Second EUFORGEN Meeting on Social Broadleaves

3-6 June 1999 - Birmendsorf, Switzerland

J. Turok, A. Kremer, L. Paule, P. Bonfils and E. Lipman, ***compilers***

EUFORGEN

European Forest Genetic Resources Programme (EUFORGEN)

IPGRI is an institute of the Consultative Group on International Agricultural Research (CGIAR)

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The International Plant Genetic Resources Institute (IPGRI) is an autonomous international scientific organization, supported by the Consultative Group on International Agricultural Research (CGIAR). IPGRI's mandate is to advance the conservation and use of genetic diversity for the well-being of present and future generations. IPGRI's headquarters is based in Rome, Italy, with offices in another 15 countries worldwide. It operates through three programmes: (1) the Plant Genetic Resources Programme, (2) the CGIAR Genetic Resources Support Programme, and (3) the International Network for the Improvement of Banana and Plantain (INIBAP).

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The European Forest Genetic Resources Programme (EUFORGEN) is a collaborative programme among European countries aimed at ensuring the effective conservation and the sustainable utilization of forest genetic resources in Europe. It was established to implement Resolution 2 of the Strasbourg Ministerial Conference on the Protection of Forests in Europe. EUFORGEN is financed by participating countries and is coordinated by IPGRI, in collaboration with the Forestry Department of FAO. It facilitates the dissemination of information and various collaborative initiatives. The Programme operates through networks in which forest geneticists and other forestry specialists work together to analyze needs, exchange experiences and develop conservation objectives and methods for selected species. The networks also contribute to the development of appropriate conservation strategies for the ecosystems to which these species belong. Network members and other scientists and forest managers from participating countries carry out an agreed workplan with their own resources as inputs in kind to the Programme. EUFORGEN is overseen by a Steering Committee composed of National Coordinators nominated by the participating countries.

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Summary of the meeting

Introduction

The main objective of the second EUFORGEN Social Broadleaves Network meeting held 3-6 June 1999 in Birmensdorf, Switzerland was to review the progress made in the conserv-ation of oak and beech genetic resources in European countries since the previous meeting and to update the joint workplan. Main tasks of the workplan concern the development of technical guidelines for gene conservation and management, common minimum documentation standards and public awareness activities (see Workplan update).

The meeting was attended by Network members from 25 countries. All country reports are published in this volume and are also available from the Internet web page. The List of Participants is given at the end of this volume.

A joint session on genetic research in oaks was organized on the first day of the meeting. A number of research partners involved in the EU/FAIR Project on Oaks (Synthetic maps of gene diversity and provenance performance for utilization and conservation of oak genetic resources) attended this session (see List of Participants). This provided an opportunity not only to present and discuss the main results obtained within the project, but also to exchange views and information regarding the further research needs in Europe. Possibilities for submitting joint project proposals for funding within the Fifth Framework Programme of the European Union and other, complementary options for cooperation and collaboration (such as bilateral 'twinning' arrangements) were discussed and will be pursued.

In view of the outcomes of the EUFORGEN Steering Committee meeting (held in November 1998), the scope of the Network regarding species was also discussed. It was agreed that a practical approach should be taken by the Network in addressing the overall gene conservation issues in oak and beech species, rather than their taxonomic status. Complementarity and possible overlap with the Mediterranean oaks Network will be clarified by the new Inter-Network Group composed of Chairs and Vice-Chairs of all five EUFORGEN Networks. At present the Social Broadleaves Network includes principal European white oaks (*Quercus robur, Q. petraea, Q. pubescens*) and related minor oak species, as well as beech (*Fagus* sp.).

The meeting was concluded by adopting the Workplan update.[1] Colleagues from the Swiss Federal Institute for Forest, Snow and Landscape in Birmensdorf were thanked for the excellent local organization of the meeting. Bulgaria offered to host the third Network meeting at a forestry training facility in the Rhodope Mountains. Implementation of the tasks agreed to be carried out by Network members and coordination of the ongoing activities will be on the agenda. The participants appreciated this offer and agreed that the meeting would be held in mid-June 2000.

[1] See Internet site http://www.cgiar.org/ipgri/euforgen for news and follow-up information.

Workplan update

Information exchange

Network members from Moldova, Ukraine, Hungary, Slovakia, Czech Republic, Austria, Switzerland, Italy, Slovenia, France, Luxembourg, Belgium, the Netherlands, Germany, Lithuania, Finland and Sweden briefly reported on the progress made at the national level since the first Network meeting (held in Bordeaux, in October 1997). Introductory country reports from Bulgaria, Croatia, Ireland, Norway, Portugal, Spain and the United Kingdom were presented.

During this period significant progress has been made in monitoring genetic diversity in both beech and oak throughout their natural distribution range. Intensive research has been carried out in a number of countries, particularly those involved in the EU/FAIR project and the project on broadleaved species in southeast Europe.

It was agreed that the introductory country reports and the updates be published in the Report of the meeting. The updates should be no longer than one single-spaced page of text plus tables/figures. They should typically mention the following items: practical conservation activities, inventories, legislation, research and public awareness.

The introductory reports should be no longer than 10 pages of text. Figures and statistics (e.g. area occupied by the species, overview of conservation activities) should be given in tables. The reports should follow the structure outlined previously (see Report of the first Network meeting):

- Occurrence and origin of Social Broadleaves in the country
- Current economical importance for the forestry sector
- Silvicultural approaches used
- Health state of the forest stands and threats to their genetic diversity
- Research activities and capacities related to genetic resources
- Current gene conservation activities *in situ* and *ex situ* (overview)
- Relevant nature protection policies and activities
- Tree improvement
- Use of reproductive material
- Institutions involved in the genetic resources activities in the country
- Summary of country priorities
- Needs for international collaboration.

All the country reports will be made available on the Internet [homepage of the Network http://www.cgiar.org/ipgri/euforgen/networks/social.htm]. Other relevant information that should be included on this Web site was recommended: list of Network members, minimum list of descriptors for databases (see below), links with research projects and with institutes hosting national information about Social Broadleaves.

The introductory country reports and the updates should be sent electronically to J. Turok for compilation in the Report of the meeting **no later than 31 July 1999**. J. Turok will contact countries not represented in the meeting and will ask for their input according to the agreed structure and deadline.

Research needs and coordination of research priorities

Ongoing EU/FAIR research project on genetic diversity in oaks

Results were presented of the EU/FAIR project entitled "Synthetic maps of gene diversity and provenance performance for utilization and conservation of oak genetic resources" (FAIR/OAK). This project brings together 12 different research stations from eight countries. Range-wide maps of chloroplast DNA polymorphism were shown and compared with fossil pollen deposit maps compiled from the European Pollen Data Base (EPD), managed by the University of Marseille. These maps revealed clear patterns of post-glacial recolonization routes across Europe. Phenotypic data for adaptive traits were compared among different provenances from a multisite provenance test established by S. Madsen in different European countries. The results indicated significant variation for survival, bud burst and growth components. Finally a genetic inventory of gene diversity based on six microsatellite loci was conducted in nine different Intensive Studied Populations (ISP) distributed across Europe. Oaks appear to be extremely variable, as indicated by the high number of alleles that were scored in all populations (from 12 to 32), but no significant trend of variation (among populations or between species) was detected for microsatellites. This project will end on 31 August 1999.

Project submitted to INCO-COPERNICUS

In 1997, an extension of the FAIR project to east European countries was submitted within the INCO-Copernicus programme. It had similar objectives as the FAIR project, particularly relating to the extension of the synthetic map of cpDNA polymorphism in east European countries. Twelve institutes were involved (six from east European countries and six from west European countries); the cooperation was planned in the form of a 'twinning' arrangement between labs.

New proposal for the EU Fifth Framework Programme (FFP)

A new proposal on oaks has been made for the Fifth Framework Programme (Quality of Life). Its objectives are: (1) to quantify intra- and interspecific geneflow, (2) to evaluate genetic and ecological consequences of geneflow, and (3) to identify effects of geneflow on the management of seed and conservation stands and on natural regeneration practices.

Future proposals for the inventory of gene diversity in the white oak complex

The extension of the survey of genetic chloroplast DNA (cpDNA) diversity to eastern Europe was discussed by the participants and a general agreement was reached to conduct these investigations following a systematic sampling scheme up to the limit of the distribution range of European white oak species (Ural Mountains). A most appropriate and feasible way was to consider separately the countries associated with EU/FFP (most Central and East European states) and non-associated countries (most European Newly Independent States), in view of the different sources for supporting cooperative efforts. These include:

- EU RTD (research, technology and development) projects
- Bilateral cooperation agreements between east and west European countries.

The following countries expressed interest in joining such a project:

EU member countries[†]	East European countries[‡]
Austria	Bulgaria
France	Croatia
Germany	Hungary
United Kingdom	Lithuania
Spain	Moldova
The Netherlands	Slovenia
	Slovakia
	Ukraine

[†] Greece was not part of the previous FAIR project but should be associated in a new cooperative project.

[‡] Contacts should be made with other countries that were not represented at the meeting. Albania, Belarus, Macedonia (FYR) and Romania will be contacted.

The general frame of cooperation could be that the east European countries contribute to the inventory and collection of material and that the partners in west European (EU member) countries share the molecular techniques for scoring the cpDNA polymorphism. Six research labs involved in the ongoing EU/FAIR project intend to join a future project aiming at the extension of the cpDNA map to eastern Europe.

J. Turok will analyze the possible funding mechanisms to submit such a project within the FFP and will circulate this information to all Network members **by 15 September 1999**. Particular emphasis should be paid to involving the Caucasus countries (Armenia, Azerbaijan and Georgia). An overview of ongoing national and international projects and programmes related to genetic resources will be extracted from the country reports and distributed to all Network members by J. Turok.

Legislation

A brief synthesis was presented by S. de Vries on the basis of the information available in the country reports from the first Network meeting in Bordeaux. A form on the status of legislation and other regulations on genetic resources of oak and beech was distributed and completed by most participating countries during the meeting. Additional modifications should be sent to S. de Vries **no later than 20 June 1999**. J. Turok will circulate the updated version before including it in the Report of the meeting.

The distribution of the latest versions of the OECD and EU regulations by L. Ackzell to all Network members was acknowledged.

Documentation

J. Jensen prepared a list of common minimum descriptors for Noble Hardwoods which was recognized as a good starting point for Social Broadleaves. The minimum descriptors on Norway spruce as well as the concept note on databases and common minimum standards for inventories on Noble Hardwoods were mentioned. Several modifications in the list of descriptors were agreed upon. The list of obligatory descriptors was completed with voluntary descriptors on conservation status and regeneration. J. Jensen will summarize the modifications and send them to J. Turok for publication in the Report of the meeting **by 15 July 1999**. Any additional comments or suggestions should be sent to J. Jensen **before 20 June 1999**. The objective is to provide a minimum common format for databases on gene conservation units at a national level.

It was agreed that an international database for oak and beech species may be set up later but is not required at the present.

Joint conservation strategies and technical guidelines

A questionnaire on the status of the conservation and management of Social Broadleaves in European countries was compiled by a working group composed of T. Geburek, R. Stephan and P. Bonfils. The questionnaire was distributed to Network members in March 1999. Response has so far been received from 12 countries. The questionnaire was divided into five chapters:

- Distribution of species
- Conservation measures implemented
- Assessment of genetic diversity within the country range
- Silvicultural management and use
- EUFORGEN Social Broadleaves Network.

The compilation was presented and discussed during the meeting. It indicated the need to clarify the following questions: completion of the survey, species covered by the Network and their natural range of distribution, monitoring of progress and technical guidelines.

All countries will either send their response or complete the missing information in the questionnaire and send it to T. Geburek **by 15 July 1999.**

It was agreed that up-to-date maps of the distribution ranges of individual Social Broadleaves should be developed in the future. Maps that are presently used in countries will be collected and completed with information about seed zones by Network members. These should be sent to T. Geburek along with the response to the questionnaire, or later, if they are not readily available. A proposal for producing joint maps will be made and discussed at the next Network meeting.

It was decided that the Network will develop Technical Guidelines on gene conservation and management of European white oaks. If the results of the survey clearly indicate the need to also consider beech, this species will be added.

The Guidelines will offer a synthesis of the knowledge available and will aim at providing advice to forest officers responsible for genetic resources at the national or regional level. Similar guidelines were produced by the *Picea abies*, Noble Hardwoods and *Quercus suber* Networks. They should be considered as a starting point for the Guidelines to be developed. The following outline was proposed and Network members were invited to contribute:

1. Introduction (A. Kremer and T. Geburek)
2. Genetic processes promoting diversity in species with natural hybridization (A. Kremer and P. Menozzi)
3. *In situ* conservation (including conservation strategies at the margins of the distribution range and conservation of valuable origins) (P. Bonfils, A. Alexandrov and J. Gracan)
4. *Ex situ* conservation (T. Skrøppa and S. Bordács)
5. Silvicultural management and use including movement of reproductive material (T. Geburek and L. Ackzell)
6. Conclusions (A. Kremer, T. Geburek, L. Paule and J. Turok).

The draft chapters will be prepared and distributed to all Network members **one month before the next meeting.** J. Turok will circulate the respective chapters from the other Networks to all authors **before 15 June 1999.**

Public awareness

D. Jacques presented a detailed outline of the slide collection and the accompanying information. Network members were strongly encouraged to contribute most relevant slides from their countries to the collection. The set of slides will be compiled and stored on a Photo-CD which will be presented during the next Network meeting. Missing items will then be identified. It was agreed that the collection will be made available separately for oak and beech on Photo-CDs (with high resolution) to Network members as well as on the Internet (with medium resolution). The name of the author and the EUFORGEN Social Broadleaves Network will be cited as source for using the collection in the future.

Slides should be sent to D. Jacques **before 15 October 1999**. All slides must be accompanied with a short text following the slide collection form proposed by D. Jacques. D. Jacques in consultation with F. Wolter will clarify the structure of the database and will send the modified version of the slide collection form to all Network members **by 15 July 1999**.

It was agreed to produce the public awareness leaflet in English **before the next Network meeting** (by IPGRI). Additional language versions will be discussed at the next meeting. Comments and suggestions on draft text (provided by I. Blada) should be sent to N. Cundall **no later than 15 September 1999**. N. Cundall, D. Jacques and J. Turok will develop the leaflet **by the end of the year**.

Progress Reports

Moldova - *In situ* conservation of pedunculate oak (*Quercus robur*) genetic resources

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Owing to the continuous exploitation of forest resources the intraspecific, floristic and phytocenotic diversity is reduced. The disappearance of certain plant varieties and species causes the reduction of the genetic potential of the populations and leads to changes in the composition and structure of the natural ecosystems. The genetic potential of the population being reduced, the stability and the productivity of the forest stands will be reduced too. Veresin *et al.* (1985) suggested that through a rational utilization of forest genetic resources the forest stands could be increased by 10-15% and their stability would also increase.

The natural conditions (climate, relief, soils, etc.) have led to the formation of a very valuable, diversified genepool in southeastern Europe. According to the *Strategy and action plan for the conservation and use of plant genetic resources in Eastern Europe and in the New Independent States* (IPGRI 1996) this part of Europe was given high attention in the context of collaborative activities on forest genetic resources in Europe. The project "Genetic resources of broadleaved forest species in southeastern Europe" was initiated. Until then research carried out in Moldova on forest genetic resources have not been well developed.

In the framework of this project, identification, sampling and description of pedunculate oak (*Quercus robur*), sessile oak (*Quercus petraea)* and beech (*Fagus sylvatica*) were carried out in 1997-98. Results of the identification and *in situ* conservation of forest genetic resources of pedunculate oak in the Republic of Moldova will be provided in the future.

Occurrence and origin of pedunculate oak

The Republic of Moldova has a low proportion of forests. According to the Report on the forest status of the Republic of Moldova (1997) the forest area covers 394 400 ha (11.7% of the territory) including 325 400 ha covered by forests (9.6%). The state forest services manage 345 600 ha or 87.6% of the forest area. The rest of the forest area, i.e. 48 800 ha or 12.4%, is managed by municipalities and agricultural farms.

Oak species occupy 140 500 ha. Pedunculate oak grows on an area of 78 200 ha. Pedunculate oak forest stands include high forest (29 198 ha - 37.3%) and coppices (49 040 ha - 62.7%). The growth of oak coppices is a consequence of their management and these are old (3-4 generations). This management has been practised during the last century.

An inventory of the most valuable oak plantations was carried out. Once certified and registered (in May 1992), the following seed production units were recognized:

- 52 forest gene resource units with 433.5 ha of *Quercus robur*
- 12 *Quercus robur* and *Q. pubescens* clonal and seedling seed orchards covering 57.8 ha (Postolache 1995).

This situation was not satisfactory for the conservation of forest genetic resources of pedunculate oak in Moldova. Therefore, research on forest genetic resources was started.

Material and methods

Forest genetic resources are conserved by *in situ* and *ex situ* methods (Benea and Stănescu 1981; Koski 1997; Turok 1997).

In situ conservation involves several stages (Enescu *et al.* 1977): exploration, sampling, description and classification.

The classification of forest genetic resources was made according to their genetic value and their utilization value. Four categories of forest genetic resources were defined:

1. *Optimal forest stands* comprise natural forest stands with an optimal (well-adapted to site) composition, structure and (timber) productivity.
2. *Forest stands with high intraspecific diversity* from the contact zone of two or three oak species.
3. *Seed stands* comprise forest stand with superior timber production qualities, which can be used for the collecting of a large quantity of seeds.
4. *Forest stands in reserves and protected areas.*

For each category certain delimitation criteria have been established. The main criterion for optimal forest stands and seed stands was superior phenotypic performance; for forest stands with great intraspecific diversity, it was the structure of the forest stand. The seed stands were chosen on the basis of the origin, age, productivity, composition and health status.

For the mapping of distribution areas, one basic method is the presentation by point (Vulf 1931; Tolmacev 1962, 1974). To reflect the distribution of pedunculate oak the scale 1:500 000 was chosen.

Inventory of pedunculate oak genetic resources

Pedunculate oak grows at different altitudes, humidity and soils conditions. In the northern part of the country (forest farms Edinet, partially Soroca and Glodeni) pedunculate oak is the principal species in the forest stands. Ninety percent of natural forests belong to the forest type "forest oak with cherry" (*Prunus avium*).

In the central part of Moldova (forest farms Calarasi, Chisinau, Soldanesti, Orhei, a part of Nisporeni, Telenesti) pedunculate oak occupies small areas and grows mainly at low altitudes, on humus-rich gray forest soil. The water table at these sites is at 1-8 m depth. In such places more productive forest associations of this type have been formed. The favourable ecological conditions lead to the formation of highly productive forest stands. In such conditions pedunculate oak reach about 30 m height; the diameter of some trees is more than 100 cm. The favourable humidity and trophic conditions allow the growth and development of a rather productive forest stand. At 70 years the growing stock is about 270-340 m^3/ha (Table 1).

In the southern part of Moldova (forest farms Iargara, Hincesti, Rezeni) pedunculate oak occupies small surfaces at low altitudes and on the slopes with northern and eastern exposure. In spite of the humus-rich soil, the low amount of soil humidity limits productivity. At 70 years the height of oak trees is about 10-15 m. The growing stock is 70-140 m^3/ha.

In the Prut and Nistru meadows, pedunculate oak grows in specific ecological conditions. In these places the sources of water supply include subterranean water as well as rainfall. The communities of this forest type differ from the zonal forests by their composition, structure and productivity. In these conditions oaks reach a height of 24-30 m, a trunk diameter of 28-45 cm, reaching 100-150 cm for some trees. The growing stock is 200-350 m^3/ha.

The characteristics of the forest types and of the phytocenotic position of oak prove the large adaptive potential of this species in different ecological conditions. It grows very well in humid conditions of meadow forests and in the "pedunculate oak with hornbeam" forests.

The "oak with cherry" forests from northern Moldova occupy an intermediate place. The lowest values are recorded in the "oak blackthorn" forests from southern Moldova. Thus, according to their adaptive capacities and the phytocenotic position, the pedunculate oak populations can be assigned to three zonal phytocenopopulations (named after the forest type): "pedunculate oak with blackthorn" forest, "pedunculate oak with cherry" forest and "pedunculate oak with hornbeam" forest and one specific phytocenopopulation from meadows (Table 1).

Cuza (1994), in the results of a study on intraspecific variability and reproductive organs of *Quercus robur*, established that leaf characters have a high (21-40%) to very high (more than 40%) variability, while reproductive organs are characterized by a considerably lower variability (coefficient of variation CV=2.9-17.4%).

The evaluation of oak variability showed that the main contribution to phenotypic variability is due to the difference between the trees and the variability of characters in their crown. This study demonstrated an adaptation of the population to the conditions of the site. It becomes evident that the ecological genetic variability of oak correlates with the ecological geographic structure of its natural habitat. The natural structure of the territory and some biological peculiarities of oak favoured the appearance of group variability on limited territories and the formation of *Q. robur* population structure. Thus *Q. robur* presents a complex dynamic population system in Moldova.

Intraspecific diversity of oak was studied by Svulescu and Rayss (1926) and Andreev (1957). Andreev (1957) recorded 10 varieties and 8 forms which indicate a great intraspecific diversity depending on the different ecological conditions and on the capacity of the species to hybridize (Table 2). Based on the appearance of the leaves and flowers two oak (*Q. robur*) varieties have been recognized: var. *praecox* Czern and var. *tardiflora* Czern (Table 3).

The presence of many presumed varieties, forms and hybrids in the forests confirms the fact that pedunculate oak is characterized by a rather pronounced diversity. The diversity of oak in the contact zones with other species (*Q. pubescens, Q. petraea*) is greater in the south of Moldova, and the intraspecific diversity is less pronounced in the forests of Central Moldova.

Some varieties are frost-resistant (var. *tardiflora* Crezn.), some are less resistant (var. *praecox* Crezn.) and some are adapted to arid conditions (var. *moldavica* V. Andreev). The varieties *praecox, tardiflora, brevipes, puberula, moldavica* are frequent in forests. Rare varieties and forms (var. *microtricha*, var. *australis*) need to be protected. Certain varieties and forms (f. *pectinata*, f. *moldavica*) have decorative qualities and present some interest for landscaping.

It was shown that the use of oak seeds for the establishment of forest plantations without taking into account the cenopopulation origins leads to the creation of forest stands which are of low productivity and have low resistance to unfavourable factors.

The intraspecific and phytocenotic diversity of pedunculate oak confirm the necessity of protection and rational use of the genepool of this species.

The total surface of the state-protected oak forests is about 1644 ha.

The genetic resources of pedunculate oak have been studied according to the research methods described above, which include several stages: exploration, sampling, classification, description, etc.

Exploration: at this stage all surfaces occupied by oak forests have been analyzed, except those unsuitable. The choice was made according to visible phenotypic characters. Only forest stands of natural origin were selected. As a result of this analysis 2258 oak subcompartments have been marked with a total surface of 25 303 ha. The highest number of surfaces was recorded in the forests from the forest type "pedunculate oak with cherry" from the north of Moldova – 11 020.8 ha, which constitutes 43.6% of the total area of pedunculate oak forests (Table 4).

Table 1. Characteristics of pedunculate oak (*Quercus robur*) cenopopulations[†]

Forest type	Height (m)	Diameter (cm)	Bonity class	Growing stock (m^3/ha)
Pedunculate oak with blackthorn (*Prunus spinosa*)	10-15	12-18	4-5	70-100
Pedunculate oak with cherry tree (*Prunus avium*)	21-24	28-40	3	250-300
Pedunculate oak with hornbeam (*Carpinus betulus*)	23-30	32-44	2-3	270-340
Pedunculate oak from meadow	24-30	28-45	2-1	200-350

[†] The notion of cenopopulation includes the totality of certain species as part of a phytocenosis.

Table 2. Pedunculate oak (*Quercus robur*) forest genetic resources

		Optimal forest stands		Seed stands		Intraspecific diversity stands		Total	
No.	Category of forest genetic resources	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)
1	Forests of pedunculate oak with cherry from the North of Moldova	5	75.7	18	460.1	9	277.6[†]	32	813.4
2	Sessile oak and pedunculate oak forests from the Nistru Plateau	8	43.4	20	374.5	14	143.2[†]	42	561.1
3	Pedunculate oak forests and black locust plantations from the left bank of Nistru	-	-	2	48.5	-	-	2	48.5
4	Sessile oak, pedunculate oak and beech forests from the Centre of Moldova	15	270	35	817.4	12	307.8[†]	62	1395.2
5	Pubescent oak forests from the South of Moldova	6	159.2	6	68.6	20	464.4[‡]	32	692.2
6	Reserves	9	181.7	2	59.3	2	6.8	13	247.8
	Total	**43**	**730.0**	**81**	**1828.4**	**57**	**1199.8**	**181**	**3758.2**

[†] Forest genetic resources of pedunculate oak (*Q. robur*) with sessile oak (*Q. petraea*) delimited in the contact zone.

[‡] Forest genetic resources of pedunculate oak (*Q. robur*) with pubescent oak (*Q. pubescens*) including 96.5 ha in the contact zone of three oak species (*Q. robur*, *Q. petraea* and *Q. pubescens*).

Sampling was made on the basis of the information collected at the exploration stage. The forest stands were sampled as forest genetic resources taking into account the criteria of quality and of forest stand classification. Forest stands with larger areas and remarkable for their value were sampled as forest genetic resources (FGR). Some forest genetic resources include subplots with at least 3 ha, other genetic resources include a few subplots, frequently adjacent, with larger areas. As a result of the sampling, 181 pedunculate oak FGR have been established.

Table 3. Varieties and forms of pedunculate oak (*Quercus robur* L.) in Moldova

No.	Variety, form	Occurrence
1	var. *praecox* Czern.	Everywhere
2	var. *tardiflora* Czern.	Everywhere
3	var. *australis* Corke	Bulaesti, Caet
4	var. *microtricha* A. et J.	Soroca (rare)
5	var. *brevipes* Beck	Everywhere
6	var. *pseudosessilis* A. et G.	Pogrebeni, Zloti
7	var. *suecica* Maly	South Moldova
8	var. *puberula* Beck	South, is rare in Centre and North of Moldova
9	var. *pubescens* Schmalh	South, is rare in Centre of Moldova
10	var. *moldavica* V. Andreev.	South of Moldova
11	f. *brevisecta* Berb.	Taul, Radenii Vechi, Albina, Dubasari
12	f. *opaca* Gurke	Briceni, Bisericani, Baurci-Mold.
13	f. *angustifolia* Gurke	Taul, Lucaceni, Cocorozeni, Lozova, Mandra, Bolceana, Zloti, Dubasari
14	f. *longifolia* Gurke	Baimaclia
15	f. *pectinata* C.K.S.	Chisinau, park
16	f. *brachybalanos* Gurke	Grigoriopol
17	f. *xylolepis* Vukot.	Avrameni, Bujor
18	f. *fastigiata* Spach	Cultivation
19	f. *macrophylla* Zapal	Baimaclia
20	f. *acutifolia* A. et G.	Vascauti
21	f. *multilobata* Gurke	Stanilesti, Vertiujeni, Purcari, Leonita
22	f. *latilobat* (Lasch.) Beck	Vascauti, Vertiujeni
23	f. *chartacea* (Schur, 1868) A. et G.	Vertiujeni
24	f. *coriacea* A. et G.	Tulbureni
25	f. *crispata* Stev.	Badicu-Mold., Baurci-Mold.
26	f. *cuneifolia* Beck	Vascauti, Vertiujeni
27	f. *Bedoi* Borb.	Mereseni, Carpesti
28	f. *asterotricha* A. et G.	Mereseni, Baurci-Mold., Carpesti, Badicu-Moldov.
29	f. *dilatata* A. et G.	Badicu-Mold., Baurci-Mold.

Sources: Svulescu and Rayss (1926); Andreev (1957).

Table 4. Number and area of the subcompartments with native pedunculate oak (*Q. robur*) forest stands recorded in the forest districts

No.	Forest district	No. of subcompartments	Area	
			ha	%
1	Pedunculate oak with cherry forest from the north of Moldova	786	11020.8	43.6
2	Sessile oak and pedunculate oak forests from Nistru Plateau	332	2893.9	11.4
3	Pedunculate oak forests and black locust plantations from the left bank of Nistru	147	965.5	3.8
4	Sessile oak, pedunculate oak and beech forests from Central Moldova	915	7400.5	29.3
5	Pubescent oak forests from the south of Moldova	434	3022.8	11.9
	Total	**2614**	**25303.5**	**100.0**

The classification of the FGR has been made on the basis of the genetic value of the selected surfaces. Four categories of forest genetic resources have been established:

- *Optimal forest genetic resources* of pedunculate oak include the most productive forest stands (290-350 m^3/ha). The tree height is 28-32 m. The diameter of the trunk is often more than 40 cm. Many trees are more than 100 cm in diameter. Their ecological conditions are optimal – rich soils and good humidity. In Moldova 34 optimal forest genetic resources of oak were established with a total area of 730 ha. The highest number

of optimal forest genetic resources of oak was established in sessile oak, pedunculate oak and beech forest district from Central Moldova.

- *Forest genetic resources - seed sources* of oak include less productive forest stands than the optimal stands (260-300 m^3/ha). They occupy larger areas. The tree height at 70 years is about 25-28 m. The diameter of the tree trunk is 31-46 cm, the growing stock is 250-300 m^3/ha. Eighty-one forest genetic resources - seed sources were established with a total surface of 1828 ha.
- *Forest genetic resources with high intraspecific diversity*. They occur in the contact zone of the pedunculate oak, sessile oak and pubescent oak. These areas are characterized by a well-pronounced intraspecific diversity. In such places Svulescu and Rayss (1926) and Andreev (1957) have recognized many oak varieties and forms. Thirty-four forest genetic resources have been established in the contact zone of the pedunculate oak with sessile oak (*Q. petraea*), 17 in the contact zone of the pedunculate oak with pubescent oak (*Q. pubescens*), 3 in the contact zone of the pedunculate oak (*Q. robur*), sessile oak (*Q. petraea*) with pubescent oak (*Q. pubescens*). In total 57 forest genetic resources have been delimited in the contact zones of the pedunculate oak with sessile oak and pubescent oak.

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Ukraine

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Practical conservation activities

Thirteen *Quercus robur* plus trees and seven *Fagus sylvatica* plus trees were selected in the Chernivtsy and Ivano-Frankivsk regions.

Two progeny tests and two seed orchards of *Q. robur* were established in Kharkiv and Rivne regions (Tables 1 and 2). All plots were established by planting 2-year-old seedlings. The seedlings were grown from acorns harvested in 1996.

Inventories

The inventory of gene resource units was carried out in the Lviv, Ivano-Frankivsk, Chernivtsy, Transcarpathian, Rivne and Ternopil regions. Table 3 gives data on the area of gene resource units including the results of the inventories, selection and establishment of new units.

Legislation

The "Main statute for conservation of genetic resources of the Carpathian region" was elaborated by the Ukrainian Research Institute of Mountain Forestry.

Research

The inventories of gene resource units included the study of diversity of oak and beech natural populations. In Rivne region two gene reserves of *Q. robur* were surveyed. The phenological types, types of bark and selection categories were determined besides the diameter and height of trees. In the Ternopil region two *F. sylvatica* and one *Q. robur* gene reserves were surveyed (Table 4.). In Crimea the studies of biodiversity of the natural population of *Q. pubescens* were continued. The morphology of leaves and acorns of 60 tree clusters was studied. Yearly observations of the flowering and fruit-bearing intensity of *Q. robur* clones have been continued at clonal seed orchards and clonal archives in Vinnitsa, Kharkiv, Kirovohrad and Rivne regions. Cytological studies of *Q. robur* clones were carried out to elucidate the causes of low fruit-bearing intensity of some clones. The buds of 18 clones with different fruit-bearing intensity were studied. The presence of unreduced pollen was found in nine clones. Three of them had polyploid pollen. The creation of the database on Social Broadleaves genetic resources has started.

Unfortunately, cuts in financial support caused reduction in research activities in Ukraine. Highly experienced specialists were lost, as well as several Research Stations. Whole regions are not covered by the studies this year. The necessary steps for gene resource conservation have not been taken because of a low level of funding for forest enterprises and they are still declining.

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Table 1. Establishment of progeny trials of *Quercus robur* in Ukraine in 1999

Region	Forestry regional enterprise	Area (ha)	Origin of trees-donors of seeds	Number of progenies
Kharkiv	Octiabrsky	0.9	Kharkiv, Donetsk and Sumu regions	31
Rivne	Klevanivsky	1.6	Rivne region	40
Total		**2.5**		

Table 2. Establishment of seedling seed orchards of *Quercus robur* in Ukraine in 1999

Region	Forestry regional enterprise	Area (ha)	Origin of trees-donors of seed	Number of progenies
Kharkiv	Hutiansky	5	Kharkiv, Donetsk and Sumu regions	27
Rivne	Klevanivsky	1	Rivne region	20
Total		**6**		

Table 3. *Ex situ* and *in situ* conservation of gene resources of Social Broadleaves in Ukraine

	Gene reserve		Plus stand (ha)	No. of plus trees	Clonal archive (ha)	Clonal seed orchard (ha)	Seedling seed orchard (ha)	Progeny trial	
	Area (ha)	No.						Area (ha)	No. of pro-genies
Fagus sylvatica									
Mixed forest	2	1	0	0	0	0	0	0	0
Forest-steppe	324.7	20	77.6	32	0	2	6	0	0
Carpathians	3855.5	51	10	177	0	0	0	0	0
Crimea	0	0	0	12	0	0	0	0	0
Total	4182.2	72	87.6	221	0	2	6	0	0
Quercus robur									
Mixed forest	2526.3	80	330.3	294	11	76.9	16	2.1	92
Forest-steppe	3295.1	130	1213.3	418	13.2	382	40.2	28	664
Steppe	269	16	30.3	323	5.6	28.6	10	3.5	119
Carpathians	1141.8	26	14.7	184	0	14	0	0	0
Crimea	0	0	0	0	0	0	0	0	0
Total	7232.2	252	1588.6	1219	29.8	501.5	66.2	33.6	875
Quercus petraea									
Mixed forest	52.4	1	27	30	0	0	0	0	0
Forest-steppe	13	1	0	28	0	0	0	0	0
Steppe	128	7	2.6	0	0.6	0	0	0	0
Carpathians	70.2	3	0	63	0	0	0	1	14
Crimea	33.7	0	0	99	0	0	0	5.4	120
Total	297.3	12	29.6	220	0.6	0	0	6.4	134
Total	**11711.7**	**336**	**1705.8**	**1660**	**30.4**	**503.5**	**72.2**	**40**	**1009**
Quercus pubescens									
Crimea	129	11	0	12	0	0		0	0

Table 4. Results of observations of the gene reserves in Ternopil region in 1998

Forestry Regional enterprises	Area (ha)	Species composition			Age (years)	Mean height (m)	Mean diam. (cm)	growing stock (m^3/ha)	Trees with straight trunk (%)
		Layer	Species	%					
Chortkovsky, Kopichinsky	1.0	I	*Fagus sylvatica*	100	209	41.7	86.9	693	75
Chortkovsky. Skala-Podolsky	3.7	I	*Fagus sylvatica*	94.0	102	38.2	46.0	650	79
			Fraxinus excelsior	3.0		37.1	54.1	26	
			Acer platanoides	1.7		38.1	44.5	12	
			Acer pseudoplatanus	0.7		26.4	44.4	3	
			Ulmus foliaceae	0.7		35.8	49.1	5	
Berejansky Pidgaetsky	18	I	*Quercus robur*	83.3	143	29.7	67	149	81
			Acer pseudoplatanus	11.1		27.0	48.2	3	
			Acer platanoides	5.6		27.4	50.2	10	
		II	*Carpinus betulus*	98.1		22.6	28.9	130	
			Ulmus foliaceae	1.42		20.4	21.6	1	
			Tilia cordata	0.47		19.1	37.6	1	

Hungary

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Oaks

Genetic and taxonomic studies on oaks
A genetic study on cpDNA markers of autochthonous oak species was started in 1997. The project was supported by the Hungarian Government from different sources. This study has been joined to the FAIR/OAK project (FAIR1-CT95-0297) research consortium led by A. Kremer. The technical guidelines for the project have been transmitted by the Austrian project partner (Austrian Research Center Seibersdorf). The following taxa have been studied: *Quercus robur, Q. petraea, Q. dalechampii, Q. pubescens, Q. virgiliana* and *Q. frainetto.* Most of the sampled populations were species-mixed but some stands in the lowland were composed of only *Q. robur* because of the natural plant association structure (forest-steppe, ash-elm-oak mixed forest). Artificial Slavonian oak (*Q. robur* subsp. *slavonica*) stands were also sampled because of their importance in Hungary and their documented origin. The sampled *Q. frainetto* trees were supposed to be planted (the natural distribution area of *Q. frainetto* extends to the southern part of the Basin).

The sampled populations showed a high diversity of cpDNA haplotypes. In total 49 populations and 254 trees were analyzed (May 1999). Haplotypes 2, 4, 5, 7 and 17 could be detected in the populations studied. No west European haplotypes were found. The west-Hungarian populations might be related to the east Austrian populations (haplotypes 2, 5). The most common variant in Hungary is haplotype 5.

The Slavonian oak stands showed a mixed haplotype structure composed of haplotypes 5, 7 and 17. Haplotype 2 could be found mostly within populations consisting of *Q. pubescens* and *Q. petraea/dalechampii* complex in western Hungary.

Gene conservation of pubescent oak
Most of the pubescent oak forests in Hungary are protected as plant association or biotope of rare (plant or animal) species. The natural origin of these oak stands might be confirmed by cpDNA studies. Some of the studied populations of pubescent oak (*Q. pubescens, Q. virgiliana*) showed a high genetic polymorphism of cpDNA haplotypes. This fact suggests a higher human influence on these 'relict populations' than supposed earlier. It is planned to study some important, strictly protected populations (Kerecsend, Ujszentmargita, etc.) on a larger scale to obtain more information. More genetic information might be helpful to re-formulate the present 'natural regeneration strategy' of extremely dry oak stands. Knowledge of the stands' origin (autochthonous, allochthonous) might also be important for establishing *ex situ* conservation stands or seed orchards.

Beech

An international beech provenance research plot was established with 36 provenances (including two Hungarian) in 1998, located in southwest Hungary (Bucsuta, Zala county). In parallel with this test a Hungarian programme started to test beech provenance in 1998. The main beech regions of provenance in Hungary would be tested under different ecological conditions. Seedlings were lifted in seed stands and transplanted in nurseries for one year. In total, seven Hungarian and one Transylvanian provenances were used for each provenance test (random blocks, about 0.1 ha/block). In total five provenance research plots were established in 1998 and 1999: (1) Bucsuta, Zala county, SW Hungary, 1998, (2)

Szilvásvárad, Bükk mountains, N Hungary, 1998, (3) Telkibánya, Zemplén mountain, NE Hungary, 1998, (4) Bõszénfa, Somogy county, SW Hungary, 1999, and (5) Nagyvázsony, Bakony mountains, W Hungary, 1999.

The research goals are:

- Measurement of morphological characters and phenotype (early test).
- Comparison of growth and growth dynamics.
- Study of genetic diversity by molecular markers (isoenzyme, cpDNA).

Institutions cooperating in the project are the National Institute for Agricultural Quality Control, the University of Sopron and the Forest Research Institute.

Czech Republic

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Oaks

Generally, sessile oak *(Quercus petraea* (Matt.) Liebl.*)* and pedunculate oak *(Q. robur* L.*)* are not distinguished from one another, i.e. they are "lumped" together in both the current Forest Management Plans and the Czech Republic Forest Tree Species Record. However, in the Regional Plans which are valid for 41 forest regions, these two species of oak are distinguished, and in the mentioned Forest Tree Species Record, *Q. cerris* L. is recorded separately (805 ha). Presently, the total distribution of all oaks is 140 240 ha or 6% of the total forest area of the Czech Republic.

Gene Bases or Gene Reserves have been established for *Quercus* sp., as well as for both sessile oak and pedunculate oak. The establishment of the first *Q. cerris* Gene Base was announced in 1998. In 1999, a Gene Bank with dominant pubescent oak (*Q. pubescens* Willd.) was established. As a result of discussions during the first Social Broadleaves network meeting (Bordeaux, October 1997), Czech authorities designated a buffer zone and a core zone for each Gene Base.

To preserve genetic resources in both main species of oak, sessile oak from the Ore Mountains and pedunculate oak from southern Bohemia are propagated by *in vitro* technology. Research has also been initiated on isoenzyme analyses of the genus *Quercus* at the Research Institute of Ornamental Gardening in VÚOZ Průhonice.

Beech

An international provenance research plot was established in 1998. As a result of drought in 1998 this plot suffered from high mortality; however, replanting was done in 1999. In 1999, three research plots have also been established using progeny from three European beech seed orchards. Three national provenance plots with material from the Czech Republic and Slovakia have been established. To preserve the remaining autochthonous populations of European beech in the Ore Mountains, grafting began in spring 1998 and later that year flowering occurred on some of the grafts.

Austria

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The conservation of genetic resources of oaks and beech in Austria has already been described more in detail by Geburek (1998). Currently the Austrian programme to conserve genetic resources in forest tree species (Müller and Schulze 1999) is being reassessed and a new concept will be worked out. Hence, a very brief update only is given in this report.

Economic importance of beech and oaks

Beech is still the most important hardwood. It is likely that the proportion of timber is still increasing at the expense of fuelwood. The trend favouring broadleaves on sites on which formerly conifers were planted - especially outside the natural distribution area of Norway spruce – is continuous and is promoted by financial incentives of the Austrian Government (BMLF 2000). The timber and fuelwood market for beech and oak is stable.

Silviculture

Oaks and beech are mainly managed in high forests. Approximately 1.55% (62 000 ha) is coppice and less than 1% (34 000 ha) is coppice with standards. Coppice with standards is restricted to oak forests located in the northeastern (Weinviertel) and eastern (Burgenland) regions. Based on previous inventory data (1981-90), 2.7% was coppice and coppice with standards. Conversion to high forest is predominantly performed in large-scale forestry enterprises.

Reproductive material

The importation of plants and seeds of beech and oaks varies heavily from year to year. Based on available records it seems that domestic production of forest reproductive material is decreasing. However, this does not mean that broadleaves are increasingly naturally regenerated. National experts assume that more plant and seed material is moved in EU-trade (Strohschneider, pers. comm.). Compared with other EU and non-EU countries, Austria has partly more restrictive regulations in order to enhance the genetic multiplicity of forest reproductive material (Anonymous 1996) but does not restrict its use in any way. If non-domestic material of inferior genetic quality is more and more employed for afforestation, genetic adaptedness and adaptability may be of concern. In this context the need to implement EU directives has to be seen with reservations and this holds especially true for the revised EU Directive that will be issued soon.

Health and threats

The forest condition in Europe was lately reported by the United Nations Economic Commission for Europe (UN/ECE 1999). Crown condition of common beech showed a slight recuperation as compared with previous years' data. Oaks remained the most damaged species. The percentage of trees severely defoliated increased by 3.3%; only 32.7% of the sample trees were classified as not defoliated. Damage by browsing, especially by game, continues to be of major concern and locally browsing is still the major obstacle of natural regeneration.

Gene conservation

As already mentioned the Austrian programme to protect genetic resources in forest trees is currently being revised. In addition to the previous country report, the following data

update on *in situ* measures may be of interest. The interested reader may also refer to Frank and Koch (1999) reporting on the Austrian network of natural forests.

For *Fagus sylvatica*, an area of 2345 ha (reduced area) of natural forest reserves (IUCN-Ia1) has been declared. It should be mentioned here, that in contrast to other countries, such as Germany, the genetic resources of national forest reserves may be used! Further, 12 forest gene reserves – each larger than 15 ha (reduced area) – of the IUCN-IV2 category with a total area of 323 ha are currently recorded. Access may be restricted by forest owners. For *Quercus cerris*, 105 ha (reduced area) of IUCN-Ia and no other *in situ* measures, for *Q. petraea* 372 ha (reduced area) of IUCN-Ia and 25 ha of IUCN-IV, and for *Q. pubescens* 26 ha (reduced area) of IUCN-Ia and no other *in situ* measures, and finally for *Q. robur* no *in situ* measures at all are recorded.

Breeding

In Austria, there are still no breeding activities in a strict sense for either *Quercus* or *Fagus*.

Research

Currently research in *Fagus* focuses on provenance tests (contact: ulrich.schultze@fba.bmlf.gv.at) and on nuclear DNA microsatellites/chloropast DNA (contact: thomas.geburek@fbva.bmlf.gv.at). In *Quercus*, chloroplast DNA (contact: burg@arcs.ac.at) and nuclear microsatellites are studied (contact: Steink@mail.boku.ac.at; christian.schloetterer@vu-wien.ac.at).

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UN/ECE (United Nations Economic Commission for Europe). 1999. Forest condition in Europe-Results of the 1998 crown condition survey. Technical Report prepared by the Federal Research Centre for Forestry and Forest Products (BFH), Hamburg. 84 pp.+ annexes.

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[1] IUCN-Ia [SNR] – Strict Nature Reserve (IUCN category 1a). Objectives are to protect communities and species and to maintain natural process in an undisturbed state in order to have ecologically representative examples of the natural environment. Areas are mainly protected for scientific purposes. This category includes Natural Forest according to the Helsinki Resolution H2. No wood harvesting!

[2] IUCN-IV [GCS] – Gene Conservation Stand (= forest gene reserve, gene reserve forest) (similar to IUCN category IV – selected and declared explicitly for the protection of genetic resources. Forests are naturally regenerated. Wood harvesting is allowed.

Switzerland

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The Swiss programme for the conservation of genetic resources in forests prioritizes its activities according to the conservation needs of the different species.

Presently, beech forests are not threatened and more than 90% of the stands are regenerated naturally. Thus, special conservation measures do not seem necessary. Oak, on the other hand, is fully integrated in the present conservation programme. Forest history studies revealed a dramatic decrease of oak in Switzerland during the last three centuries. From the historical point of view, actual oak stands appear to be not more than relicts of their former occurrence. According to observations of the forest service, the decreasing trend for oak is still ongoing. The competition of other tree species and the modest economical interest in oak silviculture will probably lead to further losses. In this context, conservation of genetic resources of oak is considered a task of high priority.

Practical conservation activities

Apart from one gene reserve established in 1993 (Galmwald), no additional gene conservation units have been established. However, according to the national concept for gene conservation, a certain number of units of special genetic interest will be proposed to the local forest services and owners in 2000. Within these areas, forest managers are supposed to work only with the local material and to enhance natural regeneration as far as possible. Special gene conservation measures will be compensated by the federal government jointly with the cantons.

Research

Since 1996, the geographic distribution and extent of genetic variation of oak have been studied at the Swiss Federal Institute for Forest, Snow and Landscape (WSL) in Birmensdorf.

Mátyás (1999) investigated the spatial pattern of chloroplast DNA (cpDNA) variation of oak species (*Quercus robur, Q. petraea, Q. pubescens, Q. cerris*). Trees from 181 collection sites distributed all over Switzerland were analyzed. Since cpDNA is inherited maternally, this marker is particularly suitable for the reconstruction of postglacial colonization pathways. The results of the study suggest oak immigration into Switzerland from two different refugia, presumably from Italy and the Balkans, respectively. Populations from a southern refugium in Italy seem to have crossed the Alps and expanded in a well-defined passage to the north. The Balkan populations colonized the territory north of the Alps in an east-to-west movement. Furthermore the observed spatial distribution of the cpDNA-types suggests a very low proportion of anthropogenic seed transfer. Only a few cases of recent seed transfer between the distinct cpDNA regions have been observed.

Another genetic study based on isoenzyme analysis started in 1998. In 26 stands, 100 individuals each were analyzed to assess genetic variation within and among populations. First results are expected in 2000.

The results of the mentioned studies will be included in the strategy for conservation of genetic resources of oaks.

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Italy

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Practical conservation activities

Protected areas continue to be created at different levels, from the state to the city. The country is moving towards implementing the ambitious goal of having almost 10% of the national territory under some form of protection. Many of these areas host social broadleaves. The species' conservation needs seem satisfied, but the quality of conservation actions needs further work. Priority should be given to the following goals: (1) increase the knowledge of the genetic resources that are actually being conserved (start a genetic inventory of genetic variability of the species conserved), (2) on the basis of this knowledge propose effective designs for genetic reserves, and (3) look for the presence of QTLs (quantitative traits loci), explore their geographic distribution, and on the basis of this knowledge propose new conservation measures.

Legislation

New legislation (proposal number 3820) on the conservation of genetic resources is being discussed by the Italian Parliament. The main issues to receive new rules inspired from EU guidelines are: (1) introduction of new species and varieties, (2) certification of provenance material, (3) nursery activities, and (4) preparation of databases and summary statistics.

Research

Beech

Within the EU project "European network for the evaluation of the genetic resources of beech" new experimental fields have been established and the geographic variation of cpDNA has been investigated (Prof. R. Giannini, University Florence). Twenty-eight Italian populations were analyzed and six haplotypes found: four present all over Europe, one found only in central Italy and one only in southern Italy. This confirms the high variability of beech in Italy. Fifty individuals from the European geographic range were analyzed by microsatellite markers. Five different haplotypes were found and their distribution is geographically structured (two, closely related, were found in Romania, one in Poland, one in a single French population, and the fifth all over Europe).

Results of a 4-year study on phenology at the within-population level have been analyzed (P. Menozzi, University Parma). Early and late plants show remarkable stability in their phenology over the years and seem to respond to climatic conditions (temperature). The two types (early and late) have been genetically studied by RAPDs.

Stomata response to water stress has been investigated using the material produced by a diallelic controlled pollination experiment carried out in Parma a few years ago. Differences in response to water stress among full-sib families have been found. An EU project: "DynaBeech: Effects of silvicultural regimes on dynamics of genetic and ecological diversity of European beech forests" has been funded for the next four years. A linkage map for beech will be prepared and used to look for loci linked to adaptive traits.

Oaks

A total of 85 oak populations distributed all over Italy were analyzed using chloroplast DNA markers. Most of these populations were represented by the species *Quercus pubescens*, only a few of them by the species *Q. robur*, *Q. petraea* and *Q. frainetto*. Polymorphism was

identified in four DNA fragments, representing non-coding regions of the chloroplast genome. This research is part of the EU/FAIR project "Synthetic maps of gene diversity and provenance performance for utilization and conservation of oak genetic resources in Europe". Polymorphism revealed the presence in Italy of five different cytotypes. Their distribution confirms previous results obtained on a smaller scale. Populations from northern and central Italy and from Sardinia were analyzed, whereas previous surveys considered mostly populations from southern Italy and Sicily. The main results are: (1) the presence of cytotypes (= haplotypes) 1, 2, and 17 (according to Dumolin-Lapegue *et al.* 1997) in Sicily, as described before (Fineschi *et al.* 1998b), (2) the presence of cytotypes 1, 5 and 17 in central and southern Italy, (3) the presence of cytotypes 1 and 17 in Sardinia, and (4) the presence of cytotypes 1 and 7 in northern Italy. This last cytotype, present all over Europe, had not been found before in Italy (Fineschi *et al.* 1998a).

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Slovenia

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Common beech is the most naturally widespread tree species in Slovenia and represents 29% of the current growing stock. Of the seven indigenous oak species, common oak, sessile oak, downy oak and Turkey oak form 8% of the growing stock, from which 82% is the sessile oak. The health state of beech has not changed in the last 3 years, while the health state of oaks worsened remarkably after 1990 and the trend was similar from 1996 to 1998. Within the framework of 173 forest reserves, 30% are oak forests, representing about 10% of the total reserves area. The total area of forest reserves will increase in the next five years from 10 400 ha to 14 800 ha.

The silvicultural approaches in Slovenia depend on the Forest Development Programme (1996) and the Forest Management Plans, which are used to prepare detailed silvicultural plans according to the Forest Act (1993). Natural regeneration is supported in all forests: out of about 6500 ha regenerated annually, only 10% are planted. If seedlings are used, they should derive from adequate seed sources, so only adequate species can be used. The use of forest reproductive material deriving from selected seed stands has been applied since 1951. At the moment there are 65 beech seed stands in eight seed units, defined after the phytocenological associations, the bedrock material and elevation zones, and 31 seed stands for five oak species. Annual needs for oak and beech seeds (Table 1) and seedlings (Table 2) according to the plans are greater than the annual seed and seedling production in the last few years.

Table 1. Collection of seed from selected seed stands and other sources in Slovenia in 1998-99[†]

Tree species	Seed quantity (kg)	Source	Quantities collected for the SFC in 1999 (kg)
Fagus sylvatica		coll. and used by SFS from the same region	1316
Quercus petraea	600	Semič, source identified, 540 m/sl, H2k and coll. and used by SFS from the same region	1429
Quercus robur	300	Adlešiči, source identified, 340 m/sl, H1k	1151
Quercus robur	300	Krakovski g., source identified, 150 m/sl, H5s	
Quercus robur		Non-certified and used by SFS from the same region	

[†] SFS: Slovenian Forest Service; Certificates of Provenance are issued by the Slovenian Forestry Institute (SFI); control of the source is by the Civil Forest Service done in collaboration between the SFS and the SFI).

Table 2. Planting and sowing of seeds and seedlings in 1998 (used in regular silvicultural measurements, not after sanitary fellings)

Tree species	Seeds sown in 1998 (kg)	Seedlings planted in 1998 (in '000)	Seedlings planted in 1998 (%)
Fagus sylvatica	4	229	13
Quercus petraea	20	152	9
Quercus robur	724		

Source: Annual report of the Slovenian Forest Service 1998.

Current activities are two-fold: those of the Civil Forest Service, and research by others.

Civil Forest Service

The Civil Foreest Service is concerned with:

- Adaptation of the legislative framework: preparation of the new Act on forest reproductive material, technical regulations on the source, quality, control, delimitation of regions of provenances, etc.
- Evaluation and renewal of the forest seed bank
- Development of an operational control system in seed collection, trade and control system
- Establishment of the central database of the Slovenian Plant and Forest Gene Bank on Internet.

The Basic needs for adaptation of the legislation are to follow the directives of the EC, to establish an operational control system in seed collection and trade, and to support trading initiatives by private owners.

Research

Research is focused on:

- physiology of seeds and seedlings (including treatments during collection and storage)
- genetic variability, origin and potential use of different populations of forest trees.

The studies of genetic variability of **beech** in Slovenia have been completed in a PhD Thesis at the Forestry Department of the Biotechnical Faculty in 1999. Beech is not a problematic species regarding its origin since it has been regenerated naturally through time. The results have been applied in the formulation of a new proposal for the delimitation of only two seed provenance regions of beech in Slovenia. Also, an **international beech provenance project** has been started in Slovenia with 31 provenances of beech in 1998.

Oaks present a complex study task because of the hybridization between species, the uncertainties about the common oak origin, the problems with decline, with silvicultural concepts, especially regarding regeneration, and with seed behaviour. Our studies are multiple, concentrated on ecophysiology of oak regeneration, genetics and taxonomy of white oaks and physiology of seed storage. International collaboration has been established as bilateral projects with France (Nancy), Croatia (Jastrebarsko) and Austria (Seibersdorf). We are currently writing up a proposal for a European Fifth Framework project on genetics, physiology and control of forest reproductive material related to oaks and spruce.

Because of the limitations and costs of forest seed storage technology, we propose that **all constituents (*in situ* seed stands; *ex situ*: seed orchards, living archives, tests and the seed bank; maybe in the future other germplasm banks) be included formally as a term *sensu lato* in the Forest Gene Bank** (see Fig. 1, schematic presentation of the plant genebank).

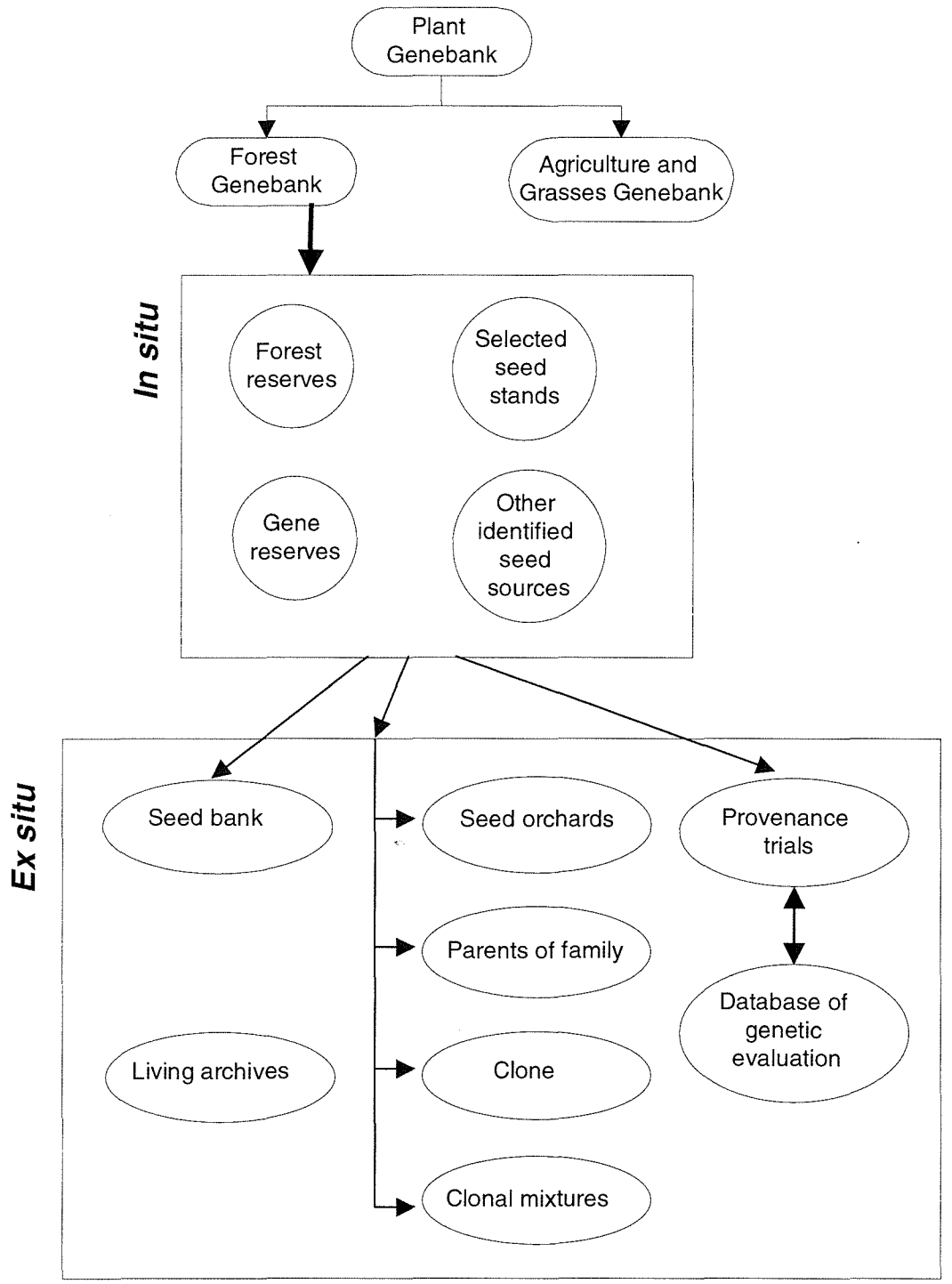

Fig. 1. Schematic presentation of the genebank (prepared by Sašu Žitnik, Slovenian Forestry Institute, Ljubljana, Slovenia.

Descriptors for selected seed stands and other identified seed sources

General

1. tree species
   - Latin name
   - common name
2. registration number
3. date of approval
4. status of conservation
5. provenance region
6. seed unit
7. isolation
8. specific purposes
9. property
10. area
11. origin
12. regeneration
13. genetic evaluation
14. type of rock
15. type of soil
16. vegetation unit
17. slope
18. position
19. situation in the country
20. relief
21. climate
22. climate diagram
23. age of the stand
24. development stage of the stand

Location

25. geographical coordinates
    - latitude
    - longitude
26. elevation
    - lower altitude of site
    - upper altitude of site
27. regional unit of Forestry service
28. local unit of Forestry service
29. forest management unit
30. forest management district
31. forest management division
32. forest management section
33. administration commune
34. cadastre commune
35. parcel number
36. map with the location
37. detail plan

Phenotypic description

38. phenotypic classification
39. health and resistance
40. adaptedness
41. uniformity
42. tightness of tree crowns
43. stand structure
44. stand mixture
45. proportion of tree species
46. rejuvenation
47. stand tending
48. type of crowns †
49. length of crowns †
50. development and width of crowns †
51. type of branches †
52. size of branches †
53. number of branches in spindle †
54. largest distance between spindles †
55. angle of branches †
56. stem purity (pruning) †
57. stem shape †
58. forked stem †
59. stem straightness †
60. stem circularity †
61. spiral grain †
62. wood quality †
63. vitality †
64. fruit bearing †
65. bark structure †
66. bark colour †
67. injuries †
68. number of trees/ha
69. medium stand height
70. upper stand height
71. medium stand breast diameter
72. stand growing stock/ha
73. annual increment of stand growing stock/ha

† Estimation of the portion of trees in the stand which belongs to the categories, which are defined for each descriptor individually.

France

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Practical conservation activities

Beech

Slight modifications are planned for the selection of conservation stands. In addition to the 27 already identified, an additional stand in the French Prealps will be chosen, and four others in the Pyrénées. A recent survey of chloroplast DNA polymorphism in this region revealed that the Pyrénées comprise an important diversity that deserves to be included in the conservation network.

Oaks

A questionnaire has been sent out to the local representatives of the French Forest Service (ONF) about the 20 conservation stands of *Quercus petraea*. The questionnaire includes queries about the location, species composition, origin of the candidate stand and its surrounding buffer zone. The answers to the questionnaire raised several practical problems for a few candidate stands that need to be solved before the final selection procedure.

Legislation

All conservation stands (in beech and oak) selected so far have been installed in public forests ("forêts domaniales") belonging to the state or to communities that warrant their maintenance in the long term. Specific legislation may be needed for conserving stands that will be established in private forests.

A Charter for the conservation of forest tree genetic resources in France has been launched by the Ministry of Agriculture and BRG (Bureau des Ressources Génétiques) to be signed by all major forestry agencies and forest owners. The Charter aims at the implementation of a Programme for the management and conservation of forest tree genetic resources at a national scale. Beech and temperate oaks are among the first species to be involved in this Programme.

Research

Beech

A range-wide study of genetic diversity is currently undertaken by B. Comps and coworkers based on isoenzymes. This study clearly indicates a geographic trend in allelic richness (southern populations being more diverse than northern), and a negative covariation between allelic richness and expected heterozygosity.

The natural regeneration in the conservation stands is conducted in small patches (from 100 to 10 000 m^2) rather than as an even process over the whole stand. Additional research is suggested to compare the effect of discontinuous and continuous natural regeneration.

Oaks

An exhaustive survey of cpDNA diversity has been conducted in the frame of an EU-supported project "Synthetic maps of gene diversity and provenance performance for utilization and conservation of oak genetic resources" (FAIR/OAK). Data from 896 populations were compiled and show that France has been recolonized from three major

refugia (Iberic Peninsula, Italy and the Balkans). First results of a range-wide comparison of provenances of *Q. petraea* (104 provenances) were obtained that confirm the clinal latitudinal and longitudinal variation of bud burst. Pollen flow was investigated using paternity analysis and revealed the important contribution of long-distance transport to pollen clouds. A saturated genetic map has been constructed in *Q. robur*, comprising 307 markers (RAPDs, SCARs, microsatellites, minisatellite, isoenzymes).

Public awareness

Oaks

The conservation of genetic resources was selected by INRA as one of its major activities to be presented at the yearly International Agriculture Show (Salon International de l'Agriculture). Posters on the distribution and dynamics of genetic diversity in managed oak stands and practical conservation activities were presented. A press conference was held and a special publication of INRA was issued where conservation activities in various plants (and particularly oaks) were described.

Oak, beech and other species

The second volume of "Les ressources génétiques forestières en France" by Arbez and Lacaze was published in 1999 (BRG/INRA). It includes chapters on oaks and beech. Another document entitled "Conservation des ressources génétiques forestières en France" will also be published. It includes 2-pages summaries on conservation activities in 10 species, including pedunculate oak and beech.

Luxembourg

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Research activities and capacities related to genetic resources

(Update to the country report published in the Report of the first Network meeting)
In vitro culture "genebank" of beech and oak for conservation of endangered stands. Occurrence and ecological regions of Social Broadleaves are shown in the figure below.

Current gene conservation activities in situ *and* ex situ *(overview)*

Luxembourg has no *ex situ* conservation activities. *In situ* conservation activities are limited to ongoing designation and management of 16 beech and oak stands (220 ha) with valuable genetic properties according to the EC legislation on the use of reproductive material.

Relevant nature protection policies and activities

- 17 nature protection areas (1862 ha)
- protection of 16 beech and oak stands for collection of reproductive material (220 ha)
- selection of 13 areas (16 019 ha) for the network 2000 of the "Directive HABITAT" (EC).

Institutions involved in the genetic resources activities in the country

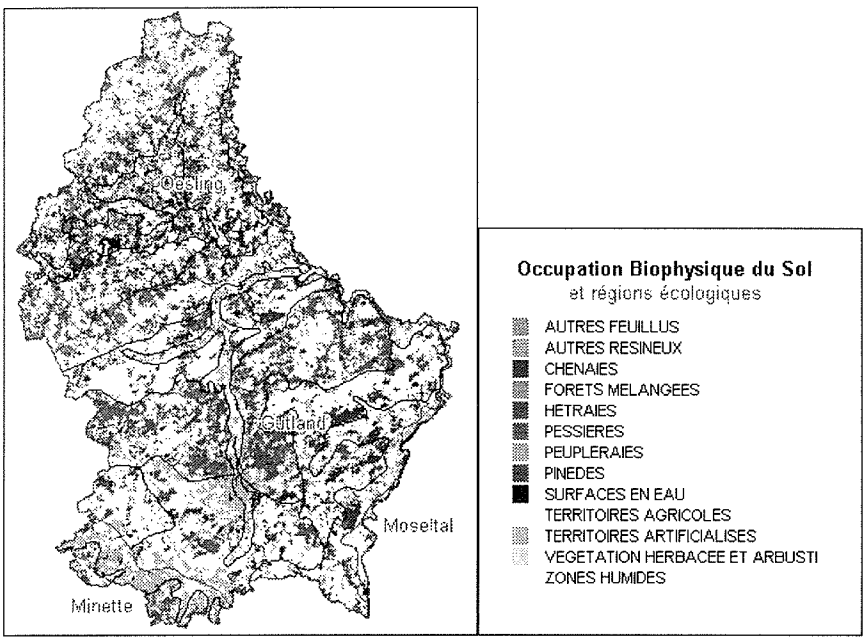
- Administration des Eaux et Forêts (<http://www.mev.etat.lu/adef/accueil2.html>)
- Centre de Recherche Lippman (<http://www.crpcu.lu/>

Summary of country priorities

Appropriate *in situ* conservation of autochthonous material.

Needs for international collaboration

- Public awareness-raising of the importance of forest genetic resources.
- Coordination of research projects.
- Elaboration of technical recommendations and guidelines.



Belgium

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A brief summary of genetic conservation activities in Social Broadleaves in Belgium from November 1997 to May 1999 is presented. This completes the comprehensive report published in the report of the first Network meeting (held in October 1997). Since then, different programmes were developed which are detailed below.

Conservation

During the last few years, special effort was made to increase the utilization of indigenous Forest Reproductive Material through seed stand selection, seed orchard establishment, significant seed collections and grants policy.

This work was carried out to complete the remaining gaps of Basic Materials with the selection of two new seed stands and 55 plus trees (Table 1) necessary for the establishment of the first seed orchard of sessile oak in Belgium.

To have a better understanding of genetic variability at the national and natural range levels, two new provenance trials of sessile oak and one of beech have been initiated. They will complete the former experiments and will constitute the main material available for further studies.

Research

In December 1998, a 4-year research project was launched, focusing on the assessment of genetic diversity within and between selected seed stands and presumed autochthonous stands of sessile and pedunculate oak, using genotypic (DNA analysis) as well as morphological data (leaves, flowers, fruits, buds). Further goals consist of tracing the possible relationship between genetic and morphological variation. In addition, the origin of the sampled stands will be assessed by relating them to the migration routes, established within the EU project entitled "Synthetic maps of gene diversity and provenance performance for utilization and conservation of oak genetic resources".

The project is financed by the Flemish Forestry Board and carried out by the Department of Plant Genetics of the Centre for Agricultural Research, Ghent.

Table 1. Genetic material selected or planted in Belgium since November 1997

	Seed stands			Provenance	
Species	**Number**	**Area (ha)**	**Plus trees**	**trials**	**Seed orchard**
Pedunculate oak	–		42	–	–
Sessile oak	1	8.80	13	2	1
Beech	1	3.33	–	1	–
Total	**2**	**12.13**	**55**	**3**	**1**

The Netherlands

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Conservation activities

In 1995 seeds were collected from nine populations of *Quercus petraea* and three populations of *Q. robur*. All populations were presumed to be autochthonous. Funds were available for the layout and establishment of a genebank. In March 1999 the genebank was established in "Kuinderbos" in the Polder area with 3-year-old material.

Inventories

Since the last meeting more areas have been searched for autochthonous material of trees and shrubs. Some new possible sources of oak were found.

Legislation

A start has been made regarding the extension of the Dutch National Catalogue of Trees with seed sources from neighbouring countries. Parts of Germany and Belgium were visited in order to judge stands of oak (*Q. petraea* and *Q. robur*) and beech (*Fagus sylvatica*).

Research

Some nationally funded research projects have been initiated in relation to oak species, among others one on parental analyses and one on the diversity in the Dutch oak seed orchard.

Since the FAIR/OAK project is in its final year the Dutch participation will be finished later this year.

IBN-DLO participates in two project proposals within the Fifth Framework Programmme of the EU, one on beech and one on oak.

Public awareness

In March 1998 a symposium on different aspects of oak species management was organized by IBN-DLO. A broad audience of scientists and end-users was invited to actively participate in the discussion after several presentations were given by speakers from different backgrounds.

Germany

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Introduction

A report on the situation of the social broadleaved species: beech (*Fagus sylvatica* L.), sessile oak (*Quercus petraea* [Matt.] Liebl.) and pedunculate oak (*Q. robur* L.) in Germany was given at the first Network meeting (Stephan 1998). The subsequent information about gene conservation activities in 1998-99 was summarized on the basis of reports given by the institutions of the German States (Laender).

The amount of felling of beech and oak in 1998 was about 7.6 million m^3 wood under bark for beech (21% of the total felling), and 1.4 million m^3 for oak (4%) (Bitter 1999). As observed in the past years, prices for stem wood remained more or less stable for beech and decreased for oak. Nevertheless, timber of high veneer quality results in high prices.

Health state

Although the proportion of severely damaged forest trees decreased in Germany from 30% in 1991 to 22% in 1999, the emissions impact on forests is still high and differs according to regions. Trees above 60 years are damaged in a higher proportion than younger trees. Particularly beech and oak showed serious damage in 1999, beech with about 32% (3% more than in 1998) and oak with about 44% (7% more than in 1998). Hence, oak is the most seriously damaged tree species in Germany, followed by beech (BML 1999). Damage in oak is caused by a complex of various biotic and abiotic agents (Wulf and Kehr 1996). Specific fungal pathogens, e.g. of the genus *Phytophthora*, can also cause serious attacks (Schubert *et al.* 1999).

Inventories

The Federal States (Laender) have been defining and establishing *in situ* conservation stands of various tree species for many years. One example may demonstrate the procedure (Maurer and Tabel 2000). In Rheinland-Pfalz (Rhineland-Palatinate) the respective beech stands were selected according to the following criteria: they should have a size of at least 10 ha, an age of about 100 years and should be situated in an area where beech occurs predominantly. Stands in state forests and stands which are approved according to the legal regulations concerning forest reproductive material have priority. Genetic inventories were carried out by analyzing buds or beech-nuts from 200 trees per stand. Mainly the variation on isozyme gene loci, but also polymorphisms on plastid DNA, were investigated.

According to the recently published list of approved basic material for forest reproductive material in Germany (status as of 1 October 1997), under the categories 'Selected' and 'Tested' the following are registered: 81 559 ha (+ 0.2% compared with 1995 status) approved stands (seed orchards included) for beech; 32 548 ha (+ 2% since 1995) for sessile oak; 9193 ha (+ 0.7% since 1995) for pedunculate oak (BML/BLE 1999).

Legislation

Rules on the conservation of forest genetic resources are not yet integrated into Federal German Laws. But a few States (Laender) have implemented recommendations in their regulations on forest management. The laws on forestry, nature protection or the international Convention on Biodiversity contribute indirectly to the protection and

conservation of forest genetic resources. An overview of national and international frameworks and activities concerning the conservation of forest genetic resources is given elsewhere (Stephan 2000).

Research

Beech (*Fagus sylvatica* L.)

Twenty-four beech field trials were established under a Concerted Action "European network for the evaluation of the genetic resources of beech for appropriate use in sustainable forestry management", financially supported by the Commission of the European Communities. The field trials are located in 16 European countries: Belgium, Croatia, Czech Republic, Denmark, Germany (7 trials), Hungary, Ireland, The Netherlands, Poland, Romania (2 trials), Ukraine, Slovakia, Slovenia, Spain (2 trials), Sweden and the United Kingdom. A total of 59 provenances representing the whole area of distribution of beech are present in the different field trials; on average a field trial comprises 31 provenances. The trials will serve as a genetic resource and will show how the different beech provenances will develop under the differing environmental conditions of the field trials. This might also be relevant for studies of the adaptation of populations to global warming.

Extensive isoenzyme studies of many beech populations (more than 40 000 individual samples were studied) by various University and Laender Institutions, carried out during recent years, were compiled and evaluated. They give important information about the genetic variation of beech in several German states and regions of provenance (Konnert *et al.* 2000).

The problem of the storage of beech acorns over long periods is still not solved. First results of cryopreservation studies show that the viability of the seed can be maintained in liquid nitrogen (–196°C). Studies about the colour of beech nuts showed that there are differences in the level of populations and/or regions (Liesebach 1999, unpublished).

Detailed information about the storage and treatment of seed of various tree species, including beech and oak, were described by Schubert (1998), in which the author's experience of many years was collected and summarized.

Oak (*Quercus* spp.)

The investigations concerning the analysis of geographic-genetic variation of the two oak species, sessile oak (*Quercus petraea*) and pedunculate oak (*Q. robur*), in Germany as assayed by polymorphisms in the chloroplast DNA (cpDNA) were conducted in cooperation with 12 partner institutions of eight European countries and supported financially by the Commission of the European Communities in the FAIR/OAK project "Synthetic maps of gene diversity and provenance performance for utilization of oak genetic resources" (CT95-0297). The project was finished in August 1999. The results will be published in several publications (in preparation). First results for the German part of the investigations on the distribution of cpDNA haplotypes are of particular interest in relation to the remigration of oak into Central Europe, the legal regulations for forest reproductive material, and the conservation of genetic resources (König *et al.* 1998).

Progress made in the storage technology of acorns and their treatment against fungal infections were published recently (Schröder 1999; Schröder and Wulf 1999).

Practical implementation

The implementation of beech and oak stands, which are considered as gene conservation stands, into the forestry practice made progress during the past years (see e.g. Maurer and Tabel 2000).

Table 1. *In situ* and *ex situ* measures conducted in 1998 and 1999

	In situ measures				*Ex situ* measures						
					Stands		Clone collections				
	Stands (ha)		Single trees		No./ ha	No.	No.	ha	No. of clones	Seed storage for conserv. (kg)	
Species	'98	'99	'98	'99	'98	'99	'98/99	'98/99	'98/99	'98	'99
Fagus sylvatica	~150	~270	2		4	4				1657.05	9.4
Quercus petraea	4.78	460.52 +58.46†		6	4/0.76						
Quercus robur	37.99	158.36	2	144				0.2	19	192.0	351.0

† Area for genetic long-term monitoring.

In situ and *ex situ* measures conducted in 1998 and 1999 are summarized for all German States (Laender) in Table 1. Emphasis was set mainly on the conservation of beech and oak stands *in situ*, the most natural and cheapest way of conservation measures. But for the establishment of *ex situ* stands, the collection and storage of seed is also important.

Coordination at national level

Measures for the conservation of forest genetic resources are coordinated by a Federal and States Working Group, of which the Federal Research Institute and 11 Institutions of the states (Laender) are members. The first edition of the "Concept for the conservation of forest genetic resources in the Federal Republic of Germany" (BLAG 1989, 1997) is at present under revision.

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Lithuania

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Research activities

The project on "Delimitation of *Quercus robur* L. breeding zones in Lithuania" was completed in 1998 at the Lithuanian Forest Research Institute. The zoning was based on the evaluation of data from forest inventory and analysis of some qualitative traits assessed in permanent plots of native oak stands.

The state project "Broadleaved tree species ecogenetic variation and conservation of their genetic resources" was initiated for the period 1999-2003. *Quercus robur* L. is also included and it is planned to study the level of genetic diversity (based on adaptive, productive and qualitative traits) and its performance over the geographic gradient and over successive generations. The results will help to construct new principles and methods for the conservation of genetic diversity. The national databases will be developed and updated for *in situ* and *ex situ* genetic resources, and will be available on the Internet.

Tree improvement

In the framework of the "National Conceptional Programme for Forest Regeneration" which will end in 2010, seed orchards for *Q. robur* L. should be established in each forest ecoclimatic region. In addition 20 oak plus trees were selected in 1998. Progeny testing is continued (over 100 half-sib families from 10 oak populations).

Use of reproductive material

A database (using Microsoft Access) for forest seed quality and origin control and documentation was implemented in 1999. In 1998, 5812 kg of *Q. robur* acorns were collected in Lithuania; 22% of this amount was collected in seed stands and gene reserves, the remaining part in stands of I and II selection categories (or breeding classes).

Finland

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This report concerns only pedunculate oak (*Quercus robur*), as other species included in the scope of the Network are not native in Finland.

Conservation

Several pedunculate oak populations have been given the status of a nature reserve. The *ex situ* collection presently includes a total of 146 seedling families from 21 populations and a few additions are planned for the year 2000. Management plans of several protected natural stands are designed to enhance natural regeneration of oak.

Inventories

Nothing new since 1997, a project has been proposed.

Legislation

Nothing new since 1997.

Research

Progeny trials of pedunculate oak have been planted in 1998 and 1999. Trials include material from 23 Finnish, 3 Estonian and 1 Danish populations, in total 440 single tree families. Marker data analyses have been continued to investigate the population differentiation and within-population spatial structure using isoenzyme, microsatellite and chloroplast DNA markers. A small clone collection has been established, mainly for research needs but also for gene conservation purposes.

Public awareness

There has been a remarkable public interest in planting pedunculate oak on old, abandoned agricultural land and several seminars on the topic were organized. Presently, the interest seems to be slightly declining, possibly owing to the high cultivation costs. The importance of pedunculate oak as a key species in valuable forest habitats and as a host of a high number of red-listed species (e.g. insects and fungi) is widely understood.

Sweden

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National Board of Forestry, Jönköping, Sweden

Practical conservation activities

The Swedish Forest Gene Conservation Programme includes six archive plantations of *Quercus robur* and *Q. petraea* consisting of 513 families. Since 1997 re-labeling and maintenance work such as clearing and vegetation treatments have taken place. A limited collection of material for cpDNA analysis has been done in collaboration with the Danish partner in the EU/FAIR project on genetic diversity of oaks.

No activities on *Fagus sylvatica* have taken place as natural regeneration is characteristic of this species.

Inventories

All selected stands of *F. sylvatica* and *Q. robur, Q. petraea* and *Q. rubra* have been re-inventoried. The result is as follows:

		Stands		
Species	**Inventoried**	**Withdrawn**	**New**	**Approved**
F. sylvatica	82	40	3	**45**
Q. robur	113	34	6	**85**
Q. petraea	20	12	0	**8**
Q. rubra	7	3	0	**4**

Research

Two provenance trials are now established in Sweden: the international beech provenance trial in 1998 and the other in the framework of a concerted action in 1995. Both are carried out in close collaboration with beech researchers in Grosshansdorf, Germany.

Progeny trials have been established from the two seed orchards of *F. sylvatica* and the two seed orchards of *Q. robur*. These seed orchards were established in the 1950s.

Sweden has taken an active part in the EU/FAIR project proposal on geneflow in *Quercus*.

Introductory Country Reports

Social Broadleaves genetic resources in Bulgaria

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European white oaks and beech are of great economic importance for the country, both in the plains and hilly areas and in the low- and middle-mountain regions. The stands of these species determine the character of the forests in the lower belt of the oak forests and in part of the middle-mountain belt of the beech and coniferous forests.

Social Broadleaves in Bulgaria include mainly sessile oak (*Quercus petraea* Liebl.), pedunculate oak (*Q. robur* L.), Italian oak (*Q. frainetto* Ten.), Turkey oak (*Q. cerris* L.), pubescent oak (*Q. pubescens* Willd.), common beech (*Fagus sylvatica* L.) and oriental beech (*F. orientalis* Lipsky).

State of the oak and beech forests

Oak forests

They are of primary importance for the environment and for wood production. The total forest area amounts to 3 236 758 ha with a volume of 395 628 000 m³. Oak forests occupy 1 050 390 ha (31.1%) of the total area with a total volume of 90 358 000 m³ (22.8%).

The composition of the oak forests, determined mainly by *Q. frainetto*, *Q. petraea* and *Q. cerris*, to a lesser extent by *Q. pubescens*, and negligibly by *Q. robur*, shows a tendency towards dry environment. They used to be more mesophilic, with wider distribution of species demanding more moisture, such as *Q. robur*, *Q. petraea* and *Q. hartwissiana* Stev. Even today these oak species are considered some of the most valuable, but their proportions have decreased.

From the Cretaceous period when the evergreen oaks appeared and afterwards through the Tertiary and the beginning of the Quaternary periods, a process of transition from more moisture-demanding and warmth-demanding species to species more adapted to conditions of a colder and more arid climate can be observed.

The best-conserved oak forests are found in the Strandja Mountains where their total area is about 167 000 ha, 36% of which are *Q. frainetto*, 26% *Q. petraea*, 12% *Q. cerris* and 3% *Q. pubescens; Q. hartwissiana* Stev. occurs only as single trees. Oak formations in the eastern Balkan Range are more mesophilic, as indicated by the higher percentage of *Q. petraea*, a species with high diversity. In contrast to Strandja Mountains and the eastern Balkan Range, the composition of the oak forests in northeastern Bulgaria is determined by *Q. cerris* and *Q. frainetto*, the main colonizers. Along the rivers Struma and Mesta, in Sakar Mountains and the eastern Rhodopes, *Q. pubescens* occurs, as well as the uncommon kermes oak (*Q. coccifera* L.) which is the most drought-resistant species in the southern regions of Bulgaria. A new oak species found in the Rila Mountains is *Q. protoroburoides* Don. et Bouz., whose occurrence is being mapped.

Structure of the oak forests: high forest formations, which are the most valuable from the environmental and economical points of view, occupy only 179 409 ha (17.1%), while coppice forests amount to a total of 555 363 ha (52.8%). When the corresponding forestry operations in these two categories of forests are carried out skillfully, the establishment of more high forest stands is possible. The greatest difficulties with oak forest management are created by the stands prescribed for reconstruction into high forest whose total area is 305 197 ha (29.1%). They have low yield capacities, as they grow in unfavourable soil and climate

conditions and are subjected to negative anthropogenic activity which has resulted in their degradation. Therefore they need changes of the species composition over large areas; at the same time all possibilities for conserving a proportion of the trees susceptible to form good stands must be looked for. The proportion of the oak forests to be managed as coppice is 10 421 ha (1.0%), but because of the demand for timber there are tendencies towards increasing their area by practising clear fellings in part of the currently existing coppice forests.

Based on typological studies, the following groups of oak forests have been differentiated: (1) floodable oak forests (longoses), (2) valley oak forests, (3) plain and plateau oak forests, (4) nearly moist low mountain oak forests, and (5) arid hill and slope oak forests (Marinov *et al.* 1995).

The health condition of the oak forests is aggravated mainly by the continuous management in the coppice forestry regime (of a few rotations) and by the uncontrolled pasture of domestic animals, as these two factors aggravate the growth conditions and resistance of the stands. Great damages are inflicted periodically by the insect pest gypsy moth (*Lymantria dispar* L.) which defoliates whole stands. However, the mass wilting of the oak forests in the last two decades has often been due to tracheomycosis caused by *Ceratocystis roboris* G. et T., which is most severe in the coppice forests where it attacks 20-30% of the trees. The insect *Scolytus intricatus* Ratz. is considered the main vector of this fungus.

Beech forests

The deciduous forests which are second in importance after oak forests are composed mainly of the two beeches *Fagus sylvatica* and *F. orientalis*. They have a great importance for wood production and also fulfil substantial environmental and recreational functions. Their total area amounts to 549 911 ha or 17% of the forested area in this country, and their wood volume to 111 257 300 m^3 (28.1% of the total volume). Their average volume and mean annual increment are 202 m^3/ha and 3.18 m^3/ha respectively, suggesting good yield capacities.

Common and oriental beeches are considered to have originated from *F. pliocenica* in Neogene, and during the Glacial period (Pleistocene) they maintained themselves in refugia in southeastern Europe, mainly on the Balkan Peninsula. Beech pollen dating from the Pre-Boreal epoch has been found in the Rila Mts., though in small amounts, and its percentage was found to have increased in the Sub-Boreal one. However, the expansion of common beech has increased in the Sub-Atlantic epoch, thus pushing spruce and fir up the mountains and oak and hornbeam down towards the plains. Common beech occupied its current niche about 5000 years ago when the vertical (altitudinal) zonation of vegetation was formed. Today the lowest formations of common beech in Bulgaria are at 150 m altitude in Bozhuritsa, near the city of Vidin, and at 200-300 m altitude in Ludogorié.

Anthropogenic activity, particularly in the last 30 years, resulted in a diminution of the total area of common beech by 31.6% and of its total volume by 23.6% (Garelkov *et al.* 1995). The total area of the high-stemmed common beech forests has been reduced down to 362 004 ha of a total volume of 80 037 900 m^3, while the proportion of the coppice beech forests belonging to the management classes for conversion, transformation and of low stems has increased up to 12 6742 ha (23.1% of beech's area) with a total volume of 24 103 800 m^3 (21.7% of beech's total volume), as well as the proportion of the common beech forests for reconstruction, up to 61165 ha (11.1%) of a total volume of 6 773 900 m^3 (6.1%).

Vast, pure stands of common beech occur on northern exposures, on nearly moist to moist rich soils, in the mountain belt where hornbeam-mixed beech stands also occur, on an area reaching about 100 000 ha, of which 70 000 ha is in the Balkan Range. In the deciduous forests, the species mixing with common beech, besides hornbeam, are sycamore, Norway maple, Balkan maple, common ash, silver birch, aspen, limes, bird cherry, rowan, wild

service tree, etc. Higher in the mountains, mixed stands of beech and fir, beech and spruce, and beech, fir and spruce occur. The latter are the most productive, with those situated at 1400 m asl in Parangalitsa Reserve in the Rila Mts. reaching a volume of 1600 m^3/ha. Mixtures of common beech with Scots and Macedonian pines occur comparatively seldom.

The poor natural regeneration in certain beech stands necessitates planting beech seedlings, plantations of which have been established in the course of 2-3 decades. Their maximum area was 2652 ha in 1987, after which it was reduced from 1467 ha (1990) down to 309 ha (1994). These seedlings are produced in two ways: traditional, i.e. in open nursery areas; and a comparatively new one, in temporary forest nurseries under the canopies of beech stands thinned down to the spacing index of 30%, which gives certain advantages.

The health condition of the beech forests is good. The most important diseases of beech are wood rot caused by fungi of the class Basidiomycetes, and branch and stem canker caused by the fungus *Nectria ditissima*.

Natural distribution ranges in Bulgaria

Sessile oak (*Quercus petraea*)

Sessile oak is distributed within a broad altitudinal range, generally from sea level up to 1600 m in almost all mountains, but most often up to 1000 m asl.

The availability of natural stands of sessile oak all over the country, within the above range, reveals its high ecological plasticity. Its adaptation to drought is accompanied by morphological characteristics such as leaf size diminution, increase of the number of secondary veins, deeply lobed leaves, pubescence of their lower surfaces, etc. (Stefanov and Kostov 1964).

Sessile oak forms pure or mixed stands. In moister places it mixes with the three lime species, common ash, Norway maple, sycamore, common beech and hornbeam. At arid sites, its associates in the mixed stands are Turkey oak, Hungarian oak, hop-hornbeam, manna ash, smoke tree, common juniper, cornelian cherry, common hawthorn, etc.

Common oak (*Quercus robur*)

When mapping *Quercus robur* it was found to be distributed mainly in the lowlands and plains, in certain hollows, and less often in the mountains, thus reaching up to 900–1000 m, though seldom exceeding 800 m asl. Based on the physicogeographical zonation of Bulgaria (Ghyorghiev 1991) and the investigations carried out on pedunculate oak, 11 centres of distribution can be distinguished: the Danube Plain, Ludogorié (the wild forest region), Eastern Dobrudja, Fore-Balkan valleys and hollows, sub-Balkan valleys and hollows, Pernik-and-Kyustendil Region, Upper Thracian Lowland, Tundja Region and Burgas-and-Karnobat Region.

European Turkey oak (*Quercus cerris*)

Its distribution range almost covers the natural ranges of the other Bulgarian oaks. It is widely spread in northeastern Bulgaria, the Danube Plain, the Fore-Balkan region, the eastern Balkan Mountain, Sredna Gora, Tundja Hilly Plain and in the mountainous regions up to 1200 m altitude.

Pubescent oak (*Quercus pubescens*)

The distribution range of pubescent oak in the country includes northwestern Bulgaria, central-north Bulgaria and northeastern Bulgaria. Pubescent oak can also be found on the southern slopes of Sredna Gora, on the slopes of the mountains along the Struma and Mesta rivers, the northern slopes of the Rhodopes, the eastern Rhodopes, the Sakar Mountain and on the Black Sea coast (Stefanov 1943-44).

Quercus pubescens is the most widely spread species in Bulgaria, after *Q. petraea* (Delkov 1988). It can be found all over the country, especially in the southern parts where it forms vast stands, strongly thinned and stunted because of their excessive cutting. It grows on the hills, elevations and submontane regions up to 1000 m altitude, mainly on the southern sunny slopes, on compact, dry and limy soils.

Italian oak or Hungarian oak (*Quercus frainetto*)

Italian oak can be found in the whole country, north in the Danube region, in the lower parts of the submontane, and partially in the lower mountain belts, rarely reaching up to 1000 m asl.

At the Black Sea coast Italian oak reaches sea level, in the Danube Plain and in the Fore-Balkan region the altitude of 500-600 m, in the Thracian Lowland and the southern part of the Balkan Mountain up to 600-700 m altitude, and in the eastern Rhodopes and at the basin of Struma river up to 800 m. In some places, owing to the existing microclimates, Italian oak reaches higher altitudes. Its wide distribution, however, is limited from sea level to 500-600 m asl.

Italian oak forms pure stands in the eastern Balkan Mountain region, dominates in the tree composition of the stands in Strandja, particularly along the periphery of the mountain, while in the region of Ludogorié only Turkey oak can compare to its area of distribution.

Common beech (*Fagus sylvatica*)

Its natural range includes almost all mountains: Stara Planina (the Balkan Range), Sredna Gora (the central mountain), Vitosha, the Rila-and-Rhodopes Massif and the Ossogovo-and-Belassitsa Mountain System. Common beech is replaced by oriental beech only in Strandja Mountains, a part of the eastern Balkan Range and in some small formations in the eastern Rhodopes. Generally, *F. sylvatica* occurs at altitudes from 150-200 m up to 1800 m, though tree groups and single trees are found outside of these limits. Common beech forms broad and pure stands and also mixed stands, most often in combination with hornbeam, less often with sessile oak, and regarding coniferous species, with silver fir, Norway spruce, and to a lesser extent Scots pine. In most cases, these stands represent a stage of the succession processes of supplantation of the coniferous species by beech.

Oriental beech (*Fagus orientalis*)

As a Pontic species, oriental beech is one of the main colonizers in Strandja Mountains where it comprises pure and mixed formations situated in deep ravines and on moist, north-facing sites. However, it occurs also in the plains at the frontier between Bulgaria and Turkey, in Lopushna Reserve. Its associates are certain evergreens, such as *Rhododendron ponticum* L., *Ilex aquifolium* L., *Laurocerasus officinalis* Roem., etc.

Though less common, oriental beech is distributed also in certain parts of the eastern Balkan Range, as its western limit reaches Vârbitsa Pass. The typical stands are in the Aytos and Kamchiya parts of the Balkan Range. In the region of the village of Obzor, along the lower reaches of Dvoynitsa river, this beech grows at 10 m asl, together with Mediterranean herbaceous associations. In the rest of the eastern Balkan Range, it occurs up to 550 m asl, most often in deep ravines and on north-facing sites. The species it mixes with are mainly *Carpinus betulus* L. and, to a lesser extent, *Acer pseudoplatanus* L., *Tilia tomentosa* Moench. and other deciduous species.

Inventory of the gene conservation units

Sessile oak (*Quercus petraea*)

Seed stands

The sessile oak seed stands are 522 for a total area of 7101.2 ha or 0.4% of the area of the oak forests in Bulgaria. The areas of the seed stands vary from 2.3 ha to 55 ha (average 13.6 ha), and their ages vary from 40 to 180 years (average 95.7 years). They span almost the whole altitudinal range of this species in the country, from the lowest altitude (100 m) with some seed stands in the state forestry districts of Tsarevo, Staro Oryahovo and Nessebâr, to the highest ones in the state forestry districts of Rilski Manastir (1500 m), Trân (1200 m), Sandanski and Borovets (1150 m) and Peshtera (1100 m). The total volume of sessile oak in the seed stands amounts to 828 930 m^3, the average values for height and diameter are 19.4 m and 26.4 cm. respectively, and the average grade (stand-quality level) is 3.3. The seed stands of the biggest volumes of sessile oak are in the state forestry districts of Sadovo, Vârbitsa and Staro Oryahovo, while those of the highest values of height and diameter are in the state forestry districts of Staro Oryahovo, Gramatikovo and Novo Panicharevo where some of the oldest stands of this species in the country are found.

About one-third of the total area of sessile oak seed stands in Bulgaria is under the Burgas Regional Forestry Board, which manages 2409.3 ha of these stands of a total volume of 256 220 m^3. Within the territories under this and the Varna Regional Forestry Board, sessile oak stands are conserved to the maximum extent.

Forest reserves

The following percentages of sessile oak have been found in 37 reserves: 16 in the Balkan Range, 6 in Strandja Mountains, 5 in the Rhodopes, 1 in the Rila Mts., 2 in the Pirin Mts., 1 in Ossogovo Mountains, 1 in Vitosha Mountains and 1 in Belassitsa Mountains The reserves of Kamchiya, Beli Lom, Boukaka and Kalfata do not belong to mountain massifs. Of the above reserves, Bistrishko Branishté, Chervenata Stena, Jendema, Kamchiya, Koupena and Steneto are included in the list of biosphere reserves, under UNESCO's Man and Biosphere (MAB) Programme and the reserves of Vâlchi Dol, Steneto and Kamchiya are included in the list of ornithologically important places in Europe, known as "Important Bird Areas", under Birdlife International.

The total area of the compartments in the reserves where sessile oak occurs amounts to 14 790 ha, the tree age varying from 41 to 165 years, with an average of 83.6 years. The average altitude of these reserves is 614.6 m with a maximum of 1340 m in Rilomanastirska Gora and a minimum of 2 m in Kamchiya Reserve. The average grade of the sessile oak stands included in the reserves is 4.3; the highest grade attained (2) is in Kamchiya Reserve. The average height and breast-height diameter of the sessile oak stands in the reserves are 13.8 m and 19.6 cm respectively; these values are considerably lower than those for the seed stands, because declaring reserves is not necessarily connected with the growth potential of the tree species therein.

National and natural parks

Sessile oak occurs in 9 of the total of 12 national and natural parks: Strandja, Rila, Central Balkan, Vitosha, Vrachanski Balkan, Sinité Kamâni, Shoumensko Plato, Roussenski Lom, Zlatni Pyasâtsi and Etâra. The total area of forest lands under protection status of national or natural park and where *Q. petraea* occurs amounts to 217 061.8 ha. Sessile oak is most widely spread in Strandja Natural Park where its percentages according to state forestry districts are 47% in Tsarevo, 36% in Kosti, 26% in Gramatikovo and 25% in Malko Târnovo. The percentage of sessile oak is high in Sinité Kamâni Natural Park (22%), while in Etâra it is negligible (less than 1%), and in Zlatni Pyasâtsi only single trees occur.

Pedunculate oak (*Quercus robur*)

Seed stands

The total area of the 41 seed stands containing pedunculate oak amounts to 440.1 ha. In the pedunculate oak seed stands belonging to the state forestry districts of Koubrat, Silistra and Tutracan this species occurs as single trees. Partial area is a more precisely indicative characteristic of the sizes of the pedunculate oak formations and the state of the species; it is approximately 250 ha for the seed stands in question. The total volume is 26 448 m^3 and the average volume per hectare 60.1 m^3, while the average volume per hectare calculated for the partial area is 106 m^3. Both these characteristics have low values, considering the high yield capacity of pedunculate oak at an average age of about 84 years and of an average grade of 2.9. According to volumetric tables, this species should have, at the above age, a volume of about 200-300 m^3/ha. The small volume is also due to the spacing index which is about 60–70%. The average height is 20.1 m, but for the stand in Compartment 102 of Staro Oryahovo it reaches 35 m, while the average breast-height diameter is 44.3 cm and in Compartment 1, Subcompartment E, of Nikopol this diameter is 120 cm. The altitudinal range is outlined by the lowest stands in Staro Oryahovo, Compartments 102B and 106A at 5 m alt., and by the uppermost one in Kazanlâk, Compartment 114D at 850 m alt. The seed stands of the largest areas are in Nova Zagora (84.9 ha), followed by those in Yambol (69.4 ha), Mâglizh. (63.1 ha) and Staro Oryahovo. (45.6 ha). The first three state forestry districts are along the Toundja river, and about 217 ha, or approximately half of the total area of pedunculate oak seed stands in the country, are included therein. The average area for the above 41 seed stands in 15 state forestry districts is approximately 11 ha. There are limited possibilities for differentiating and declaring new seed stands of *Q. robur*, such as certain protected areas; it is also possible to use single bio-groups in the farmlands for this purpose.

Forest reserves

The total area of the four reserves containing pedunculate oak is 1070 ha, the total volume 55 450 m^3 and the average volume per hectare 54.5 m^3. Kamchiya Reserve (Staro Oryahovo) is at altitudes 1-10 m, while the reserves Gorna Topchiya (Yambol), Balabana and Dolna Topchiya (Elhovo) are at altitudes of about 100 m. Single pedunculate oak trees have been found in other reserves as well: Baltata (Balchik) and Beli Lom (Razgrad).

Kamchiya Reserve is the largest genetic resource. Pedunculate oak occurs on a total area of 495.5 ha, amounting to about 17% of the reserve's territory. The total volume is 13 230 m^3, the average 26.7 m^3/ha, and the partial area 84.9 ha. Average height and breast-height diameter are 26.3 m and 48.9 cm respectively, and the average age is 134 years reaching its maximum of 180 years in Compartment 97A. The stands are in a comparatively good health condition, most of the trees being overtopped mainly by the species *Q. robur*, and less often *Fraxinus oxycarpa* Willd. This reserve is the best-preserved, most compact forest complex in Bulgaria. It is composed of the so-called "longos forests". It is at the mouth of Kamchiya river, so that its soil is moistened permanently, typical of floodable forests. The first storey is formed by *Q. robur*, *F. oxycarpa* and *Ulmus minor* Mill., and the second by *Carpinus betulus*, *Acer campestre* L. and *Sorbus torminalis* (L.) Crantz., but it also includes *Salix* sp. L., *Populus alba* L. and *Alnus glutinosa* (L.) Gaertn. In the third storey, the species *Cornus mas* L., *Acer tataricum* L., *Crataegus* sp. L., *Sambucus nigra* L. etc. can be found, as well as the lianas *Smilax excelsa* L., *Hedera helix* L., *Clematis vitalba* L. and *Vitis silvestris* L. The problem with these stands is the poor natural regeneration of pedunculate oak, which is gradually supplanted by Caucasian ash or other accessory species.

Natural parks
Pedunculate oak occurs in five of the natural parks, namely: Dâboveté (Dobrich), Roussenski Lom (Roussé), Shoumensko Plato (Shoumen), Zlatni Pyasâtsi (Varna) and Vrachanski Balkan (Vratsa) on a total area of 17 782.9 ha, the average altitude being 347 m.

Pedunculate oak's percentage in Dâboveté Natural Park is about 20% and the partial area amounts to 94 ha. A proportion of the trees have been planted, but they are of a local provenance, thus representing a valuable genetic resource.

In the remaining four parks, this oak occurs either as single trees or in small groups, and though these parks are considerably larger in area than Dâboveté, their value as a genetic resource is lower.

European Turkey oak (*Quercus cerris*)

Seed stands
The Turkey oak forests in Bulgaria occupy 258 402 ha, 31 051 ha of which are high-stem stands, 53 777 ha stands for reconstruction, 74 985 ha coppice stands, 90 192 ha coppice stands for conversion, and 8397 ha low-stem stands (Marinov *et al.* 1995). In the high-stem and coppice forests 145 seed stands are selected: 56 in northeastern Bulgaria, 66 in the Balkan Mountain and its fore-mountain regions and elevations, 13 in Strandja Mountains, 8 in the mountain of Sredna Gora and 2 in the eastern Rhodopes.

From the available 145 seed stands, over one-third are situated in northeastern Bulgaria, with an average height of 19.8 m and average diameter of 26.5 cm. They are stands of high quality, with well-expressed phenotypic characters such as straight stem form and high, genetically determined productivity.

Unlike the forests in northeastern Bulgaria where the Turkey oak is often a dominant species, in the eastern Balkan Mountain it forms mainly mixed stands. They occupy both the south and north slopes of the mountain, Kamchiiska, Eminska, Aytoska and Karnobatska Mountains inclusive, with their neighbouring hilly elevations and plateaux. In the 26 seed stands selected here *Q. cerris* appears as a "co-edificator" (species co-determining the stand composition) mainly with *Q. frainetto* and *Q. petraea* and to a lesser extent with *Q. robur*. Studies show that in its greater part the Turkey oak growing stock is over-mature - above 130-140 years, and is of III-IV quality grade. The oldest stand is above 170 years with average height 29 m and average diameter 48 cm.

The 13 seed stands in Strandja are fully sufficient, given the pontic characteristics of part of the sites and the existing reserves.

As a whole, the selected seed stands are mature and over-mature. The oldest are 140-150 years and have a maximum height of 25 m and maximum diameter of 42 cm. In half of the stands *Q. cerris* is the principal species with participation of 90% and in the rest it is a "co-edificator" with *Q. frainetto* and partially with *Q. petraea*. *Quercus hartwissiana* can also be found dispersed or in groups in these stands.

The area of the seed stands is 2143.2 ha and the total volume is 237 480 m^3. This is the productivity of the Turkey oak growing stock at average age of 79.2 years, with average height 19.8 m, average diameter 26.2 cm and average quality grade of the stands 2.6. These data demonstrate that the seed stands have a high productivity; they are selected correctly for the purpose and represent a valuable genetic resource.

Forest reserves
Investigations show that *Q. cerris* occurs in 16 of them, the smallest and biggest being situated in Strandja.

The reserve of Vodnite lilii is 2.9 ha. It is formed of *Q. frainetto*, *Q. petraea* and *Q. cerris* which have average height of 15 m and average diameter of 14 cm.

In Lopushna Reserve (1188 ha) the Turkey oak growing stock has a total volume of 7150

m^3. Its average age is 116 years, average height 18.6 m and average diameter 30 cm. It consists of 22 compartments, in only one of which the participation of the Turkey oak is 60%, in two - 20% and in five - 10%. In the remaining compartments it is an admixed species with participation below 10%.

Among the 16 reserves mentioned, *Q. cerris* is most widely spread in the Beli Lom reserve, situated in northeastern Bulgaria, occupying an area of 416.3 ha. It is characterized by the highest total volume of the growing stock (32 040 m^3) which is formed mainly of Turkey oak populations. The average age is 44 years, average height 16.5 m, average diameter 19 cm and average grade 1.9. The investigations show that *Q. cerris* is a dominant species in 9 of the 10 compartments in the reserve. Its admixed species are *Tilia tomentosa, Fraxinus oxycarpa, Q. petraea, Acer campestre* L., *Ulmus minor* and *Robinia pseudoacacia* L. Their presence indicates the good sites conditions. In the remaining reserves the participation of the Turkey oak does not exceed 20% and most often it appears as an admixed element.

The total area under Turkey oak in the forest reserves amounts to 4015 ha and the total volume is 56 215 m^3. For the total area this means 684.7 m^3/ha, at average age of 93 years, average height of 17.0 m, average diameter of 25.6 cm and average grade of 3.9. Inventory data show that the maximum height of the growing stock reaches up to 28.6 m and the maximum diameter 47 cm.

National and natural parks

The high mountain character of the national parks of Central Balkan, Rila and Pirin determines a hydrothermic regime with high amounts of rain throughout the year, low temperatures and a comparatively short period without snow. For these reasons *Q. cerris* L. is weakly distributed and can be found only on the southern exposures, in the lowest parts, mainly on limy terrain.

In the natural parks the climatic and soil conditions are favourable for the development of *Q. cerris* and in some of them it is one of the major tree species.

Quercus cerris is most widely distributed in the natural park of Zlatni pyasatsi where its participation reaches 18% and it appears as a dominant species. The participation of the other tree species is below 10%, with a very rich composition.

In the natural parks of Roussenski Lom and Dabovete, Turkey oak is of coppice origin and its participation is 0.1%. It forms oak stands with *Q. frainetto* in which it often appears as a dominant species. In the natural park of Strandja, in the region of Malko Tarnovo the participation of Turkey oak is 9%, in Gramatikovo 7% and in Kosti 2%. A typical representative of the pontic vegetation in this park is *Fagus orientalis*, with an understorey of *Rhododendron ponticum* L. and *Daphne pontica* L. As a whole the growing stock of the forest formations is over 120 years old and at many places it is of IV-V quality grade. This park includes five reserves with a view to preserving the Tertiary vegetation typical of the region.

The Turkey oak in the natural park of Vrachanski Balkan participates up to 3% in the mesophilic and xerophilic vegetation, reaching up to 800 m altitude.

In the other natural parks Vitosha, Sinite kamani and Shoumensko plato, the participation of the Turkey oak in the forest formations is up to 1%.

Pubescent oak (*Quercus pubescens*)

Seed stands

They are only four with a total area of 40.8 ha. These seed stands are used for the same purpose for other species as well because *Q. pubescens* is not frequent in them or exists as single trees. Among these four stands those with better indexes are Tsonevo 34v and Toutrakan 96zh. In this region studies for the establishment of other stands suitable for seed production could be carried out. The genetic conservation units declared so far are not enough, both in area and number, given the available resources of this species in the country.

Forest reserves
There are eight reserves containing pubescent oak with an area of 1010 ha and average density of 0.2. It occurs at an altitude of about 50 m in the reserves of Ropotamo and Baltata, while in the reserve of Ali Botush it occurs at 1230 m. The average altitude for all reserves in which the pubescent oak is distributed is 464 m. The average height of the pubescent oak is 6.1 m, the maximum value (10 m) being measured in Patleina reserve. The average total volume reaches about 7.0 m^3/ha and it is comparatively higher in the Tisata reserve (12.0 m^3/ha). This is due to the low density and the low quality grade of the stands in the greater part of the reserves containing *Q. pubescens*.

Natural parks
The area of the natural parks containing pubescent oak is 14 617 ha. Its average content is about 1-2% of the tree composition. In the natural park Sinite kamani its content is 7%. The area occupied by pubescent oak in all parks is approximately about 600 ha. The average altitude of the natural parks containing pubescent oak vary from 150-700 m.

Italian oak or Hungarian oak (*Quercus frainetto*)

Seed stands
They are 348, with a total area of 4432.8 ha. Stands with a content of Italian oak below 30%, under 2 ha area, and those under 40 years are not included. The area varies from 2-43.8 ha, with average value of 12.7 ha., the age from 40-180 years, average 112 years. The seed stands comprise almost the whole altitude range of the Italian oak distribution in the country, from 50-850 m. At the lowest altitudes (up to 100 m) there are seed stands in Staro Orjahovo, Nesebar and Sherba and at the highest altitudes those in Breznik (850 m), Kotel and Sadovo (800 m), Ihtiman and Tsaparevo (750 m). The total volume of the Italian oak in the seed stands in Bulgaria is 453 010 m^3 and the average values of the inventory indexes for height, diameter and quality grade are respectively 20.8 m, 29.4 cm, and 3.7. Stands with the highest total volumes of Italian oak are those in Staro Orjahovo, Sadovo and Nesebar and those with highest values for diameter and height in Staro Orjahovo, Gramatikovo, Aytos and Novo Panichevo where some of the oldest stands of this species in the country can be found. The area of the Italian oak seed stands and its total volumes are very irregularly distributed throughout the country. The biggest part of the Italian oak seed stands is concentrated in the Regional Forestry Boards of Varna (2168.4 ha with total volume of 263 080 m^3) and Burgas (1819.4 ha with total volume of 155 140 m^3) where they are preserved to a maximum extent and where inventory indexes are the best.

Forest reserves
Italian oak is present in 19 reserves distributed according to mountains as follows: 4 in the Balkan Mountain, 6 in Strandja, 1 in Osogovo Mountains, 2 in Malashevska Mountains; and in the reserves Beli Lom, Vodnite lilii and Kalfata which do not belong to mountain massifs.

The reserve of Valchi Dol is included in the "List of the ornithologically important places" (Important Bird Areas) in Europe of the Birdlife International.

The total area of the compartments with Italian oak is 6971.9 ha. The average age of the Italian oak in the reserves is 93 years. The oldest Italian oak stand, 190-years-old, is in the reserve of Sokolna (Tsaparevo). Stands with the lowest altitude (below 100 m) are situated in the reserves of Ropotamo and Vodnite lilii. The highest altitude this species reaches is in the Gabra reserve (982 m).

The average grade of the Italian oak stands included in the reserves is 4.2, with highest grade in the reserves Beli Lom (2.7) and Vodnite lilii (3).

The average values for the inventory indexes for diameter and height in the reserves are much lower than those for the seed stands. This is normal since the declaration of the seed

stand is connected with preliminary selection work, while the declaration of the reserves rarely is connected with the inventory indexes and the growth possibilities of the tree species they include.

National and natural parks
From the total number of three national parks and nine natural parks in Bulgaria, according to the Law for the protected territories of November 1998, Italian oak is distributed in the national parks of Rila and Central Balkan and in the natural parks Roussenski Lom, Sinite kamani, Strandja, Vitosha, Vrachanski Balkan and Zlatni Pyasatsi. The total area of the forest territory with the above-mentioned protected status in which the Italian oak can be found is 195 938.8 ha. In the natural park of Strandja, Italian oak has the highest percentage in the composition of the stands (in Tsarevo, Gramaticovo, Malko Tarnovo and Kosti respectively 33%, 31%, 27% and 16%). It is relatively high (10%) in the natural park Roussenski Lom. In the national parks of Rila and Central Balkan this species is rarely found, mainly in their lower parts.

Common beech (*Fagus sylvatica*)

Seed stands
There are 898 differentiated seed stands of common beech with a total area of 11 824.6 ha, an average size 13.2 ha, ranging from 2-54.7 ha. Their average age is 103 years varying from 40-210 years. The average height reaches 23 m (range 9-36 m), and the average breast-height diameter is 30.8 cm (minimum 10 cm, maximum 387 cm). The total volume amounts to 3 483 540 m^3 or 294.6 m^3/ha, varying for a seed stand from 150 $m^3$to 18 040 m^3. The stand quality level (grade) varies from 1 to 5, but its average value is 2.1 which indicates the high quality of the selected beech stands. The seed stands of this species are sufficient in number, not only for meeting the country's demand for beech mast, but also as a valuable source of export for other European countries. However, the periodicity in the common beech seeding creates difficulties in the regular delivery of reproductive materials, and this necessitates the use of effective methods for beech mast conservation in the years of abundant seeding. Besides, replacing some of the over-mature seed stands with new, maturing ones is necessary. The certain autochthony of this genetic resource also increases its value.

Forest reserves
Common beech occurs in 44 reserves in the Balkan Range, the Central Mountain, the Rhodopes, the Rila and Pirin Mountains, Slavyanka Mountains, Ossogovo Mountains and Vitosha Mountains; its average altitude is 1145 m, ranging from 332 m (Vâlchi Prohod) up to 1740 m (Shabanitsa). The total area of these reserves reaches 32 436.9 ha (with its minimum of 6 ha at Momin Grad and its maximum of 3410.1 ha at Jendema), and their total volume is 4726875 m^3, i.e. 145.7 m^3/ha. The average height and breast-height diameter are 19.8 m (from 9.5 m at Vrachanski Karst up to 28.7 m at Boukaka) and 28.9 cm (from 10 cm at Koutelka up to 50 cm at Momin Grad), respectively, and the average grade is 3.0 at the average age of 114 years (from 52 years at Vrachanski Karst up to 270 years at Shabanitsa). Some of the reserves, such as Boukaka, Boatin and Parangalitsa, have high values because of their inventory characteristics and very good genetic qualities.

National and natural parks
Common beech occurs in three national and seven natural parks whose areas range from 476.4 ha (Etâra) up to 55 532.5 ha (Rila). Their total area amounts to 188 644.3 ha with an average altitude of 879.7 m. Some parks, such as Central Balkan, that have large areas include hundreds of seed stands, as well as a few reserves of a rich genepool.

Oriental beech (*Fagus orientalis*)

Seed stands

The seed stands of oriental beech occupy a total of 1863.2 ha of a total volume of 27 850 m^3 or 1491 m^3/ha. The average values are: age 114 years, height 21 m, breast-height diameter 31.4 cm and grade 2.9.

From the 171 seed stands of this species in the country, 114 are in Strandja Mountains (total area 1358.5 ha and total volume 193 060 m^3) and 57 in the eastern Balkan Range (total area 504.7 ha and total volume 84790 m^3). Therefore, the area and volume of these stands in the eastern Balkan Range are two or three times smaller, compared with Strandja Mountains where the state forestry districts of Malko Târnovo and Novo Panicharevo contain the stands that dominate in these characteristics.

One of the problems with the management of oriental beech seed stands is the availability of old stands needing regeneration. In some of them, with an undergrowth of *Rhododendron ponticum*, the regeneration process is aggravated by the formation of a thick layer of undecomposed leaves. Investigations show that in an oriental beech forest with a 30% cover of *R. ponticum*, the undergrowth of oriental beech is 8.1% and that of sessile oak 44.4%, while in an oriental beech forest of various grasses without the *Rhododendron* the beech undergrowth reaches 72.5% (Garilov and Dimitrov 1984). Being a relict species, *Fagus orientalis* can be supplanted by climax formations and lose the areas it has occupied and in which oaks, aspen and hornbeam establish themselves.

Climax formations often demonstrate great resistance after they colonize a terrain, and this colonization results in narrowing the oriental beech's range and reducing the autochthonous stands of this Tertiary relict. As the sites in Strandja Mountains have almost equal edaphic and climatic conditions, the hazard of natural transfer of oriental beech seed is reduced, but genetic pollution by common beech and *Fagus sylvatica* subsp. *moesiaca* is possible in the eastern Balkan Range, because these species have been adapting in their phyllogenesis to various conditions, thus forming hill-and-plain, low-mountain, middle-mountain and high-mountain ecotypes.

Conservation of oriental beech genetic resources requires the establishment of collection plots and seed orchards, and the use of microvegetative propagation for practical purposes through the *ex situ* method.

Forest reserves

Oriental beech has been found in six reserves, one in the eastern Balkan Range (Kirov Dol) and the other five in Strandja Mountains (Lopushna, Silkossiya, Sredoka, Tissovitsa and Vitanovo). The total area of the compartments with *Fagus orientalis* is 5141.8 ha and their total volume 431 520 m^3 or 83.9 m^3/ha. The average height and breast-height diameter for the reserves are 21.4 m and 32.6 cm respectively, with an average age of 117 years (100 years for Vitanovo and 142 years for Kirov Dol). The average grade of oriental beech is 2.6 (from 1 for Kirov Dol up to 3 for Tissovitsa) and its average altitude 273 m (ranging from 187-477 m).

Natural parks

The only natural park where oriental beech occurs is Strandja where it covers a total area of 78 400.1 ha distributed into four state forestry districts: Malko Târnovo, Gramatikovo, Kosti and Tsarevo, at an average altitude of 219 m.

Besides *Fagus orientalis*, the natural forest vegetation therein is represented also by *Quercus petraea, Q. frainetto, Q. cerris, Q. robur, Q. pubescens, Q. hartwissiana, Carpinus betulus, C. orientalis* Mill., *Fraxinus excelsior* L., *F. ornus* L., *Populus tremula* L., *Acer pseudoplatanus* L., *A. campestre* L., *Tilia platyphyllos* Scop., *T. cordata* Mill., *T. tomentosa, Ulmus minor, Sorbus domestica* L., *S. torminalis*, etc.

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Beech and oak genetic resources in Croatia

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Introduction

Forests are the most valuable renewable natural resources of Croatia. They occupy over 2 million hectares, or over 35% of the entire Croatian territory. Pedunculate oak *(Quercus robur* L.), sessile oak *(Q. petraea* Liebl.) and beech *(Fagus sylvatica* L.) are the main forest tree species. Their forest stands, pure or mixed, are very stable ecosystems that are naturally regenerated. They are very rarely regenerated by direct seed sowing *(Q. robur* L.) or by planting nursery-grown seedlings. These species are very common and economically significant in many European countries.

According to the last management plan (1996), they account for over 60% of the Croatian forests. With regard to the climatic, topographic and geological diversity of the country as well as the geographic position, Croatia can be divided into the following geographical regions and vegetation belts (zones): the Euro-Siberian/North American, consisting of lowland and highlands areas, and the Mediterranean region covering the coastal area.

By signing the Rio Declaration, six Strasbourg and four Helsinki resolutions, Croatia has made a commitment to uphold sustainable management with special emphasis on the protection and conservation of forests. Croatia's forestry sector, with a long tradition of over 200 years of sustainable forest practice, should focus on the sound environmental management of forests in general, incorporating special treatment for particularly valuable natural resources and promoting biological diversity.

Occurrence and origin of beech and oaks in Croatia

Lowland forests in Croatia cover approximately 200 000 ha, of which 50 000 ha are hydrophilic forests. The densest and most beautiful are the forest ecosystems where pedunculate oak, ash and elm are the main species. Natural pedunculate oak sites in Croatia are located in the valleys of large rivers, such as the Sava, Drava, Kupa, Danube and others (Fig. 1). The forest basin of these regions are of special importance. They include the basins of Spačva, Pokupsko, Česma and Lipovljani forests, the forests of Žutica and Repaš, the Našice, Donji Miholjac and Slatina forests. In Croatia pedunculate oak is present in 18 different forest associations.

The sessile oak forests are spread throughout the hilly zones of the continental part of Croatia in nine different forest associations. Sessile oak is present on acidic and thermophilic soils (Fig. 2). The other important oak species in Croatia are: *Quercus pubescens, Q. cerris, Q. ilex* and *Q. virgiliana.*

Beech is distributed on the hills and mountains of the Velebit and Dinaric region, in the central and Panonian region (Fig. 3). Within its distribution, beech grows under diverse climatic, geological and soil conditions. Beech is the dominant species in Croatian forests. It has a large distribution range which includes submontane, altimontane and subalpine zones and corresponding bioclimates. Beech is rarely found on the colline belt dominated by sessile oak, and is only occasionally found in pedunculate oak forests. Beech grows on alkaline, neutral to extremely acid soils in continental and submediterranean parts of its distribution. It forms nine plant communities which are ecologically and floristically very diverse owing to the diversity of site conditions. It has wide altitudinal zonation, from hill forests to beech shrubby forests on the mountains. Several important beech genotypic races developed as a result of the large horizontal and vertical distributions, different soil and climatic conditions within its distribution range.

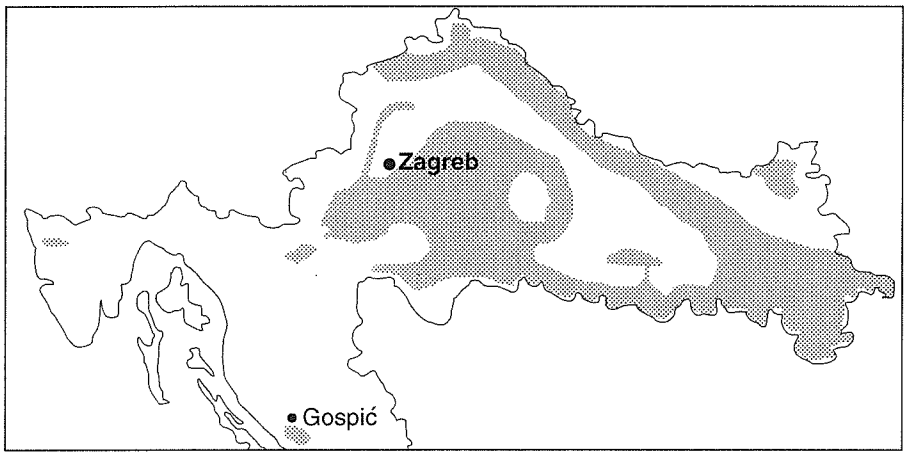

Fig. 1. Occurrence of pedunculate oak (*Quercus robur* L.) in Croatia.

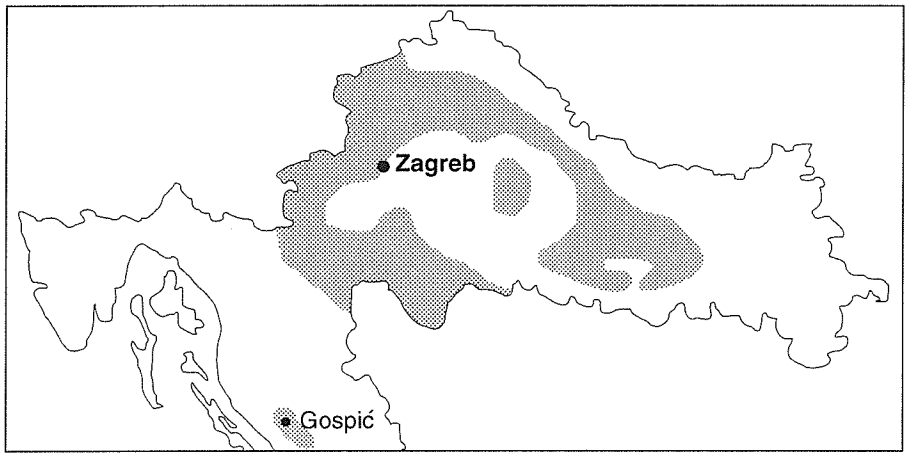

Fig. 2. Occurrence of sessile oak (*Quercus petraea* Liebl.) in Croatia.

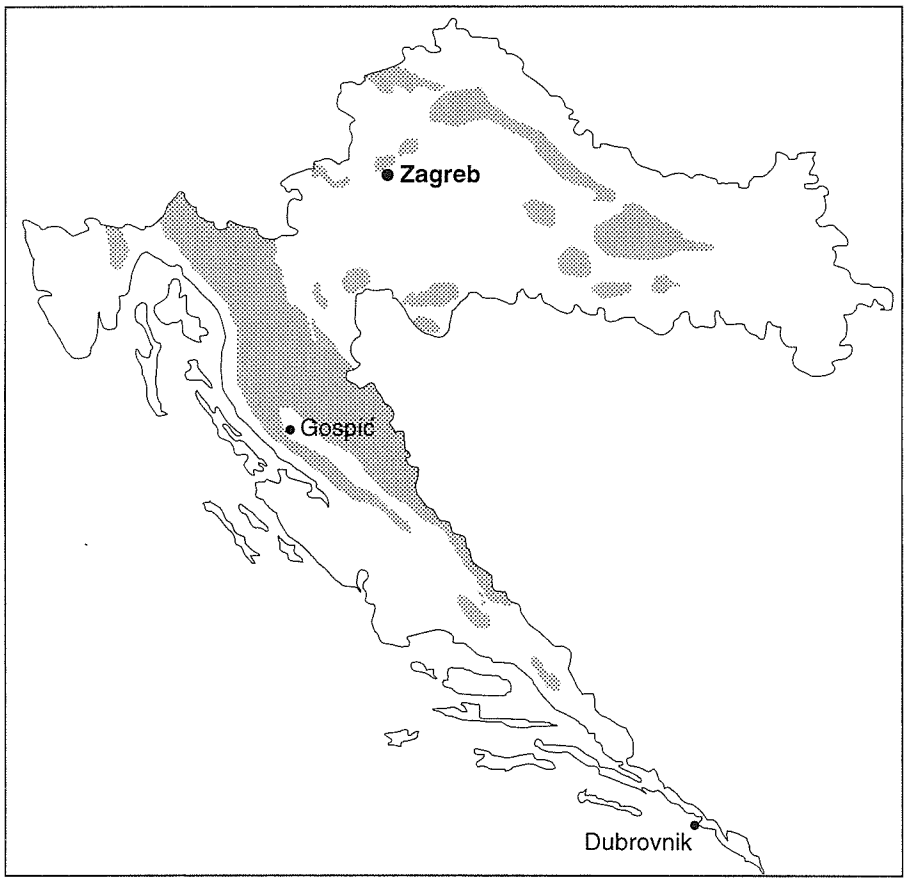

Fig. 3. Occurrence of beech (*Fagus sylvatica* L.) in Croatia.

Economic importance for the forestry sector

Forests are the most valuable natural resource in Croatia (Table 1). Forest land covers 43.5% of the territory. The total forest land area in Croatia is 2 485 300 ha of which the state-owned forests managed by "Croatian forests" cover 1 992 000 ha (80.2%); private-owned forests are distributed on 460 000 ha (18.5%) and other public-owned forests cover 33 000 ha (1.3%). According to the type and stock, 53% of forest land is covered by valuable high forests, 42.5% are coppice, and the remaining area (4.5%) is covered by artificially planted forest cultures and plantations.

Growing stock amounts to 324 million m^3 (162 m^3/ha), with an annual increment of 9.6 million m^3 and annual felling of 5.35 million m^3, or about 60% of the annual increment (Table 2).

Timber from beech and oaks has a high economic importance. The average amount of annual felling during the past 10 years was about 5.4 million m^3 of wood under bark. For beech the annual felling in average per year was 1.9 million m^3 of wood, for pedunculate, sessile and other oaks about 1.5 million m^3 of wood under bark (Table 3).

Table 4 shows the average selling prices in 1998. The highest price paid for pedunculate oak was 1100 DM per one cubic meter, for beech 522 DM per one cubic meter, and for fir 650 DM per cubic meter.

Table 1. Forest resources in Croatia (Management plan, 1996)

	Forest area		Growing stock		Annual increment	Annual felling
Type of ownership	**ha**	**%**	**'000 m^3**	**%**	**'000 m^3**	**'000 m^3**
State ("Croatian forests")	1 992 000	80.2	284324	85.8	8123	4934
Other public	33 000	1.3	7905	2.5	1352	87
Private	460 000	18.5	38028	11.7	168	33
Total	**2 485 300**	**100**	**324257**	**100**	**9643**	**5354**

Table 2. Growing stock by species (Management plan, 1996)

Species	**Growing stock ('000 m^3)**	**%**
Beech	117 676	36.2
Pedunculate oak	44 357	17.7
Sessile oak	32 237	10.0
Other oaks	12 358	3.8
Subtotal	**206 630**	**63.7**
Ash	10 543	3.3
Hornbeam	26 171	8.1
Willows and poplars	4 426	0.8
Fir and Spruce	36 381	11.2
Pines	7 919	2.4
Other species	32 176	10.5
Total	**324 256**	**100**

Table 3. Proportion of stem, industrial and fuelwood in annual felling

Species	**Stem wood (%)**	**Industrial wood (%)**	**Fuelwood (%)**	**Waste (%)**	**Total (%)**
Beech	41.2	11.6	34.4	12.8	100.0
Pedunculate oak	51.4	1.3	27.5	19.8	100.0
Sessile oak	44.6	5.4	35.4	15.6	100.0
Other oaks	23.3	3.6	60.2	12.9	100.0
Other broadleaves	24.9	5.5	58.6	11.0	100.0
Conifers	65.8	17.0	1.2	16.0	100.0
Total	**42.5**	**12.0**	**31.1**	**14.3**	**100.0**

Table 4. Average selling prices in 1998 ("Croatian forests")

	Stem wood		Industrial wood		Fuelwood		
Species	**m^3**	**kn/m^3**	**m^3**	**kn/m^3**	**M^3**	**kn/m^3**	**Total (m^3)**
Beech	544 906	419	162 846	197	415 414	102	1 123 166
Pedunculate oak	327 725	719	798	209	13 935	84	342 458
Sessile oak	96 882	518	–	–	–	–	96 882
Other broadleaves	–	–	52 422	197	319 156	71	371 578
Conifers	266 903	402	88 787	141	16 735	54	372 425
Total	**123 641**		**304 853**		**765 249**		**2 306 518**

(kn= Croatian kuna)

Table 5. Annual average use of seed for pedunculate oak, sessile and other oaks (kg)

	Purpose		
Species	**Nursery production (kg)**	**Direct sowing (kg)**	**Total (kg)**
Pedunculate oak	100 000	1 400 000	1 500 000
Sessile oak	40 000	400 000	440 000
Holm oak	500	1 500	2 000
Pubescent oak	100	300	400
Total	**140 600**	**1 801 800**	**1 942 400**

About 1.9 million m^3 saw hogs and veneer were processed in 1989, with the quantity dropping to 1.6 million m^3 in 1990 when the war broke out. In 1998, the production of oaks and beech saw hogs and veneer amounted to 969 497 m^3.

Oak in Croatia still covers an area of 331 888 ha, with over 77 million m^3 of growing stock. Beech grows in pure stands on an area of 200 000 ha, in mixed stands with sessile oak and hornbeam, with pedunculate oak and hornbeam on an area of 700 000 ha and with fir and spruce on an area of about 200 000 ha, in total over 117 million m^3 of growing stock. In general, beech grows in pure and mixed stands on 47% of the total wooded area and it constitutes about 36% of the total growing stock. Even in relation to other European countries, this is high potential for bright prospects for the development of Croatia.

The management systems applied in Croatia are: selection 70%, group selection 5%, shelter wood 20%, reconstruction and others 5%.

Silvicultural approaches used

Croatia has a long and rich legislative tradition in the field of forest management and natural regeneration. Clear-cutting is banned by the Forest Act, and natural regeneration is a fundamental postulate. Only 5% are forest cultures and plantations.

Natural regeneration is the best possible way of regeneration. Stands regenerated in this way inherit stability and productivity from the parent. Generally speaking, oaks and beech regenerate naturally. Their forest stands, pure or mixed, are very stable ecosystems. Pedunculate and sessile oak rarely regenerate by direct seed sowing or by planting nursery-grown seedlings (Table 5). As yet, in Croatia, beech is regenerated only naturally. When pedunculate and sessile oaks regenerate artificially, seed sources (acorns) should be used from local and well–adapted seed stands or region of provenances. Silvicultural treatments and forest management have a long tradition in Croatian forestry. The main aim was, and will continue to be, the sustainable use of forest resources, the protection and maintenance not only of wood production, but also regulation of watershed, social and economic functions and the conservation of biodiversity.

Health state of forest stands and threats to their genetic diversity

The survey of crown conditions in Croatia in 1998 was implemented according to the methodology of ICP-Forests in 1987. Two grid nets were established. In the grid net on a 16 × 16 km area, 2066 trees on 89 plots were included, and 97 additional plots were included on

a 4 × 4 grid net. The responsibility of carrying out the assessments lies with the Natural Focal centre, based in the Forest Research Institute in Jastrebarsko.

In comparison with defoliation from 1987 to 1998, an improvement of crown condition was observed for pedunculate oak, sessile oak and beech. The share of severely damaged trees (defoliation classes 2-4) decreased by 10% on average (pedunculate oak 1.8%, sessile oak 22.9%, beech 7.5%). Despite the trend of improvement observed during recent years, the crown conditions of pedunculate oak and sessile oak are still far from satisfactory. Among trees older than 60 years, 46.2% of pedunculate oak were severely damaged. Beech remained the healthiest with a share of 8% severely damaged trees among trees older than 60 years (Table 6).

Table 6. Defoliation of pedunculate oak, sessile oak and beech from 1987 to 1998

		Defoliation classes in %				
Species	**Year**	**0**	**1**	**2**	**3+4**	**Severely damaged 2-4**
Pedunculate oak	1987	62.3	28.8	7.2	1.7	8.9
	1988	61.8	30.1	6.3	1.8	8.1
	1990	61.9	23.1	11.1	4	15.1
	1993	39.4	24.9	30.7	5	35.7
	1994	18.2	39.4	40	2.5	42.5
	1995	23.3	39.4	31	6.3	37.3
	1996	31.6	39.4	25.6	3.4	29
	1997	36.8	36.5	24.3	2.4	26.7
	1998	30.6	40.9	26.1	2.4	28.5
Sessile oak	1987	72.1	20.6	0.1	2.2	2.3
	1988	63.4	26.2	7.8	2.6	10.4
	1990	67.9	21.7	8.2	2.1	10.3
	1993	47.8	19.3	31.1	1.8	32.9
	1994	28.1	33.3	36.5	2.1	38.6
	1995	28.5	30.6	36.6	4.3	40.9
	1996	34.7	33.1	29.9	2.3	32.2
	1997	19.4	35.8	41.8	3	44.8
	1998	34.9	43.2	19.8	2.1	21.9
Beech	1987	80.6	14.4	4.1	0.9	5
	1988	72.1	20.7	6	1.2	7.2
	1990	77.6	16.9	5	0.5	5.5
	1993	73.9	21.8	4.3	0	4.3
	1994	67.3	24.7	7.5	0.4	8
	1995	60.8	32	6.9	0.3	7.2
	1996	67.1	24.3	7.3	1.3	8.6
	1997	64.6	23.4	9	2.5	11.9
	1998	79.1	17.6	4	0.4	4.4

Current genetic conservation activities in situ *and* ex situ

The basic principles of Croatian forestry are sustainable forest management along with the preservation of the natural structure and biological diversity of the forests and maintenance of the stability and quality of wood production and generally useful forest functions. The first regulations related to sustainable forest management and conservation of biological diversity appeared as early as the 18th century. These principles of sustainability and biological diversity are a consistent part of every legal act related to forestry.

The legal regulations governing forest gene resources management and conservation are:

- Forest Act (1990, amended 1993)
- Forest Seed and Forest Plants Act (1990, revised 1998)
- Nature Conservation Act (1994)
- Environmental Protection Act (1994)
- Law on Hunting (1994)
- Law on Fire Protection (1993).

Gene conservation activities in pedunculate oak, sessile oak and beech are shown in Table 7 with respect to *in situ* and *ex situ* measures.

Table 7. *In situ* and *ex situ* conservation in Croatia

	In situ		*Ex situ*				
			Provenances test		Seed orchard		
Species	No. of seed stands	Area (ha)	No.	ha	No.	ha	No of clones
Pedunculate oak	128	11380	2	3	2	15	100
Sessile oak	34	2261	–	–	–	–	–
Beech	15	1423	2	5	–	–	–

During the last 10 years, Croatia started a programme for the establishment of pedunculate clonal seed orchards. The plan was put into action in 1991, and up to 1998 about 15 ha of experimental and productive seed orchards in the Forest district of Našice were established. The selection of pedunculate oak plus trees is underway in the following Forest districts: Vinkovci, Bjelovar and Gradiška. The plan for establishment of clonal seed orchard sessile oak and beech is still in preparation.

As with many other European countries, besides the above-mentioned activities, Croatia is included in research activities on variability (Germany), genetic structures of pedunculate oak and beech populations (France, Slovenia and Slovakia).

In order to obtain the whole picture as regards the postglacial colonization and population structure, further investigation is required, mainly on provenances from the Podravina region and southern Croatia (isolated, dispersed populations of Gorski Kotar, Lika and inner Dalmatia). Other oak species should be included as well because they are sympatric and form hybrids.

Slavonian oaks (haplotypes from eastern Posavina, Pokuplje and Podravina region) are probably of eastern origin (from the Balkan Peninsula), while it seems that the western postglacial colonization route had a direction from the Apenninian peninsula toward Austria/Hungary across western Croatia.

Relevant nature protection policies and activities

The State directorate for the Protection of Nature and Environment is in charge of the development of the National Strategy for the protection of Biodiversity. Croatian forestry has begun to develop a concept of biodiversity protection since these activities are directly connected to nature and the utilization of natural resources. As Croatian forests are mostly natural and as there are several preserved virgin forests, the concept of preservation will contribute to the protection of biodiversity.

The protection of nature in Croatia dates back to the end of the 19th century, though intensive work on different issues by law enforcement began only after the Second World War.

According to the Law on Nature Protection a total of 746 nature areas in Croatia have been protected, of which 322 units with a total area of 7.30% of the Croatian territory. Protected units are divided into nine categories:

Category	Number	Area (ha)
1. Strict reserves	2	2 395
2. National parks	7	69 420
3. Nature parks	6	317 502
4. Special reserves (Forest 32)	70	31 680
5. Park forests	23	7 660
6. Exceptional landscapes	28	17 545
7. Nature monuments	72	83
8. Horticultural momuments	114	912
9. Plant Species	44	
Total	746	557 197

Most of the areas belong to the forest ecosystems, this being the reason for their protection.

Tree improvement

Research carried out so far has shown that pedunculate oak, sessile oak and beech are very variable species, because they form local races and ecotypes. They are suitable for breeding. It has been determined that significant variability in morphological features is present, such as crown form and size, bole form, bark, leaf form and size, etc. According to the results there are differences in technical characteristics of common beech timber with different insertion of lower branches, which is related to the occurrence of false heartwood (beech).

After a single selection of pedunculate oak was completed, a 1-ha experimental seed orchard was established in the Forest district of Našice in 1991. In order to avoid irregular acorn yields, the establishment of seed orchards was intensified after 1996 in the Forest districts of Našice, Vinkovci, Bjelovar and Gradiška. Up to now, about 15 ha of clonal seed orchards of pedunculate oak have been intiated (Table 7).

The provenance experiment with pedunculate oak began in 1986, and with beech in 1991 (international cooperation with Germany) (Table 7).

Study of genetic variability of 16 populations of pedunculate oak was started in cooperation with France in 1998, and with beech population in cooperation with France in 1998 and Slovakia in 1997.

Institutions involved in genetic resource activities

In Croatia beginning in 1992 the following institutions have been involved in genetic resources activities: Forest Research Institute, Jastrebarsko; Faculty of Forestry, University of Zagreb; Public Enterprise "Croatian Forests", Zagreb; Ministry of Agriculture and Forestry, Zagreb; Ministry of Science and Technology, Zagreb. The Ministry of Agriculture and Forestry has a working group for "Conservation of Forest Genetic Resources".

Need for international collaboration

Research institutions from Croatia collaborate with the following organizations on oaks and beech:

- European Network for the evaluation of the genetic resources of beech for appropriate use in sustainable forest management (EU-funded project AIR-CT94-2091)
- EUFORGEN Social Broadleaves Network.

Summary of country priorities

Studies of genetic structure in beech and oaks in Croatia are a priority but have started only recently. Croatian institutions are partners of the international projects on beech and oak: "European Network for the evaluation of the genetic resources of beech for appropriate use in sustainable forestry management" (Germany), and "Maps of gene diversity of oak provenances" (France, Slovenia, Slovakia).

Croatia is very interested in being included in the study on conditions for long-term storage of acorns from beech and oak. Therefore, it will be necessary to continue international collaboration with all countries in which beech and oaks occur. The Social Broadleaves Network established by EUFORGEN is a first step.

Conclusion

Pedunculate oak, sessile oak and beech, together with fir and spruce, are the most valuable forest tree species in Croatia. Oaks and beech, according to their growing stock and covered area, are the most widespread species. Pure or mixed beech stands are the healthiest, most stable and best-preserved forest ecosystems in Croatia, with the exception of mixture stands with fir and spruce.

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Oak and beech genetic resources in Ireland

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Introduction

Ireland is an island of 84 421 km² (32 595 square miles) situated in northwest Europe to the west of Great Britain. It lies between latitude 51°5′ to 55°5′ N and longitude 5°5′ to 10°5′ W.

Ireland extends to 486 km (302 miles) at its greatest north/south length while its greatest width, east/west is 275 km (171 miles). Most of the country's mountain ranges are situated around the coast, often forming dramatic sea cliffs. The centre of the island is essentially a plain with a few small mountain ranges. The altitudinal range of this central plain is generally 50-150 m while the higher mountain ranges have peaks ranging from 300 to 900 m.

Situated on the western extremity of the European mainland, Ireland's climate is strongly influenced by the North Atlantic Ocean which gives the country a typical wet maritime climate. The North Atlantic Drift, moving northwards from the warm regions of the Carribean, brings with it warm waters and winds, ever-changing frontal systems and depressions, giving Ireland mild, damp winters and cool, cloudy summers with frequently varying daily climatic conditions. The temperature range is small, e.g. from a mean maximum of 14°C at most in the summer to a mean minimum of 1.1°C in winter in the midlands (Anonymous 1971). Almost the entire precipitation falls as rain spread more or less evenly throughout the year. Rainfall is lowest in the eastern lowlands and greatest in the western mountain ranges. Typical annual rainfall is slightly over 700 mm in the Dublin area (east) and over 1700 mm in Kerry (west). In western mountains the mean annual average rainfall is in excess of 2000 mm (Anonymous 1973). This kind of climate and the absence of extremes is favourable to the growth of a wide range of agricultural crops. Frost can be a limiting factor for some tree species. In these conditions, a great number of tree and shrub species from many parts of the world can be successfully grown.

Historical background of Irish forests

As the ice sheets retreated northwards at the end of the last glaciation period some 10 000 years ago, Ireland began to be colonized by trees migrating from the continent. Ash and elm migrated across Britain into Ireland while oak, alder and pine are thought to have come across a landbridge from France. Between 5000 and 7500 years ago, woodland probably covered 80% of the land surface (Joyce *et al.* 1998). Towards the end of this period Neolithic farmers began a limited clearance. As the population increased during the Bronze Age agricultural pressure on the forests became more widespread. The popular belief that Ireland still had substantial areas of ancient forest at the beginning of the 17th century is subject to controversy among authors. The latter half of the 18th century saw an attempt to restore the woodlands. By 1907 the estimated area of woodland had diminished to 1.5% of the land area.

Irish forests today

Total forest cover in Ireland is now approximately 602 900 ha or 8.8% of the country's land area (Anonymous 1999). Ireland is still the least forested country in the European Union (EU) where the average is over 30%. As stated, Ireland's soils and climate are highly favourable for growing trees and plantations. Afforestation programmes have in the past concentrated almost exclusively on Sitka spruce to the extent that it accounts for approximately 60% of the forest estate as against 24% for other coniferous species and 16% for broadleaves. There are a number of reasons for the extensive use of conifers, particularly

Sitka spruce in Irish forestry. First, past Government policy allowed only land which was unsuitable for agricultural purposes to be purchased for forestry. Consequently, sites suitable for the planting of broadleaves were only available in very limited areas and most land acquired was of the poorest soil and site types, much of it on exposed hillsides. Most of these sites were quite unsuitable for planting broadleaves. Other reasons include the general perception among administrators and foresters that conifers with much shorter rotations would give a faster and much greater return on investment. The existing broadleaved woodlands include the remnants of our indigenous forest [about 5800 ha (Table 1) and protected in national parks and nature reserves] and old woodland and scrub. Estimates of the area of semi-natural woodland present in Ireland vary (Neff 1974; Cross 1987), but the total area of broadleaved woodland is unlikely to exceed 100 000 ha, or 1.5% (approx.) of land area (O'Sullivan 1999). Most of these are in private ownership and can be broadly categorized, according to Cross (1987), as follows:

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

Broadleaf forest cover (100 745 ha or 16.7% of total forest cover) is low in comparison with most EU countries where the average is about 40%. However, broadleaf afforestation has increased substantially in recent years, supported by current grant aid and other schemes. Broadleaf planting accounted for almost 20% of all afforestation in 1995, an increase from an average of 2-3% in the mid-1980s (Anonymous 1996).

Table 1. Area of woodland (ha) protected in Irish National Parks and Nature Reserves, showing the proportions acquired/designated over decades past (O'Sullivan 1999)

	Pre-1980	1980-89	1990-98	Total
National Parks	Majority	–	–	2860
Nature Reserves	–	2275	353	2335
Other	–	–	–	541
Total	–	**2275**	**353**	**5736**

Occurrence and distribution of oak and beech

Oak

Quercus petraea and *Q. robur* are both native to Ireland and are accommodating in regard to site, with pedunculate oak occupying the heavier soils of the lowlands and sessile oak growing on the lighter soils of the hills and uplands. However, the optima for both species are deep, fertile, fine-textured, slightly acid soils in these locations. In Ireland, oak is irrevocably linked to the ancient woodlands and the number of place names with 'derry', the Irish for 'oak', points to its widespread distribution. Remnants of the once extensive oak forests of Wicklow and north Wexford (eastern Ireland) still remain at Avonmore, Coolgreaney, Rathdrum, Glendalough and Glenealy forests. Oak is found growing successfully on the drumlins of Monaghan and Cavan and its performance on heavy gleys can be seen in locations as far apart as Dartry, near Cootehill and Dromdeer, close to Doneraile in Cork. It has reached sizeable dimensions on free-draining old red sandstone soils, in south Kerry and the Slieve Aughty mountain range in Clare and southeast Galway (Joyce *et al.* 1998). In the past, oak constituted a significant part of the native woodland, which covered a large part of the country. Today only a very small area of this woodland

survives, and has been substantially influenced by human activities as previously shown (Cross 1987; O'Sullivan 1999). Inevitably the native oak population has been severely depleted both in size and possible genetic constitution (Joyce *et al.* 1998). Large-scale clear-fellings for agriculture and selective fellings of best genotypes in closed stands, which did not allow regeneration to take place, may have resulted in the loss of many valuable genotypes. In woodlands where natural regeneration occurs, many are damaged to various degrees by overgrazing by farm animals and especially deer. The introduced Japanese Sika deer, whose population has grown rapidly due to increased afforestation is a cause for major concern. Other pressures include the spread of introduced plant species such as *Rhododendron ponticum* which prevents natural regeneration taking place. Oak is still widespread in woods and hedgerows throughout Ireland.

Very little is known about the ecological characteristics and genetic variation that exists in native oak stands, although variation in vigour, stem form, branching habit and flushing date is apparent (Thompson 1998). However, information on provenance variation in oak is very limited. Studies indicate that both species hybridize freely but the tendency is for oak on upland sites to have more *Q. petraea* characteristics.

Records show that approximately 78% of the seed used in establishing oak plantations in Ireland was of home-collected origin. In recent years, the rapid increase in the national afforestation programme and the attractive incentives for planting broadleaves have resulted in the demand for seed and plants far exceeding supply. These factors, coupled with a lack of good mast years and the difficulties involved in storing acorns, have resulted in the importation of large quantities of acorns and plants which presents a very real threat of pollution of the native oak genepool. In spite of the importance of broadleaved species, particularly oak and beech, in Irish forestry, little work on the management and conservation of these species has been undertaken, mainly owing to the focus on coniferous forests.

Beech

Beech was introduced to Ireland probably in the late 16th century and formed a substantial component of estate plantations for aesthetic and commercial use during the 17th century.

Although beech is not native to Irish forests it is now naturalized throughout the country and plays an important role as one of the major broadleaf species. Beech is widely distributed throughout the country and has the capacity to grow well under a wide range of site conditions, from acid to alkaline, provided the nutrient status is satisfactory. It can be found in Ireland on low hills across the midlands, on the thin soils overlying fissured limestone in Galway and Clare and in the east in Wicklow and Wexford and even on drumlin sites in Monaghan and Cavan. With few exceptions, the sites share a common feature in that they are all free-draining (Joyce *et al.* 1998). There are approximately 5700 ha of beech forests in Ireland accounting for about 12% of the total area of broadleaved woodland. Beech is second only to oak in its importance as a broadleaved species.

From its introduction, importation of beech seed is likely to have occurred on a regular basis, at least until the first plantations matured in the middle of the late 19th century. Records show that importation continued from the start of the state forestry programme over the 50-year period prior to 1980. During this time, 34% of all beech seed sown was imported, and most of this seed came from Germany and Austria, in the years prior to World War II. During the 1960s, imports were mainly from Romania, Bulgaria and Czechoslovakia. Home collections amounted to 31 000 kg or 68% of total sowing over this 50-year period. It should be noted that beech mast was imported at irregular intervals from many of the northern and eastern European countries (Neilan 1997). This suggests a great diversity of genetic resources in Irish beech stands. In many instances seed collections were made without rigorous selection of stands or seed trees. To what extent this practice has resulted in the poor stem form seen in many beech forests is difficult to determine but it is almost certain to have had some effect (Joyce *et al.* 1998).

Current economic importance of oak and beech for the forestry sector

The economic importance of oak and beech is relatively small because of limited availability. The total annual production of hardwoods is approximately 20 000 m^3 (Pfeifer 1990), of which oak accounts for 55% of the production or 11 000 m^3, while beech accounts for 30% or approximately 6000 m^3. Average standing price varies from £90 to £50/m^3 for oak depending on quality. For beech the price varies from £60 to £40/m^3 also depending on quality. Both oak and beech are used for veneer, high-class joinery and other high-value end uses. Oak timber is widely used for furniture manufacture and joinery where strength and durability are required. Beech produces a highly versatile hardwood. It has excellent woodworking properties and forms the mainstay of the furniture industry. Good-quality logs are used in high-class joinery and veneer. It is widely used in cabinetmaking, solid and laminated furniture, desks, chairs and in flooring. However, approximately 70% of total production is of poor quality and is generally classified as firewood.

Silvicultural approaches used

Both oak and beech are established as plantations and are managed as even-aged high forest. These are mainly in the private sector where in the past they were managed for amenity and landscape as well as cover for wildlife. Many of these stands are quite small in size, have had little management in the past, are very old and in an advanced stage of natural decline and are of limited economic importance. In most instances, dysgenic selection has occurred over many centuries. In the re-establishment of broadleaf woodland in these areas, artificial regeneration is used because of the difficulties with natural regeneration.

Health status of the forest stands and threats to their genetic diversity

As a member of the European Union (EU) and under the European Community Programme on the Protection of the Community's Forests against Atmospheric Pollution, an active monitoring of forest conditions has been carried out since 1987. The programme requires an annual evaluation of the level of defoliation and discolouration of tree crowns in selected permanent plots throughout the country. The three main coniferous species were surveyed in the initial stages. However, since 1994 oak has been included in the evaluation and today, four species are covered in the survey. Results show that while the mean percent defoliation varies from year to year, the trend generally is greatest in the order oak > lodgepole pine > Norway spruce > Sitka spruce. When the data are examined, most plots show considerable fluctuation among years for both defoliation and discolouration data, suggesting that the variation may be natural. Very few plots show that there may be an actual deterioration in overall conditions (McCarthy and Delaney 1996). Generally, it is now accepted that anthropogenic sources of pollution which posed a threat to oak in Europe are decreasing and do not pose a threat to the species in Ireland.

With the spread of the grey squirrel (*Sciurus carolinensis* Gmelin) in Ireland beech is threatened in many areas and the need for specific control measures may have to be considered in the future.

Research activities and capacity related to genetic resources

The Helsinki Ministerial Conference on the Protection of Forests has introduced general guidelines for the conservation of biodiversity in European forests (Anonymous 1995). Increased diversity will impact on forestry practice in Ireland and will demand that greater attention be given to the origin and quality of plant reproductive material and in the conservation of genetic resources.

In situ conservation

Research work on the conservation of genetic resources in Ireland is mainly concerned with conserving communities of rare or unusual fauna and flora, unique land forms and geology as well as areas committed to research. The principal attempts to conserve our native broadleaved woodlands in the past were mainly in the context of establishing nature reserves under the 1976 Wildlife Act. Here, the underlying philosophy was to conserve the woodland ecosystem, rather than the trees, in order to maintain the genetic resource as represented by the flora and fauna (Cross 1987). Today, not more than 6000 ha of Ireland's broadleaved woodlands are protected for conservation, through state ownership or legislation in National Parks and Nature Reserves. The process of designating lands for conservation is very active in Ireland at present. Since 1992, two designations have been 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 (O'Sullivan 1999). NHAs will be covered by national legislation, which has not yet been introduced. In the meantime, designated lands are given special consideration by planning authorities and other public bodies. SACs are proposed under the European Habitat Directive, which was passed into national law in 1997. The Heritage Service Dúchas has recently selected a draft list of 40 oakwoods as special areas of conservation under this Directive.

Ex situ conservation

With an increasing interest in planting broadleaves and the resulting demand for oak planting stock, a series of provenance trials was recently established. In the first series, 29 seed sources of native oak provenances were collected in the mid-1980s. Field trials were established on four sites in 1988. Two further IUFRO trials were established at Clonegal, Co. Wexford in 1989 and 1990. These trials contain 23 seed sources including German, French, Dutch, British and Irish origins. It is still too early to identify the best and most suitable seed sources.

Despite the importance of beech as the second major broadleaved species in Ireland, there were no provenance studies undertaken with the species until relatively recently. In 1990 commercial seed lots from 17 different seed sources were sown with the objective of establishing the first provenance trial. The provenances consisted of 3 Irish, 2 British, 6 French, 1 Belgian, 1 Dutch, 1 Danish and 3 German seed lots. The quality of much of the seed proved to be quite variable and while some of the seed lots germinated and grew well, others were virtual failures. However, plants from some of these lots were used to establish two field trials in 1994. Subsequently, an extensive international beech provenance trial containing 49 different provenances, including 46 European and three home-collected 'naturalized' Irish sources was established in 1995 (von Wuehlisch *et al.* 1998). In 1996, a second international beech provenance trial of 34 provenances was established.

Relevant nature protection policies and activities

Forestry operations and environmental protection are regulated by a number of Acts of the Oireachtas (Irish Parliment) and EU Directives. Current forestry legislation is the Forestry Act (1946), which is the primary legislation for forestry development in Ireland. Its main provision is for the compulsory acquisition of land for forestry in Ireland. It has no provision for the conservation of genetic resources. This Act is currently under review. The 1976 Wildlife Act has been the main legislation implemented for the conservation of native woodland through the establishment of nature reserves.

Use of reproductive material

The National Catalogue of seed stands for all commercial forest tree species contains 420 registered stands. In Ireland the Forest Service is the regulatory authority responsible for the registration of seed stands. Genetics Section of Coillte Teoranta has the responsibility of

producing and updating the National Catalogue of Seed Stands (Fennessy 1999). It is generally accepted that because oak has been growing here for some 10 000 years native oak should be the best-adapted to Irish conditions and should be utilized to establish new oak woods.

The phenotypically best-performing and most productive stands are selected and registered as seed stands under EU and OECD rules. At the end of 1998 the total area registered for Social Broadleaves was 857.2 ha (Table 2).

Table 2. Number and area of Social Broadleaves seed stands registered in Ireland

Species	No. of stands	Area (ha)
Beech	9	43.6
Oak (pedunculate)	16	248.5
Oak (sessile)	17	565.1

Tree improvement

Since 1991, 95 plus trees have been selected in oak and some of these are held in a clonal archive. More recently a new initiative in cooperation with the British Hardwood Improvement Programme has resulted in the selection of a number of these for incorporation in a breeding seedling orchard (Hubert and Savill 1999). The objective is to provide the genetic material for the establishment of improved oak plantations in Great Britain and Ireland. This work is funded by COFORD, the National Council for Forest Research and Development.

In the mid-1950s a small number of beech plus trees were selected. In the late 1960s, two beech seed orchards were established using grafted material of these selected Irish trees. Unfortunately, no detailed records remain regarding origin and number of clones used at the establishment of these orchards. However, it is thought that the actual number of clones used is very limited. Although these plantations may not be useful as seed orchards, they may serve as a genebank for further future breeding work. To date no further plus trees have been selected in beech.

Institutions involved in the genetic resources activities in Ireland

In Ireland the Research and Development unit of Coillte through its Tree Improvement and Genetics Section is the main organization involved in genetic studies in oak and beech. These are generally accomplished through seed stand establishment, provenance and progeny trials as well as through cooperation with interested organizations. Teagasc, the national agricultural research organization, in cooperation with the Department of Botany at Trinity College, Dublin, is also investigating the characteristics of relic oak stands in Ireland using genetic, morphological and ecological analyses.

The National Parks and Wildlife Section of Dúchas, the Heritage Service, has the responsibility of identifying and managing National Heritage Areas and Special Areas of Conservation established under the European Communities (National Habitats) Regulations (1997). Dúchas also has the responsibility for the management of sites identified under other EU directives including areas reserved for the protection of wild birds and other natural habitats.

Need for international collaboration

The Strategic Plan for the Development of Forestry in Ireland has as its main focus the development of forestry to a scale and in a manner which maximizes its contribution to national, economic and social well-being on a sustainable basis. It proposes afforestation levels of 25 000 ha/annum to the year 2000 and 20 000 ha/annum thereafter to the year 2030. It is projected that total productive area will increase to almost 1.2 million ha or 17% of the land area. The target for annual broadleaf afforestation is to continue at 20% of total annual afforestation and oak will form a minimum of 20% of this (Anonymous 1996).

Considering these targets, local sources of reproductive material are likely to be inadequate. The need to test new provenances, while at the same time conserve and maintain the genetic integrity of native populations, is of critical importance. The requirement to fully evaluate both species requires the establishment of a comprehensive series of provenance trials in autochthonous and non-autochthonous stands of oak. In the case of beech a sufficient number of provenance tests in the international series have been established and these may prove to be quite adequate. There is a need for international cooperation of research projects and the measures required for the activation and continuance of this cooperation include:

- exchange of reproductive material
- exchange of information
- establishment of an international network on the conservation of genetic resources of oak and beech
- development of practical guidelines for the conservation of genetic resources
- standardization of methodologies in the conservation of genetic resources in all European countries.

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Conservation and state of genetic resources of oaks and beech in Norway

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Occurrence and origin of oaks and beech

Norway has three social broadleaved species, beech (*Fagus sylvatica*), pedunculate oak (*Quercus robur*) and sessile oak (*Q. petraea*). These species are all at their northernmost distribution limit in southern Norway, and the occurrence is confined to warm sites in the nemoral and boreonemoral vegetation zone near the coast (Fig. 1). Except for a narrow zone of the southernmost part of Norway the broadleaves occur in small stands or as single trees.

The Norwegian beech population is an almost isolated extension of the Swedish population. Together with Norway spruce beech was the latest invading forest tree in Norway (ca. 500 BC). As beech is exposed to spring frost, this factor might determine the northern distribution limit of the species (Frivold 1994). Low summer temperatures may also restrict flowering. In addition to the population in East Norway there is a minor fringe occurrence in western Norway near Bergen which possibly dates back to a planting at about 1000 AD (Fig. 1). Beech is presently spreading, and it successfully occupies sites far out of its natural distribution (Hultèn 1971; Frivold 1994).

The oak species came much earlier than beech, during the optimum of the post-glacial warming (6000–3000 BC). This may partly explain the difference in the distribution of the species. The oaks are spread along the entire coast of southern and southwestern Norway, and pedunculate oak also has a slightly continental distribution. As the two species partly grow in the same regions, hybridization among them most likely occurred (Gløersen *et al.* 1957).

Beech sets seeds from the age of 40 to 50, but rarely more often than every 8 to 10 years. Production of acorns in the oaks is also regular. From the age of 50-60 seed set occurs every 4-5 years. Seeds of sessile oak are exported to Denmark (Frivold 1994) where Norwegian provenances are used both for wood production and shelterbelts (Jensen 1993b). All three species are regenerated naturally in Norway and only small areas are planted. Presently there are no breeding activities going on in any of these species in Norway. The "oak decline" associated with attack of *Phytophtora cinnamomi*, such as in southern Europe (Brasier 1996), has not been reported. Rather, following a climatic warming, oaks and beech might expand substantially northward at the expense of Scots pine and Norway spruce (Prentice *et al.* 1991).

Genetic variation

No genetic studies have been performed with oaks and beech in Norway. Experiences in Denmark with oak provenances from Norway and Sweden suggest that trees from these provenances flush earlier and also have an earlier defoliation than Danish provenances (Jensen 1993a). The duration of the annual growth period is most likely shortest and the production levels lowest for the northernmost provenances owing to this clinal trend (Jensen 1993a).

Two population samples of *Quercus petraea* from Norway were included in a range-wide gene diversity survey of the species by allozymes (Zanetto and Kremer 1995; Kremer and Zanetto 1997). These two populations were among those with the lowest values of within-population heterozygosity and contained on average more alleles than populations from the central part of the distribution (Zanetto and Kremer 1995). The additional alleles appeared to be rare alleles. Populations from the edges of the range, including the Norwegian ones, were also characterized by a higher number of two-locus disequilibria (Kremer and Zanetto 1997). These patterns can be due to the population history of the species on the edges of the distribution, where fragmented populations with limited gene exchange are strongly exposed to genetic drift.

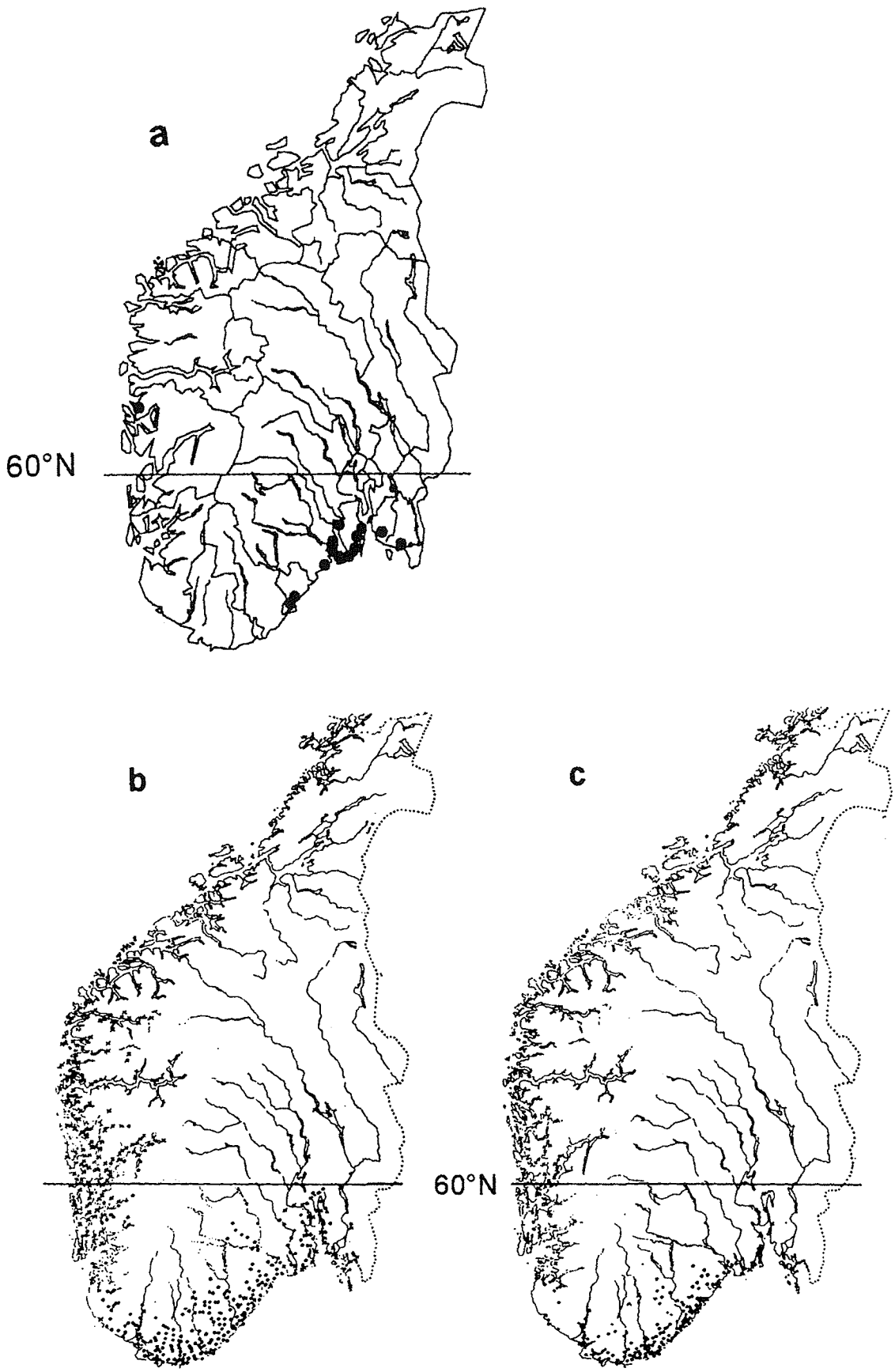

Fig. 1. Distribution maps for beech (**a**), pedunculate oak (**b**) and sessile oak (**c**) in southern Norway. Distribution of beech is redrawn from Hultèn (1971), and distributions of the oaks are from Risdal (1955). The different symbols for the latter two species refer to different sources of information.

In situ conservation and state of genetic resources

Beech occurs as a dominating species in 12 protection areas that have an adequate distribution, covering a total of 274 ha (Table 1). In addition, beech is an associated species in nine other forest reserves. Considering the small distribution in Norway, this meets the *in situ* conservation needs fairly well. More concern is associated with the regeneration, which has been particularly exposed to browsing the last 40-50 years owing to a great increase in the stock of fallow deer.

There are 44 protection areas for oaks in Norway, and the two species are associated in at least 73 more areas (Table 1). For quite a few areas we lack information about species composition, but pedunculate oak is probably included in most of them because of its higher occurrence in general. It is evident, however, that the conservation status for both oak species is deficient in central parts of East Norway, and especially along the coast of West Norway.

Like beech, the regeneration of oaks is locally threatened by browsing cattle and fallow deer. In addition, the overall geneflow is probably less in Norwegian broadleaves than in conifers and most northern deciduous trees owing to the following: the broadleaves have small or fragmented populations, and the seed-dispersal ability is limited because of high seed weights. Substantial generation time and a small seed production because of a long timespan between seed years and low seed numbers per tree also limit the overall geneflow. These factors together suggest an uncertain state of the genetic resources of the Norwegian social broadleaves. This conclusion, however, remains to be critically evaluated by further genetic studies, particularly of variation in quantitative traits.

Table 1. Numbers and sizes of protection areas for social broadleaves in Norway. The group *Quercus* spp. denotes the total amount of conserved areas for oaks

Species	Dominating/Associated	No. of reserves	Total area (ha)
Fagus sylvatica	D	12	274
	A	9	
Quercus robur	D	24	283
	A	31	
Q. petraea	D	11	162
	A	10	
Quercus spp.	D	44	849
	A	73	

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Present situation of deciduous oaks in Portugal

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Introduction

Portugal is a small country of 9 million ha, located in the southwest of Europe. Presently, about one-third of the territory is covered by forests, totalling 3 467 000 ha (DGF 1998), but strong afforestation efforts have been made in the last decades, and it is considered that total forest area can reach 60%. In the last 10 years, the total forest area increased by 8%, partly due to European funding. Public forests (state-owned and communal) represent only 7% of the total forest area (DGF 1998).

The main forest species is *Pinus pinaster*, followed by evergreen oaks (*Quercus suber* and *Q. ilex*) and eucalyptus. Deciduous oaks, including *Q. robur*, *Q. pyrenaica*, *Q. faginea* and recently introduced *Q. rubra*, occur mainly in the north, and in high mountain areas in the central part of the country. Together they occupy an area of 134 100 ha (DGF 1998). *Quercus robur* occurs predominantly in north coastal areas, where the climate has a stronger Atlantic influence, while *Q. pyrenaica* is found mainly in the interior, with a Mediterranean climate. *Quercus faginea* has a very small area (1308 ha), scattered throughout all the country, subsp. *faginea* in the north and subsp. *broteroi* in the centre and south.

These species occur often in small areas and mixed stands, with *Pinus* spp., *Castanea sativa* and *Juglans regia*; several large pure stands have also been reported. Most existing stands, prior to the 1950s, probably originated from natural regeneration or artificial sowing with local seed. More recently, as a result of the development of nursery techniques and European funding, large areas have been planted with *Q. robur* and *Q. rubra*.

These species have a minor economic importance, being mainly used for fuel by rural communities and therefore stands are often managed as coppices. Their use by the parquet industry also has some importance; 109 m^3 of oak logs were exported last year (unpublished information from DGF).

Health state of forest stands and threats to their genetic diversity

Oak stands have a generally good health condition and there are no problems with seed production. In fact, the abandonment of agricultural soil is leading to a natural expansion of oaks through dissemination of acorns by animals. On the other hand, the decrease of rural populations gives good perspectives on the conversion of the existing coppices.

Since Portuguese legislation about reproductive material is not yet implemented, afforestation with *Q. robur* seedlings imported from other countries has been practised on set-aside agricultural land, without knowledge about their adaptation to these new conditions. If artificial regeneration is necessary only reproductive material from the same origin should be used. It is also worth mentioning that this species competes with *Q. rubra* for the same areas and it is being less used on afforestation by private landowners due to the higher growth rate of *Q. rubra*.

There are no specific policies for the genetic conservation of oaks, but several Natural Reserves and Parks were created in recent years in the area of occurrence of all three species (Henriques 1998) (Table 1).

The main threats to the conservation of these species in the natural parks are forest fires, extremely frequent during summer. The conservation politics presently adopted in these parks, in which whatever exists naturally is taken as intrinsically good, largely contribute to increase the risk of fire.

Table 1. Natural Reserves and Parks with oaks in Portugal

Name of the park	Nature of the park	Total area of the park (ha)
Peneda – Geres	National Park	70 290
Montesinho	Natural Park	74 800
Douro Internacional	Natural Park	85 150
Alvão	Natural Park	7 220
Serra da Estrela	Natural Park	101 060
Serra da Malcata	Natural reserve	21 760
Serra do Açor	Protected landscape area	346
Serras de Aire e Candeeiros	Natural Park	38 900
Serra de S. Mamede	Natural Park	31 751
Sintra – Cascais	Natural Park	14 538
Serra da Arrábida	Natural Park	10 820
Total		**456 635**

Breeding activities

In Portugal there are no breeding activities in a strict sense for deciduous oaks. So far Forest services, the Portuguese authority for the control of reproductive material, have identified several *Q. robur* seed stands.

No measures are being taken regarding the other two species, because these species are not included in the European Community forest legislation.

Ongoing research activities

A brief survey of ongoing research activities led to the conclusion that only two projects concerning *Q. robur* and one concerning *Q. pyrenaica* are being developed at the moment, with national funding. These projects deal mainly with silvicultural practices and stand management, aiming to improve wood quality.

Activities plan

- Surveys of *Q. robur* and *Q. pyrenaica* stands as a tool for selection of base material and gene conservation.
- Portuguese populations are in the southern fringe of *Q. robur*. There is insufficient knowledge on their variability. The establishment of provenance tests, as well as description of genetic diversity within- and between populations through genetic markers will allow the delimitation of seed zones.
- Conservation/storage of oak acorns for at least 2 years.

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Genetic resources of beech (*Fagus sylvatica*) and oaks (*Quercus robur, Q. petraea* and *Q. pubescens*) in Spain

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Distribution of the species, ecology, origin

Beech

Beech covers in Spain a surface of 311 115 ha of pure stands, almost exclusively in the north of the country. Beechwoods are distributed almost continuously along the Cantabrian Chain, with more discrete areas in the Pre-Pyrenees, Pyrenees and Iberian Range. On southerly slopes and more littoral areas, stands are highly fragmented.

Edaphic composition does not affect beech, but it is more abundant on calcareous substrates provided soils are decarbonized. Non-calcareous soils present a greater degree of evolution than do calcareous soils. The rainfall range is quite wide (790-1700 mm) and no real drought period was found for any of the regions - the rainfall in the driest month is 22-79 mm. However, a large variation exists in the period of frost. The period of sure frosts ranges from 0 to 5 months, while the period when frosts may possibly occur varies from 3 to 6 months. Beech in Spain is a mountain species, occurring at an optimum between 1000 and 1500 m but over an altitudinal range of 200-2000 m. It prefers the shadow side, a feature more marked the more southerly the location.

According to Costa *et al.* (1990), *Fagus sylvatica* L. began to spread and take hold in Spain from refuges located in the most northerly parts of the present Iberian range of distribution. Situated in valley and ravine beds under 500 m, these date back between 7000 and 4500 years ago. Beech has been moving for some 3000 years in search of a favourable habitat on the upper levels of mountain areas. This movement followed an east-west direction along the Cordillera Cantábrica and the Eastern Pyrenees, but such linear expansion did not occur in the Western Pyrenees. There, movement has been radial, outwards from the Baztán valley in Navarre. Beech seems to have appeared in Galicia no more than 1000 years ago.

Oak

Oaks do not form a very high proportion of the surface area covered by forest in Spain: 147 095 ha, or 1.2% of the total (these figures include *Q. robur* and *Q. petraea*). Most of this area is found in the north and northeast, with the two species unevenly distributed throughout the region. *Quercus robur* and *Q. petrea* are found along the Cantabrian seaboard and the Atlantic coast, becoming less common toward the east, and of only scattered presence in the valley of the Pyrenees. Further inland on the Iberian Peninsula, *Q. robur* exists in small enclaves where local conditions allow; hybridizing at times with *Q. faginea*. *Quercus petraea*, unlike *Q. robur*, is rare in the west of the peninsula – in Galicia there are only scattered examples, which tend to be hybrids with *Q. robur* – while inland it is more abundant than *Q. robur*, growing in various enclaves of the Sistema Ibérico and Sistema Central mountain ranges. *Quercus humilis* is the least widespread species, only appearing in the northeast quadrant - mostly in Catalonia, becoming sparser eastwards toward Navarre. It is usually very difficult to identify due to its introgression with other species, particularly the *faginea* group and/or *Q. petraea*. The easiest forms to identify are in Catalonia, though these seem to be different from central European forms. It stretches inland by way of the Ebro valley and has been noted in the Balearic Islands (Mallorca and Menorca).

Oaks in Spain occur over an altitudinal range of 0-1800 m. The range of the rainfall is quite wide (565-1800 mm) and no real drought period was found for any of the regions,

except region no. 2 with 1.25 months – the rainfall in the driest month is 10-122 mm. However, a large variation exists in the period of frost. The period of sure frosts ranges between 0 to 8 months, while the period when frosts may possibly occur varies from 2 to 8 months.

Quercus robur is the most moisture-loving variety, needing at least 600 mm of annual precipitation (200 mm of these in summer). It does not withstand soil drought, but lives without problem in compact, even occasionally waterlogged soils. It is more commonly found on siliceous substrata, though it can grow on others, as long as the soil is deep, fresh and nutrient-rich. This explains the prevailing situation on plains and valley floors, where there are higher densities than on hillsides. It reaches a maximum altitudes of 1500 m in Spain. *Quercus petraea* is less demanding as to humidity and soil conditions. It needs only 150 mm summer rainfall, but above all a soil which does not become waterlogged or asphyxiating. It thus prefers hillsides, and even grows on stony substrata. It tolerates a wide chemical variety of substrata, surviving in soils with either acidic or calcareous bedrock. It reaches a maximum altitude of 1800 m in Spain, and thrives problem-free up to 1500 m.

Quercus pubescens is the most resistant of the three species to heat, sunlight and drought. It needs a mild climate without extremes, since it does not stand up well to heavy frosts or lengthy summer drought. Mean annual precipitation should be 600 mm, with 150 mm in summer. It grows mainly on calcareous or neutral substrata, but is found at times on siliceous substrata. Its altitude range is 400-1500 m.

Economic importance and silvicultural approaches used

Oak

Traditional uses for oak have been on the decline during the 20th century. While its economic yield is falling, the conservation value of oak woodland has been growing in importance, especially through the second half of the century. This is reflected in the fact that the 1994 timber outputs were 1365 m^3 for *Q. petraea* and 48 397 m^3 for *Q. robur*.

Beech

Navarre has the largest area of beech forest, totalling around 135 000 ha, i.e. 37% of the total area occupied by this species in Spain. The woods located in this region are of particular economic and social significance, owing to their situation in mountainous zones. Timber output in Navarre is of the order of 350 000 m^3, 23% of which was beechwood.

There are three main systems of beech forest in Spain:

1. Most high beechwoods are managed by the forestry administration. The stands are more or less regular, depending on the different regions and their degree of control over forestry management.

   In Asturias and Cantabria, where official policy is conservationist, there is no active intervention at present. Navarre, The Basque Country and La Rioja are the autonomous regions that display the most interest in an integrated treatment of beechwoods. The general aim is to produce regular stands, for which it is essential to protect and foster the regenerating compartments by fencing them off from livestock.

   In Cataluña, private sapling woods are more prevalent than in the rest of Spain. The primordial purpose of these woods is to produce timber.

   The tables of beechwood production in La Rioja and Navarre recommend planning rotations of 90 to 200 years, depending on stand quality, as shown in the following table.

Quality	Rotation (years)	
	La Rioja	Navarre
I	90	95
II	110	110
III	140	130
IV	200	170
V	–	+200

Sources: La Rioja (Ibáñez 1989); Navarre (Madrigal *et al.* 1992).

2. Beechwoods in coppice formation tend to reach maximum spread in periods of mass utilization of firewood and charcoal. In Spain there are woods of this kind in many locations, although they are generally in a state of some degradation and stagnation following the abandonment of exploitation.

   Beech coppice can be found under both private and public ownership. In areas where policy favours productive conservation, forestry authorities tend to turn these stands into high forest.

3. Pollarded beech woods, which are common particularly in the Basque Country, are small discontinuous stands found in woods close to population centres. They are private property. The system may be defined as one of totally artificial silvo-pascology, the silvicultural side being exploited for firewood. This type of stand is currently in decline. To become full forest it requires assisted regeneration, involving work to improve the edaphic structure followed by planting. Experiments of this kind have been going on in the Basque Country since 1980 (Buesa 1992).

Status of genetic resources, conservation activities, use of genetic resources

Fagus sylvatica, *Quercus robur* and *Q. petraea* are species which come under the Spanish Forest Reproductive Material Regulations. Regions of provenance have been defined, taking into account their climatic and soil characteristics and the geographical isolation of populations (Agúndez *et al.* 1995b; Díaz-Fernández *et al.* 1995).

Genetic resource conservation areas have also been defined, in populations which are too small or which contain too few individuals to be used commercially for seed production. These are usually isolated populations, far from the main nuclei of distribution. The area involved is not generally small, but has trees and stands scattered among scrubland or, more commonly, within stands dominated by other species. They are usually found in areas where macroclimatic conditions are unsuitable for beech and oaks. These woods may be considered as ecological islands, where elements of deciduous forest ecosystems mingle with regional communities of markedly Mediterranean characteristics. Their survival in these conditions might indicate strong natural selection forces acting on the original populations, so that these stands could have adapted themselves to conditions which are extreme for their species. Another reason for the possible differentiations of these populations is their genetic isolation from the main populations, which would favour mechanisms of genetic drift.

The unusual and original nature of these stands merits special attention, since they are an important forest genetic resource, the protection of which should have high priority in programmes of genetic improvement and resource conservation. In these stands *Q. robur* and *Q. petrea* are in contact with *Q. faginea* and *Q. pyrenaica.*

Under the grant scheme for abandoned farmlands and as a consequence of the conservation policies, broadleaved species are becoming more suitable for afforestation purposes. In most cases the objective of new plantations is timber production (only with beech), but restoration of old stands is also important. The area of active social broadleaved afforestation is that of its natural distribution.

Beech

There are 18 regions of provenance for beech, including four isolated enclaves which are classified as zones for conservation of genetic resources, such as Caurel, Moncayo, Beceite or Ayllón (Fig. 1). Currently, 21 selected stands (1083 ha) from 10 regions of provenance have been approved for seed production (Table 1).

Genetic variation is being studied using provenance tests from the northwestern zone of Spain (Puertas *et al.* 1995), and several Spanish populations have been studied with isoenzyme and DNA markers (Comps *et al.* 1993). However, there are no results available which would facilitate making recommendations on seed use.

Phytoclimate has been used as the chief ecological factor upon which recommendations of seed sources could be based (Agúndez *et al.* 1995a). A total of 120 sampling points were analyzed all over the natural distribution of beech in Spain, using phytoclimatic taxonomy. The defined regions of provenance, together with approved selected stands, were examined in order to determine homogeneity within regions, and similarity between them, with a view to selecting the appropriate stands for reforestation.

The most heterogeneous regions are those which are in transition from a Nemoral type to Mediterranean or steppe types (no. 6, 10 and 13). Otherwise, the most homogeneous regions are small in size (no. 11, 12 and 14), except for provenances no. 4 and 7. The climates of both of the latter have great oceanic influence and the altitude is always under 1000 m. These two factors could explain their more homogeneous and mild climatic characteristics. Seed sources from marginal populations (with the exception of no. 1) are those adapted to more extreme conditions, and have the lowest levels of similarity with the other regions. Thus, for adaptation studies, these are the most important stands to examine.

On the basis of the homologation of selected stands and regions of provenance, we can classify the regions of provenance into three types:

1. Broad use provenances for the areas in phytoclimatic Nemoral types: no. 2, 7, 8 and 9.
2. Broad use provenances for the areas in transition to Mediterranean and steppe phytoclimatic types: no. 10, 14 and 17.
3. Local use provenances: no. 5, 6 and 13.

In the southern part of the beech distribution area, where the climate has a Mediterranean tendency, there are currently not enough seed stands to cover seed consumption. EC regulations allow the mixing of seed from any seed stands in the same provenance region. When the climate of stands in the same region is very different, mixing of seed should not be recommended. This is the case of selected stands from regions no. 2, 8 and 13, where there are low levels of similarity.

Oak

Nine provenance regions for the three species have been defined in the north of the Peninsula, and five zones for conservation of genetic resources at certain points in the centre of Spain (Fig. 2). Currently, 13 selected stands (312 ha) from three regions of provenance of *Quercus robur* and seven selected stands (248 ha) from five regions of provenance of *Q. petraea* have been approved for seed production (Table 2).

It is difficult to find oak stands in Spain in a sufficiently acceptable state for selection, as stands have dwindled to isolated trees, lines alongside fields or roads, or small stands often made up of very poorly pollarded trees. The small size of some of the stands reflects the impossibility of finding sufficiently large ones in good condition. Nowadays oaks are not used in reforestation, except in very isolated cases.

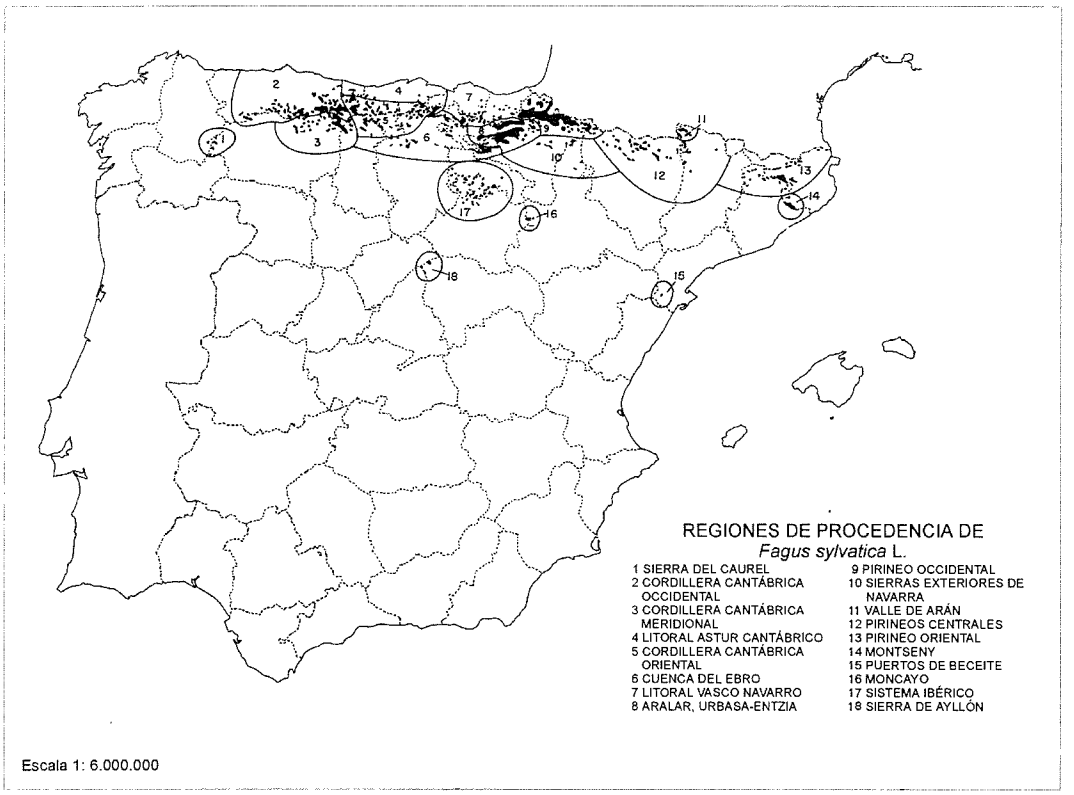

Fig. 1. Regions of provenance for beech in Spain.

Table 1. *Fagus sylvatica.* National Catalogue of Basic Material (May 1999)

Region of provenance	Code	Name	Long.	Lat.	Elevation (m asl)	Area (ha)
2. WesternCordillera Cantábrica	ES-71/02/04	Muniacos	5° 20' W	43° 15' N	800-1000	68
2. WesternCordillera Cantábrica	ES-71/02/05	Reres	5° 21' W	43° 07' N	1000-1500	85
2. WesternCordillera Cantábrica	ES-71/02/06	Peloño	5° 10' W	43° 08' N	1100-1500	120
5. Eastern Cordillera Cantabrica	ES-71/05/03	Saja	4° 19' W	43° 07' N	500-900	63
6. Upper Ebro Basin	ES-71/06/01	Erramuza	2° 33' W	42° 38' N	820	40
7. Basque-Navarre coast	ES-71/07/04	Sta. Engracia	1° 55' W	43° 02' N	700-820	83
7. Basque-Navarre coast	ES-71/07/05	Altube	2° 53' W	42° 59' N	440	13
8. Aralar, Urbasa, Entzia	ES-71/08/03	Marumendi	2° 07' W	42° 58' N	780	60
8. Aralar, Urbasa, Entzia	ES-71/08/05	Limitaciones	2° 15' W	42° 49' N	950	83
8. Aralar, Urbasa, Entzia	ES-71/08/06	Parzonería de Entzia	2° 15' W	42° 50' N	970	30
8. Aralar, Urbasa, Entzia	ES-71/08/07	Parzoneria de Gi-A	2° 17' W	42° 55' N	900	80
9. Western Pyrenees	ES-71/09/03	Espinal	1° 23' W	43° 00' N	825-925	21
9. Western Pyrenees	ES-71/09/04	Erremendia				30
10. Sierras Exteriores, Navarre	ES-71/10/02	Lumbier	1° 03' W	42° 41' N	1100-1220	41
13. Eastern Pyrenees	ES-71/13/01	Baga de Castilla	2° 20' E	42° 13' N	1100-1200	37
13. Eastern Pyrenees	ES-71/13/02	Fageda Jordá	2° 30' E	42° 08' N	600-700	52
13. Eastern Pyrenees	ES-71/13/03	Monte Rodolá	2° 18' E	42° 10' N	1100-1400	34
13. Eastern Pyrenees	ES-71/13/04	Más Espuña	2° 24' E	42° 12' N	650-900	57
14. Montseny	ES-71/14/01	Coll de Té, Convento	2° 27' E	41° 47' N	1000-1200	20
17. Sistema Ibérico	ES-71/17/01	Gallinero	2° 35' W	42° 09' N	1300	44
17. Sistema Ibérico	ES-71/17/03	Tobia	2° 43' W	42° 16' N	1400	22

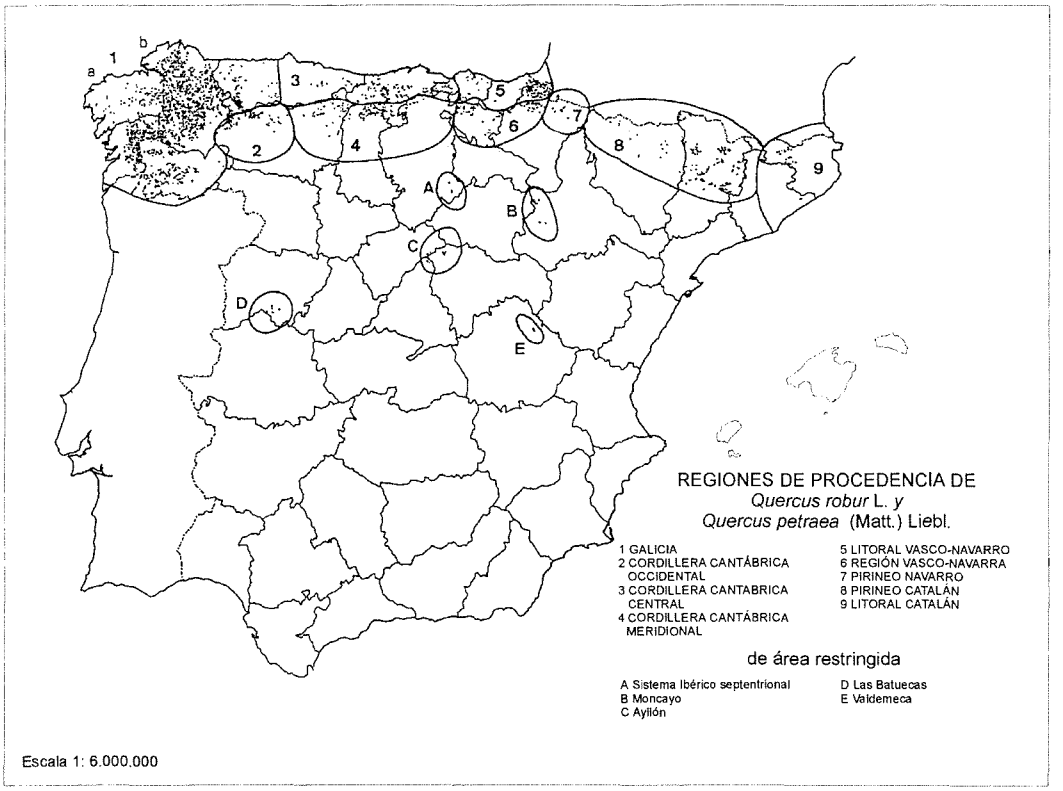

Fig. 2. Regions of provenance for oaks in Spain.

Table 2. *Quercus robur* and *Q. petraea*. National Catalogue of Basic Material (June 1999)

Region of provenance	Code	Name	Longitude	Latitude	Elevation (m asl)	Area (ha)
Quercus robur						
1.Galicia	ES-41/1/1	Caldas De Reis	8° 38'W	42° 36'N	20-30	2
1.Galicia	ES-41/1/2	Cartelos	7° 50'W	42° 34'N	600	45
1.Galicia	ES-41/1/3	Casa Do Gado	8° 00'W	43° 02'N	480	12
1.Galicia	ES-41/1/4	Becerrea	7° 09'W	42° 51'N	170	1.2
1.Galicia	ES-41/1/5	Campo Da Barcia	8° 11'W	42° 37'N	510	3.7
1.Galicia	ES-41/1/6	Cachafeiro	8° 19'W	42° 34'N	560	1.1
1.Galicia	ES-41/1/7	Golada	8° 02'W	42° 48'N	430	1.2
3. Central Cordillera Cantabrica	ES-41/3/1	Ucieda	4° 21'W	43° 16'N	300-500	20
3. Central Cordillera Cantabrica	ES-41/3/4	Canales	4° 14'W	43° 13'N	430	31
3. Central Cordillera Cantabrica	ES-41/3/5	La Calzada	3° 58'W	43° 07'N	550	22.9
4. Basque-Navarre Region	ES-41/4/1		2° 54'W	42° 58'N	640	150
4. Basque-Navarre Region	ES-41/4/2	Las Paduras	2° 53'W	42° 56'N	615	20
4. Basque-Navarre Region	ES-41/4/3	Murguía	2° 49'W	42° 57'N	620	2
Quercus petraea						
1.Galicia	ES-42/1/1	Poso	6° 52'W	42° 51'N	1050	1.6
4.Southern Cordillera Cantabrica	ES-42/4/1	Poniente	4° 12'W	43° 11'N	500-700	46
4.Southern Cordillera Cantabrica	ES-42/4/2	Hijedo	3° 57'W	42° 54'N	930	26
5. Basque-Navarre Coast	ES-42/5/1	Arlaban	2° 33'W	42° 58'N	630	20
7. Navarre Pyrenees	ES-42/7/1	Garralda	1° 17'W	42° 56'N	700-850	130
9. Catalan Coast	ES-42/9/1	Cant Torrent	2° 29'W	41° 47'N	400-600	5
9. Catalan Coast	ES-42/9/2	St. Hilari	2° 31'W	41°55'N	700-800	20

Research, current international collaboration

Beech

There is a network of experimental plots of national provenance, set up in 1986 and 1992 with seven experimental plots and 42 Spanish provenances. Since 1993, Spain has also taken part in the projects financed by the EU and coordinated by the Federal Forest Research Institute in Grosshansdorf, Germany. Three plots have been established with provenances from the whole of Europe – one with 100 provenances set up in 1993, and two with 35 set up in 1998. In 1999, 30 Spanish populations were sent to INRA-Bordeaux, France for analysis based on cpDNA markers.

Oak

In 1999 a test of Spanish provenances was started, but there has been no participation in international tests. Spain takes part in the EU-financed project coordinated by INRA-Bordeaux, France for the study of oak genetic resources in Europe. Studies based on cpDNA markers have been performed including Spanish white oaks: *Q. robur, Q. petraea, Q. pubescens, Q. faginea, Q. pyrenaica and Q. canariensis* (Herrán *et al.* 1999).

Institutions involved

- Ministry of the Environment - DGCONA. Servicio de Material Genético: Selection of basic material.
- Government of Navarre. Agriculture, Animal production and Forest Departement: Beech provenance studies.
- AZTI Granja Modelo-CIMA/Government of the Basque Country: Oak molecular markers.
- Forestry Research Institute. Lourizán (Galicia): Oak provenance studies.

Needs and priorities for international collaboration

There is a lack of information about the geographic variability of beech and about the provenance behaviour of oak.

A network made up of the selected stands can form the base for conservation of genetic resources *in situ*. With this in mind, it would be advisable to cooperate in the definition of guidelines for stand management.

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Management and conservation of oak (*Quercus petraea, Quercus robur*) and beech (*Fagus sylvatica*) genetic resources in the United Kingdom

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Occurrence and origin

Oak is the most important broadleaved species in Britain occupying approximately 172 000 ha (Locke 1987). Beech ranks second among broadleaves and occupies approximately 74 000 ha. Broadleaf planting has exceeded that for conifers over the last seven years. Within the area of recent new planting and restocking, the oaks are much more important than beech. All oak and beech woodlands in Britain have been affected by man to a greater or lesser extent.

Economic importance

The total annual production of hardwoods is approximately 100 000 m^3 of which 33 000 m^3 are oaks and 20 000 m^3 are beech. Average standing prices are from £55 to £70/m^3 for oak and from £14 to £40/m^3 for beech. Prices at the sawmill are about £25/m^3 higher than for standing timber. The market is steady for British oak, but prices for beech have recently declined because of economic trends.

Silviculture

Both oak and beech are grown as high forest, although there are small areas of coppiced oak. Both species are mainly grown in the private sector in mixture with other broadleaves and are managed for landscape, amenity, conservation and game cover as well as for timber production of limited economic value. There is a trend toward continuous-cover forestry. Natural regeneration of both species is favoured but is not reliable in the British climate. Artificial regeneration is used not only for new planting on ex-agricultural land but also to restock existing woodland.

Ecological and cultural importance

Both upland and lowland oakwoods have special ecological value (Anonymous 1994a: Forest Practice Guides 5 and 1). Western oakwoods support mats of mosses (*Musci*) and liverworts (*Hepaticae*) which are confined to oceanic climates along the western seaboard of Europe. Lowland forests such as the New Forest, Windsor Forest and Great Park are among the richest localities in Europe for original-woodland species. Beech-ash woodland is particularly important as a habitat for rare orchids (Anonymous 1994a: Forest Practice Guide 2).

Many individual ancient oaks have historical associations. A few oaks (such as the Major Oak of Sherwood Forest) have been commercially propagated by micropropagation and the potted plants are sold in garden centres.

Health of oak and beech in Great Britain

In contrast to many countries of continental Europe in which the health of oaks was generally giving much more concern than that of beech (Turok *et al.* 1998), the current position in Great Britain is that there is some concern about the health of both species, especially in certain areas. The health of hedgerow and roadside trees is generally much worse than for trees growing in a forest situation. In beech especially many roadside and hedgerow trees are in very poor condition, which is thought to be due to damage from salt

(applied to roads in winter) and to drought, rather than due to air-pollution (which however may cause some yellowing of the upper crown of beech in some localities in late summer).

"Oak dieback" is a recognized condition (Greig 1992) which occurs in South and East England and extends as far north as Yorkshire. It is not considered to be the same condition as "oak decline". Although often lethal, the prevalence of oak decline does not seem to be increasing. The causes of oak dieback have not been clearly elucidated but drought and storms (e.g. that of 1987) are probably contributory factors and the involvement of a newly described *Phytopthora* species (*P. quercina*) has been implicated in a proportion of cases.

The general condition of several species including both beech and oak is assessed annually by means of crown density of a large number of plots distributed throughout Great Britain. In oak there was an overall trend of reduction of crown density from 1987 to 1997, but a significant improvement in 1998 (Redfern *et al.* 1999). In beech there are wide fluctuations in crown density from year to year, but there does not appear to be an overall reduction of crown density as seen in oak; there was a significant improvement in beech in 1998.

Silviculture of beech is threatened in many areas by grey squirrels (*Sciurus carolinensis* Gmelin). These vermin cause serious damage to many hardwood trees, especially at the "pole" stage and control is expensive. Grey squirrels are an exotic pest which have not yet become established in continental Europe, although there is a population in Italy.

Genetic differences between provenances (or families) of oak and beech in their susceptibility to diseases, pests or adverse edaphic factors have not yet been demonstrated in Britain, presumably because there has until recently been relatively little work studying adaptive variation in these species.

Use of Forest Reproductive Material

Oak and beech fall under the Forest Reproductive Material regulations of the European Union. Seed is collected from reasonable numbers of these Registered Stands (Table 1) in good mast years which only occur every 3–4 seasons. Much seed is imported from continental Europe, especially in poor mast years for either species.

Table 1. Registered stands of oak and beech

Species	No. of registered stands	Area (ha)
Quercus petraea	21	218
Quercus robur	30	122
Mixed *petraea/robur*	14	58
Fagus sylvatica	25	134

For oak about 80% of the registered stands are in Region of Provenance 40, covering most of central and southern England, but are concentrated along the western boundary with Wales. Seed is collected from the stands of mixed sessile and pedunculate oak under derogation. By far the largest areas of beech Registered Seed Stands are in Region of Provenance 40.

Tree improvement (provenance and progeny testing)

Provenance tests

Oak

A series of mostly sessile oak provenance trials was established by Forest Research under the auspices of IUFRO in 1990 and 1992 at nine sites in England and Wales (one in Scotland). Early heights of about 50 oak seed sources have been assessed and analyzed for individual sites. In these English trials material from seed stands in England is generally more vigorous than material from seed sources from continental Europe (Cundall 1999).

Earlier work reported by Worrell (1992) indicated that European provenances of sessile oak were inferior to British but this was based on a sample of 10 seed sources only.

Beech
Forest Research has recently participated in the European Network of International Beech Provenance Trials (Von Wuehslisch *et al.* 1998). One trial which was established in 1996 in the Chiltern hills near London includes 46 seed sources and the second trial, established in 1999 at a lowland forestry site, includes 25 seed sources. Earlier work evaluating about 20 seed sources, reported by Worrell (1992), showed that the growth rates of continental provenances of beech were superior to British in about 50% of cases, provenances from northern France, Belgium and Holland being the fastest growing.

Progeny tests

Oak
Forest Research established oak progeny trials in 1993 at three sites. About 35 families from stands of sessile and pedunculate oak respectively are planted in neighbouring field trials.

Under an initiative of the British Hardwood Improvement Programme based at the Oxford Forestry Institute, 246 plus-trees of both sessile and pedunculate oak have recently been selected throughout Britain, the Netherlands, France and Ireland. The 246 trees selected were reduced to 110 using primarily the criterion of earlywood vessel size, since work has shown that large earlywood vessels are linked with an increased incidence of shake (Savill 1986). The larger vessel sizes were in Dutch oak; planting this material could increase the predisposition to shake on difficult sites. The plus trees will be used to establish Breeding Seedling Orchards (Hubert and Savill 1999). The 110 'plus' trees have been grafted onto clonal rootstock at Horticulture International, East Malling, using a "hot-pipe" technique with about 50% success. This is an example of *ex situ* conservation. This oak improvement initiative is interesting as there is emphasis on selection of economic characters, without great regard as to their local origin or species.

Beech
A tree improvement programme of plus tree selection with the establishment of untested clonal seed orchards was set up in the 1950s. Early work has been summarized by Samuel *et al.* (1993). In the beech progeny trials there was a marked negative correlation between form and vigour, although it was clear that a selection programme could be effective and that heritabilities are similar to those found in coniferous species. However modest gains of about 15% would have little benefit in a species with an average yield class of 6. The beech clonal seed orchards were removed from the National Register in 1993 as seed collection from them had been limited.

Conservation of genetic resources
The UK recognized conservation of genetic diversity as an important underpinning component of conservation of biological diversity (Anonymous 1994b: UK Biodiversity Action Plan). The importance of genetic conservation for forestry is recognized in the UK Forestry Standard (Anonymous 1998) which states that "new native woodlands provide a special opportunity to conserve the genes of locally native trees and shrubs". Another aim is to maintain genetic integrity of populations of native species.

A review of current knowledge of genetic variation and conservation of British native trees and shrubs (Ennos *et al.* 1998) is currently being considered by Forestry Commission as a basis for policy-making. The challenges of implementing genetic conservation of oaks and beech are considerable. The original genetic structure of these species has presumably been altered by the clear-felling of most of the original forests. Within woodland there has been some

tendency to fell the trees of better form, leaving the poorer trees to provide seed for the next generation ("dysgenic selection") but the genetic consequences of this have never been tested. It is also thought that historical planting of translocated oak and beech has been on a significant scale compared with the use of local and autochthonous material. Indeed, beech is only considered native to south and east England, yet is now widely distributed throughout the United Kingdom and regenerates naturally even in Scotland. On the other hand interesting patterns of genetic variation can still be discerned among oaks. Cottrell *et al.* (1999) studied the distribution of cpDNA variants among stands thought to be of native origin (some possibly autochthonous). Most British oak stands sampled proved to derive from an Iberian refugium.

Ennos *et al.* (1999) list five objectives of genetic conservation:

1. To maintain current levels of adaptation and fitness in present-day populations.
2. To maintain and where possible enhance the long-term adaptive potential of species and populations in the face of environmental change.
3. To safeguard the continued supply of genetic variation for use in all aspects of forestry, from woodland conservation to tree improvement programmes.
4. To conserve those aspects of the genetic structure of populations which reflect their unique evolutionary history.
5. To maintain and, as far as possible, restore natural genetic processes, especially geneflow and natural selection.

Conservationists naturally emphasize the importance of preservation because great efforts have been devoted to this at the species level. However Eriksson *et al.* (1995) emphasize that for forest tree populations today's genetic resources should be regarded as the starting point for gene conservation activities, but not as the goal for gene conservation programmes.

It is important for their genetic conservation that both oak and beech have very high levels of genetic diversity, as measured for example by isoenzyme heterozygosity (e.g. Comps *et al.* 1993; Herzog 1996), as would be expected for wind-pollinated, long-lived and highly outcrossed (Merzeau *et al.* 1994) species.

Much oak and beech planting stock used in Britain is currently imported from continental Europe (because of poor mast years in Britain) and the issue of the likely relative maladaptation of exotic planting material to Britain's oceanic climate is an important one. Furthermore the imported material will over time undoubtedly hybridize with native material. Ennos raises the issue of "hybrid breakdown" which may occur if exotic populations from different evolutionary units are allowed to mix. Evidence for such hybrid breakdown in oaks or beech, or for any other forest species, is lacking in Britain, however. At the practical level it is important to ensure that if oak and beech material have to be imported from continental Europe it is from areas which have been shown from provenance trial results to be relatively well adapted to British conditions, rather than from areas where seed sources are poorly adapted to a northern and oceanic climate.

As a result of concerns over genetic conservation, and pressure from conservationists to use locally native seed sources in the establishment of new native woodland, a provenance map has been published by the Forestry Commission in which the former four zones of provenance are divided into 23 seed zones (Herbert *et al.* 1999). The intention is that this would be used on a voluntary basis and would guide seed transfer of all native broadleaves, including oaks and beech. This system will have to run in parallel with European Union Forest Reproductive Material Directives which already cover both oaks and beech.

Considering all broadleaves there is as yet no comprehensive plan for the conservation of Forest Genetic Resources in Great Britain, as has been developed for example in Denmark (Graudal *et al.* 1995). However the review of genetic conservation (Ennos *et al.* 1998) which was commissioned by the Forestry Commission will undoubtedly influence policy. Ennos *et al.* (1999) have also made some recommendations for the genetic management of native species in Scotland, but there has not been a comparable published study for England or Wales.

More than 100 exotic oak species, some of which are endangered in their native habitat (e.g. *Quercus acerifolia*) are represented in the Sir Harold Gardens and Arboretum, Romsey, Hampshire[1], which holds, among others, the National Collection of *Quercus*, this being an example of international *ex situ* conservation. Living material in the collection is available for study, as is the extensive collection of wild, collected and cultivated *Quercus* material in the Harold Hillier Herbarium.

Public awareness

Public awareness of general nature conservation in the United Kingdom is high. Tree planting by various voluntary groups has been encouraged especially in connection with the forthcoming millenium. There has been emphasis on the planting of locally native trees, with an emphasis on the importance of local genetic adaptation (e.g. Browne 1996) notwithstanding the complete lack of any scientific data, from British sites, on this point. Oaks are much favoured as native species which support a wide variety of wildlife whereas beech tends to be regarded as "non-native" in some areas and not so valuable for nature conservation as oak.

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Programme

Thursday 3 June
Arrival of participants at Zürich Airport (transfer of the participants from the Airport to the hotels)

1345 Transfer of the participants from the hotels in Zürich to the Swiss Federal Institute for Forest, Snow and Landscape (WSL) in Birmensdorf
1415-1500 Opening of the meeting:
- Welcome host country/WSL
- Welcome Chair of the Network (A. Kremer)
- Introduction and format of the meeting (J. Turok)

Joint session with the EU/FAIR Project on Oaks
1500-1630 Research on oak genetic resources in Europe - results of the EU/FAIR Project:
- Phylogeographic map of chloroplast DNA diversity in oaks on a range-wide scale (R. Petit)
- Geographic variability in oaks based on provenance tests (S. Madsen)
- Comparative levels of diversity in *Quercus petraea* and *Q. robur* (A. Kremer)

1630-1645 Coffee break
1645-1830 Discussion:
- Extension of the phylogeographic map in eastern Europe
- Submission of an extended project proposal for funding to the EU Fifth Framework Programme

1830 Transfer to Zürich

Friday 4 June
0800 Transfer of the participants from the hotels to WSL
0830-0850 Social Broadleaves in the Swiss forest policy (M. Bolliger, Swiss Forest Agency)
0850-0920 Overview of legislation related to genetic resources of Social Broadleaves in Europe (S. de Vries)
0920-1000 Information and documentation (J. Jensen):
- Database of provenances in *Quercus petraea* and *Q. robur* - jointly with EU/FAIR
- Standardized protocols for leaf morphology analysis, chloroplast DNA analysis and microsatellites - jointly with EU/FAIR

1000-1030 Coffee break
1030-1230 Discussion: common minimum information standards of the Network; descriptors and databases
1230-1330 Lunch at the WSL restaurant
1330-1800 Excursion to Bülach (management of oak genetic resources)
1800-1900 Direct transfer from Bülach to the "Uetliberg"
1900 Social dinner at Zürich-Uetliberg

Saturday 5 June
0800 Transfer of the participants from the hotels to WSL
0830-1000 Brief round-the-table updates on the progress made in countries (Moldova, Ukraine, Hungary, Slovakia, Czech Republic, Austria, Switzerland, Italy, Slovenia, France, Luxembourg, Belgium, the Netherlands, Germany, Denmark, Lithuania, Finland and Sweden)
1000-1030 Coffee break

1030-1230 Introductory country reports: Bulgaria, Croatia, Ireland, Norway, Portugal, Russian Federation, Spain and the United Kingdom
1230-1330 Lunch at the "Sternen" restaurant
1330-1530 Development of joint gene conservation strategies:
- Results of a survey conducted prior to the meeting (T. Geburek)
- Discussion: technical guidelines for the sampling, design and management of gene conservation units in Social Broadleaves

1530-1600 Coffee break
1600-1800 Public awareness:
- Leaflet (J. Turok)
- Slide collection (D. Jacques)
- Other public awareness initiatives

1800 Transfer to Zürich

Sunday 6 June
0800 Transfer of the participants from the hotels to WSL
0830-1000 Miscellaneous:
- Scope of the Network regarding species
- Next meeting

1000-1030 Coffee break
1030-1200 Approval of the report of the meeting
Conclusions
Closure of the meeting
1200-1300 Lunch at the "Sternen" restaurant

Departure of participants (Transfer to Zürich/ Zürich Airport).

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