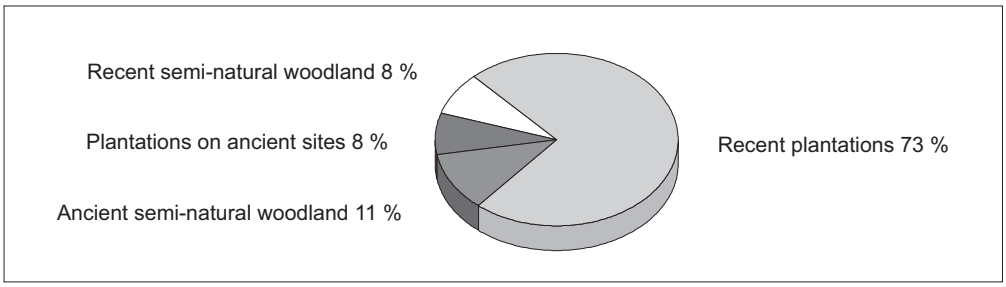

Figure 1. Area of woodland in Britain.

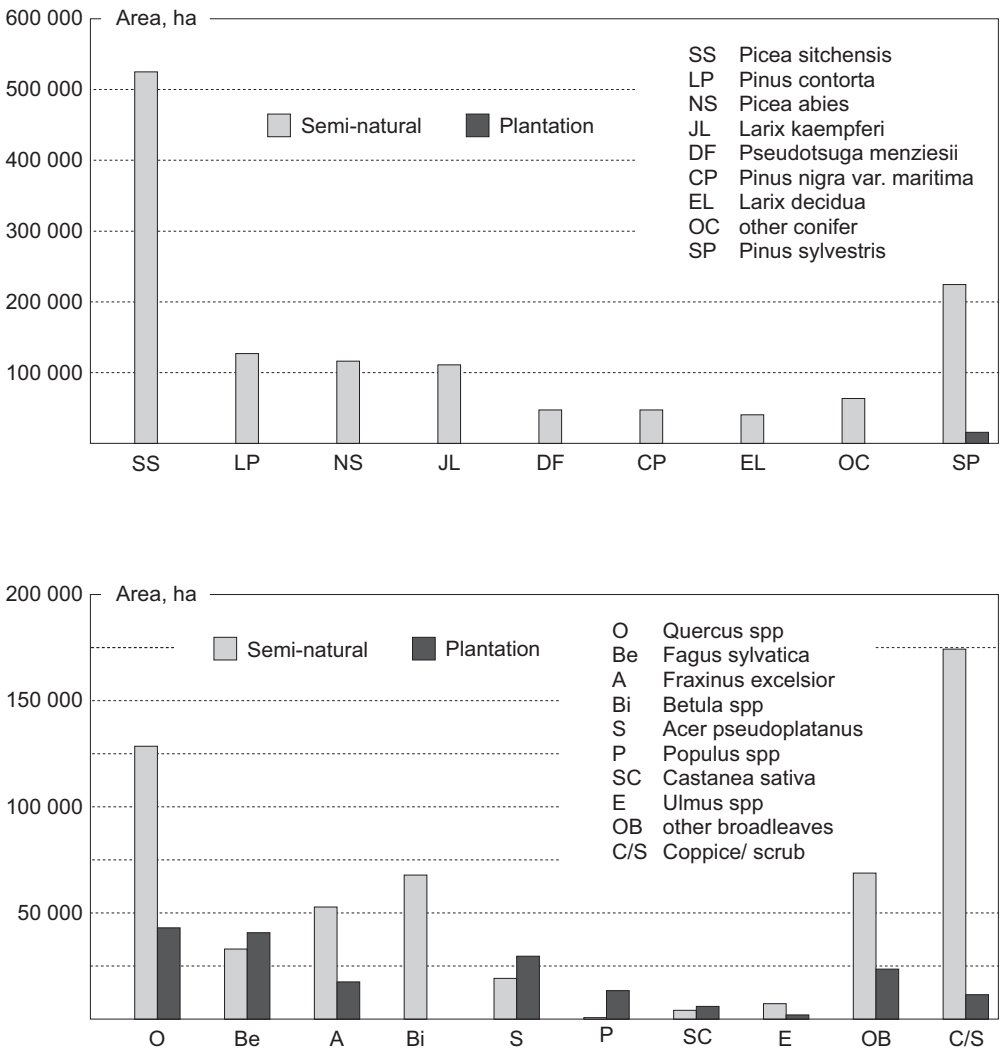

Figure 2. Area of high forest by species (1) conifers (2) broadleaves.

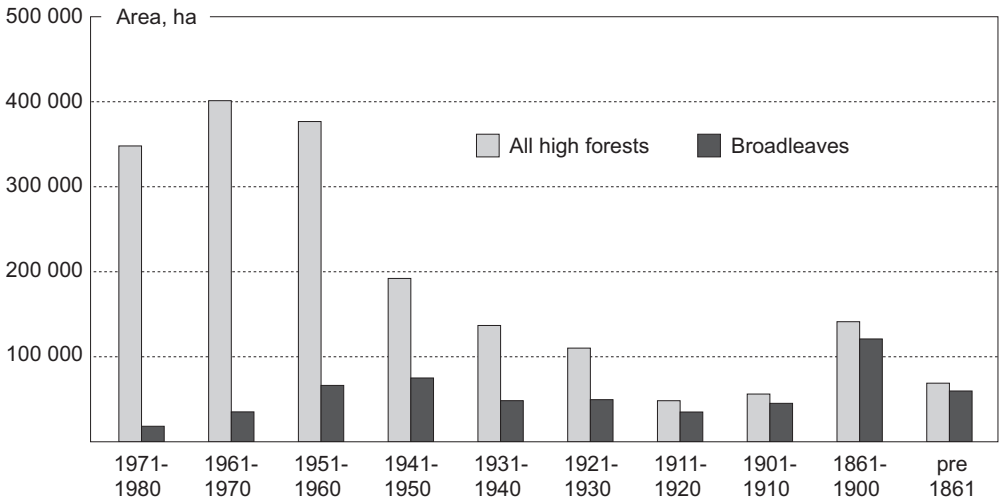

Figure 3. Area of high forest by age class.

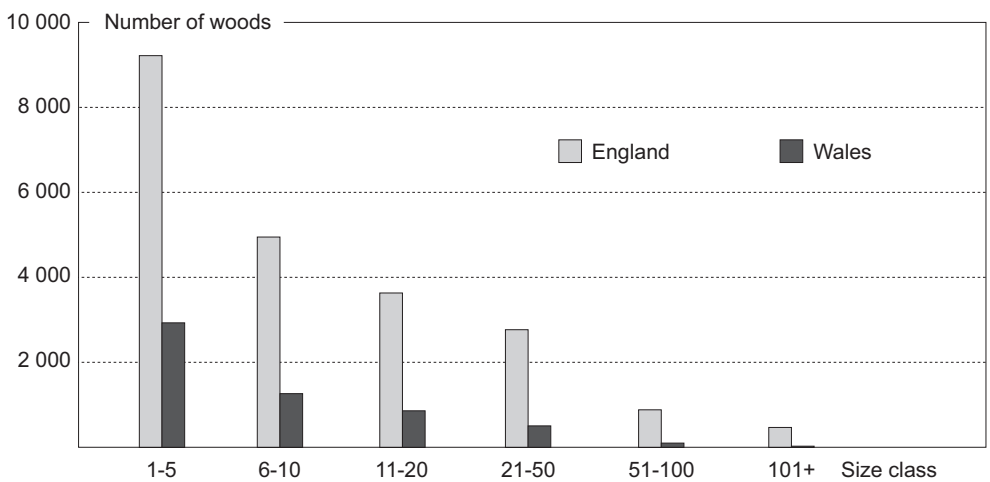

Figure 4. Size distribution of ancient woodlands.

At present more ancient semi-natural woodland is de facto minimum intervention, particularly in southern Britain, than may be desirable in the long term. Many woods have been neglected over the past 50-70 years because it was uneconomic to harvest timber from them. There are however increasing efforts by the conservation agencies and others to identify where positive decisions should be made to adopt minimum intervention (strict forest reserve status) as the long-term goal. Factors that would tend to favour adoption of minimum intervention for a site are set out in Table 4. The nature

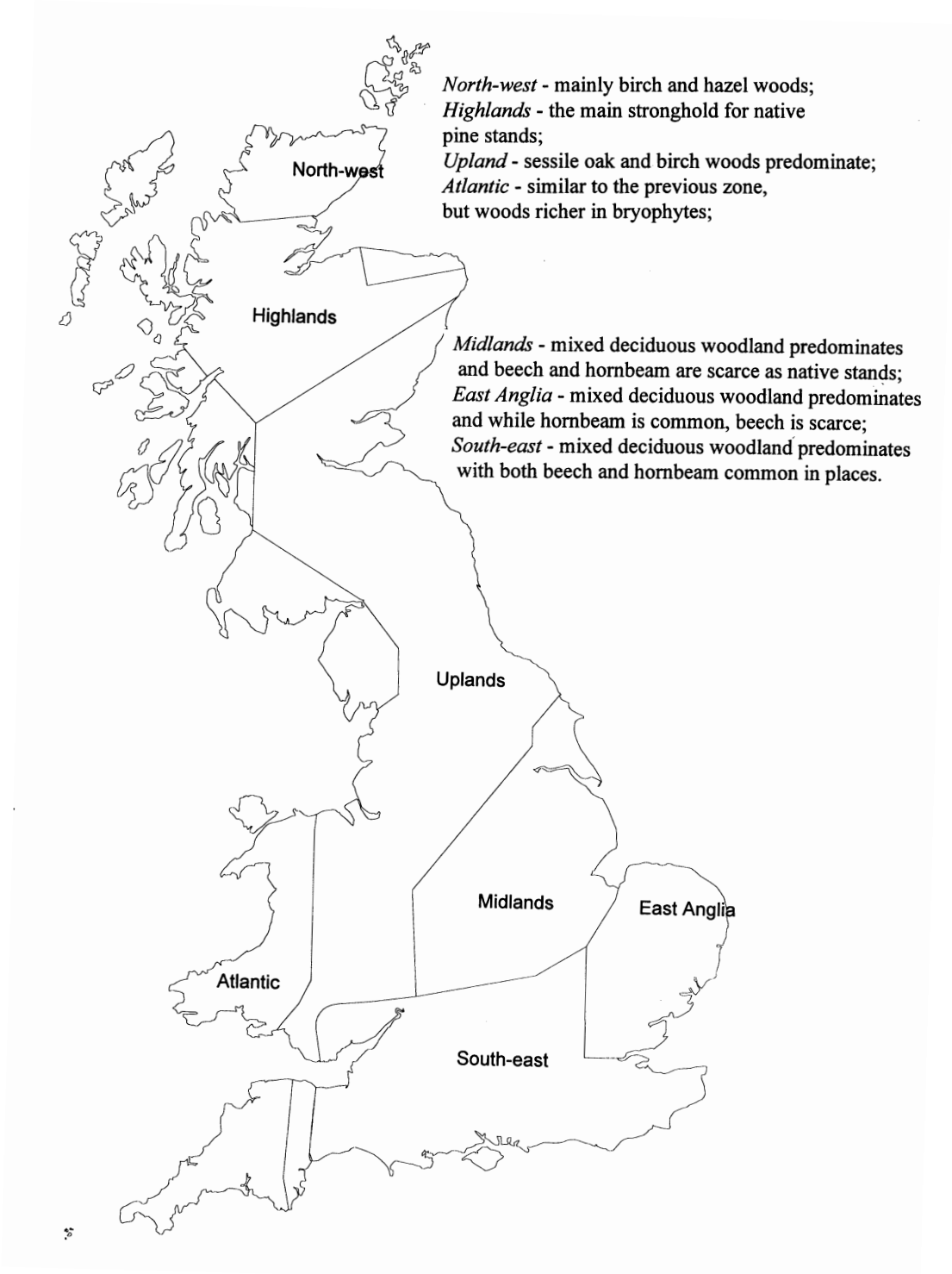

Figure 5. Major forest zones in Britain.

Table 4. Minimum intervention.

Main nature conservation benefits identified for Minimum intervention woods in Britain.
• Allows expression and study of natural woodland processes. • Potential to develop old growth forest structures and associated species. • Potential accumulation of dead wood habitats. • Undisturbed soil profiles. • Controls against which to measure change in managed woods.
Desirable characteristics for woods that are to be put into minimum intervention.
• Large area. • Compact shape. • Little recent treatment or unnatural disturbance. • Few introduced species and no highly invasive ones. • No major external deleterious factors operating, eg spray drift from neighbouring agricultural land. • Not noted for rare or unusual species that depend on management for their survival on site. • Stable ownership. • Diversity of age structure.

conservation agencies aim to establish a series of minimum intervention sites across the geographic and ecological range of British woods to act as “control“ sites that may be compared with more intensively managed woods.

The presumption within the minimum intervention series is that no silvicultural treatments will be carried out. Control of grazing/browsing animals may be necessary the integrity of the stand or important species within it are threatened. The same criterion will be used to determine whether recently introduced (non-native) species should be removed. Public access will not be actively encouraged, but must be accepted where there are long-standing rights of ways. This may lead to a legal requirement to make old trees adjacent to paths safe by felling or cutting over-hanging branches.

Decisions on long-term monitoring are frequently linked to the minimum intervention decision, but monitoring is also carried out in more actively managed areas to determine the impact of different silvicultural operations and for those species, communities or features that survive better in managed systems. Non-destructive scientific study is encouraged in all publically owned or managed woods. Destructive sampling and collecting is usually permitted where the scale of the disturbance is small compared to the perceived benefits for nature conservation from the proposed work.

3. MAJOR RESEARCH PROJECTS ASSOCIATED WITH OR USING MINIMUM-INTERVENTION AREAS

In this section we bring together two types of woodland research: (I) that which is relevant to the natural processes or species particularly associated with minimum

intervention treatment of British woodland and (ii) direct studies of minimum-intervention areas themselves.

3.1 General studies particularly relevant to minimum intervention studies

Results from the following types of research must be considered in understanding or making comparisons between minimum intervention areas. The research may however have taken place in managed (or partially managed) woodland.

- Historical and palaeoecological studies of the past composition and treatment of British woodland. These have demonstrated the high degree of past interference by humans (Godwin 1975; Rackham 1993, 1980; Peterken 1981; Bennett 1989; Smout 1997; Linnard 1982). The current condition of a wood and how it is changing are frequently determined by past treatments.
- Studies of woodland succession, regeneration and rates of colonisation by different groups of species (Watt 1934; Adamson 1932; Peterken 1974; Rackham 1980; Rose 1976). The presence or absence of many vascular plants, lichens and invertebrates is strongly influenced by site history. A range of ancient woodland indicator species have been identified.
- Research into the ecology of glade and young growth species that, under British conditions, are unlikely to be favoured by minimum intervention treatments, e. g. many woodland butterflies (Warren 1991; Thomas 1974; Greatorex-Davies et al. 1993; Buckley 1992). Few British sites are large enough to contain a sufficient area of gaps and young growth woodland to maintain the full range of invertebrates that are associated with such conditions; nor, because of the long-term fragmentation of woodland cover, is it easy for species to recolonise sites if once they are lost. Reserves which are important resources of young stage species are therefore more likely to be managed to retain that interest rather than be designated minimum intervention sites.
- Research into species of old growth conditions and dead wood that may increase in minimum-intervention areas (Harding and Rose 1986; Peterken 1996; Kirby et al. 1995; Kirby et al. in press). Historical records show that the saproxylic fauna and epiphytic flora associated with old growth conditions were once richer. We similarly presume that groups such as fungi increase in minimum intervention reserves. Natural features and processes will develop, for example shifting dominance of species in response to gap dynamics or the microtopographic patterning that develops around root plates (Buckley et al. 1994).
- A variety of studies have investigated what remains of high altitude forest in Scotland and the natural treeline would probably have occurred between 600 and 700m. Only one site, Craig Fhiaclach, is believed to still be almost natural (Pears, 1968). Regeneration in degraded areas has been observed with reduced grazing and browsing pressure, given suitable conditions of soil and vegetation and a nearby seed source (French, Miller and Cummins 1997).

- Exploration of the effects of different levels and types of large herbivores (deer, both native and introduced species, and domestic stock) on regeneration, ground flora and associated fauna of different types of woodland (Putman 1986; Mitchell and Kirby 1990; Kirby et al. 1994; Cooke 1996). No native large predators survive in Britain and some large herbivores have been lost. However domestic stock may now fulfill some of the previous functions of native herbivores and deer numbers are rising rapidly. Grazing/browsing animals within minimum intervention sites must (because the sites are small) be considered in conjunction with the surrounding managed farm or forest land. There is frequently a need for exclosures or culling of deer within reserves.

3.2 Studies of particular minimum intervention areas

3.2.1 Structure and dynamics of the tree and shrub layer.

- Permanent transects have been used to monitor changes in forest composition and structure, most comprehensively at Lady Park Wood (Gwent), where twelve transects were established in 1945 by E W Jones. Results from these transects have been used to describe general successional processes, impacts of drought and squirrel damage (Sciurus caroliensis) (Peterken and Jones 1987, 1989; Peterken 1993; Peterken and Mountford 1996).
- Similar styles of transect or plot have been recorded from Wistman's Wood (Devon), Coed Cymerau (Gwynedd), Clairinsh (Loch Lomond) the Black Wood of Rannoch (Tayside) Denny Wood in the New Forest and Monks Wood, Cambridgeshire (Backmeroff and Peterken 1989; Peterken and Stace 1987; Peterken and Backmeroff 1988; Peterken 1994; Stutter 1996, Mountford and Peterken 1998). New baseline transects were established in the mid-eighties in a number of other sites – Langley Wood (Wiltshire), Dendles Wood (Devon), Craigellachie (Speyside), Taynish Wood (Argyll), Glasdrum Wood (Argyll), Beinn Eighe and Loch Maree (Wester Ross), Glen Tanar (Deeside) and Monks Wood, Cambridgeshire (Peterken and Backmeroff 1988) and in areas affected by the widespread extreme gales in 1987 in south-east England (Whitbread 1991; Kirby and Buckley 1994) (Figures 6,7). Further work has been done in the New Forest by Henk Koop.
- A long-term surveillance system based on an array of 10 x 10m plots at grid points was established between 1973 and 1976 in Wytham Woods which are owned by Oxford University and include substantial areas under minimum intervention treatment. The structural records are less detailed than for the previously described studies but do allow the overall dynamics of the wood to be studied. The plots were re-recorded in 1991 and the results demonstrate inter alia the decrease in shrub layer and regeneration caused by a rising deer population in the woods (Dawkins and Field 1978; Kirby, Thomas and Dawkins 1996). A similar grid of plots was established at Bix Bottom (recorded 1973, 1992 but results not yet analysed).

3.2.2 Tree health/Air pollution

- The Forestry Commission has set up UN-ECE / ICP level I and II plots to determine the impact of air pollution in managed forests (Innes 1993). There are also additional plots where forest health is annually monitored in the same way as for level I plots, some of which are in non-intervention areas.

3.2.3 Ground flora

- There are fewer studies of long-term change in the ground flora. One of the best documented is that at Brigsteer Park (recorded since 1969) (Barkham 1992). Analysis of ground flora changes at Wytham is underway. There is the potential to link ground flora and structural records (described previously) particularly in those studies that used plots rather than transects, and there are ground flora records have been made in Lady Park Wood.

3.2.4 Soil

- Increases in total nitrogen concentration and decreases in pH have been found in soils from the Wytham plots described above (Farmer, 1995). These can largely be ascribed to atmospheric deposition, although changes with forest succession may also be involved. Changes with succession from arable land to woodland over a 100 year period with no management intervention has been studied at Geesetoft Wilderness, a small site at Rothamsted Experimental Station. Over this period soil pH has dropped by between 1. 4 and 2. 9 units, depending on depth (Johnston et al. 1986).

3.2.5 Faunal Groups

- There are national monitoring schemes for fauna that include minimum intervention woodland as part of the series. These include the Breeding Bird Survey and Common Bird Census coordinated by the British Trust for Ornithology (Greenwood et al. 1995); the Butterfly Monitoring Scheme coordinated by the Institute of Terrestrial Ecology (Pollard and Yates 1993) and the Rothamsted Insect Survey's network of light traps for monitoring moths (Woiwod and Harrington 1994). At least some of these sites overlap with those where long-term structural/ground flora records are available (for example ECN sites – see below), or potentially could be.

- At individual sites there are detailed studies of particular groups or species, for example the long-running studies of the population dynamics of the great tit (Parus major) (Perrins 1979) and badger (Meles meles) at Wytham Woods or of the requirements of the heath fritillary butterfly at Blean Woods NNR (Warren 1991).

Figure 6. Long term woodland vegetation plots in Great Britain.

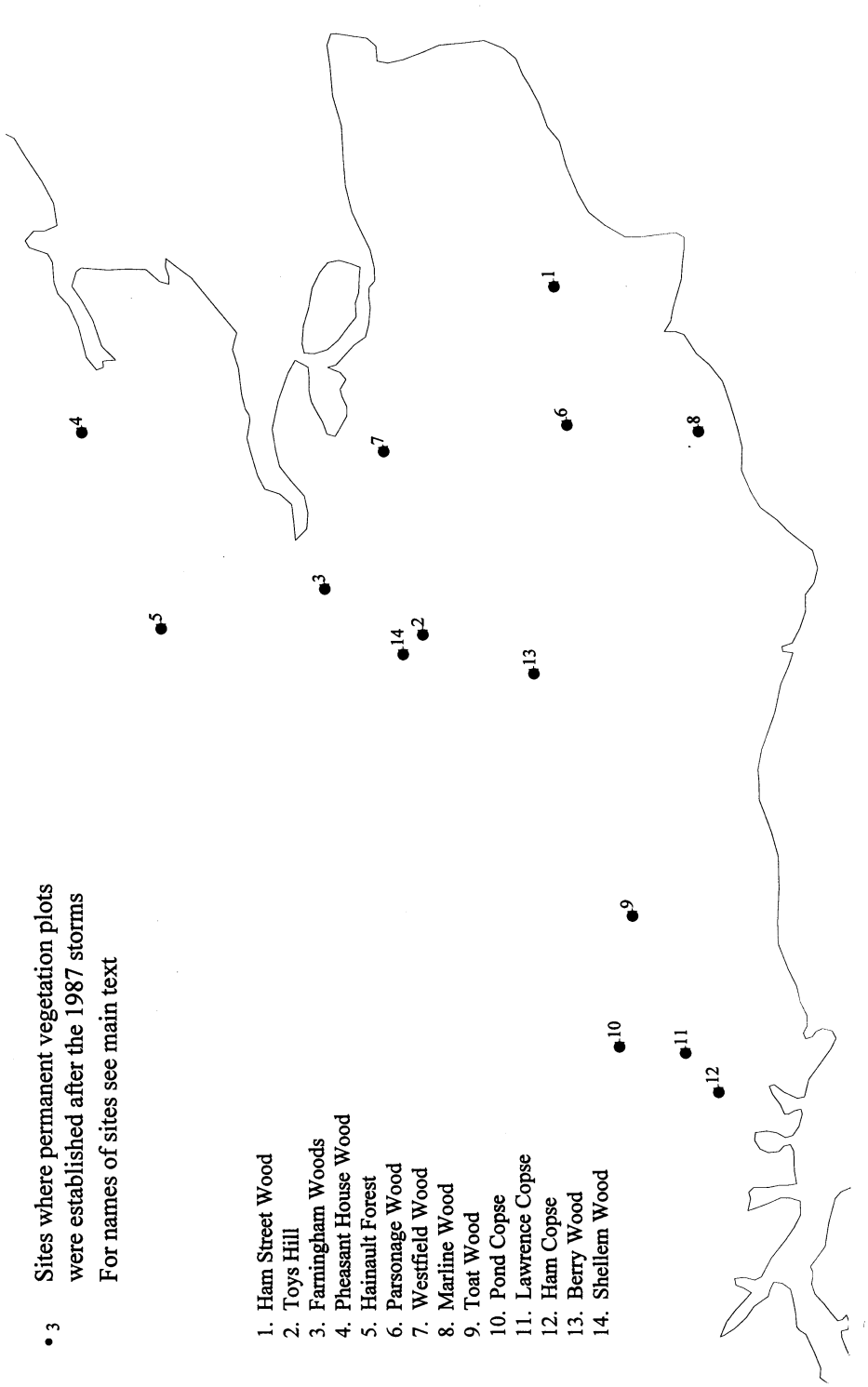

Figure 7. Storm monitoring plots in Great Britain.

3.3 Comparisons between protected and silviculturally managed forests

The Forestry Commission have an extensive research programme in managed forests. However to date there has been little coordinated and planned use of strict forest reserves in comparisons with silviculturally managed forests, partly because of the emphasis on plantations of non-native species in commercial forests. Small minimum intervention areas have proved valuable as part of comparisons of the ground flora under different treatments within native broadleaf woods (e.g. Kirby 1988, 1990); in studies of change over time in the soil seed bank (Brown and Oosterhuis 1981; Brown and Warr 1992), in the amount of fallen dead wood in managed and unmanaged stands (Kirby et al. in press).

4. ONGOING RESEARCH

The nature conservation agencies, voluntary conservation organisations and the Forestry Commission all hold some areas of minimum intervention woodland, with different degrees of monitoring and research work in progress on these reserves. A major project involving many of the sites at present is being carried out by Dr G F Peterken, funded by the European Union, to re-record various transects was noted under a previous section. Grids of plots established at The Mens are being looked at again.

Other sites where records of the tree and shrub layer have been made in a systematic way which might be followed up include the Loch Lomond Woods (Tittensor and Steele 1971); at Arriundle, Roudsea, Colt Park, Rodney Stoke Hales Wood and Kirkconnell Flow, Yarner Wood National Nature Reserves (Sykes and Horill 1979); at Johnny's Wood, Bonny Wood, Stainton Wood (R C Steele unpublished, Crampton 1996; Saunders 1990) and Ebernoe Common in Sussex.

The Environmental Change Network (ECN) is a collaborative programme involving a number of organisations. Very detailed records are kept of vegetation (including ground flora as well as tree growth and regeneration), selected animal groups, soils, climate, air pollution and hydrology. It is not restricted to woodlands, but several sites do include woodland areas, some of which, such as large parts of Wytham Woods and Geesetoft Wilderness at Rothamsted are minimal intervention areas. Detailed protocols for monitoring have been published (Sykes and Lane 1996).

The relationship between monitoring in minimum intervention sites and woodland surveillance. Woodland surveillance and monitoring takes place at a variety of scales and for a variety of purposes. Work is underway to develop better links between the various schemes to be able to relate for example changes in minimum intervention areas to actively managed sites; to compare protected versus non-protected sites and to set all within the context of what is happening to woodland species and habitats at a landscape scale.

A list of sites (mainly National Nature Reserves) where records have been made in minimum intervention areas, or that are relevant to comparisons with more actively managed woodland is given in Appendix 2.

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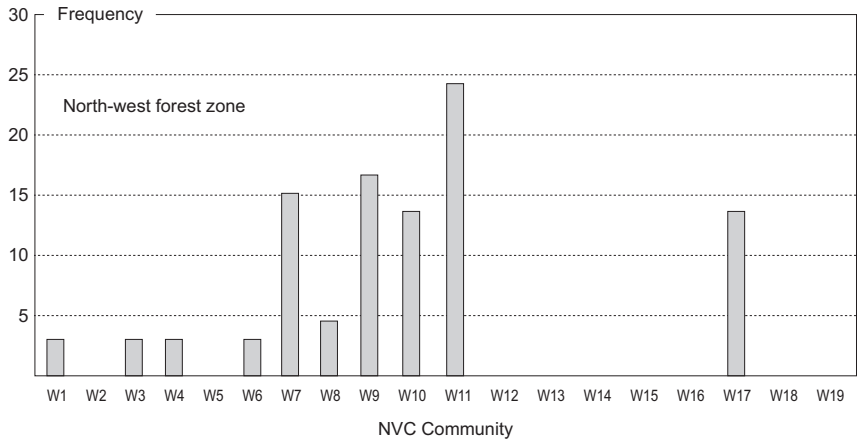
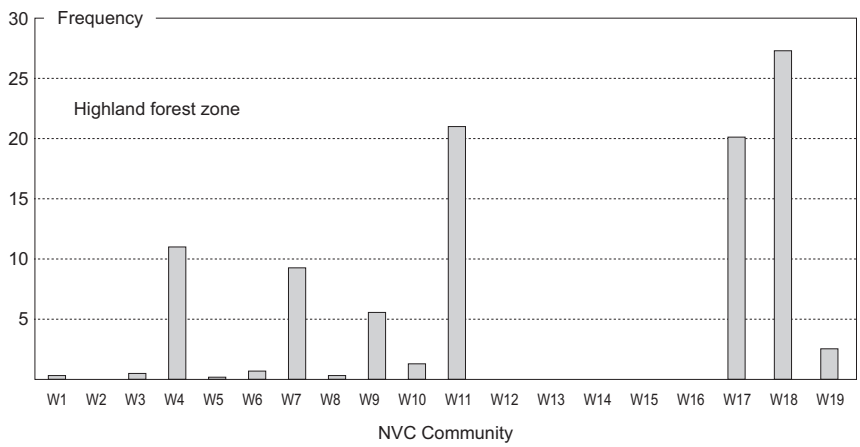
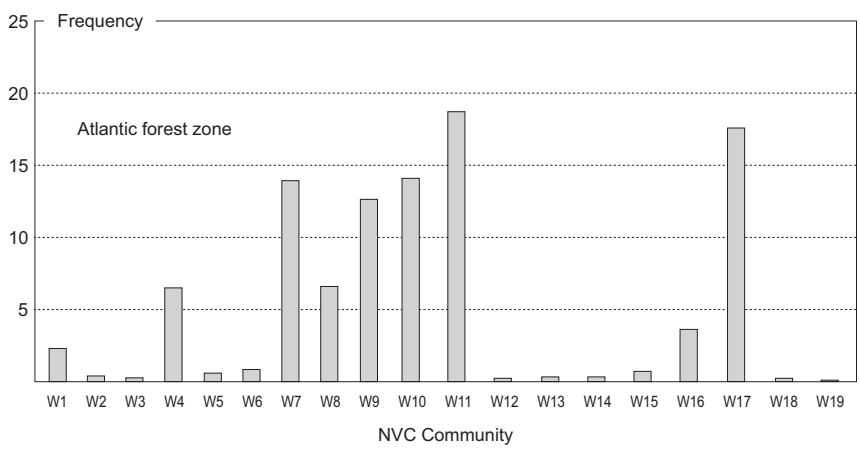
APPENDIX 1. COMPOSITION OF WOODLAND ZONES BASED ON FREQUENCY OF DIFFERENT NATIONAL VEGETATION TYPES RECORDED TO DATE.

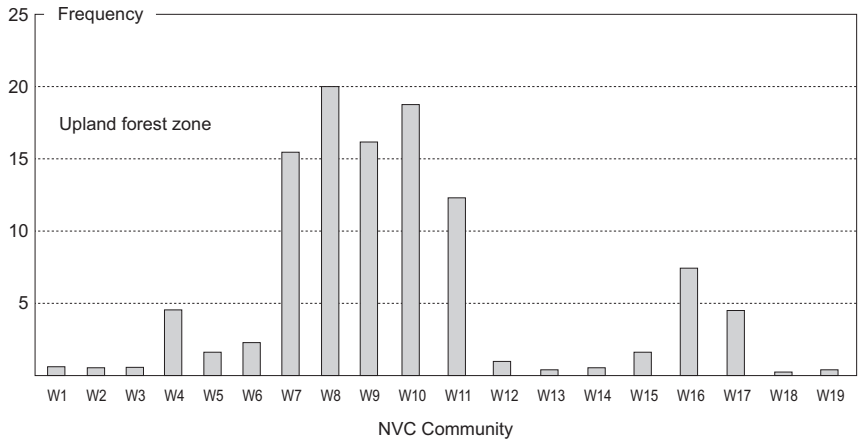
North-west	mainly birch and hazel woods;
Highlands	the main stronghold for native pine stands;
Upland	sessile oak and birch woods predominate;
Atlantic	similar to the previous zone, but woods richer in bryophytes;
Midlands	mixed deciduous woodland predominates and beech and hornbeam are scarce as native stands;
East Anglia	mixed deciduous woodland predominates and while hornbeam is common, beech is scarce;
South-east	mixed deciduous woodland predominates with both beech and hornbeam common in places.

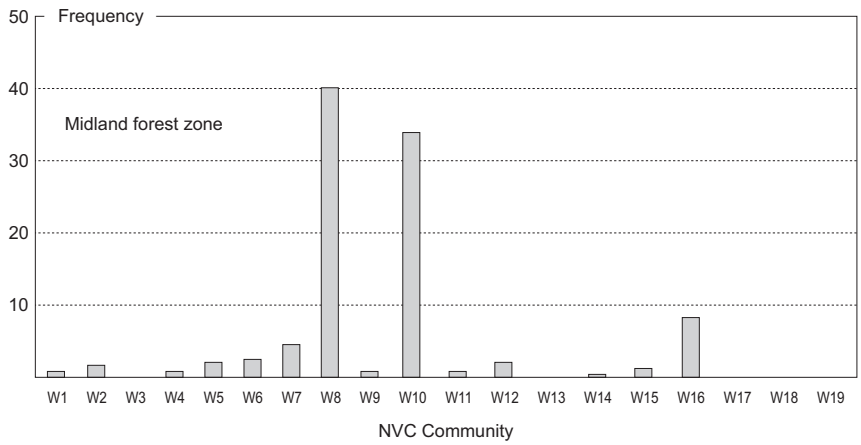
W1 *Salix cinerea – Galium palustre* woodland
W2 *Salix cinerea – Betula pubescens – Phragmites australis* woodland
W3 *Salix pentandra – Carex rostrata* woodland
W4 *Betula pubescens – Molinia caerulea* woodland
W5 *Alnus glutinosa – Carex paniculata* woodland
W6 *Alnus glutinosa – Urtica dioica* woodland
W7 *Alnus glutinosa – Fraxinus excelsior – Lysimachia nemorum* woodland
W8 *Fraxinus excelsior – Acer campestre – Mercurialis perennis* woodland
W9 *Fraxinus excelsior – Sorbus aucuparia – Mercurialis perennis* woodland
W10 *Quercus robur – Pteridium aquilinum – Rubus fruticosus* woodland
W11 *Quercus petraea – Betula pubescens – Oxalis acetosella* woodland
W12 *Fagus sylvatica – Mercurialis perennis* woodland
W13 *Taxus baccata* woodland
W14 *Fagus sylvatica – Rubus fruticosus* woodland
W15 *Fagus sylvatica – Deschampsia flexuosa* woodland
W16 *Quercus* spp. – *Betula* spp. – *Deschampsia flexuosa* woodland
W17 *Quercus petraea – Betula pubescens – Dicranium majus* woodland
W18 *Pinus sylvestris – Hylocomium splendens* woodland
W19 *Juniperus communis* ssp. *communis – Oxalis acetosella* woodland
W20 *Salix lapponum – Luzula sylvatica* scrub
W21 *Crataegus monogyna – Hedera helix* scrub
W22 *Prunus spinosa – Rubus fruticosus* scrub
W23 *Ulex europaeus – Rubus fruticosus* scrub
W24 *Rubus fruticosus – Holcus lanatus* underscrub
W25 *Pteridium aquilinum – Rubus fruticosus* underscrub

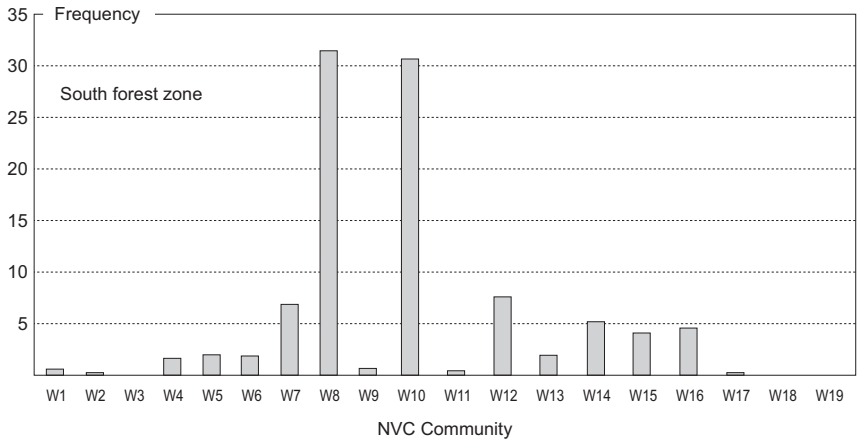

Frequency
North-west forest zone
30
25
20
15
10
5
W1 W2 W3 W4 W5 W6 W7 W8 W9 W10 W11 W12 W13 W14 W15 W16 W17 W18 W19
NVC Community

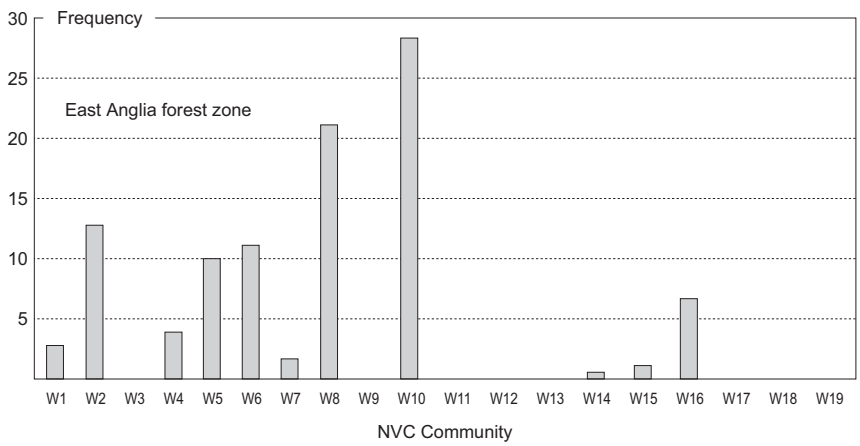

Frequency
Highland forest zone
30
25
20
15
10
5
W1 W2 W3 W4 W5 W6 W7 W8 W9 W10 W11 W12 W13 W14 W15 W16 W17 W18 W19
NVC Community


Frequency
Atlantic forest zone
25
20
15
10
5
W1 W2 W3 W4 W5 W6 W7 W8 W9 W10 W11 W12 W13 W14 W15 W16 W17 W18 W19
NVC Community


Frequency
25
20
15
10
5
Upland forest zone
W1 W2 W3 W4 W5 W6 W7 W8 W9 W10 W11 W12 W13 W14 W15 W16 W17 W18 W19
NVC Community


Frequency
50
40
30
20
10
Midland forest zone
W1 W2 W3 W4 W5 W6 W7 W8 W9 W10 W11 W12 W13 W14 W15 W16 W17 W18 W19
NVC Community


Frequency
South forest zone
35
30
25
20
15
10
5
W1 W2 W3 W4 W5 W6 W7 W8 W9 W10 W11 W12 W13 W14 W15 W16 W17 W18 W19
NVC Community


Frequency
East Anglia forest zone
30
25
20
15
10
5
W1 W2 W3 W4 W5 W6 W7 W8 W9 W10 W11 W12 W13 W14 W15 W16 W17 W18 W19
NVC Community

APPENDIX 2: SITES, MAINLY NATIONAL NATURE RESERVES, WITH LONG-TERM STUDIES OF SOME SORT

England

Ashford Hill SU565618 / Hampshire Lowland mixed deciduous woodland
Common bird survey every 5 years by voluntary warden

Ashtead Common TQ175598 / Surrey Lowland wood-pasture
Common bird survey
Annual fungi walk to monitor all fungi species
Great crested newt counts in each pond
Purple emperor adult population counts
Butterfly transect
Monitoring of beetles
900 oak pollards surveyed, tagged, photographed and mapped

Aston Rowant SU722964 / Oxon Beechwood
Beech woodland
Common bird survey
2 butterfly transects
Nest records

Avon Gorge ST560738 / Avon Western/upland mixed deciduous woodland
Butterfly transect
Dormouse box monitoring scheme

Bix Bottom SU720880 / Oxfordshire Beech woodland
Grid of plots established by Dr H C Dawkins in about 1974
Re-recorded 1991/2

Black Tor Copse SX567889 / Devon Western oakwood
Fixed point photography

Blean Woods TQ110608 / Kent Lowland mixed deciduous woodland
Heath fritillary monitoring
Butterfly transect
Influence of coppicing on populations of wood ants

Bovey Valley Woodlands SX770805 / Devon Western/upland oakwood
1994-96 nest boxes for BTO record scheme
1994-96 butterfly transect
Fixed-point photography

Bradfield Woods TL935581 / Suffolk Lowland mixed deciduous woodland
Butterfly transects

Brigsteer Park Wood SD487880 / Cumbria Western/upland mixed deciduous woodland
Permanent ground flora plots recorded 1969-1992

Brothers Water	NY403126 / Cumbria	Western/upland oakwood
1986-92 Record of changes in vegetation following exclusion of grazing		
Buckingham	SP708432 / Northamptonshire	Lowland mixed deciduous woodland
Thick Copse		
Tree health survey		
Bure Marshes	TG345160 / Norfolk	Wet woodland
Butterfly transect		
Ten-yearly aerial photograph survey		
Monthly water quality: ph, conductivity, water chemistry		
Burnham Beeches	SU950855 / Berkshire	Beech woodland/lowland wood-pasture
Monthly common bird census		
1994-96 butterfly transects		
Lichen monitoring		
Bat transects		
Dust deposition monitoring		
Vegetation transects		
Hydrological monitoring		
Burnt Wood	SJ737348 / Staffordshire	Lowland wood-pasture
5+ yrly		
fixed-point photography		
Castle Eden Dene	NZ434397 / Durham	Western/upland mixed deciduous woodland
Common bird census		
Butterfly survey		
Rothampstead insect survey		
Castor Hanglands	TF124015 / Cambridgeshire	Lowland mixed deciduous woodland
Bird census, selected species in scrub habitat		
Butterfly transects		
Weekly trapping and recording of moths		
Man orchid counts		
Chaddesley Woods	SO928727 / Worcestershire	Western oakwood
1994-96 common bird survey		
Nest box recording		
1994-96 butterfly transect		
Fixed point photography monitoring		
Collyweston Great	TF013004 / Northamptonshire	Lowland mixed deciduous woodland
Wood and Easton Hornstocks		
Fixed-point photographs set up to monitor long-term structural changes		
Colt Park Wood	SD7778 / North Yorkshire	Western/upland mixed deciduous woodland
15 short transects were initiated in 1959 and recorded again in 1977. In 1989 they were again recorded and widened to 20m		
Cotswold Commons and Beechwoods	SO888123 / Gloucestershire	Beechwood
3x60m transects in non-intervention zone in Buckholt Wood		
Performance of C. rubra monitored		
20 5x5m quadrats (baseline recordings) in Rough Park Wood		
Baseline recording of 6 20x20m plots in Saltridge Wood		

Dendles Wood SX616617 / Devon Western/upland oakwood/beechwood
Nest boxes for BTO nest record scheme
Long-term monitoring of lichens using photographic quadrats
Fixed point photography
Tree health monitoring
Permanent belt transect recording woodland structure 330 x 20m established in 1988.

Derbyshire Dales SK159644 / Derbyshire Western/upland mixed deciduous woodland
Continuous climate recording
Butterfly transect
Fixed point photography, all site covered each 5th year
Acid rainfall recording weekly

Derwent Gorge and Muggleswick Woods NZ052493 / Durham Upland oakwood
Fixed point photography network

Downton Gorge SO438732 / Herefordshire Western/upland mixed deciduous woodland
Fixed point photographic monitoring
Two plots recorded in 1987, but without mapping individual trees

Duncombe Park SE607828 / North Yorkshire Lowland wood-pasture
3,000 trees in total have been tagged and described

Dunkery and Homer Wood SS900420 / Somerset Western/upland oak woodland
Nest box recording
Heath fritillary butterfly transects

Ebbor Gorge ST525485 / Somerset Western/upland mixed deciduous woodland
Butterfly transect

Ebernoe Common SU9727 / West Sussex Beechwood
Grid of plots recorded throughout the wood in late 1980's.

Finglandrigg Woods NY218570 / Cumbria Wet woodland
6 years of Common bird census
Fixed point photography on 10 year cycle

Forge Valley Woods SE982866 North Yorkshire Western/upland mixed deciduous woodland
Recovery of ground flora/regen rates following clear/select fell of alien soft/hard woods

Gait Barrows SD480771 / Lancashire Western/upland mixed deciduous woodland
Birds survey on CBC guidelines
194-96 Butterfly transects
Moth survey

Golitha Falls SW220685 / Cornwall Western/upland oak woodland
1994-96 bird and nest box monitoring
Fixed point photography (not active '94/'95)

Hales Wood TL572404 / Essex Lowland mixed deciduous woodland
Populations and effects of grazing of deer

Ham Street Woods TQ008344 / Kent Lowland mixed deciduous woodland
A plot in oak high forest was recorded in 1964 and 1988: individual trees measured.
One transect of 20m x 160m established in 1988 in storm damaged woodland.
Butterfly transect
Fixed point photography

Hatfield Forest TL538202 / Essex Lowland wood-pasture
Lichen monitoring sites
All pollards individually labelled to monitor performance

Helbeck Wood NY784164 / Cumbria Western/upland mixed deciduous woodland
1986-92 Record change in MoD area after fencing

High Halstow TQ780763 / Kent Lowland mixed deciduous woodland
Monitoring of numbers of key bird species
Butterfly transects

Holme Fen TL205889 / Cambridgeshire Wet woodland
Common bird census
Butterfly transect

Kingley Vale SU822105 / West Sussex Yew woodland
Common bird census
Butterfly transect
Fixed point photography

Kings Wood and Urchin Wood ST451647 / Avon Western/upland mixed deciduous woodland
1992-93
2 thinning plots, 2 controls

Lady Park Wood SO293209 / Gwent/Gloucs Western/upland mixed deciduous
Transects initiated in 1945. Six transects of up to 366m long above the cliff recorded in 1945, 1955, 1977, 1983 and 1992 (old-growth) and 1945, 1966-58, 1977 and 1983 (young-growth). Three other transects recorded in 1950, 1959, 1985 and 1992. A tenth transect in adjacent managed woodland initiated in 1985. Many other records made including a complete enumeration in 1971, ground vegetation plots in 1979 and profile diagrams in 1986.

Langley Wood SU230206 / Wiltshire Lowland mixed deciduous woodland
Two 20m wide transects established 1986 totalling 638m

Monks Wood TL199800 / Cambridgeshire Lowland mixed deciduous woodland
Populations of small birds in Cambs woodlands project
Impact of muntjac deer on vegetation
Monitoring effects of frequent mowing on flora of tall herb zone of woodland paths
Tree health monitoring survey
4 permanent 20 m wide transects established 1985 for woodland structure, total length 907m.

New Forest SU20 / Hampshire Beechwood/Lowland wood-pasture
Transect established in Denny Wood by Southampton University in 1954 and recorded in 1959, 1962, 1964, 1984, 1997. Some supplementary information on dead wood and bryophytes also recorded.
In 1983 8 transects were established in unenclosed, grazed “Ancient and Ornamental“ woodlands in the New Forest by H. Koop and re-recorded in 1988 in:
Rushpole Wood, Berry Wood, White Moor, Pinnick Wood, Anses Wood, Bratley Wood, Denny Wood, Fritham Plain.

North Solent SZ415974 /Hampshire Lowland mixed deciduous woodland
2 Common Bird Census plots in woodland
Fixed point photography

Roudsea Wood SD335822 / Cumbria Western/upland mixed deciduous woodland
and Mosses
1994-96 Monitoring of next boxes
Permanent deer exclosure plots established in 1964.

The Mens TQ020230 / West Sussex Beechwood
Grid of small plots recorded throughout the wood in about 1977 but data not available. New record established in 1987 on the same set of grid samples to record storm damage. Re-recorded 1992/3

Wistmans Wood SX614776 / Devon Western/upland oak woodland
1994-96 unfenced plot – assess effects of grazing
Fixed point photography
Plot of 31 x 20m initiated in 1921, recorded again in 1965,1987, 1997.

Wyre Forest SO745760 / Worcester Western/upland oak woodland
1994-96 Common Bird Census in 6th year
Nest box recording
Butterfly monitoring
Deer census
Coppice vegetation/effects of deer browsing

Wytham Wood SP460080 / Oxfordshire Lowland mixed deciduous woodland
Grid of plots established by Dr H C Dawkins in about 1974
Re-recorded 1991/2
Environmental Change Network plots set up and recorded since 1992

Yarner Wood SX780788 / Devon Western/upland oak woodland
BTO nest record scheme
Weather station
Ground flora studies in unmanaged plots

Wales

Allt Rhyd y-Groes SN7648 / Dyfed Western/upland oak woodland
1974-78 Acorn predation studies
Tree regeneration monitoring established 1967, re-recorded 1972,74,75,88,90,92
Structure plots established 1967, re-recorded 1980

Coed Camlyn SH6539 / Gwynedd Western/upland oak woodland
2 vegetation/regeneration plots in exclosure, recorded 1967,1970, 1990
Acorn collections 1965-1975

Coed Cymerau SH6842 / Gwynedd Western/upland oak woodland
Plot established in 1964 within and recorded again in 1980, 1988 1992 (regeneration only).
10 plots established 1988 to monitor effects of goat/sheep on regeneration, re-recorded 1992
Acorn collections 1965-1975

Coed Gorswen SH7570 / Western/upland oak woodland
5 plots (10 x 10m) surveyed 1959,1961,1964
2 further plots established 1980
Acorn collections 1965-75

Coed Tremadog SH5640 / Gwynedd Western/upland oak woodland
Plots for vegetation and structure recorded 1957, 1963

Coed y Rhygen SH6836 / Gwynedd Western/upland oak woodland
Vegetation (including bryophyte) monitoring plots established in 1979

Coedydd Aber SH6671/ Gwynedd Western/upland oak woodland-Wet woodland
Monitoring of pied flycatcher Ficedula hypoleuca
Vegetation monitoring in grazed and ungrazed woodland

Coedydd Ganllwyd SH7224 / Gwynedd Western/upland oak woodland
10 vegetation/regeneration plots recorded 1988, 1992

Coedydd Maentwrog SH6741 / Gwynedd Western/upland oak woodland
Regeneration and vegetation monitoring 1988,1992
Selected saplings measured 1968,69,70,78
Acorn collections 1965-75

Cwm Crafnant Powys
10 permanent vegetation/regeneration plots established 1988.

Lady Park Wood SO293209 / Gwent/Gloucs Western/upland mixed deciduous
Listed also under England
Transects initiated in 1945. Six transects of up to 366m long above the cliff recorded in 1945, 1955, 1977, 1983 and 1992 (old-growth) and 1945, 1966-58, 1977 and 1983 (young-growth). Three transects below the cliff recorded in 1950, 1959, 1985 and 1992. A tenth transect in adjacent managed woodland initiated in 1985. Many other records made including a complete enumeration in 1971, ground vegetation plots in 1979 and profile diagrams in 1986.

Nant Irfon SN8454 / Powys Western/upland oak woodland
Regeneration monitoring
Fixed point photography
Common bird census 1979-1985
Nest box monitoring
Lichen monitoring plots established 1990
Ground vegetation monitoring plots established 1971, re-recorded 1980,1986,1990
Plantation vegetation quadrats established 1976, resurveyed 1992

Ty-Canol SN0936 Dyfed Western/upland oak woodland
Lichen monitoring
Rainfall composition monitoring
Permanent vegetation plots established 1988
50m belt transect established 1991 for tree mapping

Scotland

Beinn Eighe/ Loch Maree NH0046, NG9272 / Ross-shire Native pinewood/upland oakwood
Transects for woodland structure recording established in 1988
Deer assessments using dung counting in fixed plots
Detailed mapping of windthrow areas to follow decay and regeneration
Fixed point photography

Black Wood of Rannoch NN5555 / Perthshire Native pinewood
Five plots initiated in 1948 and recorded again in 1956 and 1984. Ten transects spaced at 200m intervals established in 1983/84 by Forestry Commission. Three of these transects, totalling 1628m x 20m recorded in detail in 1985. In addition, Institute of Terrestrial Ecology have three fenced plots in which regeneration has been recorded since 1970s.

CoilleThocabaig NG615128 / Skye
Fixed point photography to monitor regeneration

Craigellachie NH8812 / Speyside Northern birchwood
Two 20m wide transects 931m and 187m long established in 1987.

Creag Meagaidh NN4187 / Inverness-shire Birchwood
Monitoring regeneration following deer culling along transects

Dinnet Oakwood NO4698 / Aberdeenshire Western/upland oak woodland
Monitoring recovery of vegetation after rhododendron clearance
Monitoring native tree regeneration after clearance of non-native conifers
Woodland structure transect established about 1978 and recorded again in about 1988.

Glasdrum Wood NN0545 / Argyll Upland mixed deciduous
Woodland structure transect established in 1988.

Glen Strathfarrar NH45390 / Inverness-shire Native pinewood
Fixed point photography
Regeneration monitoring
Deer counts
Butterfly monitoring
Invertebrate monitoring via pitfall traps
Flowering success of Moneses uniflora

Glen Tanar NO4891 / Deeside Native pinewood
Deer damage to regeneration assessments along transects
Permanent woodland structure transect established in 1989.

Inverpolly NC1013 / Ross-shire Northern birchwood
Monitoring of regeneration following removal of sheep grazing
Butterfly transect

Loch Lomond Woods NS4090 / Upland oakwoods
Regeneration monitoring (Inchcailloch)
Two transects of 10m x 362m and 174m initiated in 1961 and recorded again in 1986. In 1986 the original transects were expanded to 20m width (Clairinsh)

Loch A' Mhuilinn NC1737 / Sutherland Northern birchwood
Monitoring of regeneration after reduction of deer browsing

Rassal Ashwood NG8443 / Ross-shire Upland mixed deciduous woodland
The large ash trees in the enclosure were mapped in 1959 and measured in 1960 and 1988.

Taynish Wood NR7384 / Argyll Upland oakwood
Two 20m wide woodland structure transects of 270m and 180m established in 1987/8.

Tynron NX8292 / Dumfries-shire Juniper scrub
Growth, regeneration and age structure of juniper
Vegetation monitoring in transects and permanent plots

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