IPGRI

Mediterranean Oaks Network

Report of the first meeting
12 - 14 October 2000 - Antalya, Turkey

S. Borelli and M.C. Varela, *compilers*

EUFORGEN

European Forest Genetic Resources Programme (EUFORGEN)

FUTURE HARVEST
<www.futureharvest.org>

IPGRI is a Future Harvest Centre supported by the Consultative Group on International Agricultural Research (CGIAR)

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).

The international status of IPGRI is conferred under an Establishment Agreement which, by January 1999, had been signed and ratified by the Governments of Algeria, Australia, Belgium, Benin, Bolivia, Brazil, Burkina Faso, Cameroon, Chile, China, Congo, Costa Rica, Côte d'Ivoire, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, Greece, Guinea, Hungary, India, Indonesia, Iran, Israel, Italy, Jordan, Kenya, Malaysia, Mauritania, Morocco, Norway, Pakistan, Panama, Peru, Poland, Portugal, Romania, Russia, Senegal, Slovakia, Sudan, Switzerland, Syria, Tunisia, Turkey, Uganda and Ukraine.

Financial support for the Research Agenda of IPGRI is provided by the Governments of Australia, Austria, Belgium, Brazil, Bulgaria, Canada, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, F.R. Yugoslavia (Serbia and Montenegro), Finland, France, Germany, Greece, Hungary, Iceland, India, Ireland, Israel, Italy, Japan, Republic of Korea, Latvia, Lithuania, Luxembourg, Macedonia (F.Y.R.), Malta, Mexico, Monaco, the Netherlands, Norway, Peru, the Philippines, Poland, Portugal, Romania, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Turkey, the UK, the USA and by the Asian Development Bank, Common Fund for Commodities, Technical Centre for Agricultural and Rural Cooperation (CTA), European Union, Food and Agriculture Organization of the United Nations (FAO), International Development Research Centre (IDRC), International Fund for Agricultural Development (IFAD), International Association for the Promotion of Cooperation with Scientists from the New Independent States of the former Soviet Union (INTAS), Interamerican Development Bank, Natural Resources Institute (NRI), Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), Nordic Genebank, Rockefeller Foundation, United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), Taiwan Banana Research Institute (TBRI) and the World Bank.

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 for 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.

Citation:
Borelli S. and M.C. Varela. 2001. Mediterranean Oaks Network, Report of the first meeting, 12-14 October 2000, Antalya, Turkey. International Plant Genetic Resources Institute, Rome, Italy.

ISBN 92-9043-469-4

IPGRI
Via dei Tre Denari, 472/a
00057 Maccarese (Fiumicino)
Rome, Italy

Contents

Summary of the Meeting

Opening

Mr. Yavuz Yüksel, vice Undersecretary of the Ministry of Forestry, welcomed the participants and underlined the importance of protecting the genetic diversity of forests. He described the forest cover in Turkey and the efforts of his country to conserve plant genetic diversity through both *in situ* and *ex situ* measures. Large conservation projects were launched with the assistance of the World Bank. He also indicated that Turkey has 18 oak species (3 of which endemic) and he described the factors that currently threaten oak forests. He underlined the important role of oaks in Mediterranean forest types.

He added that he is sure that some of the threats are common to all Mediterranean countries and that it is very important to act in a coordinated fashion at an international level. He announced that Turkey has initiated the procedure to become full member of EUFORGEN and he hoped that this would happen before the end of the year. Finally, he wished the participants a successful meeting and a good stay in Turkey.

Maria Carolina Varela, chair of the Network briefly outlined the history of the S2 resolution, of the EUFORGEN Programme and of the *Quercus suber* Network. She then introduced the scope of the new Network.

She welcomed the participating countries (13) and thanked the National Coordinator Hasan Özer, the Network member Nihal Özel, the local organizers and the Turkish Government for the excellent organization and for their participation, which shows the importance of the collaborative work on forest genetic resources.

Simone Borelli, of the EUFORGEN Secretariat, gave a brief introduction on Phase II of EUFORGEN, a brief summary of the results of the most recent meetings of other networks, highlights on upcoming meetings and activities in progress in the Programme at large.

The agenda of the meeting was adopted.

History and main outputs of the Quercus suber Network

In order to provide background information on the past activities of the *Q. suber* Network, the relevant members were asked to provide highlights of progress in the gene conservation in their respective countries.

In France, the main progress was made in research on populations. Genetic diversity and origin of the populations were studied with isoenzymes and cpDNA and two separate groups, one related to Spanish populations and the other to Italian ones, were identified. Also, some introgression from holm oak was found. Recently, new cork oak stands are being established in some regions.

In Italy, many populations are degraded and have been invaded by other Mediterranean species. As a result, the Ministry of Agriculture recently created a Task Group on the restoration, reforestation and the conservation of gene resources of this species. Subsidies are provided to owners who want to plant cork oak and in some regions, nurseries are being developed and local types are being collected for reproduction. The cork oak industry is also very interested in the protection of natural cork products.

In Morocco, the species is in regression due to problems with natural regeneration. Field tests were carried out in relation to the EUFORGEN Network and the EU FAIR project - European Network for the evaluation of genetic resources of cork oak for appropriate use in breeding and genetic conservation strategies. Thirty provenances and 88 progenies from seven countries were tested. The results of this work were presented in detail. Also studies on introgression have been carried out in collaboration with INRA.

To promote cork oak gene conservation, Portugal has been divided into 7 homogeneous provenance regions and minimum standards for conservation have been defined. Provenance trials have been carried out to assess different ecological and edaphic requirements. The demand for cork is increasing and reproductive material has to be imported, however origin is not always known.

In Tunisia, the cork oak stands have quite high economic importance, but surface is in regression. The stands are highly disturbed and are declining due to lack of regeneration. More systematic management started in 1970 and standard rotations were established. Regeneration is carried out through direct sowing and seedlings. Research is currently addressing the problems related to acorn storage and plantation techniques.

EU-FAIR project on the conservation of genetic resources of cork oak

The EU funded FAIR project was briefly presented. The overall objective was to carry out provenance trials and progeny tests using material from all countries in the distribution area. Acorns were collected and sent to Portugal. Plants were produced and trials set out in all participating countries (except Algeria). The network of trials has been quite successful and for the first time represents the entire natural distribution area. Scientific results have shown that gene conservation is compatible with economic management. A management model was proposed and will possibly be included in the technical guidelines.

Case study on genetic conservation in Spain

Pilar Jimenez presented the results of her research on genetic variation of *Quercus suber* in Spain. An isoenzyme analysis was carried out on 22 populations. Allelic richness, number of polymorphic loci identified and heterozygosity were measured. The most diverse populations were those from south of Spain. Differentiation patterns were examined. The results showed that in some marginal populations there is a strong founder effect. It also appears that geneflow and population size maintain diversity and that marginal populations are important and should be included in conservation programme.

Web page

Simone Borelli briefly presented the new structure of the EUFORGEN Web page and asked network members to provide comments and suggestions. It was agreed to follow the same layout as the one used for other networks and to include country reports and country updates as appropriate.

Bibliographic databases

Simone Borelli presented the proposed EUFORGEN bibliographic database on gray literature. Network members endorsed the idea of having a single database that would cover all species that are included in the EUFORGEN programme and would be accessible via the Internet. This would also facilitate access to the general public. An Access form has been developed and will be circulated to Network members by 31 October 2000. Excel and Word versions are also available, but contributors are encouraged to use Access whenever possible. It was clarified that each member should restrict contributions on gray literature to those available in his/her own country. However, in the case of Mediterranean oaks, international references will also be included in the database.

Technical guidelines

There is an ongoing discussion within the Networks on the preparation of a EUFORGEN “manual” on general principles of gene conservation of forest trees. This issue will be discussed at the upcoming Inter-Network Meeting. As a result technical guidelines for individual species would be restricted to describing the biology, ecology and genetic knowledge of the particular species or group of species and include practical management guidelines directed to practitioners.

The existing version of the technical guidelines was discussed and it was agreed that further clarification is needed on the following points:

- Overall objectives of the technical guidelines should be clarified
- The rationale of MPBS (choice of material could be based on expected future changes) should be explained
- A justification for proposed method for conservation of associated species should be added
- Density could be used as a criteria together with age classes
- Marginal populations should be considered
- Minimum standards should be further developed and included
- Support for natural regeneration and assisted natural regeneration when appropriate
- Both *ex situ* and *in situ* methods should be considered

Maria Carolina Varela and Gösta Eriksson will prepare and circulate a new draft of the relevant chapter by 31 March 2001.

Priorities for the Mediterranean Oaks Network

Introduction

Francesco Spada made a general presentation on the current situation of oaks in the Mediterranean. He analyzed the origin of the existing subgenera and debated whether they actually present typical Mediterranean characteristics. He also tackled the issue of taxonomy and of the problems created by a lack of communication and exchange between botanists in the past. He presented anedoctal evidence on some of the most amusing cases. He underlined the importance of gene conservation and of genetic research in finally clarifying systematics of the oak genus.

Country reports

All Networks members presented a report on the current status of Mediterranean oaks in their respective countries and will provide the Secretariat with an electronic version of the report itself by 15 November 2000.

Working sessions

After some discussion on methodology, participants were divided into two groups to discuss a number of issues related to widely occurring (group 1) and rare and threatened species (group 2). The groups were asked to respond to a number of questions related to the characteristics of the species, existing threats and current needs and priorities for conservation. The results of the working groups are summarized in annex 1.

Workplan

The working groups then reconvened to discuss which activities the Network could carry out in the coming years. Five main areas of involvement (research, information, legal and policy issues, technical guidelines and public awareness) were discussed in the two working groups. Each working group proposed a set of activities and these provided the basis for workplan below, agreed during the final session of the meeting.

Public awareness

The idea of a public awareness video was launched. However, this would require some

initial investment and some effort on the part of each country to collect footage on local forest species. Eman Calleja offered to prepare a brief feasibility study. The proposal will be circulated to network members by 31 December 2000.
There was general agreement on the preparation of a Photo CD, which would include images on all Mediterranean oaks. Each country will be responsible for providing slides on different aspects (full tree, landscape, traditional uses, morphological characters, etc.) of local species as soon as they become available. Nihal Özel offered to be in charge of collecting the images and transferring them to CD Rom. The collection would be available to all members to be used for different PA material, publications, web pages etc. The Secretariat will provide existing format by 15 November 2000.

It was also decided that a EUFORGEN brochure on Mediterranean oaks directed at a general "forestry" public and decision makers would be produced. Luís Gil and Maria Carolina Varela offered to prepare a first draft of the text that will be circulated by 15 March 2001.

Information management

A proposal was made to produce a database of genetic resources of Mediterranean oaks. This would include information on stands of relevant species in different countries. However, a prerequisite for the development of the database is the formulation of descriptors for Mediterranean oaks stands. Alexander Alexandrov offered to prepare a draft proposal, which will be discussed at the next Network meeting. The draft will be circulated one month before the meeting itself. The Secretariat will provide copies of the descriptors developed for *P. nigra* and Noble Hardwoods.

The database of stands will follow as soon as the descriptors are finalized.

It was also decided to collect existing distribution maps of Mediterranean oaks. Maps will be provided to the Secretariat for scanning and posting on the Internet by 31 March 2001.

Technical guidelines

A consensus was reached that, since there is limited knowledge of the ecological and genetic characteristics of most of the species, the elaboration of technical guidelines for Mediterranean Oaks is premature. Therefore, for the time being the Network will concentrate on finalizing those for cork oak.

Legal issues

The question of regulations of use of reproductive material for afforestation was raised. It was decided that this issue would be best tackled at the level of the Inter Network meeting and of EUFORGEN in general.

Research needs

A number of research needs were identified:

- Geneflow in species made rare by fragmentation caused by human impact (with microsatellites and/or other markers)
- Geneflow in naturally rare species
- Ecological conditions for growth of rare oak species
- Better clarification of taxonomic status of Mediterranean oaks
- Characterization of genetic structure based on adaptive traits
- Role of hybridization for gene conservation
- Impact of silviculture *sensu latu* on genetic composition
- Delimitation of regions of provenance
- Wood properties and Non Wood Forest Products

In view of the complexity of issues to be addressed it was decided to prepare concept note (2-3 pages) on possible research projects that would involve the largest possible number of countries. Luís Gil agreed to develop a proposal on *Q. ilex* and Vlatko Andonovski and Alexander Alexandrov would prepare a similar proposal for *Q. pubescens* or *Q. frainetto.*

Gösta Eriksson suggested a COST action as a possible tool to develop these proposals further. This would also provide the necessary interdisciplinary focus.

Election of Chair and Vice Chair
The Network proposed to have both a Chair and a Vice Chair, which would represent both the eastern and western part of the Mediterranean Basin. Luís Gil was elected as Chair of the Mediterranean Oaks Network and Vlatko Andonovski was elected as Vice Chair.

Both the Network members and the Secretariat expressed their sincere gratitude to Maria Carolina Varela for her commitment and efforts in the implementation of the S2 Resolution and in ensuring the success of the *Q. suber* Network and its smooth transition to the Mediterranean Oaks Network. The main role Maria Carolina Varela played in the provenance trial of cork oak and of course, her pleasant personality, were also underlined.

Maria Carolina Varela thanked all the members for the support and wished the Networks members a successful continuation of activities.

Date and Venue of the next meeting
The next meeting of the Mediterranean Oaks Network will be held in Spring 2002. It was proposed that Malta hosts the meeting, but confirmation will follow. In the event this first proposal should not be successful, Macedonia FYR also offered to organize the meeting.

Adoption of the report
The report was adopted and distributed to the participants.

Conclusions
Jozef Turok, on behalf of IPGRI, thanked Hasan Özer and Nihal Özel for the excellent organization of the meeting. Luís Gil also thanked the local hosts for their kindness and declared the meeting officially closed.

The EUFORGEN *Quercus suber* Network and the research projects for the evaluation of genetic variability of cork oak

Maria Carolina Varela
Estação Florestal Nacional, Lisboa, Portugal

Cork oak - an odd forest tree

Naturally restricted to the seven western Mediterranean countries - Algeria, France, Italy, Morocco, Portugal, Spain and Tunisia - cork oak (*Quercus suber* L.) is the only plant species capable of producing cork with the physical and chemical properties that are suited to supply an important industry: cork stoppers for wine.

Long lifespan, complex and late assessment of cork qualities and irregular reproductive behaviour are some of the aspects that make genetic studies of cork oak a difficult task.

Notwithstanding its economical interest, cork oak has often been replaced by other species and its area has been reduced. On the outskirts of the "economic" core the species is often found in small marginal and scattered populations, refugia from previous occupation. Both the rather uncontrolled propagation material supply and the conservation of genetic resources of cork oak are both a cause for concern.

Increased demand for high quality cork, boosted by the increase in consumption of bottled wine makes genetic improvement an important component of the economical sustainable management of the species.

Cork oak gene conservation

This species was designated as pilot species for the Mediterranean zone of Europe in 1992, and the cork oak network was soon enriched by the expertise on genetic improvement of long living species coming from Sweden and Germany.

Strategies for EUFORGEN Quercus suber *Network*

The overall objective of dynamic gene conservation is *to create good conditions for adaptation of the species.* The need of outlining objectives of cork oak gene conservation before taking decisions on methods was clearly stated by Varela and Eriksson (1995).

Since genetic variability and heritability depend on additive genetic variance of populations, the strategy for gene conservation of cork oak was based on the following principles:

- Small populations (above the threshold of genetic drift) evolve faster
- Saving genes with a frequency of 0.01 in diploid species is assured through populations of effective size Ne $\geq$ 50
- Rare genes show poor value for additive variance of population, the main driving force for species adaptation
- There are no means nor genetic justification to save all genes
- Man-induced environment changes are occurring at a speed higher than ever before
- Measures have to be taken before all genetic knowledge is available
- It is possible and desirable to match gene conservation with the economical exploitation models of the species
- Multiple Population Breeding System (MPBS) is the most suited methodology to increase of among-population variation.

The MPBS splits the gene resource population into 20 or more sub-populations with an effective size of at least 50, which allows to safeguard the minimum level of additive variance for adaptability

Over the years, the Multiple Population Breeding System concept was extended from intensive to simple breeding, to the management of the species under natural regeneration, and also to the conservation of associated species.

The network identified the following issues for cork oak:

- Strategies for gene conservation
- Lack of genetic knowledge of adaptive traits
- Need for improvement of cork quality and yield
- Gene conservation of associated species
- Economic management of cork oak gene resources populations
- Methods to guarantee natural regeneration under multipurpose management
- Conservation of genetic resources in face of global climate changes

Lack of genetic knowledge of adaptive traits

Lack of genetic knowledge was recognised as a major limitation for gene conservation. To assess the within and among population genetic variability of cork oak the network focused on the need to establish provenance and progeny trials. Complementary studies on genetic markers, morphology and eco physiology were also recommended.

Need for improvement of cork quality and yield

Two possible methods have been identified:

- Intensive breeding - ex situ MPBS model
  The increase of among and within population variability makes ex situ MPBS the most adequate methodology for intensive breeding (Namkoog 1984; Eriksson et al. 1993). Sub-populations selected in a wide variety of ecological conditions in addition to specific measures for small, scattered populations, allow merging intensive breeding and conservation of genetic resources.
- Simple breeding - in situ MPBS model
  While no intensive breeding programmes have been established for cork oak, simple breeding combining gene conservation and slight genetic improvement is required. For this purpose Varela and Eriksson, 1995 proposed an in situ version of MPBS through selection of sub-populations of Ne ≥50 for seed supply. In order to capture the maximum of the species potential adaptability, small marginal populations were also included.

Genetic research on cork oak

Research needs identified through the EUFORGEN cork oak network provided the basis for a concerted action called *European network for the evaluation of genetic resources of cork oak for appropriate use in breeding and gene conservation strategies* which included institutes from Portugal (coordinator), France, Italy, Spain Germany and Sweden. The participation of Algeria, Morocco and Tunisia was made possible by additional funding provided by DGIB/A- Microaction B7 4100

The project established a network of provenance and progeny trials based on common genetic entries (figure 1) from the entire distribution area of cork oak (*Quercus suber* L.).

Participants to Project FAIR 1 CT 95 and Microaction B7/4100

Dr Maria Carolina Varela Estação Florestal Nacional Portugal - coordinator	Institut Méditerranéen du Liège France
Dr Maria Helena de Almeida Instituto Superior de Agronomia Departamento florestal Portugal	Dr Rosanna Bellarosa Università degli Studi della Tuscia Italy

Dr Gabriel Catalan BachilierCentro de Investigacion Forestal (CIFOR)- INIA Spain	Prof Gösta Eriksson Swedish University of Agricultural Sciences Department of Forest Genetics Sweden
Dr Michel Bariteau INRA- Laboratoire de Recherches Forestières Méditerranéennes France	Prof Hans Muhs Institute für Forstgenetik Germany
Microaction B7 4100 DGIB/A	
Mr Benziane Mohamed Administration des Eaux et Forêts Morocco	Dr Khouja Mohamed Larbi INRGREF - Institut National de Recherche en Génie Rural, Eaux et Forêts Tunisia
Dr M. Harfouche INGREF Algeria	

General objective and main tasks of the projects:

The objective of the project was to promote the establishment of simultaneous provenance and progeny trials under standardized methodologies, representing the entire distribution area, through a network of six European and three North African countries.

Data base implementation

Among other tasks the project also addressed the issue of creating a database for information on cork oak genetic research. The database is available online on the Internet page of the Estação Florestal Nacional:

http://www.efn.net.novis.pt/f0202_2.html

Provenance and progeny sampling

The possible effect of the size and number of blocks on the control of the environmental component of the trials, together with the spacing required for adult cork oak, influenced the decision on the number of provenance and progenies.

To evaluate the genetic variability of cork oak along its natural range 35 provenances was considered the trade-off number, while identified seed lots from 20 individual trees represented each provenance.

The high number of genetic entries involved made it necessary to separate provenance and progeny trials. Using 88 progenies from mother-trees belonging to 4 out of 35 provenances provided the connection between the two kinds of trials.

The 17 trials established in France, Italy, Morocco, Portugal, Spain and Tunisia in the winter of 1997/98 (Figure 1) hold a unique collection of material that can prove useful to compare a wide variety of convergent research lines over time.

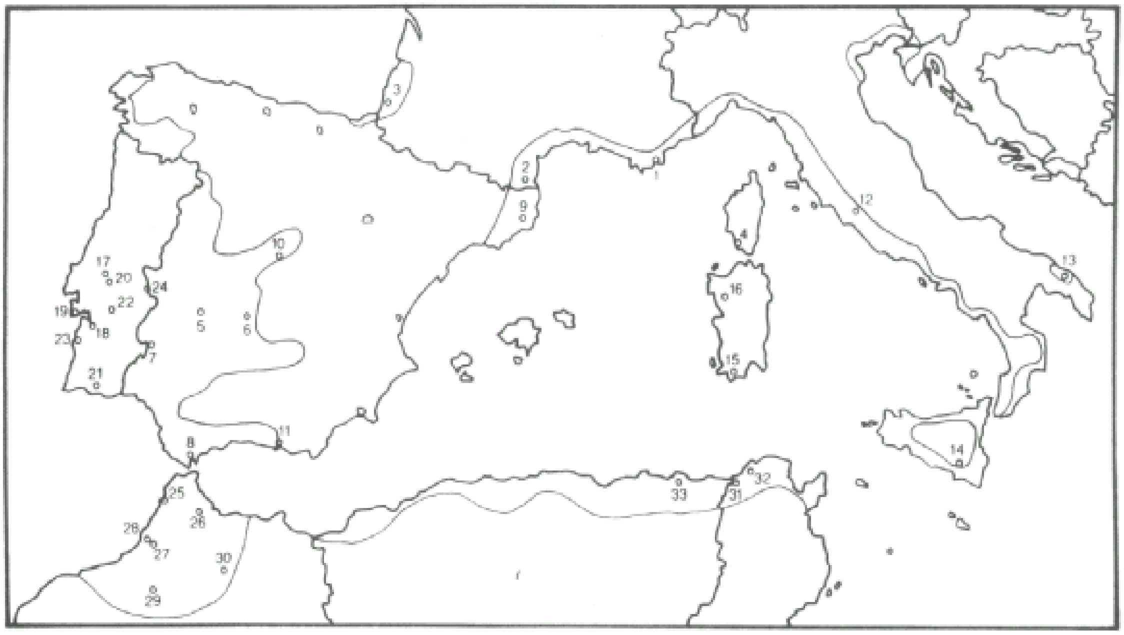


Figure 1. Natural range of cork oak, zones of provenance collection and trials establishment

Field trials were established during 1997 and 1998 through funding from the respective countries.

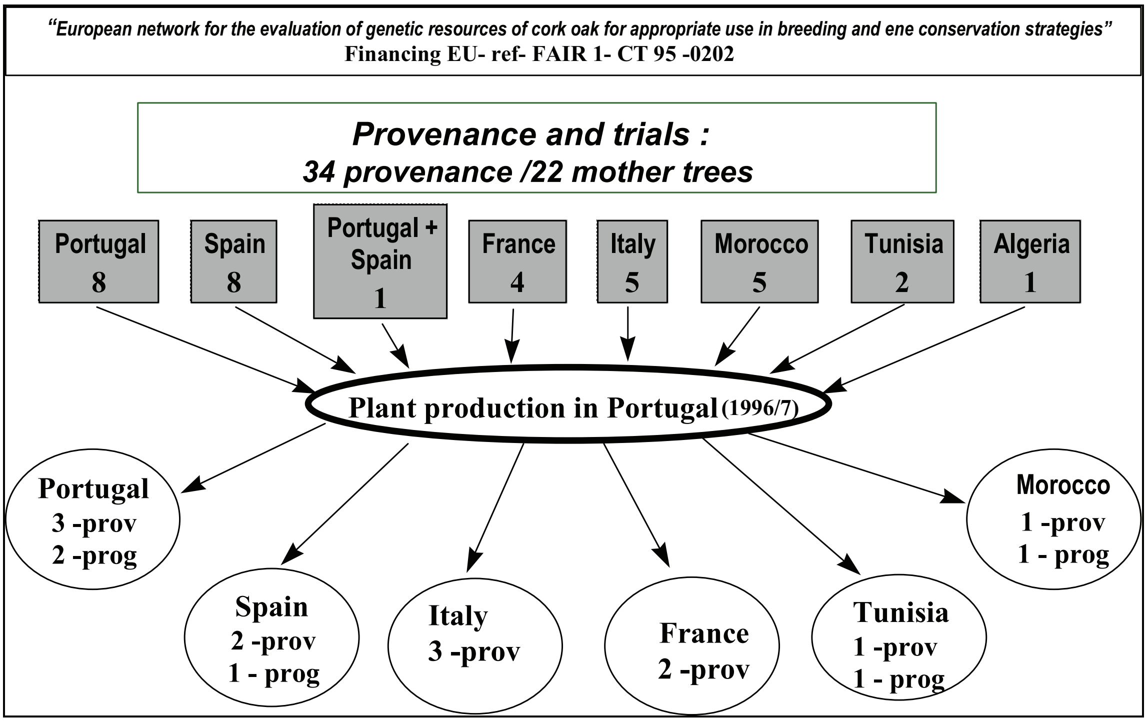


Figure 2. Schematic representation of seed lots collection and plant production and trials

Experimental design for provenance trials

Two designs were used for provenance trials:

Table 1. Provenance tests for cork oak- m.t. -mother trees - Design 1

	Plot	Block	Trial	Observations
Genetic entries: 34 provenance	4 plants	All m.t.	30 blocks	
Design	Square plot (m)	RCB		
Acreage	Initial=3 x 3 Final= 6 x 6	36 x 34=1224 m^2 = 0.125 ha	1224 x 30=36720 m^2= 3.7 ha	
N. of plants	Initial= 4 Final= 1	Initial= 136 Final= 34	Initial= 136 x 30= 4080 Final= 34 x 30= 1020	2 thinnings

Table 2. Experimental design for provenance tests for cork oak- m.t. -mother trees - Design 2

	Plot	Block	Trial	Observations
Genetic entries 34 provenance	8 plants	All m.t.	15 blocks	
Design	Row plot	RCB		
Acreage	Initial= 6 x 1.5 Final= 6 x 6	72 m^2 x 34= 2448 m^2 = 0.25 ha	2448 m^2 x 15= 36 720 m^2= 3.7 ha	
N. of plants	Initial= 8 Final=2	Initial= 272 Final= 68	Initial= 136 x 30= 4080 Final= 34 x 30=1020	2 thinnings

For progeny tests, the proposal for a progeny trial of 5 provenances + 1 common provenance was not feasible due to the insufficient number of plants in a considerable number of mother trees (m.t.). Progeny trials had to be based on 3 or 4 populations making use of the full set of m.t. for which enough plants were available at the end of the nursery phase.

Links were made through the common populations used on the progeny trial network (some of the populations were used as «bridge population» between pairs of sites). The experimental design was a complete block design with one-tree plots, organised as a split plot, in order to assume a single thinning.

Table 3- Experimental design for progeny tests for cork oak- m.t. -mother trees

	Plot		Trial	Observations
Genetic entries: 3 - 4 provenances	1 plant	All available m.t. of the chosen provenance	22 blocks	
Design	Single tree plot	Restricted complete randomization		
Acreage (for an average n. of 22 m.t. and 4 prov.)	Initial= 6 x 3 Final= 6 x 6	18m^2 x 22m.t. x 4prov.= 1584 m^2 = 0.16ha	1584 x 22= 34848 m^2 = 3.5 ha	
N. of plants	Initial = 2 Final = 1	Initial = 176 Final = 88	Initial= 3872 Final= 1936	1 thinning

Since afforestation actions could not wait for scientific answers to become available, an informed use of results obtained during the trials allowed for some indications on choice and use of reproductive material.

While provenance trials provided an indication of among population genetic variation, progeny trials were the tool for evaluation of within population variability. The knowledge of these two components is essential for understanding the possibilities for advanced improvement and gene conservation programmes.

Provenance trials

Under the pressure of increased demand for cork from the wine industry and the push for new afforestation and setting aside of farm land coming from EU or from national support for slow growing forest species, several thousands of hectares of cork oak are being established in the European Union and North Africa every year.

Once, natural regeneration or seed collection in the vicinity were the dominant patterns for the establishment of new stands. Nowadays, sowing or planting can only be supported through large-scale seed procurement.

Transfer of reproductive material has always been a part of forestry activities, and in some situations exotic material has either overcome or outperformed the local one.

Unfortunately, the inappropriateness of seed source may reveal itself only several years later, leading to failures and showing that success is a matter of mere contingency if not supported by results from provenance trials.

With the current knowledge, conclusive results from field tests on cork quality cannot be obtained before the age of 40, when the second cork stripping takes place. However, early results complemented by laboratory studies may be used for practical guidance.

The population structure of cork oak is being addressed through various genetic markers studies. Jimenez (see page 15), found a migration rate of 7 individuals per generation, which reveals high levels of gene flow. However, the available results show clear differences in provenance behaviour, which might be due to strong natural selection overcoming the effect of population differentiation caused by the migration effect.

Provenance trials are expected to provide information on among population variation, particularly on aspects such as:

- Adaptation to local climate, especially winter temperatures and summer drought. Cork oak spreads naturally on wide ranges of rainfall (2500 mm to 450mm), summer drought (1 to 5 months < 30mm) and winter temperature from mild to below zero. Within this wide range, populations may have evolved adaptations leading to shock when transferred to different sites.
- Soil type. Apart from hydromorphic or active calcareous soils cork oak is able to colonise a broad variety of soils. The species spreads on rich and deep soils as well as on sandy ones usually characterised by poor water retention. Tolerance to drought may have evolved differently leading to problems in vigor when moving provenance material.
- Genotype × environment interaction. Decisions on the use of alien reproductive material should be based on the appraisal of the level of genotype × environment interaction. High interaction can cause considerable failures due to provenance shock, while low G×E interaction allows basing the choice of afforestation material on economic characteristics, independently from of the origin of the seed.

In conclusion, with the current knowledge, the use of local material is the most suitable method for artificial regeneration of cork oak.

Short term results

Preliminary trials have already revealed different performances of the various provenances. By age 10, a part of the climatic variation is expected to take place, and some insights may be drawn for intermediate practical recommendations. Provenances with high rate of mortality along the various blocks should be considered unsuitable for afforestation in edapho-climatic conditions similar to those of the trial site. Decisions upon provenance of intermediate behaviour will be postponed.

Long term results
Considering that 40 years is a time span in which occurrence of major weather fluctuations is probabilistically included, the ecological adaptation of the various provenances is expected to be concluded at the time of the second and third cork stripping, that takes place around the age of 40-50 (according to site conditions and individual tree growth).

An interactive processing of data coming from the trials on the various countries is expected to provide complementary results, enhancing the appraisal of genotype × environment interaction.

Complementary studies
Even though they are not suitable for appraising the adaptive profile of populations and individuals, studies on genetic markers, eco-physiology, histology and other domains are very important for characterising gene flow and mating patterns.

Reproductive behaviour of cork oak is also an important research area for providing complementary information on the strategy for genetic improvement of the species.

Both aspects are currently being addressed through various research activities (Varela 2000; Varela *et al.* 2000; Carvalho and Varela 2000).

Progeny trials
The main objective of the progeny trials established after the concerted action FAIR 1 CT 95 0202 and the EU Microaction B7 4100 for North Africa countries was to assess the degree of genetic control on cork production and quality.

In order to enhance the information from field trials, trials of 88 open-pollinated progenies coming from 4 provenances (from the set of 35) were established under a split-plot single-tree experimental design. The 4 provenances were chosen by each country based potentially interesting characteristics such as drought or cold tolerance, cork quality, etc.

The possible effects of global climate change on the cork oak distribution range, such as the probability of periods of extreme warmth, which would cause a reduction of growing season and soil moisture levels due to greater evapotranspiration (Wigley 1992), also influenced the choice of provenances for the progeny trials.

In order to get unbiased heritability values, progeny trials were based on a random sample of trees rather than on selection of plus trees. Therefore, mother-trees were chosen among the dominant strata on the basis of fruiting ability and health status. Trees with obvious poor quality cork were not included. In order to mitigate the outcrossing rate, trees to be included on the progeny trials were required to be at least 50-100m apart.

Genetic improvement or intensification of management will be privileged based on the results of the progeny trials and according to the level of heritability.

Short term results
Poor progeny results are expected at an early age due to the longevity of the species and the fact that all plants are half-sibs.

The phenotypic aspect of cork growth that is used in practice for early evaluation and thinning still lacks scientific base. Histology observation and gene markers on progenies will complement studies on phelogene - the tissue responsible for cork production - in order to make early selection sounder.

Long term results
The half-sib progeny tests will allow for appraisal of heritability *sensu stricto*, although conclusive results will not be available before the age of 40.

As they include 88 half-sib progenies, the trials included in this project are insufficient for individual genetic selection. However, since the 88 progenies come from four of the provenances used in the trials complementary results may be expected.

Economical management of cork oak gene resources populations

Since knowledge on adaptive traits of cork oak is very limited, Varela and Eriksson (1995) argued that gene conservation and economical management of the species should be merged through the identification of gene resource populations that cover a wide range of edapho-climatic conditions.

Gene resource populations have been selected in order to allow for seed collection for afforestation purposes.

The conceptual approach underlined the delimitation of regions of provenance for cork oak in Portugal (Varela 2000) as a basic step for seed supply, in order to capture all existing species adaptability.

Natural regeneration under multi purpose management and conservation of genetic resources

In a considerable number of cork oak stands, natural regeneration is used and has proven to be the best method. A simple breeding and conservation method of cork genetic resources, which considers associated species, is proposed in figure 3.

To combine the various objectives, the area designated for natural regeneration should be divided into plots closed to grazing and other activities that could damage the seedlings for a period long enough to include 3 mast years. In order to maintain genetic variability area $\mathbf{A}_N$ should contain a sufficient number of adult fruit trees to ensure that Ne $\geq$50. Taking into consideration the reproductive profile of cork oak (Varela, 1994; Varela *et al*, 2000; Carvalho and Varela, 2000) the closing time should be around 15-20 years and the plot should include about 250 adult trees, which means 4- 6 ha for Portuguese average conditions for cork oak forests.

During the regeneration process, management should be focused on thinning and pruning practices as well as on shrub control in order to minimise fire risks. By the age of 15, trees are usually able to withstand cattle pressures.

Furthermore, this process has a positive environmental influence and reduces movements of fragile Mediterranean soils; particularly the poor and shallow ones where cork oak stands usually grow. However, closing plots could lead to a temporary loss of income and European Union or national programmes could support this practice, as is the case for artificial regeneration.

Conservation of genetic resources of small marginal populations

Marginal populations growing in extreme environmental conditions may carry particular adaptations useful for overall species evolution. Marginal populations with an effective size >50 should be included in an *in situ* network. For populations of Ne <50 it is necessary to promote an increase in effective size. Supplying local seedlings or seeds to forest owners free of charge is a low-cost alternative for conservation of genetic resources from small marginal populations.

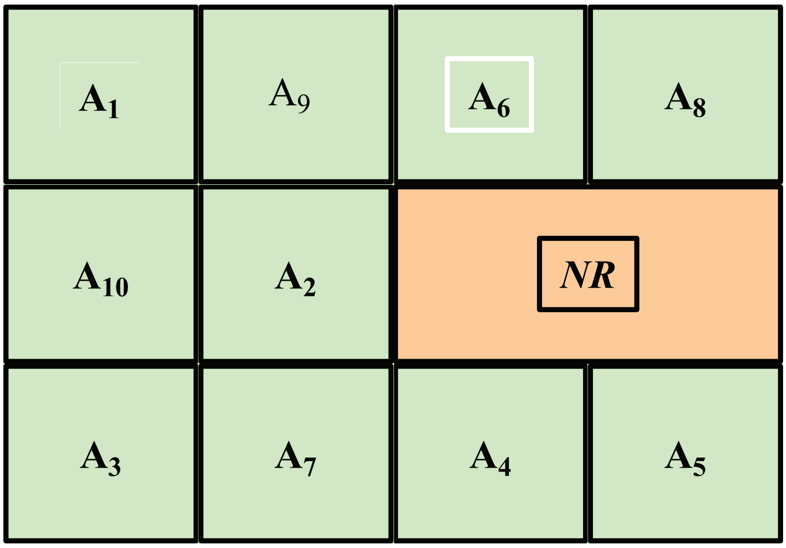


Figure 3. Model for combining simple breeding and conservation of cork genetic resources while taking care of associated species, under natural regeneration of multiuse exploitation of cork oak. A=area to be closed to grazing and/or agriculture during 15/20 years. In order to include Ne > 50 for cork average conditions the minimum area is 5 ha. NR=nature reserve for associated species

References

Carvalho, A. M. and M.C. Varela. 2000. Contribution à l'Étude de la Floraison et de la Fructification du Chêne-liège au Nord-est du Portugal- in preparation

Eriksson, G. 2000. Gene conservation of noble hardwoods. In print in Investigaciones INIA, Madrid Spain

Eriksson, G. 1998. Sampling for gene resource populations in the absence of genetic knowledge. Pp. 61-75 *In* Noble Hardwoods Network. Report of the Second Meeting, 22-25 March 1997. Lourizán, Spain. Turok J., E. Collin, B. Demesure, G. Eriksson, J. Kleinschmit, M. Rusanen and R. Stephan (compilers)

Eriksson, G., G. Namkoong and J. Robberds. 1993. Gene conservation of forest trees for uncertain futures. For. Ecol. Manag. 62:15-37

Turok, J., G. Eriksson, J. Kleinschmit and S. Kanger (compilers). 1996. Noble Hardwoods Network. Report of the First Meeting. 24-27 March 1996, Escherode, Germany. IPGRI, Rome, Italy.

Varela M. C. 2000. Regiões de Proveniência para o sobreiro (Quercus suber L.) em Portugal- In print- Dir. Geral das Florestas, Min Agric. Des Rural e Pescas, Lisboa

Varela M.C. , P. Oliveira, R. Brás, I. Barros and C. Meierrose. 2000. Réproduction et hybridization entre chêne vert et chêne liège- in preparation.

Varela, M.C. and G. Eriksson. 1995. Multipurpose gene conservation in Quercus suber - a Portuguese example. Silvae Genet. 44:28-37.

Wigley, T.M.L. 1992. *In* Climatic change and the Mediterranean. Ed. by L. Jeftic, JD Milliman and G Sestini. United Nations Environment Programe (UNEP).

Genetic variability of *Quercus suber* L. : applications to genetic resources conservation

***Pilar Jiménez*[1], *Ricardo Alía*[2] *and Luis Gil*[1]**
[1] *Unidad de Anatomía, Fisiología y Genética. ETSI Montes, Universidad Politécnica de Madrid,. 2804 Spain*
[2] *Departamento de Mejora y Biotecnología, CIFOR-INIA, 28080 Madrid, Spain*

Introduction

Due to the economic and ecological importance of cork oak, breeding and conservation programmes are being developed. Therefore, delineation of the genetic variation within cork oak is becoming an urgent task. However, the limited knowledge available on the genetic structure of the species has precluded the use of well-targeted approaches.

Several recent studies have addressed genetic variation in *Q. suber*. Bellarosa *et al.* (1996) compared *Q. suber*, *Q. cerris* L. and *Q. crenata* Lam., by comparing seed storage proteins and rDNA genes. Hybridization between *Q. ilex* and *Q. suber* was studied by Elena-Rosselló *et al.* (1992), and introgression of *Q. ilex* and *Q. suber* has been described in mixed stands (Toumi and Lumaret 1998). In a range-wide isozyme study, Toumi and Lumaret (1998) found high levels of heterozygosity and identified intraspecific differences in populations from two areas that are only partially geographically distinct. Allozyme variation restricted to seven Spanish populations (Elena-Rosselló and Cabrera 1996) confirmed the high levels of heterozygosity and inter-population differentiation in these populations, but did not ascribe differences to geographic area. The relevance of demographic and geographic factors to the maintenance of genetic variability of the species needs to be investigated. In this sense, the complex of fragmented cork oak forests found in Spain is of great interest for studying cork oak genetic variation.

Results presented here are part of a study on genetic variation of cork oak in Spain, with the following objectives:

- to assess diversity levels of *Q. suber* by means of molecular markers
- to establish geographic structuration of variability
- to compare central and marginal populations
- to obtain relevant information for gene conservation programmes.

Materials and Methods

Genetic variability was assessed by means of isozyme analysis, using starch gel electrophoresis. Seeds were collected from 22 populations distributed throughout the natural range of the species: eighteen from Spain, and one each from Portugal, Morocco, Sicily and continental Italy (Figure 1).

Each population was classified as being central or marginal, depending on the degree of isolation. A stand was considered isolated if it was more than 50 km from the closest cork oak stand. Marginal populations are generally located in the periphery of the range and can be subdivided into three different types: 1) relatively large isolated populations; 2) a series of small and nearly sympatric populations isolated in the same area; or 3) isolated and small stands.

A total of 15 enzyme systems were analysed (GOT, ACPH, ADH, CAT, LAP, MDH, MNR, 6PGD, PGI, PGM, SKDH, SOD). Allelic frequencies and parameters of intra- and interpopulation diversity were calculated.

The contribution of each population to total diversity was calculated following the method developed by Petit *et al.* (1998).

Figure 1. Natural range of *Q. suber* (dotted area) and location of populations included in the study.

Results

Fourteen loci were evaluated for the 12 enzymatic systems, 9 of them showing variation. The total number of alleles was 29, including the monomorphic loci. Most of the variants appear in every population. Only two private alleles (i.e. restricted to a single population) were found (Adh-3 and 6Pgd-B-1), and others were present in few populations. The case of Acph-C-1, appearing in populations from the northwest and centre of Spain is remarkable (Figure 2).

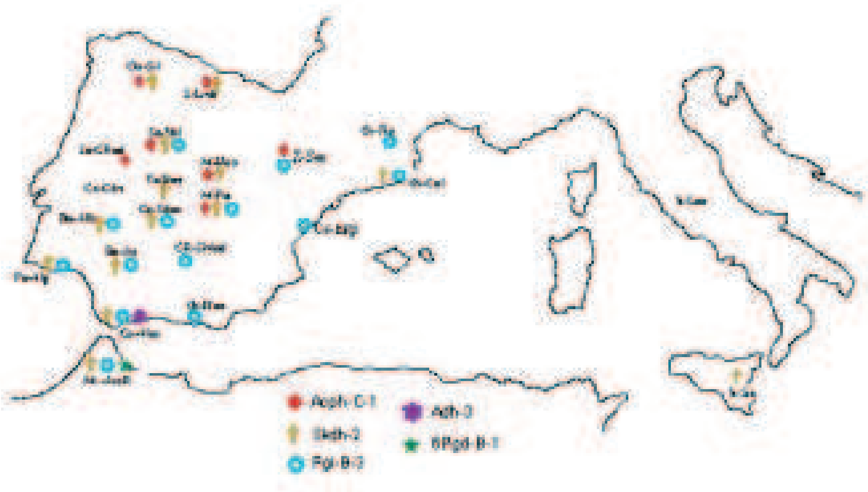


Figure 2. Distribution of restricted alleles

The species shows a low level of polymorphic loci: 64% (at the 99% confidence level), with a range of 43 to 64% between populations. The mean number of alleles per locus was 2.07, ranging from 1,64 to 1.93 between populations. Regions with higher allelic richness are southern and central Spain (the main range of cork oak in Spain), while less variation was found in Italy and in the north-northeast of the Iberian Peninsula. This loss of alleles corresponds with small or isolated populations, where drift events can easily occur (Table 1).

Levels of expected heterozygosity within populations (He) varied from 0.116 to 0.168, with a mean value of 0.157. The highest values were found in southern populations and in some populations from central Spain. A pattern similar to that of allelic richness can be appreciated: higher variation in the south of the range and in central Spain.

Multilocus analysis shows high allelic richness, from 17 to 59 different genotypes in each population. Difference between observed number of genotypes and genotypic diversity (v^2) (Gregorius 1978) indicates that genotypes do not have a uniform distribution. Total population differentiation (δ_T), which equals 1 when all the sample members are different, is always higher than 0.9. This can be correlated with the mating system of cork oak: outcrossing and diversification of flowering time within and between trees.

Table 1. Parameters of diversity for each population *Na*: number of alleles; *Ne*: effective number of alleles; *Pl-95*: polymorphic loci at 95% criterium; *Pl-99*: polymorphic loci at 99% criterium; *He*: expected heterozygosity; v^2: genotypic diversity; δ_T: total differentiation.

Pop	*Na*	*Ne*	*Pl-95 (%)*	*Pl-99 (%)*	*He*	v^2	δ_T
Ba-Alb	1.86	1.22	5 (35.7)	8 (57.1)	0.134	10.029	0.913
Ba-Jer	1.86	1.27	5 (35.7)	8 (57.1)	0.152	12.738	0.932
Ca-Alm	1.93	1.31	7 (50)	9 (64.3)	0.167	26.130	0.971
Cc-Cñm	1.86	1.25	6 (42.8)	9 (64.3)	0.149	12.919	0.933
Cc-Cñv	1.71	1.24	6 (42.8)	8 (57.1)	0.147	12.569	0.929
CR-SMad	1.79	1.29	7 (50)	9 (64.3)	0.163	22.827	0.967
Cs-Esp	1.64	1.25	5 (35.7)	6 (42.8)	0.141	13.760	0.936
Gi-Col	1.79	1.29	4 (28.6)	7 (50)	0.149	20.146	0.963
Gi-Fig	1.64	1.25	4 (28.6)	6 (42.8)	0.138	17.801	0.955
Gr-Haz	1.79	1.31	6 (42.8)	9 (64.3)	0.168	27.222	0.973
It-Laz	1.64	1.19	4 (28.6)	8 (57.1)	0.116	10.136	0.911
It-Sic	1.71	1.26	4 (28.6)	8 (57.1)	0.148	12.276	0.928
M-Hoy	1.79	1.24	7 (50)	9 (64.3)	0.149	21.254	0.962
M-Par	1.93	1.29	7 (50)	8 (57.1)	0.165	14.773	0.941
Mr-AinR	1.93	1.28	5 (35.7)	9 (64.3)	0.163	26.866	0.971
Ou-Sil	1.86	1.25	6 (42.8)	8 (57.1)	0.154	9.375	0.908
Po-Alp	1.86	1.25	5 (35.7)	7 (50)	0.144	12.319	0.929
S-Lieb	1.79	1.25	4 (28.6)	8 (57.1)	0.139	12.829	0.933
Sa-CRod	1.79	1.27	5 (35.7)	9 (64.3)	0.158	13.827	0.940
Sa-Val	1.93	1.29	6 (42.8)	8 (57.1)	0.164	21.228	0.961
To-Bay	1.79	1.30	6 (42.8)	7 (50)	0.164	18.630	0.958
Z-Ses	1.71	1.27	6 (42.8)	6 (42.8)	0.152	20.915	0.964
Total	**2.07**	**1.28**	**5 (35.7)**	**9 (64.3)**	**0.157**	**16.844**	**0.944**

Comparison central-marginal populations

Comparison between central range and peripheric (marginal) populations does not show significant differences between these groups, either for number of alleles (*Na*) or heterezigosity (*He*) (Table 2). But, taking into account demographic size and geographic isolation, higher allelic richness is observed in central populations in comparison to isolated and small stands. However, there are differences within the marginal group, and some peripheric stands are more diverse than central ones. Then, it can be concluded that marginal populations do not constitute a homogeneus group with similar genetic processes. Demographic factors are probably overlapping with geographic variation and with historic events (Jiménez *et al.* 1999).

Table 2. Mean comparison for number of alleles (*Na*) and expected heterozygosity (*He*) for each of

central and marginal groups. *= significant differences at 95% confidence level.

Groups	*Na*	*He*
Central – Marginal	0.0416	-0.005
Central – Unique large stands	0.1071	-0.0039
Central – Unique small stands	0.1071*	0.0118
Central – Several small stands	-0.0238	-0.0084
Unique large stands – Several small stands	-0.1309	0.01575
Unique large stands – Unique small stands	0.0000	-0.0045
Several small stands – Unique small stands	0.1309*	0.0202*

Geographic structuration

F-statistics values (Table 3) show how most of diversity is within populations. Interpopulation differentiation (F_{ST}) is 3%, a low figure typical of forest species. Number of migrants (Nm) is high, indicating an important gene flow that leads to the homogeneity of populations. In consequence, Nei's genetic distances were rather low. The dendrogram, however, makes it possible to identify a geographic structure. Italian populations are clearly separated, being on a different line (Figure 3). Furthermore, southern and western populations appear to be two coherent groups. The structure is distorted by marginal populations, in which drift events randomly modify allelic frequencies.

Table 3. Wright's *F*-statistics (F_{IS}, F_{IT} y F_{ST}) and number of migrants (*Nm*) estimated as $(1-F_{ST})/4F_{ST}$

Locus	F_{IS}	F_{IT}	F_{ST}	*Nm*
Acph-C	0.151	0.174	0.027	8.908
Adh	0.060	0.085	0.026	9.268
Got-B	0.169	0.192	0.028	8.786
Lap-A	0.015	0.033	0.018	13.447
Mdh-A	0.179	0.193	0.017	14.145
6Pgd-A	0.121	0.130	0.011	22.940
6Pgd-B	0.119	0.130	0.013	19.822
Pgi-B	0.047	0.100	0.056	4.254
Skdh	0.019	0.057	0.039	6.201
Mean	**0.053**	**0.085**	**0.033**	**7.331**

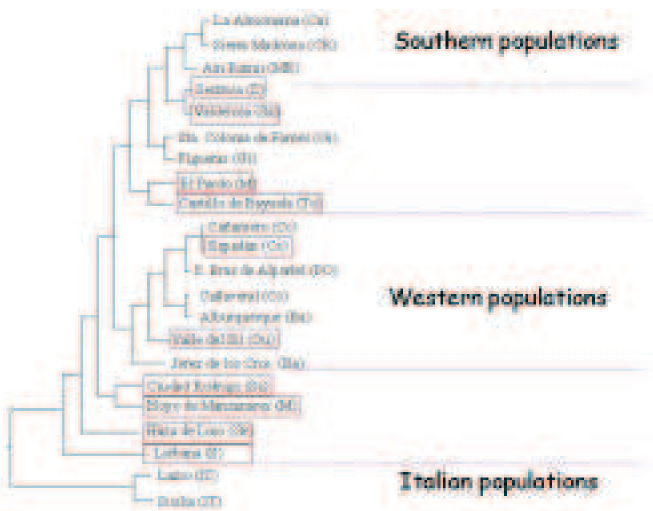


Figure 3. Dendrogram obtained from Nei's genetic distances

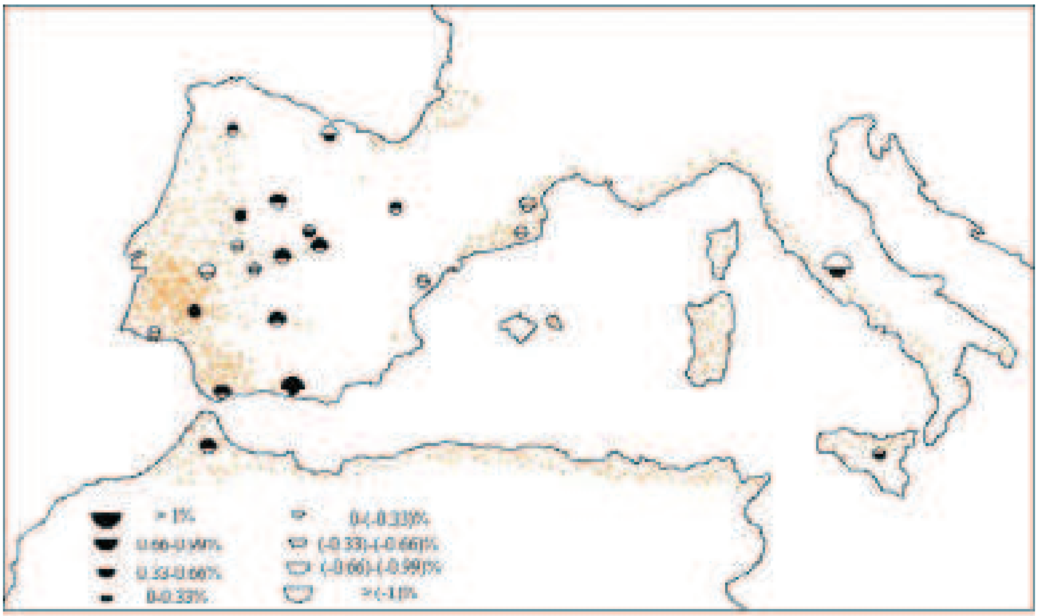


Figure 4. Contribution to total diversity of each population. Semicircle above = diversity component; semicircle below = differentiation component. Positive values are represented in black, negative ones in white

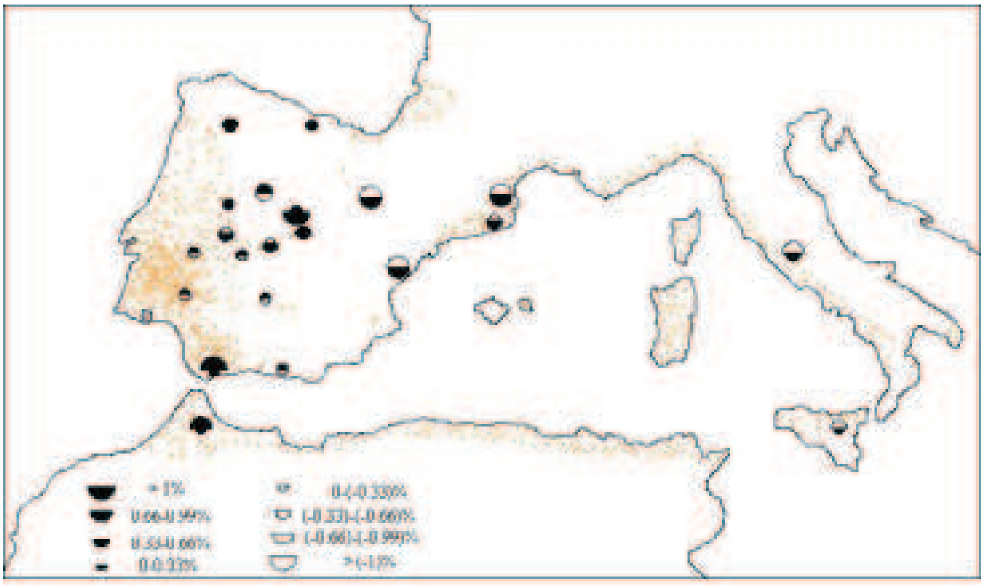


Figure 5. Contribution to total allelic richness of each population. Semicircle above = diversity component; semicircle below = differentiation component. Positive values are represented in black, negative ones in white

Contribution to total diversity of each population

The importance of each population for conservation was estimated as described in Petit *et al.* (1998). Each contribution is calculated for diversity (*He*) and for allelic richness (*Na*) subdivided into two components: contribution due to the diversity of the population itself, and contribution due to its differentiation.

The most diverse populations (South of the range and central Spain) logically have positive contributions to total diversity, but usually they are not differentiated from the rest

(Figure 4). Within marginal populations, both positive and negative contributions are found, but many of them present important differentiation components. This divergence is even more marked in the contribution to allelic richness (Figure 5): some marginal populations have positive values in spite of a reduction in the number of alleles. These populations can be considered, as the most differentiated component of the species, and constitute an important part of its variability.

Implications for conservation

Some conclusions can be drawn from the enzimatic study presented above:

- Genetic structure of cork oak in Spain reveals a strong influence of historic events. Loss of diversity in the north and east of the country is probably related to colonization patterns (founder effects).
- Gene flow and demographic size appear to be determinant factors in the maintenance of gene diversity within populations.
- Marginal populations constitute a relevant element for conservation programmes, since they do not show a generalized reduction of diversity and they have divergent genetic patterns. In this sense, in order to include all the variability of cork oak, marginal areas should be included among the conservation zones together with a number of central populations.
- Since the characteristics of mating systems generate high intrapopulation variability, management of the species should promote natural regeneration as a method to preserve gene diversity.

References

Bellarosa, R., B. Schirone, F. Maggini and S. Fineschi. 1996. Inter and intraspecific variation in three Mediterranean oaks (*Q. cerris, Q. suber, Q. crenata*). *In*: Proceedings of the Workshop on inter- and intraspecific variation in European oaks: Evolutionary Implications and Practical Consequences. 15-16 June 1994, Brussels. Off. Publ. of the European Communities, Luxembourg.

Elena-Rosselló, J.A., R. Lumaret, E. Cabrera, E. and H. Michaud. 1992. Evidence for hybridization between sympatric holm oak and cork-oak in Spain based on diagnostic enzyme markers. Vegetatio. 99-100: 115-118.

Elena-Rossellò, J.A. and E. Cabrera. 1996. Isozyme variation in natural populations of cork.oak (*Quercus suber* L.). Population structure, diversity, differentiation and gene flow. Silvae Genetica. 45:229-235.

Gregorius, H.R. 1978. The concept of genetic diversity and its formal relationship to heterozygosity and genetic distance. Math. Biosciences. 41:253-271.

Jiménez, P., D. Agúndez, R. Alía, R. and L. Gil. 1999. Genetic variation in central and marginal populations of *Quercus suber* L. Silvae Genetica 48 (6): 278-284.

Petit, R.J., A. El Mousadik, and O. Pons. 1998. Identifying populations for conservation on the basis of genetic markers. Conservation Biology 12:844-855.

Toumi, L. and R. Lumaret. 1998. Allozyme variation in cork oak (*Quercus suber* L.): the role of phylogeography and genetic introgression by other Mediterranean oak species and human activities. Theor. Appl. Genet. 97:647-656.

Some remarks on the conservation of genetic resources of Mediterranean oaks

***Bartolomeo Schirone*[1] *and Francesco Spada*[2]**
[1] *Disafri, University of Tuscia, Viterbo, Italy*
[2] *Dept. of Plant Biology, University la Sapienza, Rome, Italy*

Introduction

When dealing with Mediterranean oaks, it is crucial to identify a sufficiently univocal definition of the term "Mediterranean".

A first option is to consider as Mediterranean the evergreen species whose main range is centred in the coastal and subcoastal districts of Southern Europe, Near East and Northern Africa. This assumes that the evergreen habit is a distinctive character of Mediterranean vegetation. Following this approach (cf. Polunin and Huxley, 1974), the evergreen *taxa* among the oaks (and subordinately the semi-evergreen ones) have traditionally been given the *status* of diagnostic elements in the current definition of Mediterranean woody vegetation as a thicket (the "maquis") mainly dominated by evergreen shrubs and small trees displaying a steno-Mediterranean distribution type.

This interpretation is, therefore, based on functional characteristics of the species and on the prevailing physiognomy of the vegetation within the districts where Mediterranean climatic condition are recorded (according to current classifications). Thus, the term "Mediterranean" is given an ecological delimitation.

Other scholars give the term a merely geographical definition. In this sense, temperate forests at medium altitudes on the Mediterranean mountains, as well as grasslands and heaths on summits are also classified as "Mediterranean". From a strictly biogeographical point of view this is consistent with the distribution patterns of the taxa in their floras at a continental scale. The populations of temperate, winter-deciduous oaks which grow in extrazonal and azonal outposts and isolated stands of boreotemperate Eurosiberian vegetation scattered in districts dominated by an ecologically defined Mediterranean (evergreen) zonal vegetation are a typical example. On these sites they are represented by *taxa* at subspecies or ecotype level that have their own taxonomical dignity and ranges, which are geographically "Mediterranean" (cf. *Q. pedunculiflora, Q. dalechampii, Q. virgiliana*).

Based on the above considerations, both deciduous and evergreen species could potentially be included or not in the cluster of "Mediterranean" oaks, depending whether the emphasis is on the ecological delimitation of Mediterranean species and ecosystems or on the biogeographical one.

The weakest point of this argument is the assumption that evergreenness is a distinctive characteristic of Mediterranean vegetation. In all likelihood, this is not completely correct, suggesting that evergreennes *versus* deciduousness are not the critical characteristics to be used in the definition of the Mediterranean oaks. As some examples from the evolutionary history of the taxa will show, Mediterranean adaptations and Mediterranean ranges are not as clearcut attributes as they appear. Phylogeny, distribution and adaptive traits are largely overlapping features.

The evergreen species

Nevertheless, if we were to refer to evergreen oaks only, we ought to consider *Quercus ilex* (including its subspecies *rotundifolia* and other western Mediterranean closely related *taxa*), *Q. suber, Q. coccifera* (including its subspecies *calliprinos*), *Q. aucheri* (assuming it possesses the dignity of species and is not a mere geographical differentiation of *Q. coccifera*) and *Q. alnifolia* as Mediterranean species. To these we should add more common hybrids such *Q. morisii* (*Q. ilex* × *Q. suber*).

In this case, the whole subgenus *Schlerophyllodrys* Schwarz, but also part of the subgenus

Cerris Schwartz (which displays evergreen, semideciduous and deciduous *taxa)* is included into the cluster of the Mediterranean oaks.

Dealing with the subgenus *Schlerophyllodrys* and, in particular, with *Q. ilex*, it is interesting to observe that, according to most authors (Champion *et al.,* 1965; Khan *et al.*, 1977), this species has a very large range, reaching at least the Western Himalayas, where it is represented by a closely related *taxon*, *Q. baloot.* In fact, Shah *et al.* (1996) suggest, on the basis of morphological comparisons and patterns of seed reserve proteins, that this *taxon* is distinct from the European populations of *Q. ilex s.l.*

Nonetheless, it is fact that the "Mediterranean area", i.e. the area isoclimatically delimited according to Daget (1977), does extend exactly as far as Pakistan. As a consequence, we ought to include many Asiatic species with ranges that go far beyond the geographical boundaries of the Mediterranean region into the cluster of Mediterranean oaks. This should not be so controversial if we consider that the reproductive cycle of *Q. baloot,* like the ones of other Himalayan oaks, is similar to the one displayed by *Q. ilex* and *Q. coccifera.* Moreover, the environment in which *Q. baloot* grows, and the functional traits of its associated vegetation are very similar to the ones recorded in the Mediterranean region.

This evidence is also useful to understand the origin of evergreen Mediterranean oaks and the evolutionary history of the genus *Quercus* in the Old World, stressing the non-specificity of the definition "Mediterranean".

This could mean that *Q. ilex s.l.*, or rather its ancestors, descends from an evergreen shrub of tropical mountains, which later adapted to the undergrowth of coniferous forest (see related species in the Himalayas: *Q. semecarpifolia* still grows along a belt close to the timberline). In fact, these forests of *Picea, Abies*, *Cedrus* and *Taxus* are relics of the old forest formations that existed prior to the outburst of the Angiosperms, which were able to survive across the Neogene at the lower latitudes in the areas of the Holoarctis affected by the Alpine orogenetic upheaval. The analogies with the evolutionary history of the present-day species of *Ilex* and especially *Ilex aquifolium* of W-Eurasia are striking. Later on, this subtropical evergreen *taxon,* formerly scattered along the coasts of the Tethys, might have survived in the areas corresponding to the present-day Mediterranean and in Western Himalayas, disappearing in the areas in between as a consequence of the Neogene climatic deterioration (desiccation), changes in the reassessment of land masses (obliteration of the Tethys) and to the subsequent (semi-) desertification in the Middle and Near East. This distribution gap enhanced the genetic drift and is likely to have been larger than it is today during some of the main climatic fluctuations of the Quaternary.

According to this interpretation, the subgenus *Sclerophyllodrys* could have maintained leaf persistence as an atavistic trait (see Scharfetter, 1953). This trait would have survived thanks to the lack of climatic constraints in the coastal and subcoastal districts of the Mediterranean regions (where relatively mild maritime conditions buffer the drought) and in Western Himalayas, where the local patterns of monsoonal climate allow it. In these areas some kind of climatic relaxation is a constant throughout time, and is to be always recorded somewhere in the Mediterranean or in the surrounding regions even during the most extreme glacial maxima (North Africa, Sahara: see Zohary, 1973).

Therefore, *Sclerophyllodrys* is refugial at least in the Mediterranean areas and its evergreennes is probably an adaptation. In this sense, evergreenness can by no means be the diagnostic trait in the definition of the Mediterranean oaks.

The semideciduous species

If we broaden the cluster of Mediterranean oaks to encompass the semi-evergreen ones, the *Q. macrolepis*/*Q. aegilops*/*Q. ithaburensis* species swarm should be included too. These *taxa* all belong to subgenus *Cerris* Schwarz and exhibit a true Mediterranean distribution pattern. Leaf subpersistence is also recorded in *Q. faginea* and *Q. fruticosa* (=*Q. lusitanica*), an Iberian endemite belonging to the subgenus *Quercus* Schwarz (into which the most significant species of the European temperate forests, *Q. robur* and *Q. petraea* are included).

As the Mediterranean climate is sufficiently mild to prevent the evolution of specific adaptations, such as a complete, rapid leaf-fall at the onset of winter, the semi-evergreen *Q. afares, Q. libani and Q. trojana* and the hybrid between *Q. cerris* and *Q. suber* (× *Q. crenata*), can be included in the Mediterranean cluster. That is to say, the whole subgenus *Cerris* gets included, except for *Q. cerris*, which is fully deciduous (on the other hand, populations where juveniles retain some green leaves during the winter have been recorded on the coast of central Italy).

Q. cerris is very common up to medium elevations in peninsular Italy and Greece, and is also found scattered over large areas with sub-continental climate throughout the Balkans (Horvat *et al.*, 1974). In Turkey, it occurs as far inland as the transition zone between the forests and the Anatolian steppe, where its deciduous habit is fully developed and well adapted to the true continental and often semi-desertic conditions of its local range. This reinforces the interpretation of deciduousness as a derived character in the subgenus *Cerris*. It also gives the semideciduous habit of most of its *taxa*, characterised by leaves which, though dry and withered, remain on the tree until the new ones appear at the beginning of spring *(Q. trojana)*, a transitional *status*.

Probably, of all species that differentiated from the primitive *Q. drymeia* (fossil prints of leaves belonging to this species closely resemble those of the subgenus *Cerris*) in the area between the Caucasus and Western Persia during the Pliocene, *Q. cerris* was the one that best exploited its adaptation to drought. Its biennial reproductive cycle is well suited to overcome stress due to winter cold, and allowed the species to migrate northwards (reaching the southern slopes of the Alps). The same route was followed to a lesser degree by *Q. trojana*, which does not occur North of Central Bosnia (cf. Schirone and Spada, 1995). The other species belonging to the subgenus exploited the same fruit maturation strategy and were able to colonise areas of the Mediterranean with a semiarid climate (*Q. libani, Q. macrolepis s.l.*, *Q. afares*), or to reach the much drier territories at the border of Afghanistan (*Q. regia, Q. persica, Q. eherembergii, Q. castaneifolia*). Thus, the expansion of *Q. cerris* toward the western limits of its range (Italy), is probably a recent phenomenon, induced by the glacial cycles, while its present day frequency in stands is largely a product of human impact on the formerly mixed forest of the peninsula. Moreover, *Q. cerris* seems to behave as one of the late successional species in recovering stands of formerly disturbed Mediterranean forests dominated by evergreen *Q. ilex* and *Q. suber*, at least in peninsular Italy. This suggests that, in areas with true Mediterranean climate, a "pure" evergreen community is likely to be a mere consequence of long-lasting human disturbance.

It is worth mentioning that according to Camus (1936-54), on the basis of morphological characteristics, *Q. libani*, *Q. macrolepis s.l.*, *Q. afares*, *Q. regia*, *Q. persica*, *Q. eherembergi*, *Q. castaneifolia*, *Q. trojana* belong to a distinct subsection *Macrolepides*, whereas she includes *Q. cerris* into subsection *Eucerris*. *Q. cerris* should therefore represents the transitional *taxon* to the section *Mesobalanus* of the subgenus *Quercus* Schwarz, which includes many *taxa* with the bulk of their range in the Mediterranean region, such as *Q. pontica*, *Q. infectoria*, *Q. macranthera*, *Q. vulcanica*, *Q. frainetto* and *Q. pyrenaica* (= *Q. toza*). Among these, *Q. pontica*, though extremely interesting from the ecological and conservational point of view, does not fall within the areas with a Mediterranean climate *sensu* Daget (1977), whereas *Q. macranthera* is only partially included in it. *Q. frainetto* is the only well defined species of the group, while, the phylogenetic relationships of the other four with other taxa of the subgenus *Quercus* and in particular with the *Q. robur* species group, are still partially unclear.

The deciduous species

So, what is an operational definition of the Mediterranean oaks for the purpose of the conservation of their genetic resources?

Historically, a first attempt to label Mediterranean oaks was provided by Camus (1936-

54), who argues that both evergreen and deciduous taxa should be considered. She lists all species of the subgenus *Schlerophyllodrys* Schwarz, all species of the subgenus *Cerris* Schwarz including *Q. cerris* (with several infraspecific *taxa*), and a number of species of the subgenus *Quercus* Schwarz. In particular, the latter group included *Q. frainetto* and other earlier quoted *taxa* of the section *Mesobalanus* (*Q. faginea*, *Q. lusitanica*) and especially many infraspecific *taxa* of the large species swarm related to *Q. robur, Q. petraea* and *Q. pubescens* (the *Q. robur* of the Linnean taxonomy: cf. for the flora of Italy, Fiori, 1923).

This list seems to be largely acceptable. But, if we wish to maintain some kind of ecological consistence, which is operationally adequate when using the delimitation of the Mediterranean area proposed by Daget (1977), we must exclude *Q. robur s.s.* and *Q. petraea s.s.* These are species with their main range in Central Europe, growing in areas with a temperate and subcontinental climate. They are represented by a large number of local differentiations in southern Europe, either mere ecotypes or taxa at infraspecific level, be it phenospecies or semispecies, which appear to be ecological or geographical manifestation of a large syngameon.

Among the closely related *taxa*, *Q. pubescens* is representative of the difficulties of clustering Mediterranean oaks, a real borderline case within its own taxonomic group. The species, which was previously considered as a subspecific *taxon* of the Linnean *Q. robur,* is extremely polymorphic and is likely to be genetically very heterogeneous, due to local patterns of genetic flow, local persistence of atavistic characters, local patterns of hybridisation and introgression. The taxonomic legitimacy of most *taxa* listed by the Authors of Mediterranean Floras can be seriously argued. Many endemic species described as endemic in S Europe are likely to be phenospecies or represent individual variations of *Q. pubescens s.l.*

In fact, this species cannot be rigorously defined Mediterranean, as its range extends far beyond the area characterized by Mediterranean climatic conditions. It occurs largely in the most extremely continental territories of Eastern Europe, North and East of the Black Sea, where it represents the arborescent component of the western Eurasian forest steppe (Horvat *et al.,* 1974). The *Q. pubescens* species swarm probably differentiated from a more mesic ancestor within the Arctotertiary oaks, in an environment centred around what is today the transcaucasian steppe. Due to a long lasting condition of continental climate, this region was one of the core-areas for the evolution of xeromorfism during the Neogene. There is evidence suggesting that its colonisation towards the South and the West could be related to the spread of semidesertic or steppic ecosystems over large areas of southern Europe during the glacial peak of the Quaternary. Its biogeographical significance and adaptive history is similar to the one of *Q. cerris*, though it probably evolved in a harsher continental environment. In Italy, *Q. pubescens s.l.* is extremely frequent in the structure of the evergreen or mixed mesothermophilic forest. It is difficult to say whether this is a result of the fragmentation due to human impact (logging, forest grazing, forest fires) which might have favoured *Q. pubescens* (which exhibits a larger ecological amplitude and tolerance for climatic instability than *Q. ilex* and *Q. suber*) or is it the heritage of a former, aboriginal mixed forest structure. In any case, *Q. pubescens* seems to be a constant member in the succession of the Mediterranean forest of S Europe. In many cases, scanty, disturbed woodlands dominated by *Q. pubescens s.l* in Mediterranean Europe (Sibljak sensu Adamovic; see Horvat *et al.,* 1974) basically represent degraded stands of former Mediterranean forests dominated by evergreen oaks.

For these reasons, *Q. virgiliana, Q. amplifolia, Q apennina,* should also be included in the cluster of the Mediterranean oaks, as long as they represent real *taxa* and not mere individual variations along a morphological gradient, or simply synonyms. They represent at least local, not yet properly known denominations for true Mediterranean manifestations of *Q. pubescens s.l.* This would justify the inclusion of *taxa* with taxonomically controversial *status* like *Q. dalechampii, Q. congesta, Q. polycarpa, Q. infectoria* subsp. *boisseri,* etc., as long as their taxonomic relationships with *Q. pubescens s.l.* are confirmed. They should be excluded from the cluster if biosystematic evidence would suggest infraspecific ranking into the geographical differentiation of S European *taxa* of the temperate *Q. petraea* or *Q. robur*.

Conclusions

The list of the Mediterranean oaks should include *Q. ilex*, *Q. coccifera, Q. suber*, *Q. macrolepis*, *Q. trojana*, *Q. libani*, *Q. alnifolia, Q. afares*, *Q. frainetto*, *Q. faginea*, *Q. cerris* and *Q. pubescens s.l.* These appear to be core species, well delimited on a morphological, biological and ecological basis. Other *taxa* (among which *Q. infectoria*, *Q. pyrenaica*, *Q. virgiliana,* etc.) which are to be considered ecological or geographic differentiation of the non-completely Mediterranean *Q. robur*, *Q. petraea* and *Q. pubescens s.l.* group, can be included if their relationships with *Q. pubescens* are proven.

Hybrids like *Q. crenata* (*Q suber* × *Q. cerris*) or *Q. morisii* (*Q.suber* × *Q. ilex*) should be added too.

This model is strictly biogeographical. According to it, deciduous and semideciduous euromediterranean and submediterranean oaks occurring as successional members in forest communities of zonal character in Mediterranean regions are included in the group. Deciduous oaks phylogenetically related to deciduous species with their range centred in central Europe, and therefore mainly associated to the temperate deciduous forest-belt (sensu Zohary 1973), are often recorded in Mediterranean areas. These populations, usually grow on sites where local conditions preserve outposts of temperate broadleaved communities of azonal or extrazonal heterotopic character, and should therefore not been taken into account.

As a consequence of its high economic importance (and of the activities of the EUFORGEN network), data about the patterns of genetic variability in *Q. suber* is becoming available. Some basic studies on the genetic variability of *Q. ilex* and *Q. coccifera* also exist (cf. Yacine and Lumaret, 1989). Information about other *taxa* is still practically nonexistent, except for some data on the interspecific differences between some of the species quoted in Bellarosa *et al.* (1996).

Anyhow, a first important step is to clarify the taxonomic status of species described as being “Mediterranean”.

In this perspective, the subgenus *Cerris*, which appears to be a characteristic *taxon* for Eurasia, is particularly interesting for the reconstruction of the evolutionary history of the whole genus *Quercus* in the Mediterranean region. Italian scientists (cf. Schirone and Spada, 1995; Bellarosa *et al.,* 1996) have been collecting biosystematic and phytogeographical data on species of this subgenus, with the exception of *Q. suber*, for a long time.

However, the patterns of variability within the individual species are still unknown. Even more complex and poorly known is the group of species belonging to the subgenus *Quercus* Schwarz. The main problem here is whether or not the patterns of genetic variability allow the identification of some true species. Ongoing investigations on this topic carried out on populations of the species group *Q. robur/Q. petraea/Q pubescens* in Italy (Spada and Bullini, personal communications), seem to exclude real connections between the *taxa* listed so far in the morpho-taxonomical literature and the continuous clinal variation within this large syngameon. Therefore, *Q. apennina, Q. amplifolia, Q. virgiliana* are probably mere developmental states of the same polymorphic *taxon* (*Q. pubescens s.l.*), site- and nutrient-dependent morphisms with an unpredictable potential for recombination of characters and with no reliable taxonomic stability.

Perhaps ”true”, morphologically distinct species may be recorded only at the outermost limits of the Mediterranean region (Spain, Maghreb), or on Mediterranean islands, where genetic drift has been heavier and long lasting.

Consequently, *in situ* conservation policies may be meaningful only for some of the species (*Q. alnifolia*, *Q. trojana*, *Q. macrolepis* in SE Italy, etc.) and not be a realistic conservational goal for other minor *taxa*. Often, the possibility of preserving the identity of a *taxon* with unclear or shifting taxonomic *status,* restricted to refugial areas and genetically isolated, will depend on the choice of forest management practices that prevent modifications of the surrounding environment. *Ex situ* conservation of these *taxa* outside their natural range, is both difficult and unrealistic.

References

Adamovic, L. 1933. Die Pflanzegeographische Stellung und Gliederung Italiens. Jena.

Bellarosa, R., B. Schirone, F. Maggini and S. Fineschi S. 1996. Inter- and intraspecific variation in three Mediterranean oaks. Proceedings of the workshop "Inter- and intra-specific variation in European oaks: Evolutionary implications and practical consequences". European Commission, Science Research Development, EUR 16717 EN.

Camus A. 1936-54. Les Chenes. Monographie du Genre Quercus. 1, 2, 3. Le Chevalier. Paris.

Champion, H.G., C. H. Seth and G.M. Khattak. 1965. Forest Types of Pakistan. Pakistan Forest Institute. Peshawar.

Daget, Ph. 1977. Le bioclimat Mediterraneen: Caractères génèreaux, modes de caractérisation. Vegetatio, 34:1-20.

Fiori, A. 1923. Flora Italiana. Tipografia Ricci. Firenze.

Horvat, I., V. Glavac and Ellenberg. 1974. Vegetation Sudosteuropas. Stuttgart.

Khan, F.W., P.G. Khan and A.G., Marwat. 1977. Chemical evaluation of *Quercus ilex* and its oil. Pak. J. For. 27:98-100.

Polunin, O., A. Huxley. 1974. Blumen am Mittelmeer. BLV. Munchen.

Scharfetter R. 1953. Biographien von Pflanzensippen. Wien.

Shah, M., B. Schirone and C. Pelosi. 1996. On the affinity between *Quercus baloot* Griffith and *Quercus ilex* L. Natural History Bullettin, 2:1-8.

Schirone, B. and F. Spada F. 1995. Anomalies in reproductive phenology and vegetation history: the case of SE Italy. Colloques Phytosociologiques, XXIV: 847-857.

Yacine, A. and R. Lumaret. 1989. Genetic diversity in Holm oak (*Quercus ilex* L.) insight from several enzyme markers. Silvae Genet. 38:3-4.

Zohary, M. 1973. Geobotanical foundations of the Middle East. 1-2. Stuttgart.

Country reports

Albania

Maxhun Dida
Forest and Pasture Research Institute, Tirana, Albania

Albania is a small, mountainous country with a population of 3.3 million and a surface area of 28 748 km^2. A great variety of microclimates is present in Albania, due to the two contrasting types of predominant climate, the Mediterranean and the central European, with their intervening transitional zone. This, coupled with wide differences in bedrock formation, altitude, and aspect, as well as the varied origin of species, makes for a great diversity in plant communities. A variety of habitats and vegetation types are found within the country, including alpine and subalpine mountain ecosystems, Mediterranean shrubs, grassland and marshland, streams and rivers, lakes and reservoirs, coastal lagoons, sand dunes and psammophilous vegetation, river delta, rocky coastal and marine ecosystems.

Albania has a rich flora, with about 3250 native vascular plant species distributed in 165 families and about 910 genera, i.e. about 30% of the c. 11.600 European species (Paparisto.K.1989)

Main species (brief description of ecology and distribution)

There are 12 oak species in Albania, distributed almost all over the Albanian territory:

Q. ilex L.-Holly Oak, *Quercus coccifera* L.-Kermes Oak, *Q. calliprinos* Webb, *Q. macrolepis* Kotschy-Vallonea, *Q. trojana* Webb-Macedonian Oak, *Quercus robur* L-Common Oak, *Quercus frainetto Ten.*-Hungarian Oak, *Q. cerris* L.-Turkey Oak, *Q. pubescens* Willd-Pubescent Oak, *Q. virgiliana* (Ten.) Ten., *Q. petraea* (Mattuschka) Liebel-Chestnut Oak, *Q. dalechampi* Ten. (Mitrushi 1955, Paparisto 1989)

The structure and distribution of these units or forest formations are briefly presented below.

Formations of *Quercus pubescens*

In the Balkan region, most of these oak forests have been destroyed or degraded into woodlands known as *Shibliak*, as a result of illegal cuttings or overgrazing.

Quercus pubescens forests are well distributed in Albania, generally in the Central and Southern part but as in most of the Balkans, they are rather degraded. In general, this species is associated with other oaks such as *Quercus cerris* L. and Quercus *frainetto* Ten. Other trees typical of these forests are *Carpinus orientalis* Miller, *Ostrya carpinifolia* Scop., *Sorbus domestica* L., *Fraxinus ornus* L., etc., while the understorey is characterized by *Rosa sempervirens* L., *Amelanchier ovalis* Medicus, *Cotinus coggyrgia* Scop., *Spartium junceum* L., *Pistacia lentiscus* L. etc.

Formations of *Quercus frainetto*

Quercus frainetto is the most common oak species in Albania, especially in the districts of Tropoja, Kukes, Peshkopi, Mat, Kruje, Tirana, Librazhd, Skrapar and Permet.

Fitosociological interpretation of these forests is very difficult due to the important changes in their floristic composition. *Quercus frainetto* grows in a fitoclimatic area of mixed deciduous broadleavs communities; it never forms pure oak forests. Characteristic or indicator plant species of the *Quercion frainetto* alliance are: *Quercus frainetto*, *Quercus cerris, Rosa arvensis*, *Carex caryphylllea*, *Silene viridiflora*, *Galium mollugo*, *Symphytum bulbosum* etc. (Mitrushi 1955).

Formations of *Quercus cerris*

In Albania, *Quercus cerris* has a plastic ecology and is distributed from 100 to 1200 m above sea level, between the Cemi Stream in the northern part and the Vjosa River in the southern part of Albania, forming pure or mixed forests with *Quercus petraea* (Matt.) Liebl., *Quercus frainetto* Ten., *Sorbus torminalis* (L.) Crantz, *Carpinus betulus* L., etc. (Vangjeli 1989).

Formations of *Quercus trojana*

Quercus trojana in Albania is more common in the Mediterranean regions, up to 800 m above sea level, such as in the Rrenc Mountains and in the Kashnjet, Librazhd, Gjirokaster, Korça and Erseka districts. *Quercus trojana* is found mixed with *Q. pubescens, Q. cerris, Carpinus orientalis*, *Fraxinus ornus* etc. The more common species in the understorey are *Coronilla emerus, Colutea arborescens, Pistacia terebinthus, Pyracantha coccinea, Juniperus oxycedrus* etc. The herbaceous layer is dominated by *Alyssum murale, Silene italica, Geranium sanguineum, Cistus incanus*, *Satureja juliana*, *Helianthemum numularium* etc. (Vangjeli 1989)

Formations with *Quercus petraea*

Quercus petraea forests are distributed all over Albania, but occur more often in Northern and Central Albania. In general they are found in upper oak zone forming small forests along cool valleys, on northern exposures and in the submontane beech zone, on eastern and southern exposures, 550-800 m above sea level. (Mitrushi 1955)

Formations of *Quercus ilex*

In Albania, especially in northern part, the area of *Quercus ilex* is very fragmented and no significant stands are found, except in some small isolated areas such as Ksamil, Karaburun and Shushica Valley.

The shrub layer is characterized by *Pistacia lentiscus* L., *Buxus sempervirens* L., *Rhamnus alaternus* L., *Arbutus unedo* L., *Philirea latifolia* L., *Erica arborea* L. etc. The herbaceous layer includes *Euphorbia caracias* L., *Viola alba* Besser, *Rubia peregrina* L., *Asparagus acutifolius* L. etc.

In the past, this oak species was widely distributed in the Mediterranean belt. Today it is very rare because of overcutting and is classified as an endangered species (Red book, 1999). It is important, therefore, to include this species in protected areas and approve measures for the development and protection of this species.

Formations of *Quercus macrolepis*

Quercus macrolepis Kotschy in Albania forms important forests, up to 800-900 m above sea level, mainly in Southern Albania, between Konispol and Vlora Bay. It is found in pure or mixed forests.

These forest formations colonise deep alluvial soils, with humid and warm microclimate. Generally the understorey belongs to the *Quercion ilics* and *Oleo-Ceratonion* alliances. The phytosociological classification of *Quercus macrolepis* forests is rather difficult as a result of changes of the natural vegetation structure that, in many cases, is heavily degraded, i.e. toward the formations of *Phlomis fruticosa.* The vegetation of *Quercus macrolepis* forests is generally quite sparse, with wide clearings.

Formations with *Quercus robur*

Quercus robur in Albania does not play an important role compared with other European countries and especially with those of Central Europe. In fact, this species is mostly found in areas with mild climate and in alluvial or deep soils, which corresponds with the area of the *Alno-Quercion roboris* alliance. As a result of reclamation and of other agricultural interventions, *Quercus robur* is endangered almost to exctintion (Red book). The damage or alteration of vegetation structure is so heavy, that only scattered trees remain as an attestation of former existence of forests in this very interesting zone of Albania.

According to type of substrate it is possible to distinguish two different types of vegetation that are included in the *Aceretosum tatarici* Raus 1971 and *Caricetosum remotae* Horv. 1938 subassociations.

Due to the extremely endangered status of this forest type, it is very important to create the conditions for its regeneration in the future, with the objective of creating a *Quercus robur* dominated forest, which is the most valuable forest of these environments (Red book, 1999).

Economic and social importance

Oak forests represent an important natural forest fund in Albania not only for the fact that they occupy a large surface, 336.800 ha i.e. 31% of all forestry surface, (IKPK, 1999) but also because they represent an important source of timber, 19% of the total. Oak forests are also valued for the high nutritive value of leaves and acorns for cattle, especially during the winter.

The multiple uses of oak forests and the deforestation for new agriculture lands have caused their massive degradation, the reduction of biodiversity and the appearance of soil erosion.

Oak forests in Albania are managed in two ways: high forests and coppice, but there are some oak areas under mixed management. In general about 74% of oak forests are coppice and 26% high forests (IKPK, 1999).

*Conservation (*in situ*, *ex situ* measures) and use*

During the last 40 years, about 300 000 ha of oak forests have been cleared for agricultural land. Natural alpine pastures have been damaged for planting patatoes and in the chestnut zone oak species were cleared and replaced by forage for sheep. On the other hand, during the last 3 years farmers refused about 60 000 ha of cleared forest land because of low agricultural productivity (Dida 1996).

The abandonment of lands has a lot ecological consequences such as soil erosion, loss of plant and animal biodiversity and damage to landscape in mountain and tourist areas.

Exploitation and overgrazing without clear technical criteria has decreased the productivity of oak forests to 1.2 m^3/ha/year. In these conditions it is important to study these degradation processes, identify means for rehabilitation and for better use of the ecological potential of these habitats. So far there has been no conservation programme for oaks in Albania, but at least two species (*Q. ilex,* and *Q. suber)* need conservation and rehabilitation projects.

Inventories

Three forest resources inventories were carried out in Albania in 1953, 1968 and 1985.

Table 1 below shows figures for forest cover in general and for oaks in particular.

Table 1. Summary results of forest inventories (IKPK, 1953,1968,1985,)

Year	Forests		Oaks	
	Ha	%	Ha	%
1953	1 328 000	100	408 051	30.7
1968	1 009 550	100	366 690	36.3
1985	1 045 540	100	332 630	31.8
1999	1 027 710	100	324 380	31.5

Legislation

In Albania, all forest species are managed according to the Forest Law of 1992. However, the Forest and Pasture Strategy indicates that about 40% of Albanian forests should be transferred to local communities. Oaks cover about 80% of these areas.

Research

High forests are generally less damaged, due to their distance from urban area, while coppices are more damaged as a result of overharvesting and overgrazing. In the past, oak forests were simply mined for timber, and cut irrationally, without any consideration for regeneration. Currently their rehabilitation is being studied, through the study of climatic, soil and geographic factors, which will be closely linked to the identification of the silviculture measures to be undertaken

References

Balla, R. and S. Karadumi. 1989. Pyllezimet.

Camus, A. 1934. Les Chênes. Monographie du genre Quercus. 1. 1936-38.

Dida, M. 1996. Abandoned lands and conservation strategies for their rehabilitation. Soil Resources in Albania. Kamza.

Dida, M. 1999. Dushqet (brochure).

Dubrovev, I. 1991. Limites de la conversion des taillis sous sutaible en futaie et ses unités. Rev.For.Fr.nr.2.

Horvat, I., Glavac V. and H. Ellenberg. 1974. Vegetation Sudeuropas, Fisher Verlag. 1-768.

IKPK. 1989. Planet e mbareshtrimit te ekonomive pyjore, Shkalle, Gorice, Fan, Tregtan.

IKPK. 1999. Fondi Pyjor.

IKPK. 1953,1968,1985. Inventari I Pyjeve.

Mitrushi, I. 1955. Druret dhe Shkurret e Shqiperise.

Paparisto, K. *et al.* 1989. Flora e Shqiperise, vol. 1.

Pellecuer, B. 1976. L'écologie des chênes en forêt de morimond et ses applications silvicoles.

Oswald, N. 1981. Résultats principales des places d'éxperience de chêne du centre national de récherches forestiérès. Rv.For.Fr.n.spp.

Pite A. 1984. Trajtimi i pyjeve te lisit ne vendin tone. Ekonomia pyjore.

Red book, Threatened and rare plants species of Albania. 1995. Tirana. Academy of Science.

Vangjeli, J. 1988. Te dhena biosistematike mbi speciet gjetherenese te gjinise *Quercus* L. ne Shqiperi. BSHN, 2.

Vangjeli, J. 1988. Te dhena gjeobotanike mbi dushqet gjembore (*Quercus coccifera* grup) ne Shqiperi. Bul. IKB, 6.

Bulgaria

Alexander H. Alexandrov, Konstantin Genov, Emil Popov
Forest Research Institute, Sofia, Bulgaria

Main species

Mediterranean oaks in Bulgaria include, in order of economic and social importance, Adriatic oak (*Quercus cerris* L.), Italian oak (*Quercus frainetto* Ten.), pubescent oak (*Quercus pubescens* Willd.), kermes oak (*Quercus coccifera* L.) and cork oak (*Quercus suber* L.), which is an introduced species. As far as conservation of their genetic resources is concerned, *Quercus frainetto* Ten. and *Quercus suber* L. have high priority, *Quercus pubescens* Willd. and *Quercus coccifera* L. have medium priority and *Quercus cerris* L. has low priority.

Ecology, distribution, inventories and conservation

Adriatic oak (Quercus cerris L.)

The stands of Adriatic oak are irregularly distributed in the different forest vegetation regions. They are best represented in the Moesian and meet rarely in the Southern Border Region.

In the Moesian Region, Adriatic oak forests amount to 152 426 ha, which represents 59% of their total area. 90 304 ha are situated in the plain-hilly and hilly-piedmont belts and 62 122 ha are found in the mid-mountain one. These soils are mainly alkaline, which is a prerequisite for the formation of xerophilic vegetation and xerophilic oak formations dominated by *Quercus cerris* L. (Marinov *et al.* 1995).

In the Thracian forest region, forests of Adriatic oak cover 90 700 ha, or 35.1% of the total area of *Quercus cerris* L., and in the Southern Border one they are 15 276 ha, or 5.9%. In both vegetation regions, the presence of Adriatic oak in the midmountain belt is rare. This is the result of afforestation activities and of the rehabilitation of oak stands including their replacement with Austrian pine.

Research on the current situation of the areas covered by this species show that coppice stands for conversion and for transformation represent respectively 34.9% and 29.1% of the total. A rather large percentage, 20.8%, of Adriatic oak forests is designated for rehabilitation. Low-stemmed Adriatic oak stands are 3.2% and high-stemmed ones 12%. Having in mind that oppice stands designated for conversion and transformation are potentially high-stem ones, they are included in the present high-quality class and are managed as such, so we can say that the condition of the Adriatic oak forests in Bulgaria is very good.

The inventory characteristics of the Adriatic oak seed stands and protected areas are shown in tables 1, 2 and 3.

Table 1. Inventory characteristics of 145 Adriatic oak (*Quercus cerris* L.) seed stands

	Altitude (m)	**Area** (ha)	**Age (years)**	**Stem height (m)**	**Stem diameter (cm)**	**Growing stock (m^3)**	**Grade (I-a … V-a)**
Average	324	14.8	79	19.8	26.5	1 649.2	2.6
Minimum	100	2.0	40	12.0	12.0	40.0	5
Maximum	900	54.7	170	29.0	50.0	9 620.0	1
Total	-	2 143.2	-	-	-	237 480.0	-

Table 2. Inventory characteristics of 16 reserves containing Adriatic oak (*Quercus cerris* L.)

Name of Reserve	**Altitude (m)**	**Area (ha)**	**Age (years)**	**Stem height (m)**	**Stem diameter (cm)**	**Growing stock (m3)**	**Grade (I-a..V-a)**
Beli Lom	227	416.3	44	16.5	19.0	32 040	1.9
Boukaka	454	62.6	94	23.5	25.0	250	2.0
Gabra	983	89.6	110	17.1	29.5	400	4.5
Kirov dol	170	97.6	151	24.9	45.0	1 160	4.0
Lopoushna	167	1 188.0	116	18.6	30.1	7 150	4.2
Orlitsa	755	117.8	114	12.8	22.5	290	5.0
Patleina	152	16.9	55	10.0	14.0	50	5.0
Ropotamo	54	727.3	84	16.3	25.3	6 445	4.4
Silkossia	210	117.1	82	16.3	22.0	380	4.0
Sredoka	231	331.6	103	16.6	25.4	1 990	4.6
Tissovitca	202	334.4	71	14.4	16.0	1 150	3.8
Uchilishna gora	584	135.1	56	15.4	19.5	1 095	3.5
Vâlci prohod	332	43.1	122	20.9	29.0	650	4.0
Vârbov dol	466	38.8	105	21.6	34.0	430	4.0
Vitanovo	458	295.9	105	18.4	27.5	2 885	3.8
Vodnite lilii	100	2.9	55	15.0	14.0	40	3.0
Average	237	49.6	93	17.2	25.5	694	3.8
TOTAL	-	**4 015**	-	-	-	**56 215**	-

Tabl.3. Inventory characteristics of 12 national and nature parks containing Adriatic oak (*Quercus cerris* L.)

Name of Park	Altitude (m)	Area (ha)
Central Balkan	1264	51 206.9
Dâbovetè	265	468.1
Etâra	733	476.4
Pirin	1 939	30 133.9
Rila	1 687	55 533.1
Roussenski Lom	158	2 325.7
Shoumensko plato	414	3 876.0
Sinité kamâni	667	7 094.7
Strandza	219	78 400.2
Vitosha	1 058	23 851.9
Vrachanski Balkan	704	19 660.8
Zlatni pyasâtsi	170	1 320.7
Average	773	22 862.4
Total	-	**274 348.4**

Pubescent oak (*Quercus pubescens* Willd.)

This oak has a comparatively wide distribution in Bulgaria. Stands are concentrated mainly on the southern slopes of the hills and the mountains, up to about 1 000 m altitude. The largest area of this species is found in Central South Bulgaria were most of the stands with participation of *Quercus pubescens* Willd. are heavily thinned and often do not form canopy. This species is very light demanding, does not tolerate shading and fruit bearing is rare, with an average period of 5-7 years. The acorns germinate quickly but are sensitive to extreme meteorological conditions. Thus, reproduction is generally unsatisfactory. It usually occupies poor, eroded and steep sites which, according to the forest management plans, are intended for rehabilitation, i.e. for changing the tree composition with more productive species. In recent years, however, the national forest policy has changed and these stands have been left to self-restoration.

Tables 4, 5 and 6 include the inventory characteristics of pubescent oak seed stands, forest reserves and nature parks.

Table 4. Inventory characteristics of 4 pubescent oak (*Quercus pubescens* Willd.) seed stands

	Altitude (m)	Area (ha)	Age (years)	Stem height (m)	Stem diameter (cm)	Growing stock (m^3)	Grade I-a…V-a
Average	277	10.2	102	10.6	14.3	-	3.7
Minimum	120	1.6	40	6.0	10.0	-	2.0
Maximum	200	16.4	140	15.5	18.0	60	5.0
Total	-	**40.8**	-	-	-	**100**	-

Table 5. Inventory characteristics of 8 reserves containing Pubescent oak (Quercus pubescens Willd.)

Name of Reserve	Altitude (m)	Area (ha)	Age (years)	Stem height (m)	Stem diameter (cm)	Growing stock (m^3)	Grade (I-a.V-a)
Ali botush	1 230	71.0	40	5.0	6.0	30	5.0
Tisata	441	559.2	60	5.5	11.0	6 715	5.0
Ropotamo	48	229.5	67	7.3	14.3	245	5.0
Baltata	50	27.0	56	6.7	13.1	10	5.0
Gabra	984	29.0	30	8.0	10.0	20	3.0
Ostritsa	991	106.9	38	6.1	11.0	355	5.0
Boraka	350	11.1	40	4.5	8.0	70	5.0
Patlejna	152	16.9	55	10.0	14.0	110	5.0
Total	-	**1 050.6**	-	-	**11.4**	**7 555**	-
Average	**464**	**131.3**	**57**	**6.1**	**12.3**	**7.2**	**4.9**

Table 6. Inventory characteristics of 4 national and nature parks containing Pubescent oak (*Quercus pubescens* Willd.)

Name of Park	Altitude (m)	Area (ha)
Roussenski Lom	158	2 326.0
Shoumensko Plato	414	3 876.0
Zlatni Pyasâtsi	170	1 321.0
Sinité kamâni	667	7 095.0
Total	-	**14 617.0**
Average	**474**	**3 654.0**

Italian oak (*Quercus frainetto* Ten.)

Italian oak is frequently encountered in the plain, hilly and piedmont forests of Bulgaria. The soils on which Italian oak forests grow are shallow to mid-depth, sometimes stony and submitted to surface erosion. Mixed forest of Adriatic and Italian oak are widely spread. In the past, *Quercus frainetto* Ten. occupied an even greater distribution range in the plain regions of the country. The strong anthropogenic pressure on the plain forests has caused a decrease in their area and stunted their growth. This pressure was most intense and continuous in the regions with more fertile soils and more developed agriculture. During the 1950s part of the forests in the plain regions were cleared and transformed into arable lands. However, small forests, groups or even single trees of Italian oak, including century-old ones, remained in some of these regions.

Data for Italian oak seed stands and protected areas are given in tables 7, 8 and 9.

Table 7. Inventory characteristics of 348 Italian oak (*Quercus frainetto* Ten.) seed stands

	Altitude (m)	Area (ha)	Age (years)	Stem height (m)	Stem diameter (cm)	Growing stock (m^3)	Grade (I-a..V-a)
Average	240	12.7	112	20.8	29.4	1 773	3.7
Minimum	50	2.0	40	6.0	10.0	50	5.0
Maximum	850	43.8	180	29.0	48.0	6 000	1.0
Total	-	4 432.8	-	-	-	453 010	-

Table 8. Inventory characteristics of 19 reserves containing Italian oak (*Quercus frainetto* Ten.)

Name of Reserve	Altitude (m)	Area (ha)	Age (yrs)	Stem height (m)	Stem diameter (cm)	Growing stock (m^3)	Grade (I-aV-a)
Beli Lom	220	266.0	45	15.0	16.5	4 600	2.7
Borovets	362	36.0	45	10.0	12.0	80	4.0
Gabra	982	89.6	71	14.0	20.8	60	3.7
Izgoryaloto gyuné	413	31.7	40	6.4	6.9	455	5.0
Kalfata	466	38.8	105	21.8	35.0	730	4.0
Kirov Dol	246	53.5	165	26.6	43.1	3 920	4.0
Kresna	461	60.1	60	6.0	6.0	50	5.0
Lopoushna	184	2 572.8	116	18.0	29.3	60 165	4.3
Ropotamo	47	862.9	72	13.3	20.3	35 710	4.4
Silkossya	196	396.5	104	17.2	25.5	5 215	4.1
Sokolata	731	211.5	168	17.7	32.2	20 650	5.0
Sredoka	278	584.6	85	14.9	21.8	12 420	4.3
Tissovitsa	204	720.9	84	18.2	21.3	23 585	3.4
Uchilishtna Gora	584	135.1	60	15.1	17.5	4 450	3.5
Vâlchi Dol	444	615.8	36	5.9	7.7	6 555	4.9
Vâlchi Prohod	332	43.1	118	20.5	29.0	2 270	4.0
Vârbov Dol	332	68.5	140	19.0	30.0	7 190	5.0
Vitanovo	449	181.6	110	18.4	30.4	4 855	4.3
Vodnite lilii	100	2.9	55	15.0	14.0	300	3.0
Total	-	**6 971.9**	-	-	-	**193 260**	-
Average	**252**	**366.9**	**93**	**15.8**	**23.6**	-	**4.2**

Table 9. Inventory characteristics of 2 national and 6 nature parks containing Italian oak (*Quercus frainetto* Ten.)

Name of Park	Altitude (m)	Area (ha)
Central Balkan	1251	26 299.5
Rila	1 819	36 985.3
Roussenski Lom	158	2 325.7
Sinité Kamâni	667	7 094.7
Strandja	241	78 400.2
Vitosha	1 058	23 851.9
Vrachanski Balkan	711	19 660.8
Zlatni Pyasâtsi	170	1 320.7
Total	-	**195 938.8**
Average	**835**	**9 330.4**

Kermes oak (*Quercus coccifera* L.)

The total area of stands with different participation of kermes oak is 152.4 ha. The largest one is in the State Forest of Tsaparevo, with 95.3 ha and 36.9 ha of total and partial area respectively (table 10).

The mixed stands in which this species is found are scrub forests formed by xerotherm deciduous and evergreen species with the dominance of *Carpinus orientalis* Mill., *Quercus pubescens* Willd., *Fraxinus ornus* L., *Juniperus oxycedrus* L., *Paliurus aculeatus* L. and *Rosa canina* L., and as secondary elements *Quercus frainetto* Ten., *Pistacia terebinthus* L., *Corylus avellana* L., *Crataegus monogyna* Jacq., etc. In general, 8 woody, 9 bushy and 77 herbaceous plants are found in these stands (Velchev and Vassilev 1982). The populations of *Quercus coccifera* L. are mostly situated on steep and very steep terrain with southern exposure. The soils are mostly stony, poor and deeply degraded, with continuous grazing that leads to strong erosion and to the xerothermic character of the stands.

In the near past, and even today some stands with *Quercus coccifera* L. are intensively grazed and cut without control. These factors, as well as the slow growth of the species, determine the bushy aspect of its stands. However, the presence of small-sized populations, groups and single specimens 7-8 m high and diameter of 30-40 cm show that the scrub form of *Quercus coccifera* L. is a result of anthropogenic activity.

The dense and impenetrable communities that kermes oak forms are managed to reduce erosion processes in sparse xerophyte scrub forests, mainly on steep, often inappropriate sunny and dry spots.

The density of the stands with participation of *Quercus coccifera* L. is usually low. In 69% of them it is 0.2-0.4 and rehabilitation is planned. On these sites it is hard to form more resistant and productive stands, so that plantation of Austrian pine is inappropriate. The rehabilitation of these autochthonous stands will cause reduction of the genetic potential of *Quercus coccifera* L. in its most northern occurences and therefore it is necessary to declare some of them protected areas. *Quercus coccifera* L. has not yet been included in afforestation programs and genetic investigations have not been carried out. However, some measures have been taken in connection with seed stand development and definition of population structure.

Table 10. Forest Inventory data of *Quercus coccifera* L. stands

State Forestry	Area (ha)	Reduced Area (ha)	Age	Altitude (m)	H (m)	$D_{1.3}$ (cm)	Vol. (m^3)	Density	Slope (degrees)
Kresna	6.8	1.36	25	250	2.5	6.0	-	0.7	27.0
Tsaparevo	95.3	36.96	29	215	2.9	4.5	22.5	0.47	29.0
Katuntsy	50.3	24.63	51	430	1.7	6.0	-	0.3	30.0

Cork oak (*Quercus suber* L.)

The evergreen cork oak, *Quercus suber* L., is cultivated in the southern regions of the country, including the south coast of the Black sea. This species is not found on the territory of Bulgaria as paleontologic material, therefore it is likely that the area of cork oak in the Pliocene corresponded to the current distribution.

The introduction of the cork oak in Bulgaria started in 1954 and so far 1 500 ha of experimental, experimental-productive and productive plantations have been created, located on the territories of State Forestries as follows: Blagoevgrad, Simitly, Kresna, Tsaparevo, Sandansky, Petrich, Parvomay, Katuntsy and Gotse Delchev as a part of Regional Forestry Board of Blagoevgrad; Kardjaly, Momchilgrad, Krumovgrad, Ivailovgrad, Svilengrad, Harmanly and Haskovo as a part of Regional Forestry Board of Kardjaly; Nessebar, Burgas, Aitos, Tsarevo and Grudovo as a part of Regional Forestry Board of Burgas.

The forest plantations created with introduced cork oak, including the oldest ones, survived low temperatures between -18°C and -20°C, and some of them an absolute minimum of -27,5°C without significant damage. Plantations over 15 years old already produce acorns and in some areas natural regeneration is also observed. This is an indicator for naturalisation of *Quercus suber* L. under certain conditions in the most southern parts of the country.

Observations on male and female reproductive organs morphogenesis, biology of bearing fruits, phenologic diversity and opportunities for genetic exchange between simple phenoforms and growing up particularities of the varieties are carried out in the seed production stand of Dervishitsa (Genov, 1985, 1998).

In general, the phytosanitary condition of *Quercus coccifera* L. and *Quercus suber* L. is very good. Pest damage on leaves is insignificant, but in some years *Balaninus* and *Carpocapsa* sattack the acorns causing a significant crop decrease.

Research as shown that in Bulgaria climatic conditions are suitable for the creation of a few thousands hectares of cork oak production plantations, and the Struma valley is one of the most suitable areas for this purpose. In the State Forestry area of Parvomay alone there are 238 ha plantations of this species.

The existing cork oak plantations are insufficient to create an effective economic activity. In fact, the climatic conditions in the southern areas of the country would provide opportunities not only to satisfy the regional needs of cork, but also to export this product. The 45-year-old plantations studied are a confirmation of the acclimatisation of the species and of its potential for use in afforestation.

However, it should not be forgotten that industrial growing of *Quercus suber* L. has a strong scientific basis and suitable methods should be followed for the creation of plantations and for their cultivation and management, including the production of planting material and pruning of stems and branches for the production of cork (Petrov, 1994).

In other countries of the Balkans such as Turkey, Greece, Yugoslavia and Albania, the introduction of *Quercus suber* L. is just beginning, and reproductive materials from Bulgaria has been made available to the relevant institutions in Greece and Macedonia, FYR.

Outlook

The genetic resources of *Quercus cerris* L., *Quercus frainetto* Ten., *Quercus pubescens* Willd., *Quercus coccifera* L. and *Quercus suber* L. in Bulgaria are being studied through a project called: "Biological diversity, genetic and physiological investigations on the forest tree species" carried out by the Forest Research Institute, Sofia.

The participation of Bulgaria in the EUFORGEN activities on Mediterranean oaks will contribute to research and conservation of the Mediterranean vegetation in the Balkans, and to the exchange of reproductive material with other countries from southern Europe and North Africa.

References

Genov, K. 1985. Morphogenesis and Biology of Bearing Fruits of Cork Oak (*Q. suber* L.) in Bulgaria. PhD Thesis (in Bulgarian).

Genov, K. 1997. Comparative Studies of the Growth in Diameter of Oak Trees of Annual and Biannual Cycles of the Formation and Ripping of Cork Oak Acorns, Forest Science, v. 1-2.

Marinov, M., K. Kostadinov, G. Popov, V. Stiptsov, Ch. Bojinov, D. Denev and S. Horozov. 1995. The oak forests in Bulgaria. Zemizdat. Sofia. (in Bulgarian)

Petrov, M. 1994. Cork Oak and its Growing up in Bulgaria. “Marin Drinov” Academic Publishers, Sofia (in Bulgarian).

Velchev, B. and P. Vassilev. 1982. *Quercus coccifera* L. in Bulgaria and its Protection. National Theoretic Conference on Protection and Reproduction of the Environment. 1 - 5 November 1982, Sunny Beach, v. 1 (in Bulgarian).

Cyprus

Christou K. Andreas
Research Section-Forestry Department, Ministry of Agriculture, Natural Resources and Environment, Cyprus

Indroduction

The genus *Quercus* includes about 450 species distributed in Europe, North Africa, temperate and sub-tropical Asia, North America and Western South America. Many of the species provide valuable timber and also bark and galls used for tanning hides (Meikle 1985)

In Cyprus there are three species belonging to the genus *Quercus*. Two of them are evergreen shrubs, *Quercus alnifolia* that is endemic and *Quercus coccifera* ssp. *calliprinos*. The other is *Quercus infectoria* ssp. *veneris*, which is a tree with very narrow distribution in Cyprus (see Map 1) but with a wider one in Turkey, Syria and Palestine then east to Iraq and S.W. Iran (Zohary 1973, Meikle 1985). The importance of the three species is mainly ecological although, in the past, the above species were very important from the economic and social point of view.

Ecology and distribution

Quercus infectoria ssp. *veneris* (Cyprus Oak) is a deciduous, semi-evergreen tree found in mountain valleys on igneous formations and in low land areas preferably on calcareous formations. The woodlands occur in habitats characterized by dry and subhumid conditions (rainfall ranging form 400mm to 900mm). It grows at altitudes ranging from sea level to 1400m and seems to perform better along gullies and streams where moisture and deep soil are available (Meikle 1985). From the phytosociological point of view, the *Quercus infectoria* woods of Cyprus have been attributed to a distinct association, namely *Anagyro foetidae – Quercetum infectoriae* (Barbero and Quezel 1979). It associates with a number of members of mediterranean maquis such as *Anagyris foetida*, *Styrax officinalis*, *Quercus coccifera* subsp. *calliprinos*, *Crataegus azarolus*, *Pinus brutia*, *Pistacia terebinthus*, *Pistacia lentiscus*, *Arbutus andrachne, Calycotome vilosa, Cistus creticus* and *Ptilostemon chamaepeule* var. *cypria.*

Cyprus oak is confined to the Troodos mountain range and mainly to the western part of the island (see Map 1). It is found either as isolated trees or rarely as small groups in cultivated fields and is distributed in an area of about 127 km^2 (Pantelas 1998). A rough estimation of the number of trees shows that only few hundred thousand stems exist. Occasionally, it is found in the forest of *Pinus brutia*, but never forms pure forest. Most of the woodlands of Cyprus oak are found in private land and only few of them belong to the State.

The small groups and isolated scattered trees of Cyprus oak represent remnants or relicts of older and more extensively distributed forests in Cyprus (Jones *et al.* 1958). This opinion is supported by the fact that isolated individuals are found on field margins, as well as within the cultivated fields themselves. Human impact and unsuitable management practices seem to be the destructive factors, since the deep soils, where it grows, have been used for agricultural purposes already for several centuries. According to Schoener (1987), highly fragmented populations are vulnerable to extinction and losses of genetic variation and it seems that, since the populations are characterized by fragmented distribution, small sizes, and declining numbers, Cyprus oak is under threat.

Economic, social and ecological importance

The utilization of *Quercus infectoria* ssp. *veneris* woodlands for economic purposes is not included in the present management programme despite its wood, which is hard and durable. This is due to the restriction of the species in small areas and the long period demanded for marketable timber production. In fact, the woodlands have been abandoned and there is no great concern by the owners. However, in the past, the species was of great importance to farmers (Chapman 1967) since it was one of the few multiple use trees available (production of acorns used in animal husbandry, production of fuel wood for both heating and cooking, production of dyes, etc).

Nowadays, the importance of *Quercus infectoria* is mainly ecological, while the economic one has declined. In fact, it is one of the few broadleaved forest trees growing in the extensive conifer forests of Cyprus, enriching the biodiversity of the forest and producing food for wild animals. It is considered one of the tree species enriching the landscape reaching majestic proportions among cultivated lands and offering variety of colors throughout the year. According to Mosseler (1992), the loss of a tree species threatens ecological stability and future economic potentiality in areas of limited biodiversity, something that is very apparent in the agricultural lands of Cyprus.

Conservation and use

The importance of genetic variation for the stability of the ecosystem is obvious, since it is strongly connected with the adaptability of populations (Allendorf and Leary 1986) while maintenance of genetic variation is considered essential for the long-term survival of a species (Frankel and Soulé 1981).

Cyprus oak has high ecological and aesthetical value for Cyprus, but is currently under threat by factors such as drought, fire, diseases and unsuitable management practices. Especially, the repeated low rainfall years of the last decade have put the species under an increased stress threatening its survival in the island.

The conservation and sustainable use of *Quercus infectoria* ssp. *veneris* is an important step to stop the degradation and depletion of its genetic resources and even the extinction of the species from the island. Measures for the conservation and use of the species have been developed only during the last years. They include both *in situ* and *ex situ* methods though in some cases they are insufficient and some additional measures should be taken.

In situ measures include the following:

- Protection of natural habitats against fire by establishing a better system of detecting and fighting fire.
- Introduction of a forest law that regulates cutting of Cyprus oak. Cutting is only possible after the permission given by the Director of the Cyprus Forestry Department.
- Declaration as nature monuments of a number of trees with impressive shape and majestic dimensions by the Cyprus Forestry Department.
- Development of a tree surgery programme. During the last years, many oak trees throughout Cyprus have been included in the programme for nature monuments conservation (Papachristophorou 1993).
- Proposal to include certain habitats of *Quercus infectoria* ssp. *veneris* in the Special Areas of Conservation (Directive 92/43/EEC – Life Third Countries Project, LIFETCY98/CY/172). The implementation of the project will contribute enormously to *in situ* conservation.

Ex situ measures only include the production of seedlings in forest nurseries, which are used for small-scale plantings in riverine forests and parks.

Another measure contributing to the conservation of Cyprus oak is education in forestry and other environmental matters. This programme is undertaken by governmental organizations and NGOs and aims at raising public interest and awareness. Finally, the gradual decline of the traditional animal husbandry (uncontrolled free grazing) in rangelands seems to contribute to the protection of the species.

Need for additional measures

The conservation and use of *Quercus infectoria* ssp. *veneris* genetic resources can be improved through a number of additional measures, which should include:

- A more detailed mapping of the natural distribution of the species to examine ownership, growing stock and regeneration dynamics.
- Research on the genetic variation and ecological demand of the species. It is necessary to assess the variation of the species in various characters, especially those related to growth, adaptation, and disease or stress resistance.
- Establishment of two ex s*itu* plantations (conservation plantations) for insuring the species against fire and other catastrophes. These should established in areas with appropriate ecological conditions and sufficient protection against fires and other human activities. The material should come from a number of natural habitats to ensure high genetic variation.
- Research and survey on pests and diseases attacking the species.
- Promotion of the species in afforestation and reforestation programmes undertaken by Forestry Department and NGOs
- Selected material should be promoted in other countries and be included in provenance trials as a future provenance in plantations for timber production.
- The proposed habitats of Cyprus oak as Special Areas of Conservation should be reinforced with appropriate legislation while villages and people should be involved in the management of these areas.

It is unrealistic to believe that in Cyprus it is possible to create extensive forest with Cyprus oak. This is due to the fact that on State forest land the ecological conditions for Cyprus oak are only favorable in a few sites, mainly along streams, while in private lands the competition by other agricultural products is much stronger and excludes oak that has a comparatively low return. However, the conservation of *Quercus infectoria* ssp. *veneris* genetic resources is of great importance to Cyprus ecosystems and much effort should be paid to the implementation of the measures mentioned above.

References

Allendorf, F.W. and R. F. Leary. 1986. Heterozygosity and fitness in natural populations of animals. In Soulé, M.E. (ed.). Conservation Biology: The Science of Scarcity and Diversity. Sunderland, Mass. Sinauer Associates. Pp. 57-76.

Barbero M. and P. Quezel. 1979. Contribution à l'étude des groupments foréstiers de Chypre. Documents phytosociologiques, Lille, IV: 9-34+1Tab.

Chapman, E. 1967. Cyprus Trees and Shrubs. Public Information Office. Nicosia, Cyprus.

Frankel, O. H. and M. E. Soulé. 1981. Conservation and evolution. Cambridge University Press, Cambridge, England.

Meikle, R.D. 1985. Flora of Cyprus. Vol. I. Bentham-Moxon Trust, Royal Botanic Gartens, Kew.

Mosseler, A. 1992. Life history and genetic diversity in red pine: implications for gene conservation in forestry.

Pantelas, V. 1998. Priority Areas for Forest Conservation in the Mediterranean Region for Cyprus. Project No. 9E0129.01, WWF.

Papachristoforou, T. 1993-1994. Basic instructions in tree conservation. Forest Treasures. Vol.XXXVIII, Cyprus Forest Association.

Schoener, T.W. 1987. The geographical distribution of rarity. Oecologia. Berling, 74: 161-173.

Zohary, M. 1973. Geobotanical Foundations of the Middle East. Vol. I, pp. 283-284. Gustav Fischer Verlag, Stuttgart, Swets and Zeitlinger, Amsterdam

France

Roselyne Lumaret
Group of Plant Population Genetics, Centre d'Ecologie fonctionnelle et Evolutive (C.E.F.E.), CNRS, France

Three evergreen Mediterranean oak species, holm oak (*Quercus ilex* L.), cork oak (*Q. suber* L.) and holly oak (*Q. coccifera* L.) grow naturally in France. In addition, the occurrence of *Quercus cerris* L. and of *Q. crenata* Lam. has been reported in a small area located in Provence. These populations have not been studied so far. *Quercus pubescens* L. is also widely distributed in France but its area extends substantially beyond the Mediterranean climate region where it grows at medium or high elevation in North-facing biotopes. *Q. pubescens* belongs to the white oaks group and can hybridise with several other species of that group whereas no hybrids between Q. pubescens and any of the evergreen Mediterranean oak species have been reported. This species, therefore, may not fit into the group of Mediterranean oaks. Genetic variation is analysed in the French populations of *Q. pubescens* by the genetics group of INRA-Pierroton, which also studies several other species of European white oaks.

Geographic distribution and genetic variation in holm oak

Holm oak is mostly distributed all along the French Mediterranean border, along the Rhône valley up to Valence, along the Atlantic coast, from the Spanish boundary to the South of Brittany, and in Corsica. Two morphological types are observed. The "rotundifolia" type, a small round-leaved morph, occurs in Languedoc and Roussillon but shows tremendous morphological variation as compared to the same morph observed in central Spain. In the other regions of France, the other morph "ilex" which is a large, elongated leaf morph is predominant. Trees showing morphological characters intermediate between those of the two morphs also occur in several areas. In France, as in many other countries, holm oak was used mostly as firewood and to produce charcoal and human genetic impact on that species was neglectable. Holm oak can adapt to many soil and climate conditions and its demographic dynamics is good. Regeneration problems were reported in very few areas such as Corsica due to intensive acorn predation by pigs.

Populations of holm oak from several French regions were analysed genetically using allozymes and chloroplast DNA RFLP variation as nuclear and cytoplasmic markers, respectively (Michaud *et al.* 1995; Toumi and Lumaret 1998). Three groups of populations were distinguished. Populations from Corsica and Provence (ilex morph) that are genetically close to the Italian populations and show the same phylogeographic origin. Populations from Languedoc, Roussillon and a part of the Rhône valley (close to the rotundifolia morph) which are clearly related to the Spanish populations and the populations from the Atlantic coast which showed the *ilex* morph, specific variation for allozymes and chlorotypes related to those observed in Spain. This situation reflects the phylogeographic history of those populations, particularly the two distinct recolonisation routes after the last glaciation period, via Italy and Spain respectively, as well as the distinct sensitivity of the characters versus the selective pressure of environmental conditions.

Geographic distribution and genetic variation of holly oak

The species occurs along most of the Mediterranean border but becomes predominant on limestone, more particularly in the "Garrigues" formation (Languedoc). This species has an important vegetative propagation and is favoured by fire because it can regrow very quickly after forest fire. Holly oak is also a good competitor in open areas and there is no problem with regeneration. In several areas, local people consider the species as a pest. Genetic analyses were carried out in populations of holly oak using allozymes and chloroplast DNA variation (Toumi 1995). These populations showed the *coccifera* morph, which is usually observed in the western part of the Mediterranean Basin. In this species, high variation was observed for nuclear genes and, according to the site area, cpDNA chlorotypes were distinct or similar to those observed in holm oak, suggesting the occurrence of genetic introgression between the two species which belong to the same oak section (*Sclerophyllodrys*).

Geographic distribution and genetic variation in cork oak

In France, cork oak occurs in four geographically isolated regions, Landes, Roussillon (Catalogne), Provence and Corsica. As reported previously, cork oak is declining in France. From an area of 200 000 ha at the beginning of the 20th century, it is now restricted to about 70 000 ha of which only 43 000 ha are more or less extensively managed for cork production. Moreover, with no management, cork oak plots are observed to close up rapidly because they are invaded by other more competitive species (mostly holm oak) leading to absence of regeneration and even death of many adult trees which cannot cope with lack of light. This evolution was clearly described by Santelli (1998) in cork oak populations of Provence. However, cork oak is considered to be a useful species to maintain Mediterranean forests and avoid soil erosion so, during the last 15 years, several programmes were developed to improve species conservation and even to introduce cork oak in plots which were previously cultivated with crops (Bourgouin 1998).

Genetic studies were carried out in a limited number of cork oak populations using allozymes and chloroplast DNA variation (Toumi and Lumaret 1998 and unpublished data). Two groups of populations were distinguished; one includes the cork oak populations from "Landes" and French Catalogna, which show higher genetic diversity than populations of the other group located in Provence and Corsica. Variation for cpDNA shows the occurrence of two distinct colonising routes via Italy and Spain respectively. Moreover, in several areas, it was found that part of the genetic variation observed in cork oak was due to genetic introgression by cpDNA of holm oak (Toumi and Lumaret 1998). Further studies are needed to better identify the geographical distribution of introgressed populations and the factors that favour genetic introgression between the two species.

Suggestions to improve conservation of genetic resources in Mediterranean oaks growing in France

No particular conservation strategies are needed for holm oak and holly oak populations. However, a good knowledge of the geographic organisation of their genetic variation is needed to introduce adapted tree material into new areas. For cork oak, in several areas management (more particularly clearing) is necessary to maintain the remaining populations. In addition, further research studies aim to improve our scientific knowledge on the genetic variation of cork oak populations, including genetic introgression by other oak species and, in local areas, the possible effect of consanguinity on acorn fertility as the result of founder effects associated with long periods of empirical selection for cork quality.

References

Bourgouin, D. 1998. La subéraie française: état, réhabilitation et programmes de recherche. Ann. INRGREF : 114-125.

Michaud, H., L. Toumi, R. Lumaret, T.X. Li, F. Romane and F. Di Giusto. 1995. Effect of geographical discontinuity on genetic variation in *Quercus ilex* L. (holm oak). Evidence from enzyme polymorphism. Heredity 74: 590-606.

Santelli, J.1998. Communication de l'Office National des Forêts sur la régénération des forêts de chêne liège varoises. Ann. INRGREF: 48-62.

Toumi, L. 1995. Etude de la structure génétique et introgressions éventuelles chez les chênes sclérophylles méditerranéens à l'aide de marqueurs alloenzymatiques. Thèse de doctorat, Université Marseille III, France [French and English].

Toumi, L. and R. Lumaret. 1998. Allozyme variation in cork oak (*Quercus suber* L.): the role of phylogeography, of genetic introgression by other Mediterranean oak species and human activities. Theor. Appl. Genet. 97 : 647-656.

Macedonia FYR

Vlatko Andonovski
University Ss. Kiril and Metodij, Faculty of Forestry, Macedonia FYR

Main species (brief description of ecology and distribution)

The genus *Quercus* in the Republic of Macedonia, FYR is represented by the following species:

1. *Q. coccifera* L.
2. *Q. macedonica* DC (*Q. trojana* Webb.)
3. *Q. cerris* L.
4. *Q. frainetto* Ten. (*Q. conferta* Kit.)
5. *Q. pubescens* Willd. (*Q. lanuginosa* Thurill.)
6. *Q. petraea* Liebl. (*Q. sessilis* Ehrh.; *Q. sessiliflora* Salisb.)
7. *Q. robur* L. (*Q. pedunculata* Ehrh.)

According to some authors, the territory of the Republic of Macedonia is covered by the areals of the following oak species : *Q. policarpa* Schur., *Q. daleschampii* Ten., *Q. virgiliana* Ten. (*Q. pubescens* var. *virgiliana* (Ten) Hay.) and *Q. pedunculiflora* K.Koch.. But so far, the presence of these species is not fully confirmed nor is there scientific data on their ecological and morphological characteristics.

Six of the above species are included in the EUFORGEN Mediterranean Oaks Network. These are: *Q. coccifera* L., *Q. macedonica* DC, *Q. cerris* L., *Q. frainetto* Ten., *Q. pubescens* Willd., and hypothetically *Q. virgiliana* Ten. Table 1 gives the environmental parameters and the area covered by each species. Their range of distribution is shown on Map 1.

Table 1. Environmental parameters and the area covered by Mediterranean *Quercus* species in the Republic of Macedonia

Species	Habit	Altitude	Annual rainfall (Summer) (mm)	Lithology	Forest association	Area (ha)
Q. coccifera	Shrub sclerophyllous	70- 600 (800)	700 (>150)	Calcareous and siliceous	Coccifero-Carpinetum orientalis macedonicujm	40 000
Q. macedonica	Tree semi-deciduous	150-1000	480- 600 (>110)	Calcareous and siliceous	Querco-Ostryetum carpinifoliae	70 000
Q. cerris	Tree deciduous	150-1400 (1500)	515- 890 (>311)	Calcareous and siliceous	Quercetum-frainetto cerris	240 000
Q. frainetto	Tree deciduous	150-1000 (1150)	515- 890 (>311)	Siliceous	Quercetum-frainetto cerris	240 000
Q. pubescens	Tree deciduous	150-1000 (1200)	480- 700 (>130)	Calcareous and siliceous	Querco-Carpinetum orientalis macedonicum	360 000

The most economicaly important oak of the Mediterranean group is *Q. pubescens.* This is due to the broad distribution of this species, its closeness to populated areas and its exploitation as firewood. Clearcutting is practiced quite often in the forests of this oak, so they are highly degraded and in the stage of coppices or bushes. The other oaks (*Q. macedonica, Q. cerris* and *Q. frainetto*) are less represented. These species are also used for firewood and the management practices are similar to those for *Q. pubescens.* As a result, the forests of these oaks are also partially degraded. *Q. coccifera* is the only shrub-like and evergreen oak present, forming pseudomaquis in the southernmost and the warmest part of the sub-Mediterranean region of Macedonia. Pseudomaquis of *Q. coccifera* are spread on the lowest altitudes, and are mixed with the oriental hornbeam (*Carpinus orientalis*). Together, they form the *Coccifero-carpinetum orientalis macedonicum* association. Forests of *Q. pubescens* are found in the same region, but further north. The other *Quercus* species are found at higher elevations in this region. *Q. macedonica* grows in warm and stony areas along with oriental hornbeam (*C. orientalis*), while European hornbeam (*Ostrya carpinifolia*), *Q. cerris* and *Q. frainetto* form forest associations on deep alluvial soils.

With respect of the basic substratum (lithology), *Q. coccifera* and *Q. pubescens* are indifferent, *Q. macedonica* prefers calcareous soils, and *Q. cerris and Q. frainetto* prefer soil with lower pH.

Economic and social importance

As a result of their closeness to populated areas, oak forests has always supplied firewood to the local population, and were also used for cattle grazing. Until World War II, in Macedonia, cattle herding was nomadic, and the forestry sector was not yet organized. Due to these factors, oak forests were degraded and transformed into coppices. After the war, with the introduction of forestry management practices and organized cattle breeding, the oak forests were restored and their quality improved. Now, the management of the oak forests is planned but clearcutting is still practiced. Fast growing species have been introduced n some oaks forests but only as a transitional stage, and the oaks remain as a permanent stage of the landscape. However, due to their characteristics (wood quality, resistance and ability for regeneration by resprouting), oaks still remain one of the best and most important forest species in Macedonia.

Conservation and use

To date, no special protection is applied nor have any improvement measures been taken in the oak forests of Macedonia. There is a plan within the state tree improvement program for selecting oak seed stands as indicated in Table 2.

Table 2 - (Planned) seed stands of *Quercus* sp. in the Republic of Macedonia, FYR

No.	Species	Number of seed stands
1.	*Quercus macedonica*	2
2.	*Quercus cerris*	2
3.	*Quercus conferta*	3
4.	*Quercus pubescens*	2

For still some time, the forests of Mediterranean oaks will remain the main source of firewood for the population of Macedonia, and very little will be used for timber production.

Inventories

The range of distribution of every oak species is shown in detail in the Vegetation Map of the Republic of Macedonia. The management practices and the timber volume of the oak stands are given in the state forest enterprise management plans, but these do not cover the whole country.

Legislation

According to the Macedonian law on forests, tree seed stands and seed orchards have been defined as areas for special use and therefore are protected. The planned oak seed stands will be protected according to the same law.

Research

No specific research has been carried out on the *Quercus* species in Macedonia apart from some phytocenological inventories. Future research should focus on morphology, taxonomy, genetics and tree improvement.

References

Andonoski, A. 1998. Multy-Country Forestry Programme. National Report for the R. Macedonia

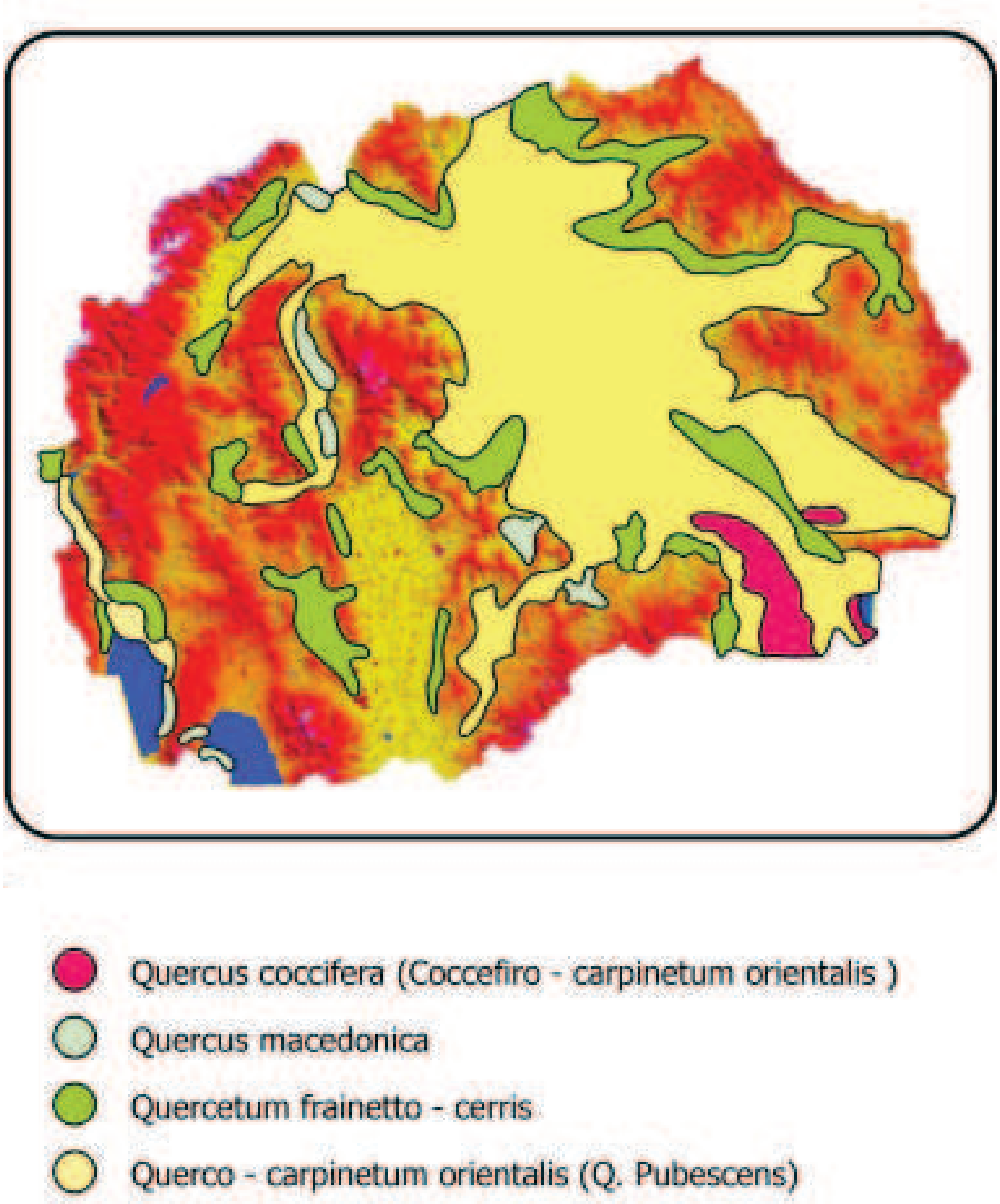
Andonoski, A. 1998. The status of Macedonian forest gene-fund and measures taken for its conservation. 10th Congress of dendrology, Sofia

Bornmuller, J. 1925-1928. Beitrage zur flora Macedonien. Engl. Bot. Ib., Leipzig

Dzekov, S. 1988. Dendrology, Skopje

Em, H. 1967. Survey of dendroflora in Macedonia. Skopje

Hayek, A. 1927. Prodromus Florae peninsulae Balcanicae. Dahlem bei Berlin



Map 1. Range of distribution of Mediterranean oaks in Macedonia, FYR

Malta

Eman Calleja
Wied Incita Nursery, Department of Agriculture, Malta

Introduction

There is only one species of oak that is known to be native to the Maltese Islands, namely *Quercus ilex* (Holm oak). Other species also occur (*Q. robur, Q. cerris* and *Q. infectoria* subsp. *veneris),* however these are not indigenous.

Status of Quercus ilex *in the Maltese Islands*

Holm oak *per se* is on the whole rare, and has a restricted distribution in the Maltese Islands (Lanfranco 1989, 1996a; Stevens, 1995). It is thence listed in the 'Red Data Book for the Maltese Islands' (Schembri and Sultana 1989). *Quercus ilex* is also (strangely) completely absent from the islands of Gozo (Lanfranco 1996b) and Comino. It grows locally in maquis and forest remnants belonging to the *Quercetalia ilicis,* where the main accompanying species are *Pistacia lentiscus*, *Pistacia* x *saportae*, *Rhamnus alaternus*, *Laurus nobilis*, *Olea europaea, Ceratonia siliqua* and *Crataegus* spp., with *Asparagus aphyllus*, *Clematis cirrhosa*, *Hedera helix, Lonicera implexa*, *Rubia peregrina*, *Rubus* spp. and *Smilax aspera* as the main climbers.

The reason for its rarity is mainly because Maltese forests, which probably occupied large areas of the Maltese Islands prior to human colonisation, are now almost non-existent (Schembri 1991; Grech 1994, 1996); what remains are only a few remnants of the original native forests, all located on mainland Malta. These sites are dominated by this species, which represents the climax community of the Mediterranean scrub series. In fact, some of the *Quercus* trees present in the forest remnants are estimated to be between 500 to 900 years old, probably the oldest trees on the islands (Lanfranco, 1989), and some have a girth of 4 to 6m (Borg, 1995).

Forests remnants are nowadays restricted to four localities, namely Ballut tal-Wardija, L-Imgiebah, il-Bosk and Ta' Baldu (Sommier and Caruana Gatto 1915; Borg 1922, 1927; Grech 1996; Haslam *et al.* 1977; Schembri *et al.* 1987; Lanfranco 1989; Borg 1995; Stevens 1996). As one may notice, the former locality has their name derived from the Maltese name of the holm oak (Ballut). Apart from these sites, there are also some other localities where some individual relict trees can still be observed, such as Gnien il-Kbir and Wied Hazrun.

Besides these, other sites are known to have had a holm oak forest cover, e.g. Ballut ta' Ras il-Gebel, where an oak wood remnant was known at least up to the 1930s (Borg 1922; 1927), but from which *Quercus ilex* have long disappeared presumably due to a combination of fire and grazing; and Wied Hazrun, where the holm oak copse was almost completely destroyed by a fire in 1989 (Grech 1992, 1996; Stevens 1996, 1998; Stevens and Gauci 1997). Place-names like Wied Ballut and Il-Ballut ta Marsaxlokk also indicate the former existence of holm oaks in these areas, though these trees have probably disappeared centuries ago; indeed, those at Wied Balluta had already disappeared by the mid 17th century (Abela 1647). As a whole, the locations of the forest remnants as well as the sites where holm oak used to occur until recently are in very different regions of the island of Malta, possibly indicating a more widespread cover in the past.

In addition to these forest relicts, there are also a few semi-natural woodlands, where oak and pine trees, originally planted by man, are now self-regenerating. Of these only Buskett (in the vernacular, this means 'small wood') (fig 3 and 4), in the south-west of mainland Malta, can be adequately classified as a forest, due to the presence of both a forest flora and fauna; this may be due to the fact that, originally, Buskett was probably a forest relict and a maquis area.

Quercus ilex is more frequently encountered as planted in various localities, both in the wild (*e.g.* Ghallis and Wied Ghollieqa*)* and in non-rural areas.

Uses

Holm oak is used locally both as a street tree and in afforestation projects. It is presently the most frequently employed afforestation species after Aleppo Pine (*Pinus halepensis*) and it is quite frequent in government and private nurseries. Most of the material is grown from locally available stock (at least for government departments), though local stock is often augmented with foreign stock, especially in private nurseries.

Hunters often plant oaks to attract game. In fact, some remnant forest stands are highly valued by locals for this reason.

No other uses are known at present, though in the past the wood was utilised as firewood, for timber or for the production of tools and utensils. Its tannins were also used, mainly to dye animal skins (Grech 1992, 1996). The acorns used to be fed to goats, pigs and other domesticated animals, and even roasted and ground to be employed with chicory instead of, or even mixed with, coffee (Lanfranco 1993). All these practises have fallen in disuse.

Conservation and silviculture

Ex situ conservation measures for *Q. ilex* in the Maltese Islands only relate to its growing in nurseries, and eventual planting in appropriate sites. *Q. ilex* usually seeds in the first weeks of December. Its acorns are collected from mid-December till the beginning of January and are sown almost immediately in normal calcareous soil. They are usually planted about 2 years after germination, or at a size of about 50 cm.

With respect to *in situ* conservation measures, all oaks above 200 years of age are legally protected under the Antiquities Act of 1925. Apart from this, legal protection of Q. *ilex* has been proposed in the Tree and Forest Protection Regulations; analogously, all trees occurring in the holm oak forest remnants (four in all) and Buskett have been proposed as Woodland Nature Reserves under the same regulations. Monitoring of existing oak populations is also regularly carried out as part of the Biodiversity Monitoring Programme of the Environment Protection Department. Another example of *in situ* conservation measures includes Wied Hazrun, where work is being carried out by the Environment Protection Department to favour the natural regeneration of the extant oaks of the area.

Threats

Holm oaks are highly susceptible to fire, particularly the very old stands. Fire has already almost completely eradicated the population at Wied Hazrun, where oak resprouting was lower than expected, probably also because of the great age of the trees.

Felling of trees in order to convert forest land to agriculture is also a serious threat, particularly because some relict trees occur within agricultural areas (as at *Gnien il-Kbir* and *Wied Hazrun).*

Research and needs for gene conservation

Little research has been carried out on *Quercus ilex,* though Bonello (1991) has carried out some preliminary studies. In this work, two localities, namely Il-Ballut tal-Wardija and *Buskett* (which in this study also included Il-Bosk), were compared for abiotic and biotic factors influencing oak growth and regeneration, such as soil depth, pH and acorn infection. A short inventory of flora and fauna encountered in such stands is also given.

The results indicated that the conditions for tree growth were more favourable at *Buskett* than at Il-Ballut tal-Wardija due to various reasons ranging from increased competition due to denser shrub-undergrowth vegetation and lower soil depth at Wardija, whilst the conditions for regeneration seemed more favourable at Il-Ballut tal-Wardija due to a low grass density (but not shrub density), greater amounts of shade and humidity and a lesser degree of acorn infection than at Buskett (Bonello 1991).

As far as genetics and genetic resources are concerned, no research has been carried out.

Nonetheless, increased knowledge on the regenerative and resprouting abilities of holm oak, and on the effect of pesticides on holm oak growth and survival (since some trees occur near agricultural fields), is required. Also, genetic approaches would be useful to determine whether the Maltese stock has Sicilian or North African affinities, and whether the Maltese populations are genetically distinct from other insular and continental stocks. Unfortunately, due to lack of equipment, human resources and financial resources, such analyses cannot be presently carried out.

References

Abela, G.F. 1647. Della descrizione di Malta: Isola nel Mare Siciliano con le sue antichita' ed altre notizie. Paolo Bonacota. Malta.

Bonello, C. 1991. The ecology of the oak tree (*Quercus ilex* L.) from two sites in Malta. Bachelor of Education (Hans.) dissertation, University of Malta.

Borg, J. 1922. Cultivation and diseases of fruit trees in the Maltese Islands. Government Printing Office. Malta.

Borg, J. 1927. Descriptive flora of the Maltese Islands. Government Printing Office. Malta.

Borg, J. 1995. The story of the Maltese forest. Media Centre. Malta.

Grech, C.F. 1992. Wied Hazrun: Mediterranean evergreen oak maquis forest in peril. Arbor the Society for the Protection of Trees and the Natural Environment. Malta.

Grech, C.F. 1994. An environmentally sound woodland strategy for the Republic of Malta in the light of its land-use policy. European Masters in Environmental Management dissertation [English].

Grech, C.F. 1996. Il-Balluta - Sigret il-Masgar Malti. ln-Natura 16:4-10.

Haslam, S.M., P.D. Sell and P.A. Wolseley. 1977. A Flora of the Maltese Islands. Malta University Press.

Lanfranco, E. 1989. The Flora. *In* Red Data Book for the Maltese Islands (P.J. Schembri and J. Sultana, eds.). Department of Information. Malta.

Lanfranco, E. 1996a. Plants. *In* Wildlife of the Maltese Islands (J. Sultana and V. Falzon, eds.). Environment Protection Department. Malta.

Lanfranco, E. 1996b. The flora and vegetation of Gozo. *In* A Focus on Gozo (J. Farrugia and L. Briguglio, eds.). University of Malta (Gozo Centre), Ministry for Gozo and the Foundation for International Studies.

Lanfranco, G. 1993. Hxejjex medicinali u ohrajn fil-Gzejjer Maltin. Media Centre Publications. Malta.

Schembri, P.J. 1991. Malta Structure Plan Technical Report 5.4: Report of Survey - Natural Resources. Colin Buchanan and Partners, Generale Progetti S.p.A. & Planning Services Division. Malta.

Schembri, P.J. and J. Sultana (eds.). 1989. Red Data Book for the Maltese Islands. Department of Information. Malta.

Schembri, P.J, E. Lanfranco, P. Farrugia, S. Schembri and J. Sultana. 1987. Localities with conservation value in the Maltese Islands. Environment Division, Ministry of Education. Malta.

Sommier, S. and A. Caruana Gatto. 1915. Flora Melitensis Nova. Firenze: Stabilimento Pellas.

Stevens, D.T. 1995. List of trees and large shrubs native to the Maltese Islands. *In* Il-Balluta.

Stevens, D. T. 1996. Tree, large shrub and woody climber update - Part One. *In* Il-Balluta.

Stevens, D.T. 1998. Vegetation appraisal of part of Wied Hazrun. Unpublished Environment Protection Department Report.

Stevens, D.T. and M. Gauci. 1997. Report on oaks and carobs at Wied Hazrun (l/o Dingli). Unpublished Environment Protection Department Report.

Morocco

Hassan Sbay
National Forest Research Center, Rabat, Morocco

List of Quercus *species in Morocco*

In Morocco the *Quercus* genus is represented by the following species:

1. *Quercus coccifera* L.
2. *Quercus rotundifolia* L.
3. *Quercus faginea* Lamk.
4. *Quercus pyrenaica* Willd.
5. *Quercus fruticosa* Brot
6. *Quercus suber* L.

Quercus coccifera L.

Small tree, but more often a bush, *Quercus coccifera* is found in the sub-humide and semi-arid bio-climates. It prefers chalky or siliceous rocky slopes of the Mediterranean coast and low mountains.

In Morocco, it is strictly restricted to the Rif Mountains, especially on the Mediterranean slope, from Tangiers to the Algerian border. An isolated stand is found in the mountains near Taza. It has not been found elsewhere in Morocco.

It is a polymorphous species and the following forms have been identified in Morocco: var. *imbricata* D.C. with short, lanceolate scales and bit displayed at maturity; var. *integrifolia* Lag., with very narrow and elongated leaves; var. *brachycarpa* Willk. with short acorns; var. *Auzendei* (G.G.)D.C. is distinguished by the slight pubescence on the bottom face of the leaf, like those of *Quercus rotundifolia*, but in this case acorns are located on branches of the previous year.

This last variety, because of the characters indicated above, is considered by many botanists as a hybrid between *Quercus coccifera* and *Quercus rotundifolia*.

This oak is also infested by *Coccus (Lecanium) ilicis* that provides a red dye analogous to that of other cochineals.

Wood is very solid, very hard and very heavy. It is valued as firewood and is also used for tanning hides.

The main roles played by this species can be summarized as follows:

- Soil protection
- Firewood, charcoal, acorns and forage production
- Habitat for wildlife
- Aesthetic value of the landscape

Quercus rotundifolia Lamk. (Holm oak)

Quercus rotundifolia is in fact divided in two different species: *Quercus ilex* and *Quercus rotundifolia*. This difference is based on morphological and biochemical characters on the one hand, and ecological requirements of the two species on the other. Thus, the holm oak name possibly corresponds to two different species: *Quercus ilex* L. in the center and eastern part of the Mediterranean basin; and *Quercus rotundifolia* Lamk. in North Africa and southwestern Europe (Spain and Portugal).

Holm oak is polymorphous and exhibits large individual variations in its botanical characters. It hybridizes easily with cork oak, giving *Q.* × *morisii* with corky bark, which has been described in Algeria in regions of Bouira and Tlemcen and in Sardinia. The hybridization of holm oak and cork oak is also observed in Spain where this hybrid is very common and is commonly named mesto. Holm oak also hybridizes with *Q. coccifera* and *Q. trabutiana* is found in Algeria and *Q. auzandei* in Morocco (near Mélilla).

It has a high vitality, and sprouts vigorously until a very advanced age. It also produces root suckers, particulary when the stump or the strong roots have been damaged by fire or other mechanical causes.

Holm oak is very widely distributed and is the main element of the Moroccan forest. It covers 1.364.100 ha in Morocco. This area is divided as follows:

Middle Atlas:	648 100 ha
High Atlas:	409 000 ha
Saharian Atlas:	90 000 ha
Atlantic:	88 000 ha
Souss region:	75 000 ha
Rif:	54 000 ha

In the Rif Mountains, holm oak succeeds thuya, cork oak, and Aleppo pine and reaches 2 200 m to mix with cedar, fir and deciduous oaks.

In Eastern Morocco, it forms beautiful forests. In the High Atlas and Middle Atlas, it spreads essentially on the Atlantic exposure and forms very beautiful groves in subhumid bioclimates notably in the middle atlas sector between 600 and 2 900 m. It is also found in small copses or clusters in the oriental sector of the High Atlas (Tassaout and Aghbar).

The most southern station of holm oak is found in the Jbel Kest of the Anti Atlas. Other locations have been described inside the country, for example the mid-Rif (Zalagh and Zerhoun) and Sidi Bettache.

The ecological plasticity of holm oak allows it to thrive in almost all bioclimates, with the exception of the arid and saharian ones.

In Morocco, holm oak begins to appear from 300 mm of precipitation in the western part influenced by the ocean and goes up to 1 200 mm in the Middle Atlas.

It tolerates winter cold, with minimum temperatures of -20°C, and can withstand frost and snow for several weeks. From the bioclimatic point of view, holm oak prospers in semi-arid to humid areas. But it prefers sub-humid and humid ones. Holm oak is indifferent to the kind of soil, nevertheless, the best holm oak stations are found on calcareous brown soils or well-drained soils.

Holm oak forests play a very important socio-economic role given the diversity of their products: wood, environmental protection, tourism and hunting, forage resources.

Holm oak provides the best firewood in Morocco, a country in which firewood still supplies approximately 30% of the national energy demand. The utilization of this product is however limited to domestic uses, industries and traditional services (heating, cooking, kilns). The annual capacity of firewood production from natural forests is estimated at 2,3 millions m^3 of which 840 000 m^3 from the holm oak (37.26%), with an estimated value of about 126 millions Dh/year (150 Dh by m^3).

Its wood is very resistant both to torsion and compression, but it is very heavy. It is used for the manufacture of tools, for construction poles and for railway sleepers.

Besides the valorization of its wood, holm oak is used for feeding cattle (foliage, acorns, other shrub and herbaceous species that are associated with it). The importance of forage units (UF) available and provided by these forest is estimated at 449 million UF on a national total of 1 521 millions UF (29.5%). This pastoral resource has to be valorized and managed in an optimal way in order to ensure the sustainable use of these ecosystems.

Holm oak forests are often subjected to pressure that exceeds their capacity for natural regeneration and sometimes lead to very severe degradation. The main cause of degradation of these ecosystems is grazing. Fires and illegal clearing and cutting by rural populations create other problems.

Others factors participate in the degradation of the holm oak, such as insects (*Lymantria dispar*, *Bombyx sp.*, *Tortrix viridana*, *Thaumetopea processionea*), harmful weeds such as cuscute that attacks sprouts (*Cuscuta monogyna*) or fungi such as oidium that attacks leaves.

The majority of holm oak forests have undergone generalized exploitations and are currently very dense copses with a reduced capacity for forage and wood production.

Thus, the establishment of efficient silviculture systems to maximize the sustainable production of wood and forage is a priority. Rational management is also required in order to preserve the natural structure, the status of the species and its associations, so that it may continue to play its social and ecological role. Currently, the only activities that take place in the forest are cuts, and occasionally thinnings.

However, holm oak is mainly used for heating and this makes the species of secondary economic importance. In order to ensure sustainability and long term valorization of holm oak stands the possibility of others utilization (i.e. veneer) should be further investigated.

Quercus faginea Lamk

Quercus faginea includes 4 sub-species and many varieties.

Trees can reach 30 m in height and 1.50 m in diameter. Cracked brown bark, hairy buds then hairless. Leaves are pubescent in the young stage; very variable limbs. It lives up to 150 years. It regenerates easily by seedling and sprouts and suckers vigorously. Wood resists to rot. It prefers sub-humid to humid bioclimates with fresh and mild winters. It is found from sea level (Tangerois), to 1 800 m in the High Atlas. It is indifferent to soil type, nevertheless, the best stands are found on deep soils.

The wood is used for rail sleepers, firewood and mine poles.

In Morocco it covers an area of 8 000 - 10 000 ha and is mainly found in the Rif (Tangier Peninsula up to Arbaoua), Middle Atlas, central plateau and High Atlas. Many small stations are spread along the mountains between Ksiba and Asni. It once occupied a much vaster area.

Quercus pyrenaica Wild

This tree can reach 20 m in height and 1 m of diameter, suckering abundantly. The trunk is covered by a blackish and cracked bark. Leaves are deeply lobed are are pubescent, grayish below, green, more or less hairy above, with 5-8 pairs of lobes.

It prefers a humid bioclimate with cold and fresh winter in areas with abundant summer fogs. It does not tolerate alkalines soils.

It is found on low and middle humid mountains, between 200 and 2 000 m.

The wood is used for rail sleepers, firewood and mine poles.

It covers about 16 000 ha in the Western Rif, Jbala and the Outka Mountain.

Quercus suber L.

This tree can reach 15-20 m in height and 2 m of diameter. It has light bark, very thick, cracked. Buds are ovoidal and hairy on the margin of scales. Leaves persist for 2 or 3 years, are dark green, petiolate with and more or less toothed margin, hairless above, gray ash-gray pubescent below, with5-7 pairs of nervatures. It prefers semi-arid, sub-humid and humid bioclimate. It thrives on more or less deep sandy - clays, with no limestone. It does not tolerate excess clay or salt.

Moroccan cork oak stands cover an area of 350 000 ha representing 15% of the world total cork oak area. It occurs in the northwestern region from the coastal plains to the Central Rif and Middle Atlas. Plain forests represent about 51% of the area and mountain forests 49%.

It is found in the region of Casablanca to Rabat, Sebou Basin, western Rif, with some stations in the Middle and High Atlas at altitudes of 0-2400m. However, it is rarely found above 800m.

The main areas are summarized as follows:

- Humid bioclimate: Rif, Taza south (900 ha).
- Subhumid bioclimate: vaste area, Gharb, Oulmes, Taza north (90 000 ha).
- Semi-arid bioclimate: Maamora, Zaers, Chaouia, 2/3 of its area in Morocco (190 000 ha).

Conclusions

In Morocco, oak forests play a very important socioeconomic, ecological and recreational role.

The potential value of the Moroccan oak genepool is more or less known. Local species and ecotypes have developed adaptive strategies to cope with prevailing conditions. Hardiness, drought and disease tolerance are some examples of characters associated with Moroccan germplasm. This large genetic diversity is, however, at risk.

Available data clearly indicate that degradation is occurring in many species. Once again, the main factors of this degradation are drought, lack of natural regeneration, overgrazing, fire, bad harvesting practices, urbanization, problems in acorn conservation, etc.

In recent years, there has been an increasing awareness in Morocco that conservation and forest sustainable use are essential. Therefore, conserving plant genetic resources has received considerable attention. Several national and international research institutions are now working to produce the knowledge required to conserve and make better use of local plant genetic resources and an overall strategy for the improvement of forest tree species has been elaborated.

In addition to this a Plan of Protected Areas has been recently established. The Plan has identified 154 reserves (SIBE) and has proposed management models for 9 national parks. Many of these protected areas include oak ecosystems.

References

Achhal, A. 1979. Le chêne vert dans le Haut Atlas central : étude phytoécologique. Problèmes posés par les aménagements de la chênaie. Thèse doct. 3[e] cycle, Univ. Aix-Marseille. 116 p.

Barbero, M. 1996. Ecologie et variabilité des chênaies sclérophylles : chimiotaxonomie du complexe chêne vert. In Forêt méditerranéenne 17 (3):129-136.

Boudy, P. 1950. Economie forestière Nord-Africaine.II : Monographie et traitement des essences forestière, Paris, Larose.

Boudy, P. 1952. Guide du forestier en Afrique du Nord. Paris, Maison Rustique.

Ducrey, M. 1996. Recherches et expérimentations sure la conduite sylvicoles des peuplements de chêne vert. In Forêt méditerranéenne 17 (3):151-168.

Ducrey, M. 1998. Le fonctionnement écophysiologique d'un taillis de chêne vert : comparaison entre taillis fermé et taillis éclairci. Groupe Chênes, réunion de Bordeaux, 21-22-23 Avril 1998.

Ducrey, M. 1998. La croissance et la dynamique des taillis de chêne vert : effet des coupes rases et des éclaircies. Groupe Chênes, réunion de Bordeaux, 21-22-23 Avril 1998.

Emberger, L. 1938. Les arbres du Maroc et comment les reconnaître. Larose. Paris.

Emberger, L. 1939. Aperçu général sur la végétation du Maroc : commentaire de la carte phytogéographique au 1/50.000. Veroff. Geobot. Inst. Rübel Zurich. 14:40-157.

Marion, J. 1953-54-55. Les peuplements artificiels en chêne-liège dans la forêt de la Mamora (Maroc). Annales S.R.F., tome 3, fasc. 2.

Metro, A. and Ch. Sauvage. 1955. Flore des végétaux ligneux de la Mamora. Rabat.

Sauvage, Ch. 1956. Recherches géobotaniques sur les suberaies marocaines. Inst. Chérifien. Sér. Bot., n[os] 21 et 22, Rabat.

Sauvage, Ch. and J.Vindt. 1952. Flore du Maroc, analytique, descriptive et illustrée. Travaux de l'I.S.C., Tanger.

Yacine, A. 1987. Une étude d'organisation de la diversité génétique inter et intra-population chez le chêne vert : *Quercus ilex* L. Thèse de 3[e] cycle. Univ. Sci. Tech. Languedoc. Montpellier.

Yacine, A. and F.Bouras. 1997. Self - and cross-pollination effects on pollen tube growth and seed set in holm oak *Quercus ilex* L., (Fagaceae). Ann. Sci. For. 54:447-462.

Portugal

Maria Carolina Varela
Estação Florestal Nacional, Lisboa, Portugal

Depending on the taxonomic classification, several Mediterranean oaks are found in Portugal:

1. *Quercus suber*
2. *Quercus pyrenaica*
3. *Quercus faginea - Quercus canariensis*
4. *Quercus lusitanica*
5. *Quercus ilex- Quercus rotundifolia*
6. *Quercus coccifera*

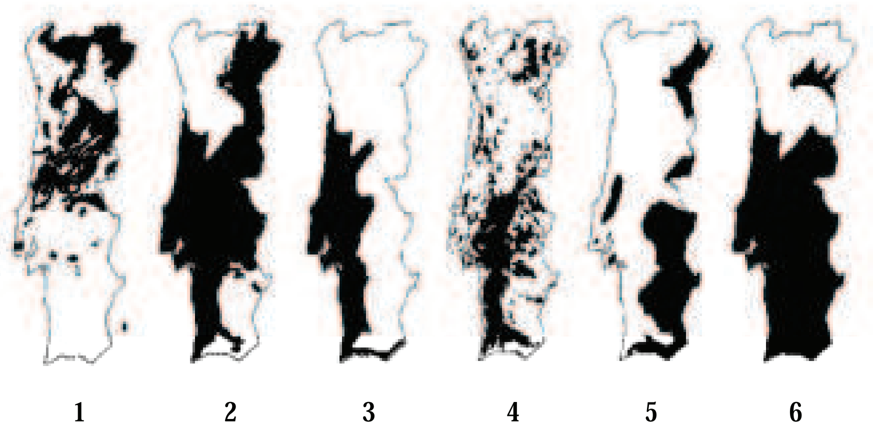


Figure 1. Potential area of Mediterranean oaks in Portugal

Quercus suber L. - cork oak

The status of cork oak in Portugal has been described in the reports of previous EUFORGEN cork oak network meetings (Frison *et al.* 1995; Turok *et al.* 1997).

Quercus pyrenaica Wild

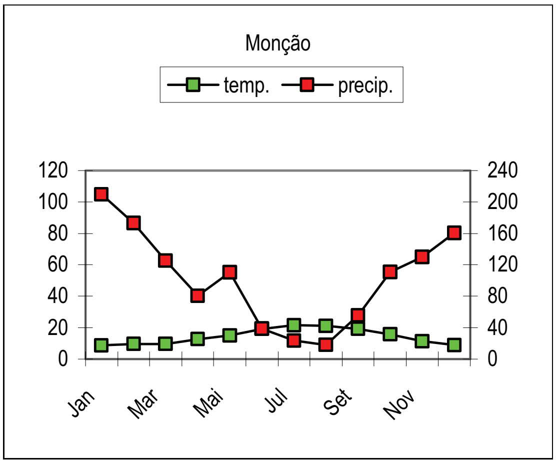
Common Portuguese name - Carvalho negral

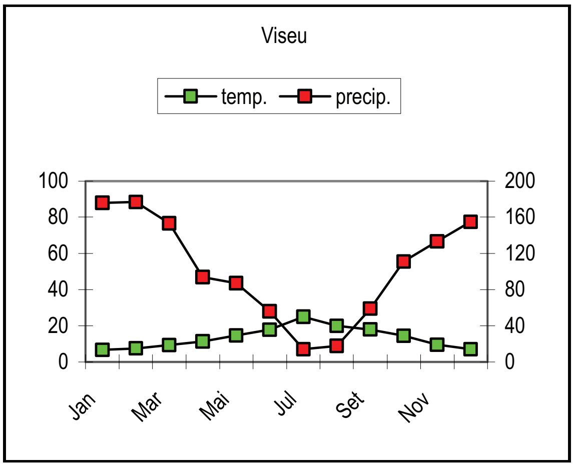
It is a deciduous species occupying large areas of the northern half of Portugal where the climate is Mediterranean but with cold winters (Figure 1; Figure 2a and 2b). The 700mm/year line marks the lower pluviometric limit.

It may be found in association with *Quercus robur* and *Quercus ilex*, more rarely with cork oak.

General description

Nowadays it is a species of limited economic importance. During the past decades the species has been substituted by agricultural crops and other forest species of higher economical interest such as *Pinus pinaster* and *Eucalyptus globulus*.





Figures 2a and 2b. Ombrothermic diagrams of two locations representative of *Q. pyrenaica* climate preferences

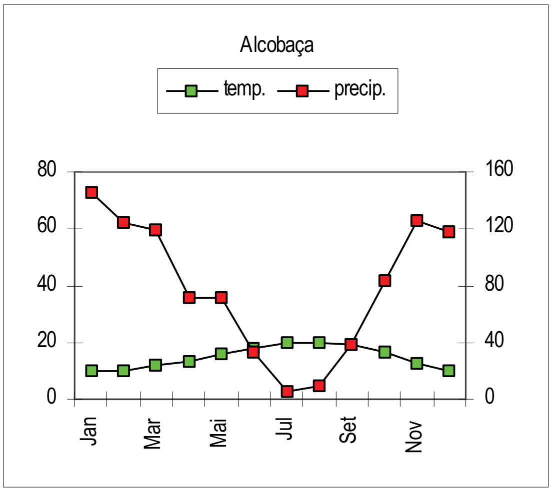
However, due to rural abandonment, in the last thirty years the species is vigorously recovering. There is no accurate data about the area of *Q. pyrenaica* since forestry inventories group the areas for all minor broadleaves under one single heading.

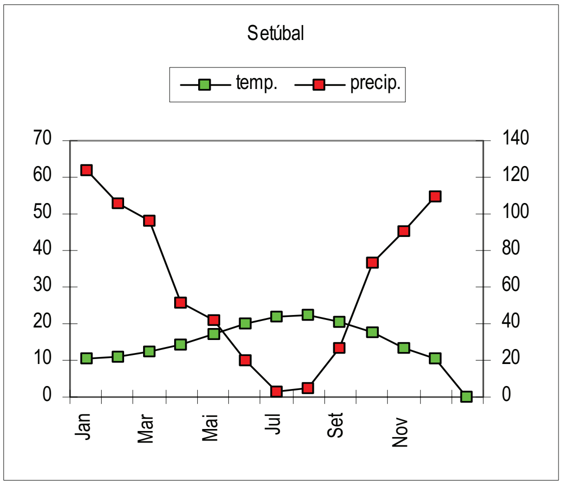
During the substitution process, some particular population may have been lost. To obtain an accurate assessment of the gene conservation status of the species it would be necessary to carry out inventories of its previous and current distribution.

Marginal population should be monitored for effective size in order to estimate whether founder effects or genetic dritf are taking place. Rates of hybridisation with other oaks should also be evaluated.

Quercus faginea - Quercus canariensis

Common Portuguese name - Carvalho cerquinho





Figures 3a and 3b. Ombrothermic diagrams of two locations representative of *Q. faginea* climate preferences

The taxonomic classification for these species is confusing. Therefore, the two will be addressed as *Quercus faginea sensu lato.*

The ecological preference of the species goes to Mediterranean climate with mild summers and winters (Figure 1; Figure 3a and 3b)

General description

Since the ecological requirements of *Q. faginea* coincide with those for *Pinus pinaster*, *P. pinea* and *Eucalyptus globulus*, all of higher commercial interest, the species has been drastically replaced

It is now confined to nature reserves, to roadsides, to borders of agriculture plots or to abandoned land. It is likely that populations with particular adaptations have been lost or face risk of genetic drift due to low effective size.

This species was used for contruction wood and for the production of wine and brandy barrels. It has been replaced for both uses by oak wood imported from other European countries and United States.

The distribution area of the species has been greatly reduced and it is now mostly confined to small groves and scattered groups of trees. Mata do Gaio in Alcobaça, a state-owned stand of about 60 ha is probably the biggest stand of the species.

When ecological conditions allow for mixed stands of *Q. pyrenaica*, cork oak and *Q. faginea* to the different fructifying seasons of the three species create a very favorable situation for pig husbandry.

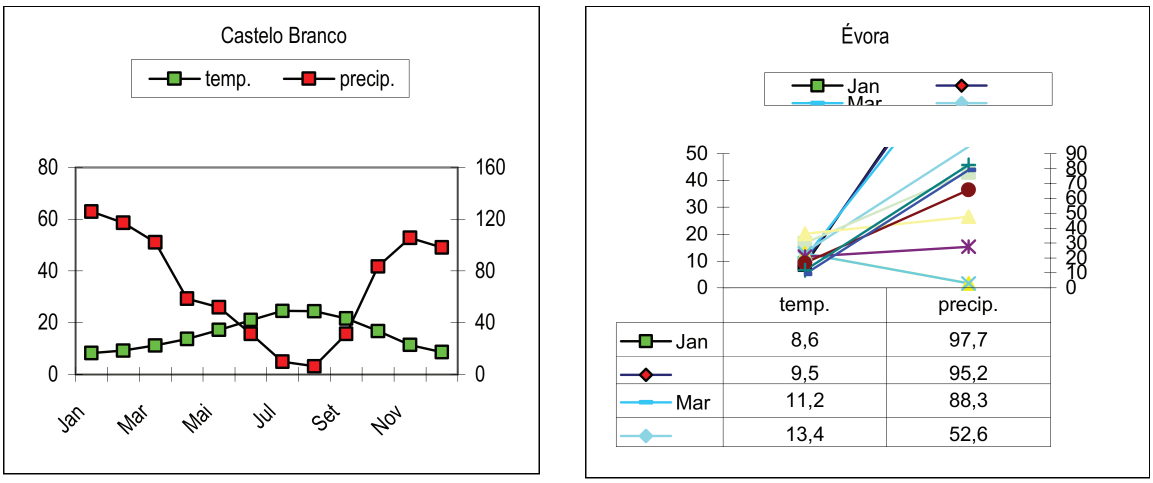
Research needs: Inventories, rate of hybridisation and effective size of existing population are needed for the design of a gene conservation strategy for the species.

Quercus ilex - Quercus rotundifolia

Common Portuguese name - Azinheira. Common English name- Holm oak

In spite of the decreased economic interest after the "African pig pest" that hit Portugal in the first half of the 20th century, holm oak still covers an area of about 450 000.

It is a very frugal species standing harsh climate and calcareous soils. Along with *Q. coccifera* it is the oak species that resist better to summer drought and cold winters (Figure 1; Figure 4a and 4b).



Figures 4a and 4b. Ombrothermic diagrams of two locations representative of *Quercus ilex- Quercus rotundifolia* climate preferences

General description

Portuguese law 11/1997 of January 14, 1997 protects the species along with cork oak.

Its ecological requirements have been acting as a natural protection for the species. Only *Pinus pinea* shows interesting growth rates on the natural distribution area of holm oak, however without fructifying at interesting commercial rates.

As a result of national and European Union financial support, particularly EU regulation

2080 for set aside of farmland, many areas of holm oak have been saved or replanted. The species is appreciated for hunting activities and the husbandry of black pig is showing some recovery. However, seed supply is poorly regulated and no Region of provenance or seed stands has been defined for this species.

Holm oak plays an important role in the dry areas of inland Portugal, where it can stand the harsh climate that prevails.

Research needs include provenance research, especially related to climate change, and studies on hybridisation with cork oak. Under the current circumstances there are no serious threats to genetic resources of holm oak.

Quercus lusitanica

Common Portuguese name: Carvalhiça

It is a minor species on the Portuguese forest landscape. It is a shrub that rarely attains the dimensions of a tree.

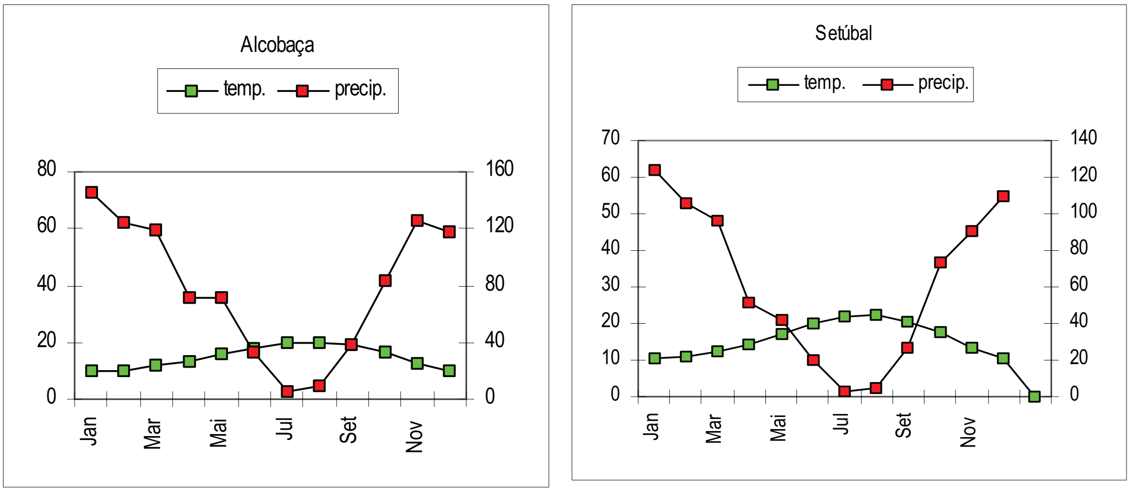
It occupies the coastal areas of southern Portugal where climate is mild in winter and summer, mitigated by humid air currents from the Atlantic (Figure 1; Figure 5a and 5b).

General description

It is a frugal species in what concerns soil requirements. As all oaks, it is more interesting for wildlife than any of the substituing species such as *Pinus* or *Eucalyptus*.

Inventories for accurate data on the status of the species are the major research need.

Under the actual circumstances there are no serious threats to the genetic resources of *Q. lusitanica* in Portugal.



Figures 5a and 5b. Ombrothermic diagrams of two locations representative of *Quercus lusitanica* climate preferences

Quercus coccifera

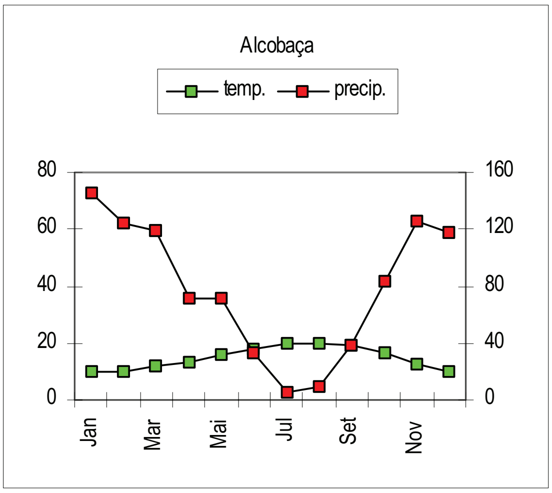
Common Portuguese name: Carrasco

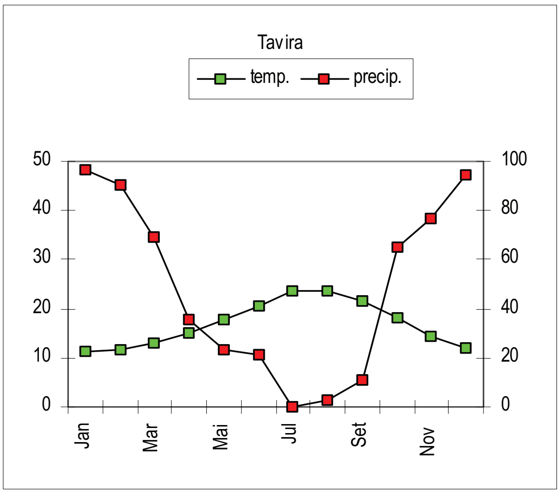
It does not stand the cold winters of the interior of northern Portugal nor the wet summers of the north coastal strip (Figure 1; Figure 6a and 6b).

General description

It is a very rustic and common shrub in the understory of the forests of southern Portugal. It is frugal in its soil requiment and tolerates lime. It sprouts profusely after fires.

Currently, there are no serious threats to the genetic resources of *Q. coccifera* in Portugal.





Figures 6a and 6b. Ombrothermic diagrams of two locations representative of *Q. coccifera* climate preferences

Needs of research and ongoing research activities

Currently, research activities are limited to cork oak. However, due to its ecological importance regions of provenance as well as minimum requirements for seed stands should be defined at least for holm oak.

Increasing world wide production is driving intensive competition among wine producers that are more and more keen to attract consumers on the basis of differences. In this scenario the reintroduction of Mediterranean oaks wood for barrels for ageing wines and brandies should be stressed. Common research projects with wineries should be promoted

Frison E., M.C. Varela and J. Turok (compilers). 1995. EUFORGEN *Quercus suber* network. Report of the first two meetings 1-3 December 1994 and 26-27 February 1995. - Rome, Italy. IPGRI

Turok J., M.C. Varela and C. Hansen (compilers). 1997. EUFORGEN *Quercus suber* Network. Report of the third and fourth meetings, 9-12 June 1996, Sassari, Sardinia, Italy, and 20-22 February 1997, Almoraima, Spain. International Plant Genetic Resources Institute, Rome, Italy.

Spain

Pilar Jiménez and Luis Gil
Unidad de Anatomía, Fisiología y Genética Forestal, Universidad Politécnica de Madrid, Ciudad Universitaria, Madrid, Spain

Main species (brief description of ecology and distribution)

Eight out of the 10 *Quercus* species growing naturally in Spain are included in the EUFORGEN Mediterranean Oaks Network. Some of these species are widely distributed and occupy a great diversity of habitats. Table 1 brings together environmental parameters and the area occupied by each species while their distribution is presented in Fig. 1. *Q. ilex* is the most important species due to the great extension it covers and to the exploitation of its stands. In Spain, the two subspecies (*ilex* and *rotundifolia*) are recognized, although *Q. rotundifolia*, well adapted to continental and dry habitats, is much more frequent. Three species have a local range: *Q. lusitanica* and *Q. canariensis*. *Q. pubescens*, restricted to the north and east of the Peninsula, is strongly introgressed with other species (*Q. petraea*, *Q. faginea*), so it is difficult to estimate the area covered by this taxon.

Q. coccifera and *Q. lusitanica* are shrublike species, but all the others have the ability to resprout to a varying degree. In fact, a large part of the area of some species is coppiced.

Altitudinal ranges of most species are rather wide. It is possible to find, in a small area, the same species living at very different altitudes. The termicity index (I_t) shows also the broad range of temperatures of the site in which they are present. The continental conditions that some species (mainly *Q. ilex*, *Q. pyrenaica* and *Q. faginea*) can stand are reflected in the very low I_t (areas with rather cold winter), and low summer rainfall (summer drought). The most thermophile species (those with higher I_t) are *Q. coccifera* (lives under the most arid conditions of all), *Q. ilex* and *Q. suber*. The first two are more resistant to frost and drought than the latter.

Table 1. Ecological traits of Mediterranean *Quercus* species in Spain. AR: annual rainfall; SR: summer rainfall; I_t: (termicity index) = (T+m+M) x 10 (T: annual mean temperature, m: mean temperature of minima in the coldest month; M: mean temperature of maxima in the coldest month). (Modified from: Ortuño and Ceballos 1977; Ruiz de la Torre 1979; Franco 1990 and Rivas-Martínez and Sáenz 1991).

Species	**Habit**	**Altitude (m)**	**AR (SR) (mm)**	**I_t**	**Lithology**	**Area (ha) (%forest) (%coppice)**
Q. ilex	Tree, sclerophyllous	0-2000	>300 (>100)	70-470	Siliceous and calcareous	2 927 247 (56.4) (43.5)
Q. suber	Tree, sclerophyllous	0-1200 (1500)	>400 (>150)	160-470	Siliceous	365 847 (84.5) (15.5)
Q. pyrenaica	Tree, deciduous	(0)400-1600 (2100)	>600 (>125)	70-300	Siliceous	588 705 (36.3) (63.7)
Q. pubescens	Tree, deciduous	(360)400-1500	>600 (>150)	120-350	Calcareous	No data
Q. faginea	Tree, deciduous	(200)500-1000 (1900)	>400 (>150)	100-380	Siliceous and calcareous	281 394
Q. canariensis	Tree, deciduous	300-1000	>600 (>125)	120-400	Siliceous	(35.2) (64.8)
Q. coccifera	Shrub, sclerophyllous	0-1000 (1200)	> 200	160-470	Siliceous and calcareous	No data
Q. lusitanica	Shrub, deciduous	0-600	>600 (>100)	280-400	Siliceous	No data

Lithological characteristics are key factors in explaining the distribution of five of the species, while the other three are indifferent to this factor, or they have geographical varieties adapted to different lithologies. The intraspecific variation of these species is important in relation to their use in afforestation.

Figure 1. Range of the Mediterranean oaks in Spain

Economic and social importance

Oak species have had and still play a key role in Spanish land use systems. *Q. ilex* and *Q. suber* have been the most appreciated species, *Q. suber* due to cork industry, and *Q. ilex* mainly for the value of its sweet acorns as cattle feed (and even for humans). Fruits and leaves of the other species have been also used for the same purpose.

The different management systems of these species have lead to different landscapes. The most remarkable one is the “dehesa”, in which the original forest has been cleared to create a savanna-like formation. Dehesas are multifunctional systems that are exploited for agriculture, grazing, acorns, firewood and cork (when cork oak is present). *Q. ilex* and *Q. suber* are the species that more frequently form dehesas, but the other species can also participate. Dehesas predominate in western Spain, where soils are too poor for intensive agriculture (Figure 2).

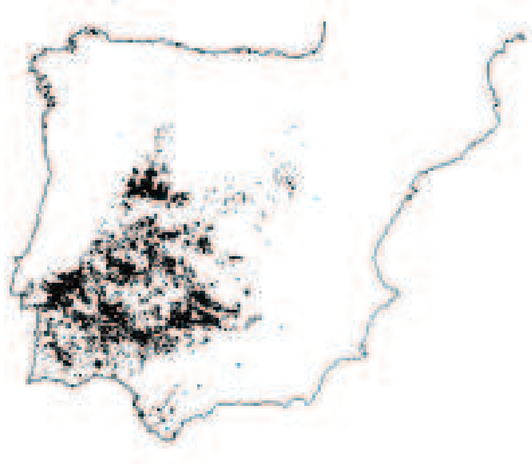


Figure 2. Distribution of "dehesas" in the Iberian Peninsula (from: Blanco *et al.* 1997)

The resprouting ability of *Q. pyrenaica*, *Q. faginea* and *Q. ilex* has influenced their management. These formations have been periodically clearcut to obtain charcoal and fuelwood, leading to the transformation of woodlands into coppice.

The less extensive range of *Q. pubescens* and *Q. canariensis* limits their use, but where they appear, the management is similar to that of the other oaks. Shrublike species, on the other hand, have been little used. *Q. lusitanica* has a merely anecdotic presence and a very small size, so it has no economic importance. *Q. coccifera* formations, are exploited for grazing, charcoal, hunting, apiculture, etc.

Conservation and use

Nearly 400 000 ha covered by Mediterranean oaks are included in the different types of protected area (National or Natural Parks, Reserves, etc.) (Table 2). In the case of *Q. canariensis*, 90% of the range is under protection. This of course is made easier by the fact that it has a very localised distribution. Cork oak is another species with an important proportion of protected areas (more than 40% of its pure stands).

Table 2. Area of each species with any type of legal protection (From: 2nd National Forest Inventory)

Specie (s)	Protected area (ha)	% of species' total area
Q. ilex	119 795	14.55
Q. suber	44 649	42.83
Q. pyrenaica	10 968	4.16
Q. faginea	261	0.5
Q. pyrenaica + Q. ilex	8 791	11.42
Q. faginea + Q. ilex	29 821	15.24
Q. ilex + Q. suber	123 909	22.07
Q. suber + Q. canariensis	43 449	90.38
Q. ilex + P. halepensis	11 497	13.55
Q. ilex + J. thurifera	4 970	4.0
Total	**398 110**	-

The arborescent species are being widely used in farmland afforestation programmes. As an example, we can mention the figures for *Q. suber*: from the beginning of the programme (1994) to December 1998, 21 353 ha were afforested with cork oak, and 42 391 ha with cork oak and holm oak (MAPA 2000). This strong demand led to occasional problems with seed supply, with the corresponding problems in controlling seed movements, in spite of regulations.

For *Q. suber,* several actions have been carried out in the last years. Marginal populations were characterized and potential risks of disappearance assessed (Gil *et al.* 1997). Two provenance and one progeny trials have been established within the frame of the Concerted Action EU/FAIR 1-CT 95-0202. A better understanding of genetic variability of the species has been gained through molecular studies (Elena-Rosselló and Cabrera 1996; Jiménez *et al.* 1999; Jiménez 2000).

Inventories

The range of all species is known in detail thanks to the national Forest Maps (Ceballos 1966; Ruiz de la Torre 1990). The most recent one provides additional information on composition and characteristics of the stand, secondary species, etc.

For tree species, silvicultural aspects (area, existences, regeneration, structure, etc.) are monitored through the National Forest Inventories (last one was carried out between 1986 and 1996).

The marginal populations of *Q. ilex*, *Q. suber*, *Q. pyrenaica*, *Q. faginea* and *Q. canariensis*, were catalogued when provenance regions were defined. The purpose of this catalogue was to stress the importance of these populations as unique genetic resources due to isolation and/or environmental singularity within the range of the species.

Legislation

Provenance regions for identification of forest reproductive material have been defined for all the tree species (Díaz-Fernández *et al.* 1995a, b; Jiménez *et al.* 1996, 1998). *Q. ilex*, *Q. suber*, *Q. faginea* and *Q. pyrenaica* are included in the regulation on commercialization of reproductive material, and a catalogue of selected stands has been elaborated and is periodically updated.

In regions with important areas of *dehesas,* specific legislation aimed at the maintenance and improvement of these management systems exists.

Research

Several research lines that focused on species of the genus *Quercus* can be mentioned.

Field trials established for *Q. suber* have made it possible to study the adaptive characters in this species. Ecophysiological studies, mainly focused on drought resistance, are being carried out at this moment. There is also a series of works on ecology of *Q. ilex* (ecophysiology, dynamics, nutrient cycling) (Escudero *et al.* 1992; Lledó *et al.* 1992; Rodá *et al.* 1999).

Molecular variation has been investigated in *Q. suber* by means of isozymes (Elena-Rosselló and Cabrera 1996; Jiménez 2000), RAPDs (Gallego *et al.* 1997) and AFLPs (Celestino *et al.* 1999; Toribio, pers.com.). Variability of citoplasmatic DNA has been assessed for *Q. pyrenaica*, *Q. faginea*, *Q. pubescens*, *Q. canariensis* and *Q. fruticosa* (Herrán *et al.* 1999; Olalde *et al.* 2000) and for *Q. suber*, *Q. ilex* and *Q. coccifera* (Jiménez 2000 and unp.data). Hybridization between *Q. ilex* and *Q. suber* has been studied with the aid of molecular markers (Elena-Rosselló *et al.* 1993; Elena-Rosselló and Cruz 1997).

There is also a long tradition of classical works on silviculture, pathology, management, etc., mainly on *Q. suber*. Phenological and fructification studies have been carried out in the most important species: *Q. suber* (Elena-Rosselló *et al.* 1993; Díaz-Fernández 2000) and *Q. ilex* (Siscart *et al.*, 1999).

Finally, another line is focused on the development of micropropagation techniques, with a special interest in *Q. suber* (Fernández-Guijarro *et al.*, 1994; Celestino *et al.*, 1999).

References

Blanco, E., M.A. Casado, M. Costa, R. Escribano, M. García, M. Génova, A. Gómez, F. Gómez, J.C.

Moreno, and C. Morla. 1997. Los bosques ibéricos. Una interpretación geobotánica. Ed. Planeta. Barcelona.

Ceballos, L. (dir.). 1966. Mapa Forestal de España. Ministerio de Agricultura. Madrid.

Celestino, C., B. Fernández Guijarro, I. Hernández, M. Molinas, P. Puigderrajols, I. Martínez, J. Hornero, F.J. Gallego, J.L. Manjón, J. Díez, and M. Toribio. 1999. Somatic embryogenesis in cork oak (*Quercus suber* L.). *In* Proceedings of International Congress "Applications of Biotechnology to Forest Genetics". Vitoria-Gasteiz, Spain. September, 22 - 25, 1999.

Díaz-Fernández, P.M. 2000. Variabilidad de la fenologia y del ciclo reproductor de Quercus suber L. en la península Iberica. PhD. Thesis. Universidad Politécnica de Madrid. España.

Díaz-Fernández, P.M., P. Jiménez, G. Catalán, S. Martín and L. Gil. 1995a. Regiones de procedencia de *Quercus suber* L. en España. ICONA. Madrid.

Díaz-Fernández, P.M., M.P. Jiménez, S. Martín, M. de Tuero, and L. Gil. 1995b. Regiones de procedencia de *Quercus robur* L., *Q. petraea* (Matt.) Liebl. y *Q. humilis* Miller. ICONA. Madrid.

Elena-Rossellò, J.A. and E. Cabrera. 1996. Isozyme variation in natural populations of cork.oak (*Quercus suber* L.). Population structure, diversity, differentiation and gene flow. Silvae Genetica. 45:229-235.

Elena-Rosselló, J.A. and P..J. de la Cruz,. 1998. Levels of genetic diversity in natural, mixed populations of oak species. *In* Steiner, K.C. (ed) Diversity and Adaptation in Oak Species. Proceedings of the 2nd meeting of Working Party 2.08.05, Genetics of Quercus, of the IUFRO. October 12-17, 1997. University Park. Pennsylvania, USA, pp 166-171.

Elena-Rosselló, J.A., J.M de Río, J.L. García Valdecantos, and I.G. Santamaría. 1993. Ecological aspects of the floral phenology of the cork oak (*Q. suber* L.): why do annual and biennial biotypes appear? Ann. Sci. For. 50(1):114-121.

Escudero, A., M. del Arco, and M.V. Garrido. 1992. The efficiency of nitrogen retranslocation from leaf biomass in *Quercus ilex* ecosystems. Vegetatio 99-100: 225-238.

Fernández-Guijarro, B., C. Celestino and M. Toribio. 1994. Somatic embryogenesis in *Quercus suber* L. *In* Pardos, J.A., Ahuja, M.R. and Elena-Rosselló, R. (eds.) Biotechnology of Trees. Investigación Agraria. Sistemas y Recursos Forestales. Fuera de Serie 4: 105-110.

Franco, J.A. (1990) *Quercus* L. *In* Castroviejo, S. *et al.* (eds.) *Flora Iberica.* Vol. II. Real Jardín Botánico, C.S.I.C., Madrid.

Gallego, F.J., I. Martínez, C. Celestino, M. Toribio. 1997. Testing somaclonal variation using RAPDs in *Quercus suber* L. somatic embryos. Int. J. Plant. Sci. 158: 563-567.

Gil, L., M.P. Jiménez and P.M. Díaz-Fernández. 1997. Characterization of marginal populations of *Quercus suber* in Spain. *In* J. Turok, M.C. Varela and C. Hansen (comp.). *Quercus suber* Network. Report of the third and fourth meetings. 9-12 June 1996, Sassari, Sardinia, Italy, and 20-22 February 1997, Almoraima, Spain. IPGRI. Rome.

Herrán, A., S. Espinel, and P.G. Goicoechea. 1999. Utilización del polimorfismo del ADN de cloroplastos para definir regiones de procedencia materna en los robles blancos de la península Ibérica. Investigación agraria, Sistemas y Recursos Forestales. 8 (1):139-150.

Jiménez, M.P. 2000. Análisis de la variabilidad genética de *Quercus suber* L. mediante marcadores moleculares y su aplicación a la conservación de recursos genéticos. PhD. Thesis. Universidad Politécnica de Madrid, España.

Jiménez, M.P., P.M. Díaz-Fernández, S. Iglesias, M. de Tuero and L. Gil. 1996. Las regiones de procedencia de *Quercus ilex* L. en España. ICONA. Madrid. 93 pp + mapas.

Jiménez, M.P., P.M. Díaz-Fernández, S. Martín and L. Gil. 1998. Regiones de procedencia de *Quercus pyrenaica* Willd., *Quercus faginea* Lam., *Quercus canariensis* Willd. ICONA. Madrid.

Jiménez, M.P., D. Agúndez, R. Alía, and L. Gil. 1999. Genetic variation in central and marginal populations of *Quercus suber* L. Silvae Genetica 48 (6): 278-284.

Lledó, M.J., J.R. Sánchez, J. Bellot, J. Boronat, J.J. Ibáñez, and A. Escarré. 1992. Structure, biomass and production of a resprouted holm oak (*Quercus ilex* L.) forest in NE Spain. Vegetatio 99-100: 51-59.

Ministerio de Medio Ambiente. 2000. Estrategia Forestal Española. Secretaría General de Medio Ambiente. Dirección General de Conservación de la Naturaleza.

Olalde, M., A. Herrán, S. Espinel, and P.G. Goicoechea. 2000. White oaks phylogeography in the Iberian Peninsula. For. Ecol. Man. (in press).

Ortuño, F. and A. Ceballos. 1977. Los bosques españoles. INCAFO.

Rivas-Martínez, S. and C. Sáenz. 1991. Enumeración de los *Quercus* de la Península Ibérica. Rivasgodaya 6: 101-110.

Rodá, F., J. Retana, , C.A. Gracia, and J. Bellot (eds.) 1999. Ecology of Mediterranean Evergreen Oak Forests. Ecological studies, 137. Springer-Verlag. Berlin Heidelberg, Germany.
Ruiz de la Torre, J. 1979. Arboles y arbustos. Fundación Conde del Valle de Salazar.
Ruiz de la Torre, J. (dir.) 1990. Mapa Foretal de España. ICONA. Madrid.
Siscart, D., V. Diego, and F. Lloret. 1999. Acorn Ecology. Pp. 75-88 *in* Ecology of Mediterranean Evergreen Oak Forests (F. Rodà, J. Retana, C.A. Gracia and J. Bellot, eds.). Ecological studies, vol. 137. Springer.

Tunisia

Noureddine Akrimi
Institut National d'Agronomie de Tunisie, Tunis, Tunisia

Introduction

In Tunisia, forests occupy 831 000 ha, that is to say nearly 5% of the national territory. Fifty five percent are deciduous forests and the remainder are maquis and garrigues. These forests are confined to the tops and the slopes of the Tunisian dorsal all the way to the Atlas chain and in some mountain of Mogods and Kroumirie.

Five oaks with different importance are present, three evergreen ones, cork oak, holm oak and kermes oak and two deciduous ones, zeen oak and afares oak. Only cork oak and zeen oak take part in the formation of pure or mixed forest stands. The others are found either as very degraded understorey (holm oak) or as bushes. The presence of afares oak is limited to few individuals.

The evergreen oaks

*Cork oak (*Quercus suber *L.)*

The last forest inventory (Direction Generale des Forets, 1995) estimates the cork oak area at 73 000 ha. Compared with the estimates carried out in 1950 of 127 000 ha, this area decreased by about 35% in less than 50 years. However, it is necessary to add a few thousand hectares in mixture with zeen oak, maritime pine, umbrella pine, radiata pine, brutia pine and eucalypts.

The Tunisian cork oak forests can be divided into two distinct geographical categories: the Mogod stands in a state of advanced degradation with a surface of 27 000 ha and those of Kroumirie, with a better facies and a surface of 46 000 ha. The cork oak area is limited to the humid and sub-humid bioclimatic stages where annual rainfall is above 750 mm and winters are moderate, mild or warm. Being strictly intolerant to limestone, cork oak occupies the acid substrates of numidic grez offering deep and sometimes hydromorphic grounds. On limestone soils it yields to Pinus pinaster.

Economic importance

The annual production of cork is about 10 000 tons, sold for about 9 million Tunisian dinars, that is to say 2/3 of the whole market of forest products (Regie d'Exploitation Forestiere, 1999). The wood production of 50 000m^3 is classified either as service woods (stakes poles…) or as charcoal. According to Abid and Selmi (1998) the cork industry provides 90 million stoppers, 12 000 tons of white agglomerate, 20 000 m^3 of black agglomerate, 600 tons of semifinished cork boards, 50 000 m^3 of decorative cork.

Other secondary products of cork oak forests are: 800 tons per year of heather stumps supplying two pipe manifacturing plants of pipes and an important amount of *Myrtus communis* being used for distillation of essential oils.

Extension and development of Tunisian cork oak forest

Normally, cork oak resprouts vigorously and buds germinate easily, but its natural regeneration in Tunisia poses serious problems. All stands have had their natural equilibrium disrupted, in particular by cutting, fires and overgrazing which is responsible for the destruction of the understorey and of the herbaceous cover including, the pedoflore and the pedofaune.

No regeneration cut or clearing had been applied to cork oak stands since the beginning of cork exploitation in 1896. To improve this situation, management plans were applied since the end of the 1960's. The plans are mainly based on:

- Exhaustive inventory of the stands.
- Urgent forest intervention supporting the regeneration of declining stands
- Balance between production potential and anthropo-zoogenic pressure
- Determination of age of exploitability at 96 years and rotation period fixed at 24 years (2 rotations of 12 years for debarking)
- Total surface for regeneration should not exceed a quarter of the total forest at any given time.

Regeneration in the managed forests

Regeneration by renovation cut (resprouting) is limited to some stands. The two most used modes are direct sowing and plantation. These methods can only be successful if conservation and production of acorn is adequate and if seedling production, soil preparation, and seedling installation and care in the field are carried out in an appropriate manner.

In the case of acorn conservation, this poses problems because of the acorns brittleness and their “recalcitrant” nature (can not be desiccated beyond a certain threshold of moisture below which their viability will be compromised.).

The following factors influence acorn viability:

- Maturity: the immaturity of acorns facilitates their conservation but weakens their germinative capacity (Hasnaoui 1992).
- Water content: dehydration should not descend below a rate of 30 to 40% (CEMAGREF 1983)
- Temperature: the optimum is around 1°C. At 6 °C, many cryptogamic attacks occur and below 1 °C the acorns undergo irreversible damage due to the destruction of their enzymatic system
- Breathing is related to temperature and moisture content: high levels entail an intensification of breathing activity synonymous with exhaustion of reserves and deteriation of seed viability.

According to Stiti (1999), the following precautions are likely to enhance acorn conservation:

- Sorting and testing of viability of the acorns at the place of harvest
- Treatment of the collected acorns with heat and a suitable fungicide
- Packing the acorns in barrels alternating layers of acorns with peat or pine litter
- Storage of acorns in a cool-room at a temperature of 1 °C and a relative humidity of 80% paired, after two months of storage, with a thermoatomizing with fungicide.

The production of seedlings also plays an important role. This operation used to represent a genuine barrier to afforestation programmes that included cork oak. The use, during the last decade, of modern seedling production techniques, based on new substrates of local composts, adequate containers and undercutting made it possible to produce seedling in sufficient numbers and quality. Six modern nurseries with a capacity of one million seedlings each are currently operational. Their number will increase to twenty by 2004.

The techniques for seedling establishment in the afforestation site have in turn advanced, particularly for what concerns the choice of the afforestation sites and the generalisation of mechanic preparation (subsoiling, bank ploughing).

Some research projects are currently carried out as:

- Selection of the best provenances
- The behaviour of cork oak in a youthful state live with some constraints
- Optimisation of cork cutting

The extent and the gravity of the problems arising from this priority species of first importance, for the country, require more ambitious research programmes and more consequent means.

Holm oak (*Quercus ilex *L.)

Its presence in Tunisia is related to Aleppo pine of which it forms the understorey in the most dynamic facies. Pure stands are very rare and occupy the most favourable sites from the point of view of climate and soil. It is found in the semiarid and especially subhumid bioclimatic stages, exceptionally in arborescent form, but mostly as bush or shrub. This is a clear indication of the double stress that it undergoes due to human activities (high quality charcoal) and of his herds (foliage and acorns are well appreciated by sheep and goats). It is generally confined to the mountains of the Tunisian dorsal up to an altitude of 400 m and in particular is found in Jl Abderrahman, Jl Mansour, La Kessra, Jl Ouargha, Jl Takrouna, Touiref, Jl Semmama and Jl Chambi. In Kroumirie, there are some stands north of Ghar Dimaou.

Natural regeneration is practically non-existant due to the scarcity of seeds, caused by coppicing and grazing. In addition, acorns, when they exist are very palatable. Under these conditions its regeneration is ensured by sprout and suckering. The latter regeneration mode is particularly favoured by fire, which causes abundant emission of suckers.

***Kermes oak* (Quercus coccifera L.)**

In Tunisia, it is common on humid, sub-humid and sometimes semi-arid coastal areas from Tabarka to Hammamet. It occupies coastal dunes and, sometimes, coastal hills subjected to maritime influence. It usually takes a shrubby aspect with a 1 m height, rarely that of a maquis with 1 to 2 m height and exceptionally that of a tree of 5 to 7 m height (a single station in Tabarka). It resists well to cattle grazing thanks to its persistent, coriaceous and thorny foliage. It can hybridize with holm oak, and this confers it great polymorphism. Kermes oak sprouts vigorously and suckers abundantly even after the extraction of its stumps. It plays a very significant role in the fixing of maritime dunes and constitutes an essential component of the coastal ecosystems in northern Tunisia.

The decideous oaks

***Zeen oak* (Quercus canariensis = Q. faginea = Q. mirbeckii)**

Its presence in Tunisia is limited to the humid bioclimatic stages. Its surface has constantly decreased over the last decades. In 1950, it was estimated at 40 000 ha, of which 10 000 ha in pure stands and the remainder in mixture, some with the cork oak, while in 1995 the surface determined by the National Forest Inventory of 1995 was of only 6 414 ha in pure stands, with no indication about mixed stands. Both pure and mixed stands of zeen oaks always occupy the wetter stations with the deepest soils, often at altitudes exceeding 700 m on northern exposures and 800 m on southern exposures. However, it is also found at the bottom of valleys along the banks of wadis due to the favourable edapho-climatic conditions.

The main stands are located in the mountains of El Feija, Tegma, Ain Draham, and Tabarka. Its southermost limit is Jl Takrouna, near Sakiet Sidi Youssef, localised in the wettest and most inaccesible valleys.

The wood of the zeen oak is not much appreciated because of its limited technological properties (difficult to dry, very hard to work, etc.). It was used, in the past, for rail spleepers, mine poles, and for firewood.

In spite of the abundant production of acorns with high germination capacity, there is a widespread problem with natural regeneration. This phenomenon is due to excessive anthropo-zoogenic pressure (Hasnaoui, 1992). Indeed, despite the acorn abundance, the intermediate growth classes between the seedling stage and adult are practically non-existant.

Research programmes aiming at favouring natural regeneration and improving technological characteristics of wood are crucial in order to guarantee the future of this species and to assign it an economic role.

*Afares oak (***Quercus afares** *L.)*

Only some relic individuals of this species, isolated and scattered among the cork oak and zeen trees, remain in Ain Zana, El Feija and Jl Ghorra up 900 m of altitude. *Q. afares* requires more moisture than the zeen and cork oaks and is confined to the higher elevations where annual rainfall is up 800 mm.

Stands regeneration is a problem for this species too. Obviously this phenomenon is made all the more serious by the fact that this species is extremely rare and is seriously threatened of disappearance.

References

Abid, H. and K. Selmi. 1998. La suberaie tunisienne, importance et orientations pour une gestion durable. *In* Actes du Séminaire Méditerranéen sur la Régénération des Forêts de Chêne Liège. Annales de l'INRGREF, numéro spécial pp 63-72.

CEMAGREF. 1983. Régénération artificielle du chêne liège. Note technique n° 50 ; 72p.

Direction Generale des Forets. 1995. Résultats du premier inventaire forestier national en Tunisie.

Hasnaoui, B. 1992. Chênaies du Nord de la Tunisie, écologie et régénération. Doct. es-sc. nat. Univ. de Provence-Aix-Marseille I.

Régie d'Exploitation Forestière, 1999. Rapport annuel

Stiti, B. 1999. Contribution à la maîtrise des méthodes de conservation des glands de chêne liège en Tunisie. DEA, Fac. Des Sciences de Tunis.

Turkey

Nihal Özel
Aegean Forestry Research Institute, Izmir, Turkey

Introduction

The oak genus, which has more than 200 species in the world, has 18 species in Turkey. Their identification keys are provided in Box 1.

Box 1. Identification keys for Turkish oaks

1. Leaves thickly coriaceous, evergreens (Section Ilex*)*
2. Leaves glabrous beneath when adult, usually spiny ***Q. coccifera***
2. Leaves tomentose beneath when adult, entire to spiny serrate
3. Fruit maturing in second year; cupule to c. 2.5 cm diameter; leaves waxy tomentose beneath; acorns sweet ***Q. aucheri***
3. Fruit maturing in one year; cupule c. 1.5 cm diameter; leaves not waxy tomentose beneath; acorns bitter ***Q. ilex***
1. Leaves herbaceous, sometimes ± coriaceous, deciduous or persisting over winter till spring
4. Fruit maturing in second year; peduncle of mature fruit very sturdy (2.5-5 mm diameter); at least some cupule scales clearly spreading or deflexed (Sect. Cerris*)*
5. Leaves glabrous beneath, oblong to oblanceolate
6. Petioles 8-15 (-20) mm; leaves c. 7-12×2-3 cm ***Q. libani***
6. Petioles 2-6 (-8) mm; leaves 3-8 ×1.5-3 cm ***Q. trojana***
5. Leaves ± densely tomentose beneath, ovate, ovate-oblong to oblong-elliptic
7. Leaf lobes mucronulate or scarcely so; buds with ± persistent stipules; cupule scales linear-subulate ***Q. cerris***
7. Leaf lobes aristate or mucronate; stipules deciduous; cupule scales linear-oblong or rhomboid
8. Leaves ± regularly serrate; cupule scales broadly rhomboid ***Q. brantii***
8. Leaves with ± irregular triangular acute lobes; cupule scales linear-oblong, woody at maturity Q. ithaburensis *subsp.* macrolepis
4. Fruit maturing in one year; peduncle of mature fruits ± slender (1-3 mm diameter); cupule scales adpressed or spreading only near apex (Sect. Quercus*)*
9. Leaves ± regularly serrate with up to 30 teeth ***Q. pontica***
8. Leaves lobed to entire, never serrate
10. Leaves semi evergreen, narrowly oblong to ovate, entire to ± crenateserrate ***Q. infectoria***
10. Leaves deciduous, ± obovate, usually ± deeply lobed
11. Peduncle prominent, to 12 cm
12. Intercalary veins present, leaves ± deeply lobed; young shoots light brown to reddish brown ***Q. robur***
12. Intercalary veins absent, leaves with ± shallow lobes; young shoots dark reddish brown ***Q. hartwissiana***
11. Peduncle absent, or to 5 mm
13. Leaves densely stellate- pubescent beneath
14. Stipules persistent on terminal buds; cupule scales loosely adpressed to ± spreading ***Q. macranthera subsp. syspirensis***
14. Stipules deciduous; cupule scales adpressed
15. Petiole 5-10 mm; leaf margin strongly undulate ***Q. pubescens***
15. Petiole 6-20 mm; leaf margin ± flat ***Q. virgiliana***
13. Leaves with a ± thin indumentum beneath
16. Leaves sessile, auriculate, clustered at shoot apices ***Q. frainetto***
16. Leaves petiolate, distributed over shoots
17. Intercalary veins well developed, secondary leaf lobes present ***Q. vulcanica***
17. Intercalary veins absent or nearly so; secondary leaf lobes absent or present ***Q. petraea***

In addition to these species, some botanists have reported that *Quercus calliprinos*, which is common in Israel, occurs in Eastern Taurus Mountains. However, there is not enough evidence to support this claim.

The taxonomical position of *Quercus* is not clear in Turkey yet, especially in cases such as *Q. infectoria, Q. pubescens* and *Q. cerris*. These taxa are very variable in morphological characters and frequently interact with each other. On the other hand, *Q. vulcanica*, which is endemic and endangered in Turkey and Q. *petraea,* are very similar in morphology. All these species need detailed studies.

Turkey's oaks, based on anatomical characteristics of their wood, maturation period of fruits and especially on their leaves and bark can be grouped as follows: 1- White oaks, 2-Red oaks, 3-Evergreen oaks.

White Oaks (Section: *Quercus*) include *Q. robur, Q. petraea, Q. hartwissiana, Q. frainetto, Q. vulcanica, Q. pontica, Q. infectoria, Q. pubescens, Q. macranthera* subsp. *syspirensis,* and *Q. virgiliana*.

Red Oaks (Section: *Cerris*) include *Q. libani, Q. trojana, Q. cerris, Q. brantii*, and *Q. itheburensis* subsp. *macrolepis*.

Evergreen oaks (Section: *Ilex*) include *Q. coccifera, Q. ilex*, and *Q. aucheri*

These species can grow with all kinds of soil types and climatic condition. Most of them, particularly Mediterranean oaks, are also resistant to drought, poor soil conditions and can grow on very loose soils. They rarely form pure stands. Most of them are secondary trees in mixed stands or understorey shrubs in coniferous forests and pure or mixed maquis areas.

Economical value of oak species

Quercus species are the second most important group of deciduous species after *Fagus* species in Turkey. Indeed these species spread all over Turkey from North to South and East to West. The different species are used as coppice (especially *Q. cerris*), for timber (in the Black Sea region), for secondary products from acorns (Valonea oak), for erosion control and for fodder (in south and southeast Anatolia). Mostly, the utilization by local people for these different purposes is not regulated and these species should be given greater attention.

The General Directorate of Forestry, Ministry of Forestry, owns the coppiced areas and manages them through Forest Enterprises. The Enterprises give 80% of the production to the forest villagers in return for their work, and sells the rest to other villagers. Improving the coppice areas is also a responsibilty of the Enterprises. However, forest villagers as well as other people use the coppice area in an uncontrolled way for different purposes.

Conservation status in Turkey

With its richness in genetic diversity, Turkey has a unique position. Two important gene centres (Near East and Mediterranean) described by Vavilov (1951) are located in the country. Besides these two gene centres, Turkey has also centres of for many wild, transitional and cultivated forms of annual, perennial, herbaceous and woody plants. It is also a transitional area of the European-Siberian, Irano-Turanian and Mediterranean flora regions.

Being in temperate climatic belt, Turkey is very rich in habitat diversity due to the diversity in its geomorphology, topography and climate. As a result, Turkey is very rich in plant species. Studies have shown that there are approximately 10 000 species of vascular plants in Turkey and about 3000 of them are endemic. Turkey also has gene centres of some forest trees such as fir, spruce, cedar, juniper, sweet gum etc. and wild relatives of cultivated plants such as wheat, barley, lentil chickpea, apple, pear, cherry, walnut, pistachio etc. which are crops of worldwide importance.

Being a bridge between Europe and Asia where many ancient civilisations lived, the natural landscape of Anatolia has been changed by the long-term human impacts on natural resources. It is generally accepted that in most of the country the present steppe dominated vegetation is the result of long term anthropogenic effects. The structural changes have become faster in last a few centuries due to:

- Agricultural activities (ploughing pastures for cultivation, overgrazing, stubble burning)

- Industrialisation, urbanisation and construction highways and dams
- Harvesting plants from nature
- Forestry activities and wildfires
- Tourism.

Particularly after the 1950s, these activities have created pressure on biological diversity beyond the carrying capacity of the land. The most important consequences of these activities are the reduction and fragmentation of natural habitats.

Because of all this, the Turkish Government and related Institutes have tried to take some measures. In the forestry sector, for example, national parks, nature parks nature conservation areas, nature monuments, biogenetic reserve areas, gene conservation forests, protection forests, seed stands and gene management zones have been created to protect at least part of the remaining natural areas. Today they are 32 national parks, 11 nature parks, 32 nature conservation areas, 54 nature monuments, 7 biogenetic reserve areas and 322 seed stands for 26 different forest trees.

The creation of Gene Management Zones (GMZ) for *in situ* conservation of plant genetic diversity is a new approach for Turkey. The Ministry of Forestry, the Ministry of Agriculture and Rural Affairs and the Ministry of Environment have carried out a project on this subject with the support of the World Bank under Global Environmental Facilities Program. After the project several GMZs were chosen according to their biodiversity and their boundaries have been identified.

The Turkish Biodiversity Action Plan also addresses some of the main factors that cause increased pressure on natural resources. These are:

- A considerable portion of the Turkish population still lives in rural areas close to forests or pastures and they depend on fuelwood for heating and cooking. Also, people living in rural areas are the people with the lowest incomes. With the current population growth rate, the demand for natural resources will increase in the future. Therefore, developmental projects for improving the life styles of these people are essential for continuity and effectiveness of conservation programs dealing with natural resources.
- There is still a large area in Turkey, which is mainly covered by forests and grasslands and there are agricultural lands within these areas. To determine the ownership of these lands, cadastral work has to be completed in the whole country. Otherwise, many forest and pastureland habitats will be lost for agricultural purposes.
- Due to urbanisation and tourist development, in recent years there has been an increasing pressure on forest and maquis, pasture and even agricultural lands. Without strict land use regulations, it is very difficult to preserve these habitats for very long. Therefore, environmental as well as natural resources impact assessment reports should be carried out before any developmental or industry related projects are implemented

Conservation status for oaks

There are not enough protected areas for oak in Turkey. There is only one national park, which has been specifically created to protect *Quercus vulcanica*, which is endemic to Turkey and is currently endangered. Thus, further attention should be given to this subject.

In Turkey, one of the most important problems is lack of land use classification. This is a problem in oak areas too. According to cadastral maps, these areas are forest land and are owned by the State. But most governments have ignored the oak areas for political reasons, and some enterprises have transformed them into coniferous forest in the name of productivity. Additionally, terrorism problems have caused the loss of many *Quercus* areas, especially in Eastern and Southeastern Anatolia. Even genetic reserves have been totally lost in some areas. Therefore, oak areas and their genetic base has shrunk.

Conclusions

According to the 1984 inventory of management plans, *Quercus* species cover 6.5 million hectare area of which only 750 000 hectare is high forest in good conditions while 5 750 000 hectares are coppice, degraded coppice and maquis areas. With respect to Turkey's total forest area, which is 20.7 million hectare, this amount is very large and important. However, loss of oak genetic diversity is continuing to occur in whole Turkey and relevant institutions should take measures as soon as possible. Considering the increase in Turkey's population, the problem becomes even more serious.

Suggestions

1. In all countries, species to be conserved should be identified and endemic, endangered and economical species must be given priority.
2. Taxonomical, biological, ecological and genetic studies related to *Quercu*s species should be completed.
3. Researchers, decision-makers and implementers should collaborate closely.
4. The most suitable conservation method(s) and strategies (*in situ*, *ex situ*, genebank or all) should be identified and applied in all countries.
5. Adaptation and provenance trials should be carried out in Mediterranean countries with similar ecological conditions.
6. To conserve target *Quercus* species and to reduce pressure on *Quercus* areas, forest villagers should be trained and supported, particularly in developing countries.

Programme

Wednesday 11 October - arrival of participants

Thursday 12 October

Opening of the meeting:

9:00 Welcome (Host country and Chair of the Network)
9:15 Introduction (IPGRI)
9:30 Adoption of the agenda and nomination of rapporteurs

Presentation of the history and main outputs of the *Quercus suber* Network:

9:40 Highlights on progress made in countries (R. Lumaret, F. Spada, H. Sbay, M. C. Varela, L. Gil, N. Akrimi)
10:30 Case Study: Conservation of genetic resources of cork oak in Spain (P. Jimenez)
11:00 Coffee Break
11:30 Web Page (EUFORGEN Secretariat)
11:45 Bibliography (EUFORGEN Secretariat)
12:00 Technical guidelines (EUFORGEN Secretariat)
12:30 EU-FAIR Project "European network for the evaluation of genetic resources of cork oak for appropriate use in breeding and gene conservation strategies" (M. Carolina Varela)

13:00 Lunch

Assessing priorities for the Mediterranean Oaks Network:

14:30 Genetic diversity of Mediterranean oaks (F. Spada)
15:00 Country reports on Mediterranean oaks (All countries, approx. 10' each)
16:30 Coffee break
17:00 Country reports - continued
17:30 Presentation of the priority table (EUFORGEN Secretariat)
17:45 General discussion on needs and priorities

Friday 13 October

8:30 Working sessions on conservation strategies for different groups of Mediterranean oaks (economically vs. ecologically important, widely occurring species vs. rare and threatened species)
10:30 Presentation of results of the working groups on conservation strategies
11:00 Coffee break
11:30 Working sessions on the activities proposed for the workplan (e.g. information management, legal and policy issues, technical guidelines and methodologies, public awareness tools)

13:00 Lunch

14:30 Presentation of results of the working groups

15:00 Development of the workplan for the Mediterranean Oaks Network
16:00 Coffee break
16:30 Development of the workplan (continued)

Saturday 14 October

Field trip (1/2 day)

15:00 Election of Chair and Vice Chair
15:30 Date and place of next meeting
16:00 Coffee break
16:30 Any other business
17:00 Adoption of the report
18:00 Conclusions and closure of the meeting

Sunday 15 October – departure of participants

List of participants

Maxhun Dida
Forest and Pasture Research Institute
Rr. Halit Bega 23
Tirana
Albania
Tel: +355 4371237
Fax: +355 4371242
Email: ikpk@albaniaonline.net

Alexander Alexandrov
Forest Research Institute
Klimant Ohridski Blvd. 132
1756 Sofia
Bulgaria
Tel: +359-2-622961
Fax: +359-2- 622965
Email: forestin@bulnet.bg

Christou K. Andreas
Dpt of Forest
1414 Nicosia
Cyprus
Tel: +357-2-303836
Fax: +357-2-303935
Email: publicity@cytanet.com.cy

Roselyne Lumaret
Centre Louis Emberger
1919 Route de Mende
BP5051
34033 Montpellier
France
Tel.: +33 4 67613273
Fax: +33 67412138
Email: lumaret@cefe.cnrs-mop.fr

Francesco Spada
Department of Botany
Universitá Degli Studi di Roma
Piazzale Aldo Moro, 5
00185 Rome
Italy
Tel: + 39 066833878
Fax: +39 06
Email: francesco.spada@vaxtbio.uu.se

Vlatko Andonovski
Faculty of Forestry
PO Box 235, 1000 Skopje
Macedonia, FYR
Tel: +389 91 135033
Fax: +389 91 381813
Email: silva@mkinter.net

Eman Calleja
Wied Incita Nursery
Department of Agriculture
Attard
Malta
Tel: +365-419125
Email: emanc@orbit.net.mt

Hassan Sbay
Centre National de Recherche Forestière
PO Box 763
Agdal, Rabat
Morocco
Tel: +212 37 75 31 45
Fax: +212 37 67 11 51
Email: hsbay@mailcity.com

Maria Carolina Varela
Estação Florestal Nacional
Procalfer- Quinta do Marquês
2784-505 Oeiras
Portugal
Tel: +351 21 441 57 63
Fax: +351 21 441 56 60
Email: mcarolina@mail.telepac.pt

Luís Gil
ETSI Montes
Universidad Politecnica de Madrid
Ciudad Universitaria
28040 Madrid
Spain
Tel: +34 91 3367113
Fax: +34 91 5439557
Email: lgil@montes.upm.es

Gösta Eriksson
Swedish University of Agricultural Sciences
Box 7207
75007 Uppsala
Sweden
Tel: +46 18671240
Fax: +46 18673279
Email: gosta.eriksson@sgen.slu.se

Noureddine Akrimi
INAT
43 Avenue Charles Nicolle
1082 Tunis Mahrajene
Tunisia
Tel: +216-1-287110; 892 785
Fax:+216-1-799 391
Email: akrimi.noureddine@inat.agrinet.tn

Nihal Özel
Aegean Forestry Research Institute
Karsiyaka
35530 Izmir
Turkey
Tel.: +90 232 3697693
Fax: +90 232 3697534
Email: nihalo@rocketmail.com

Simone Borelli
IPGRI Regional Office for Europe
Via dei Tre Denari, 472/a
00057 Maccarese (Fiumicino)
Rome
Italy

Observers

Hasan Özer
Research and Environment Dept.
Ministry of Forestry
Kizilay - Ankara
Turkey
Tel. +90-312 4177723
Fax +90-312 4179160
Email: hasanozer@yahoo.com

Pilar Jimenez
ETSI Montes
Universidad Politecnica de Madrid
Ciudad Universitaria
28040 Madrid
Spain
Tel: +34 91 3367113
Fax: +34 91 5439557
Email: pjimenez@montes.upm.es

Tom Bazuin
IPGRI-CWANA
PO Box 5466
Aleppo, Syria
Tel: +963-21-2231412
Fax: +963-21-2273681
Email: t.bazuin@cgiar.org

Unable to attend

Joso Graçan
Forest Research Institute
10450 Jastrebarsko
Croatia
Tel: +385 1 6281492
Fax: +385 1 6281493
Email: josog@sumins.hr