IPGRI

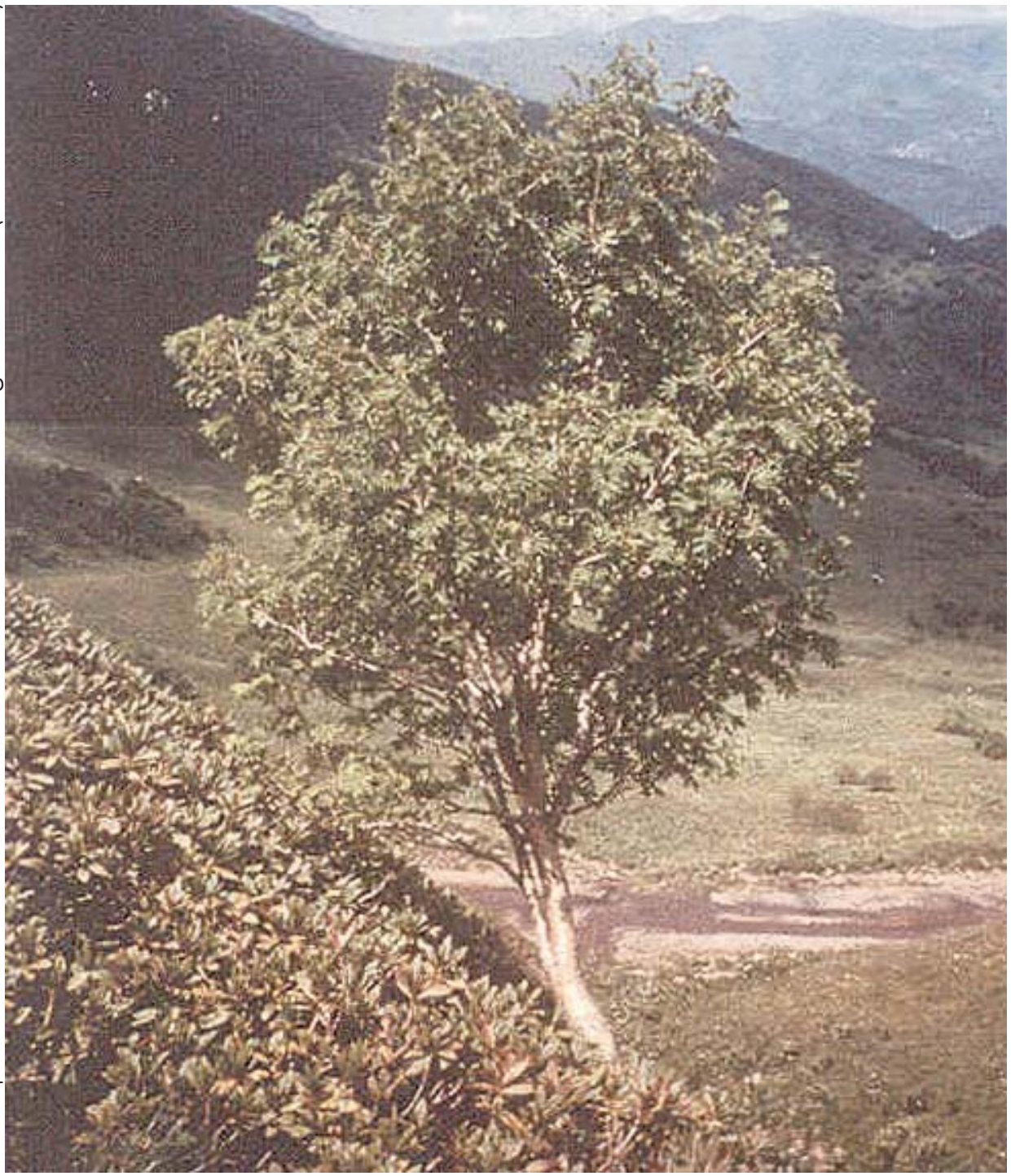
Noble Hardwoods Network

Report of the fourth meeting—4–6 September 1999—Gmunden, Austria and the fifth meeting—17–19 May 2001—Blessington, Ireland

J. Turok, G. Eriksson, K. Russell and S. Borelli, *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)

Noble Hardwoods Network

Report of the fourth meeting—4–6 September 1999—Gmunden, Austria and the fifth meeting—17–19 May 2001—Blessington, Ireland

J. Turok, G. Eriksson, K. Russell and S. Borelli, ***compilers***

European Forest Genetic Resources Programme (EUFORGEN)

Citation:
Turok, J, G. Eriksson, K. Russell, and S. Borelli. 2002. Noble Hardwoods Network, Report of the fourth meeting, 4–6 September 1999, Gmunden, Austria, and the fifth meeting, 17–19 May 2001, Blessington, Ireland. International Plant Genetic Resources Institute, Rome, Italy.

ISBN 92-9043-496-1

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

Contents

Summary of the fourth meeting (Gmunden, Austria)[1]

European long-term gene conservation strategies

Two new strategy documents were presented (*Alnus* spp. by Davorin Kajba and *Juglans* spp. by Josefa Fernandez). They provided an overview of the current status of knowledge, objectives and methods used for gene conservation. These documents aim at assisting countries in the development of their national strategies for Noble Hardwoods. Eric Collin submitted a revised European strategy on elms, which was adopted by the Network. All the three strategy documents will be published in the Report of the meeting. They will be completed by the authors and sent (electronic version and printed copy) to the EUFORGEN Secretariat before 15 October 1999.

Technical guidelines

The outline of all chapters (see Report of the previous meeting) was discussed in working groups and agreed upon by the plenary (Annex 2). It was agreed to add a chapter on silvicultural management of Noble Hardwoods (Peter Rotach). G. Eriksson, J. Kleinschmit and J. Turok will compile and edit the advanced draft version that will be sent for comments and suggestions to all Network members by the end of 1999. The Technical Guidelines will be completed and printed during the year 2000.

Progress made in national gene conservation

Introductory country reports from Armenia, Ireland, Luxembourg and Norway were presented. Brief round-the-table updates on the progress made in each country since the last meeting (June 1998), were provided by all participants. The reports presented at the meeting will be sent to the Secretariat by 15 October 1999. The following main highlights should be mentioned in the country updates: inventories, legislation, research, practical implementation, coordination at the national level, public awareness. Relevant data should be presented in additional table(s)—see Annex 3. In order to facilitate discussion at the next Network meeting, country updates will be requested, compiled and distributed by the Secretariat before the next meeting.

Inventories and documentation

It was agreed that common minimum information on Noble Hardwoods genetic resources should be shared among countries. Network members acknowledged the agreed list of descriptors. A group composed of Jochen Kleinschmit, Eric Collin and Karen Russell will prepare a concept note with the objectives of the information system stated and the coding characters specified. This will be circulated to Network members for comments and suggestions before 30 September 1999. The concept note will be included in the Report of the meeting. The Secretariat will make the requested minimum information accessible on the Internet before 31 March 2000.

Bibliography

Prototype of a home page was presented and the concept of publishing joint bibliography on the Internet endorsed. A taxonomic table will be added. Network members from countries that have not yet sent references will inform the Secretariat about the status of their compilation. The Secretariat will circulate a note (before 30 September 1999) reminding all Network members to send references in the specified format, or to send an update if the references have already been submitted.

[1]This workplan was adopted at the end of the fourth Network meeting.

Research

Several presentations on research topics of interest to the Network were made. EU-funded research projects, ongoing or under preparation, were mentioned.

Miscellaneous

It was suggested that the next Network meeting be held in spring 2001 in Ireland. Several themes were proposed for discussion at that meeting: the role of species hybridization in gene conservation (Eric Collin), links between gene conservation, tree breeding and utilization (Jochen Kleinschmit, Brigitte Demesure and Tor Myking), health status of Noble Hardwoods resources in Europe and exchange of genetic material. It was felt that the first theme should be given priority attention at the next meeting. The tentative agenda will be sent in due course.

Summary of the fifth meeting (Blessington, Ireland)

Opening of the meeting

Diarmuid McAree, Chief Forestry Inspector of the Irish Forest Service welcomed the participants to Ireland and wished them a successful meeting. Currently, 9% of Ireland is forested but the plan is to increase this proportion to 17% over the next 30 years, with 30% of this being broadleaves. He also indicated that hybridization of ash is a problem and hybrids are currently being removed. Dutch elm disease is a concern and alder is also experiencing problems with *Phytophthora*. Rowan and birch are other priority species for Ireland. The availability of reproductive material (particularly acorns) is a also a priority of the Forest Service.

To have all timber produced in Ireland from sustainable forest management is another objective together with conservation and enhancement of native resources. A new scheme for conserving or recreating 30 000 ha of native woodlands is being launched under the New Native Woodlands Scheme that has multiple objectives.

In fact, forestry is seen as a good way of creating employment and establishing a sustainable production system for future generations. Wildlife management, creation of bio-corridors for reducing fragmentation and carbon sequestration are also included among the aims.

He concluded by saying that the work of EUFORGEN is highly appreciated by the Irish Forest Service and is considered as a very cost effective international mechanism. Jozef Turok thanked him for his words of encouragement and briefly introduced the programme of the meeting.

Prof. Gösta Eriksson, Chair of the Network could not attend and it was proposed that selected Network members moderate the different sessions of the meeting.

Progress made in countries

Twenty-four countries (Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Lithuania, Luxembourg, the Netherlands, Norway, Poland, Portugal, Russian Federation, Slovakia, Slovenia, Switzerland, Turkey, United Kingdom and Ukraine) attended the meeting and three more were unable to attend (Armenia, Spain and Sweden. Turkey attended for the first time.

All countries briefly presented the progress made since the last meeting (held in September 1999) on inventories, legislation, research, practical implementation, coordination at national level and public awareness. Many of the participating countries carried out inventories and several new populations of Noble Hardwoods were identified. In some cases, maps were also produced. Regarding legislation, it appears that many countries are in the process of discussing and implementing or adopting EU Directive 1999/105/EC concerning trade and certification of forest reproductive material.

A number of collaborative research projects using both molecular and traditional quantitative techniques are ongoing. Specific results were presented in later sessions. New seed orchards for Noble Hardwood species have been established in a few countries. In general, it appears that coordination at national level continues to develop and it was recognized that further effort is needed.

Public awareness initiatives of the different countries were highlighted. These range from nationwide efforts such as the 'Tree of the year' to more localized training programmes, directed at forest practitioners and managers. Further discussion on public awareness took place in a later session.

Peter Rotach gave a comprehensive presentation on a project on Rare Noble Hardwoods in Switzerland, which could provide as a useful model for similar initiatives in other countries. The main objective was the promotion of rare species in forestry activities. The

project included 10 different species. A first important step was the identification of core populations and genepools, assessing the extent of fragmentation, and genetic and demographic risks. All information collected through inventories was digitized and mapped and priority populations were identified.

Motivation and training were essential components of the project and a large number of foresters were included in the activities both receiving training and providing feedback. Realistic strategies and priorities were identified based on the results of the inventories and incorporating the additional information from local practitioners. Technical guidelines directed at forest practitioners were produced for all species and also included region-specific information to increase local relevance. (the guidelines can be ordered for SF 12. per copy through http://www.admin.ch/edmz with the order number 310.094d for the German version and the order number 310.094f for the French version). A second phase of the project will be starting this year.

Murat Alan gave a full report on the conservation status of Noble Hardwoods in Turkey. He gave an overview of the general situation in his country. In particular, he highlighted the high biodiversity of Turkey and its importance as centre of origin for many species. He also proposed to include five new species in the list of Noble Hardwoods, i.e. *Liquidambar orientalis*, *Alnus orientalis*, *Pterocarya fraxinifolia*, *Platanus orientalis*, *Ostrya carpinifolia.* These will be incorporated in the Network's list, which will be updated on the Internet.

Seminar: The role of species hybridization in gene conservation

Eric Collin made a presentation on the role of species hybridization and illustrated the different scientific and 'philosophical' aspects of hybridization. He also provided different definitions of the 'species' concept and examples of different types of hybridization.

He indicated that general understanding of the dynamics of the ecosystem and of how the natural environment is constantly evolving is limited. Depending on circumstances, hybridization can be viewed as a negative, neutral or positive event in evolutionary terms. There is a need to clearly distinguish between hybridization of naturally occurring species and introduced species. Molecular studies can be very useful in the identification of the level of hybridization and/or introgression. In any case, 'methods should match objectives'.

He concluded that time and space are key elements in defining whether hybridization is acceptable, depending on individual perceptions. In any case, man has an important role in accelerating the process through mass seed transportation and habitat manipulation. It was clear that, in many countries, the divide between introduced and naturalized species is not well defined and is somewhat discretionary.

Eric Collin proposed to select some populations within gene conservation networks in which hybridization occurs and monitor their evolution. He will provide a written contribution to be added to the Report of the meeting, which will summarize his presentation and capture the views expressed during the discussion.

Technical guidelines

The outcomes of the first Inter-Network meeting of Chairs of the EUFORGEN Networks were presented (held in October 2000). The role of the Inter-Network Group is to harmonize priorities and coordinate activities among the five Networks, in order to share experience and avoid duplication of efforts. With regard to the technical guidelines, the Inter-Network Group agreed that a general document on the objectives, principles and methods of forest genetic conservation should be prepared within EUFORGEN, as a basis for the species-specific guidelines that could be developed as separate modules. This general document is being prepared with inputs from all Networks.

The outcomes of the Inter-Network Group meeting were discussed at length in order to harmonize them with the original concept of the technical guidelines for Noble Hardwoods

(see Summary of fourth Network meeting, held in 1999), which consisted of widely occurring species/situations, rarely occurring species/situations, plus case studies on elms and chestnut.

It was agreed that a separate chapter on the concept of rarity should be added to the general document, and that species modules for Noble Hardwoods should be produced as follows:

- *Acer pseudoplatanus* (M. Rusanen and T. Myking)
- *Sorbus torminalis* (B. Demesure)
- *Sorbus domestica* (P. Rotach)
- *Ulmus* sp. (E. Collin)
- *Prunus avium* (K. Russell)
- *Castanea sativa* (F. Lopez)
- *Fraxinus excelsior* (A. Pliura and M. Heuertz)
- *Malus sylvestris* and *Pyrus pyraster* (R. Stephan)
- *Alnus glutinosa* (J. Gracan)
- *Tilia cordata* (J. Jensen)
- *Liquidambar orientalis* (M. Alan)

Each module should be no longer than 4 printed pages, including illustrations etc. The final text should, therefore, be limited to 1200 words. Each module will be composed of the following components: standard introduction paragraph, distribution map (native and naturalized distribution will be highlighted in different colours), biology and ecology of the species, threats to genetic diversity, genetic knowledge, importance and use, and guidelines for genetic conservation and use. The guidelines will consist of a sequence of actions, or steps, ordered according to their technical and economic feasibility, which are required to ensure the conservation and sustainable use of genetic resources within the species' distribution areas in Europe.

The target audience, as agreed at previous Network meetings, includes forest officers and agencies responsible for applied forest genetic conservation in each country. The sheets will be first produced in English, but the template of each will be made available to Network members, who will be responsible for their translation and adaptation to national conditions. The modules will include relevant graphs, figures and illustrations. References for further reading will be included at the end of each module. There will also be a blank box (half-page) in the template, which should be used for specific information related to the individual country. All Network members will search for appropriate illustrations and provide them directly to the authors *as soon as possible*. Essential photos would include botanical features and habit, plus other illustrative material.

The Secretariat will send the standard introduction paragraph and distribution maps for each species or group of species to Network members for comments *before 31 August 2001.* All authors will send draft modules to the Secretariat *before 30 November 2001*. The Secretariat will edit the modules for language and consistency and will circulate them through the EUFORGEN listserver for broader consultation *before 31 December 2001*. The authors may seek inputs or review of the draft modules from other Network members and other specialists as appropriate. The first species modules will be printed *before the next Network meeting*.

Information and documentation

Report of the fourth and fifth Network meetings

The format of country reports was discussed and it was agreed that these would be published in a printed version together with material produced for the previous meeting. The Internet web page (http://www.ipgri.cgiar.org/networks/euforgen/euf_home.htm) will contain the full version of the introductory country reports and the current progress reports.

The table attached to the country update will only reflect the current situation of *in situ* and *ex situ* conservation measures (i.e. total figures). It is the participant's responsibility to ensure that the electronic version of all reports is made available to the Secretariat. Participants were encouraged to visit the web page and check the content relevant to them. Missing material should be sent to the Secretariat by *15 June 2001*.

EUFORGEN bibliography

The EUFORGEN online bibliography was presented and discussed. It was agreed that, to make grey literature accessible, a contact address needs to be provided. Permission from the contributors to use their names will be sought. The Secretariat will add a field for 'contact' to the existing Access format and circulate it through the listserver. The issue of what type of references the database should contain was also raised and there was general agreement that contributions should concentrate on grey literature. However, the existing references to refereed journals will be maintained. An introductory text will be added to explain the content of the bibliography and its focus on grey literature. A link to the IPGRI Library website, which includes links to other reference databases, will also be added.

Information platform

The new web page of the IPGRI Regional Office for Europe was presented and the link to national programmes highlighted. At present, the only information provided are details of the National Coordinators and the results of a survey conducted in 1998. In order to make these pages more informative, Network members were encouraged to provide links relevant to their national activities on forest genetic resources to be added to the country pages. To facilitate contacts, it is also proposed to provide details of participants to the last meetings of the five EUFORGEN Networks.

Public awareness

The recommendations of the Inter-Network meeting were briefly presented. A general EUFORGEN brochure is currently under preparation and will be available shortly.

Network members were strongly encouraged to promote genetic conservation at national level and to produce, adapt and use EUFORGEN material as appropriate. The opportunity to take advantage of existing initiatives, particularly those of conservation organizations, which could be more effective in promoting the conservation of forest genetic resources, should not be underestimated.

Sven de Vries reported on the discussion that was held in the Social Broadleaves Network and on the process of creating an interesting and effective poster.

There was general agreement that a set (3-4) of posters on Noble Hardwoods would be useful for raising public awareness on the importance of their conservation. The posters would have to use an attractive photo(s) and contain a simple and clear message. It was agreed that Sven de Vries, Tor Myking and Natalia Demidova would develop the message to be included on the posters. An initial draft will be provided to the Secretariat and *circulated to the Network for discussion at the next meeting.*

It was decided to create a slide collection on CD-ROM to be used by the Network for publications, public awareness, presentations etc., and Bart de Cuyper kindly offered to act as a focal point. It was agreed to acknowledge the source of images every time they are used. Instructions for contributions to the collection will be circulated by the Secretariat before *31 May 2001* and Network members are encouraged to provide slides to Bart de Cuyper by *30 September 2001*.

Research overview

CYTOFOR

Brigitte Demesure presented the current activities and results from the multi-species EU-funded project, which will end in June 2001. Nine countries were involved in the project and the activities concentrated on 22 species of 7 different families (14 trees, 7 shrubs and one epiphyte).

The project had a number of objectives, and included phylogenetic studies, history (postglacial migration routes), hybridization between species, linking ecological and population genetic studies, which will have practical implications for forest management. The tools included chloroplast DNA markers for phylogenetic studies. Postglacial migration routes were studied for all species and possible refugia were identified. Recolonization patterns were found to be quite different for the various species, and for some species, no obvious refugia could be defined. Geographical distances and genetic distances for the different species were compared. Distribution patterns of haplotypes appear to be strongly related to the biology of the species or history of the populations. *Sorbus torminalis* showed no geographic structure whereas the patterns for *Ulmus* were comparable to those for *Quercus* showing a clear geographic pattern in Europe.

Final results of the project will be available in a number of papers to be published in different journals. More information can be found at
<http://www.pierroton.inra.fr/Cytofor/Introduction.html>)

CASCADE

Alfas Pliura presented the EU-funded CASCADE project that focuses on evaluation of genetic diversity at adaptive traits and genetic markers in *Castanea sativa* in relation to evolutionary factors and human impact and on the formulation of long-term conservation strategies. Twelve institutions from Greece, France, Italy, Spain, Sweden and UK participate in this project.

The project includes six work packages that cover different research issues and socio-economic aspects of gene conservation. Preliminary results from studies of adaptive traits through phytotron studies, progeny trials and QTL analysis with different molecular markers were presented. (http://soi.cnr.it/~chestnut/home.html).

ResGen78—Conservation of Elm Genetic Resources

Eric Collin presented this project funded by the EU in the framework of the Genetic Resources programme of EU Regulation 1467/94. The project was based on existing *ex situ* collections of European elms (*Ulmus glabra, U. minor, U. laevis*). It includes 14 partners in 9 countries. The different partners provided different expertise such as molecular markers, cryopreservation, entomology and pathology. The project included six steps: (1) inventories and databases; (2) molecular characterization for taxonomy (nuclear DNA) and mapping migration routes (cpDNA); (3) testing tolerance to Dutch elm disease and identification of adaptive and ornamental traits; (4) building a core collection; (5) maintenance of the core collection; and (6) dissemination of results. More information can be found at http://www.cemagref.fr/English/ex/rural-areas/Elms/Elms02.htm

Genetic Resources of Broadleaved Forest Trees Species in Southeastern Europe

Myriam Heuertz presented the objectives of the second Phase of the project and emphasized the complementarities between *in situ* and *ex situ* conservation, as well as capacity building and exchange of scientists between the countries involved and other countries in Europe. The project is carried out in Bulgaria, Moldova, Romania and Ukraine in cooperation with Luxembourg. Species covered by the project include oak, beech, ash and maple. Activities include inventories of genetic resources, production of distribution maps and identification of seed stands. Joint micropropagation experiments were carried out and training on molecular genetics was provided.

Emil Popov presented the results of the inventories of *Fraxinus* sp. and *Acer* sp. in Bulgaria.

Phylogeography of *Fraxinus* sp. in Europe

Myriam Heuertz presented the results of a research effort that aimed at analyzing cpDNA of *Fraxinus excelsior* with regard to its phylogeography in Europe. Chloroplast microsatellite markers were used. A large number of populations and individuals were sampled across Europe. Haplotype distribution was mapped and main differentiation zones and migration routes were identified. The genetic data were congruent with fossil pollen data. Similar work was carried for *Fraxinus angustifolia* and *F. ornus.* The possibility for identifying origin of non-autochthonous populations was emphasized.

Some data from a geneflow study of *Fraxinus* in southeastern Europe were also presented. Sampling was carried out on 10 stands in Bulgaria and one stand in Romania. Nuclear microsatellite markers were used for characterization. The results were used for calculation of neighbourhood size but contrasting results were found at different scales within populations. Therefore, further investigation is needed.

Improving *Fraxinus* productivity for European needs by testing, selection, propagation of improved genetic resources (RAP)

Gerry Douglas of Teagasc, Ireland presented this new EU-funded project that addresses genetic diversity, breeding, sexual and vegetative propagation and other aspects of ash productivity. Existing provenance trials will be analyzed and new provenance trials will be established in six countries.

Bottlenecks for production and utilization of genetically improved material will be identified and evaluated through social studies involving all stakeholders. The chain of influence will be characterized and impacts on certification will be demonstrated.
Demonstration plots will be established.

National Council for Forest Research and Development, Ireland (COFORD)

Eugene Hendrick, director of COFORD, provided an overview of the history of the institution and its strategic objectives. The role of COFORD is to coordinate and fund national forestry research in Ireland. The new research programme (2000-2006), is funded by the Irish Government under the National Development Plan. Forest genetics and breeding is one of the subject areas. There are six priority species (*Quercus robur, Q. petraea, Fraxinus excelsior, Acer pseudoplatanus, Betula pendula, B. pubescens*). Strategic actions include inventories of these species, designation of *in situ* conservation areas and selection of seed collection areas. Within forest genetics there will be capacity building and increased cooperation with EUFORGEN Networks was highlighted. In Ireland, several different research organizations (Coillte, Teagasc, University College Dublin, Trinity College Dublin and Duchas) are involved in forest genetics and breeding (http://www.coford.ie).

Research needs and priorities and dissemination of results

The problem of *Phytophthora* damage to *Alnus glutinosa* was raised and it appears that this is a common concern in many countries. The disease is also damaging other tree species and seems to be gradually spreading. Some research is being carried out in Germany and United Kingdom. It was proposed to invite a phytopathologist to one of the forthcoming meetings.
Hybridization was also thought to be a research priority and it was hoped that there would better information on mating systems (i.e. of *Fraxinus, Sorbus*) available in the near future. There appears to be scope for a research project on hybridization of fruit trees, however it was currently not possible to identify more concrete possibilities.
The need for research funding opportunities for east European countries was raised. Several relevant programmes and projects of the European Union were mentioned. IPGRI will make

available results of a preliminary survey on research funding opportunities conducted in European countries. Bilateral contacts were encouraged among Network members that can provide a further basis for research cooperation.

A request for cooperation and support for genetic research on *Liquidambar* in Turkey was also made.

Election of the Chair and Vice Chair

On behalf of the Network, Sven de Vries expressed the gratitude of the group to Gösta Eriksson for his leadership and the outstanding input he made to the creation and operation of the Noble Hardwoods Network and conveyed best wishes for his prompt recovery. Jochen Kleinschmit, who acted as Vice Chair of the Network, was also thanked for his excellent contribution. It was proposed that Mari Rusanen and Peter Rotach would be the next Chair and Vice Chair of the Network. The Network endorsed the proposal.

Adoption of the report

The participants adopted the summary report of the meeting.

Date and place of the next meeting

An official offer to host the next Network meeting was received from Armenia. Portugal also kindly offered to organize the meeting. The participants appreciated both offers. The potential impact of a Network meeting in Armenia on advancing genetic conservation in the mandate group of species was discussed and the participants expressed their preference for the next meeting to be held in that country. If, for some reasons, this first choice should not be feasible, then the meeting would be held in Portugal. It was proposed that the meeting should take place in early June 2002.

A proposal was also put forward that one of the forthcoming meetings be held in the United Kingdom in conjunction with a meeting of the Fruits Working Group of the European Cooperative Programme for Crop Genetic Resources Networks (ECP/GR). The participants expressed their strong interest in a joint meeting on issues related to complementary conservation strategies in species with both forestry and horticultural importance.

Any other business

It was proposed that a concise summary of the Network's activities, which was recently published in the journal Investigación Agraria (INIA, Spain), could be included in the printed Report of the fourth and fifth Network meetings. The Secretariat will confirm the feasibility of including English version of the summary in the Report.

Adolf Korczyk and Richard Stephan announced that they would be retiring in the near future and therefore would not be able to join next meeting. They expressed their satisfaction with having been associated with this Network and wished everybody successful continuation of activities.

Conclusions and closure of the meeting

The Secretariat and the Network members expressed their gratitude to the local organizers for the excellent arrangements and organization.

The newly elected Chair closed the meeting.

Introductory country reports

Ireland

***Michael Lally*[1] *and John Fennessy*[2]**

[1]*Coillte Teoranta, The Irish Forestry Board, Research Laboratory, Newtownmountkennedy, Ireland*
[2]*Coillte Teoranta, The Irish Forestry Board, National Tree Improvement Centre, Kilbride, Ireland*

Introduction

Ireland is one of the least-forested countries in Western Europe, and the native tree species are exceptionally few in number (Table 1). A striking aspect of native Irish flora is the fact that so many species which could be expected to occur based on their present-day natural distribution and ecology are absent (O'Sullivan 1999).

Total forest cover in Ireland is now approximately 602 900 hectares or 8.5% of the country's land area (Anonymous 1999). Ireland's soils and climate are highly favourable for growing trees and plantations.

Table 1. Native Irish trees

Latin name	Common name
Alnus glutinosa	Common alder
Arbutus unedo	Strawberry tree
Betula pendula	Silver birch
Betula pubescens	Downy birch
Corylus avellana	Hazel
Crataegus monogyna	Hawthorn
Euonymus europaeus	Spindle
Fraxinus excelsior	Common ash
Ilex aquifolium	Holly
Juniperus communis	Common juniper
Malus sylvestris	Crab apple
Populus tremula	Aspen
Prunus avium	Gean, wild cherry
Prunus padus	Bird cherry
Quercus petraea	Sessile oak
Quercus robur	Pedunculate oak
Rhamnus catharticus	Purging buckthorn
*Salix alba**	White willow
Salix altrocinerea	Sally
Salix caprea	Goat willow
Salix fragilis	Crack willow
Salix pentandra	Bay willow
Sambucus nigra	European elder
Sorbus aucuparia	Rowan
Sorbus hibernica	Whitebeam
Taxus baccata	Yew
Ulmus glabra	Elm

Source: Cross (1987).
*Possibly introduced.

Afforestation programmes have, in the past, concentrated almost exclusively on lodgepole pine and Sitka spruce to the extent that they now account for approximately 60% of the forest estate as against almost 24% for other coniferous species and over 16% for broadleaves.

The existing broadleaved woodlands include the remnants of our indigenous forests, about 5800ha (Table 2), and protected in National Parks and Nature Reserves, and old woodland and scrub.

Table 2. Area of woodland (ha) protected in Irish national parks and nature reserves

	Area (ha)
National parks	2860
Nature reserves	2335
Other	541
Total	**5736**

Source: O'Sullivan (1999).

Estimates of the area of semi-natural woodland present in Ireland today vary (Neff 1974, Cross 1987, Anon. 1996), but the total area of broadleaved woodland is unlikely to exceed 110 000 ha, or approximately 1.5% of the land area. Most of these are in private ownership and can be broadly categorized, according to Cross (1987), as follows:

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

Broadleaf forest cover, estimated at 110 000 ha (18%), is low in comparison to most European Union (EU) countries. However, broadleaf afforestation has increased substantially in recent years, supported by current grant aid and other support schemes. Broadleaf planting accounted for over 20% of all afforestation in 1995, an increase from an average 2–3% in the mid- 1980s (Anon. 1996).

Table 3. Breakdown of broadleaved woodland in Ireland

Species	Private (prior to 1973)	Coillte (prior to 1995)	Total (ha)	Total (%)
Oak	8110	4767	12 877	12
Beech	7858	5854	13 712	12.8
Ash	5460	2856	8316	7.8
Sycamore	3080	538	3618	5.4
Elm	1664	-	1664	1.5
Birch	4452	1400	5852	5.5
Alder	1158	-	1158	1.1
Other Broadleaves	1065	1443	2508	2.3
Scrub	57 000		57 000	53.4
			106 705	**100**

Source: Keogh (1987) and Hickie (1990).

In Ireland there are eight species (Table 4) which the EUFORGEN Network designates as native Noble Hardwoods: common alder (*Alnus glutinosa*), silver birch (*Betula pendula*), common ash (*Fraxinus excelsior*), wild crab apple (*Malus sylvestris*), wild cherry (*Prunus avium*), common whitebeam (*Sorbus aria*), mountain ash (*Sorbus aucuparia*) and wych elm (*Ulmus glabra*). Other Noble Hardwoods that have become naturalized in Ireland include sycamore (*Acer pseudoplatanus*), sweet chestnut (*Castanea sativa*), wild pear (*Pyrus pyraster*) of which sycamore is now widespread throughout the country while the others occur at an occasional localized level and in gardens and arboreta.

Table 4. Summary of the status of Noble Hardwoods species in Ireland

Species	Common name	Native	Ecologically important	Economically important	Improvement Programmes
Acer campestre	field maple	No	No	No	No
Acer lobelii	Lobels maple	No	No	No	No
Acer platanoides	Norway maple	No	No	No	No
Acer pseudoplatanus	sycamore	No	No	Yes	Yes
Alnus cordata	Italian alder	No	No	Potential	No
Alnus glutinosa	common alder	Yes	Yes	Potential	No
Betula pendula	silver birch	Yes	Yes	Potential	Yes
Carpinus betulus	hornbeam	No	No	No	No
Castanea sativa	sweet chestnut	No	No	Yes	No
Fraxinus angustifolia	narrow-leaved ash	No	No	No	No
Fraxinus excelsior	common ash	Yes	Yes	Yes	Yes
Juglans regia	English or Persian walnut	No	No	No	No
Malus sylvestris	wild crab apple	Yes	Yes	No	No
Prunus avium	wild cherry	Yes	Yes	Potential	Yes
Pyrus amygdaliformis		No	No	No	No
Pyrus pyraster	wild pear	No	No	No	No
Sorbus aria	common whitebeam	Yes	Yes	No	No
Sorbus aucuparia	mountain ash	Yes	Yes	No	No
Sorbus domestica	service tree	No	No	No	No
Sorbus torminalis	wild service tree	No	No	No	No
Tilia cordata	small-leaved lime	No	No	No	No
Tilia platyphyllos	large-leaved lime	No	No	No	No
Ulmus canescens		No	No	No	No
Ulmus glabra	Wych or Scotch elm	Yes	Yes	No	No
Ulmus laevis	European white elm	No	No	No	No
Ulmus minor	European field elm	No	No	No	No
Ulmus procera	English elm	No	No	No	No

Distribution of native Noble Hardwoods

Common alder (*Alnus glutinosa*)

Alnus glutinosa or common black alder is widespread throughout Ireland, favouring wet habitats and along riverbanks where it sometimes forms pure woods if left undisturbed. Alder seldom grows to very large trees. The frequency of natural populations increases towards higher rainfall areas of the west. Common alder is very undemanding and it will grow on all but the most infertile soils. However, it will form woodland usually on rich, damp soils especially when the soil is waterlogged, and on neutral or acid peats (Nelson and Walsh 1993).

Silver birch (*Betula pendula*)

The native birches, silver birch (*Betula pendula*) of Ireland and downy birch (*B. pubescens*) of Britain are complicated, perplexing plants according to Nelson and Walsh (1993). They seem interminably variable, and often the variation apparent to the naked eye is deceptive. Attempts by botanists to divide our native birches into clear-cut, easily distinguishable

species using characters visible to the naked eye have not led to any consensus or to any unambiguous partition (Nelson and Walsh 1993). In Ireland, birches are found over a range of sites from midland peat bogs to mountain slopes, usually in open scrub. The range of the two species overlap and they hybridize but silver birch most commonly occurs on lighter acid soils and shallow peat in the drier parts of the country at low altitudes. Downy birch also grows well on fertile mineral soils but is also tolerant of met or waterlogged conditions and of heavy and deeper peat. Both species are attractive but rather short-lived pioneers. The main silvicultural value of the birches is their soil improving and nursing quality, and their considerable amenity value.

Common ash (*Fraxinus excelsior*)

Ash is a native species that occurs abundantly throughout Ireland. Unlike oak and beech, it is rarely found in pure stands of any extent. More usually it forms a component of broadleaved mixtures (Joyce *et al*. 1998). Ash is a very exacting species in its site requirements. Best growth occurs on deep, moist, freely draining soils of almost neutral reaction. It is particularly susceptible to late spring frosts and although most healthy plants will recover they will almost certainly be forked (Kilbride 1997). The facility with which ash regenerates naturally from seed ensures that it is one of the most common trees of the countryside and is the main species in hedgerows. Yet, despite this capacity for regeneration, the number of good quality ash stands in wood production in Ireland is extremely few. This may be due to the high demand for hurley ash material but it is also undoubtedly a reflection of the general unsuitable nature of previously acquired state forest land for ash production (Joyce *et al.* 1998).

Ash is currently the most sought after commercial broadleaved tree in Ireland. It is the only species suitable for the manufacture of hurleys and also provides valuable wood for the manufacture of furniture. Inventory data indicate an area of 8316 ha of ash, either pure or in mixed stands exist in state forests which accounts for over 7.8% of all broadleaves.

Very little ash was imported prior to 1990. The earliest imported ash seed was only 0.4 kg from Argyll Scotland in 1943. A further 11 kg was imported in 1966. In 1968, approximately 500 kg of seed was imported from Nobbet Osterskov Denmark. No record of the performance of any of this material exists. The expansion of broadleaf establishment in 1990 resulted in significant increases in the importation of ash material. Provenances used were as shown in Table 5.

Table 5. Sources of Ash Planting Stock imported during the period 1990-91

Country	Region
Netherlands	NL-2, NL-3 - Netherlands
Germany	811-01 north east Germany 811-04 and 811-05 southern Germany around Mainz, Stuttgart and as far south as Munich
France	Ft.St.Gobain, Ft. de Mont Dieu, Ft de Mountblainville - Gondrecourt55, Franche Court, Ardennes 08 and Central and Eastern France

Despite the preponderance of imported planting stock since 1990, it is still clear that most of the existing ash stands in Ireland originated from home collected seed from high quality stands.

Policy in Ireland has been to use home collected seed where possible and to supplement this with seed from England and Holland when shortfalls arise. This policy is based on the assumption that local provenances of native species tend to out perform those from different latitudes and climates. Because ash naturally regenerates and coppices freely it is thought that selective fellings in the past would not have had an impact on the genetic constitution of the species.

Wild crab apple (*Malus sylvestris*)
The true wild crab apple is a relatively rare tree in Ireland. In the wild it often hybridizes with cultivated apples and it is usually found in hedgerows, copses and occasionally in oak woodland at low elevations. It is of no importance as a timber tree but is an attractive addition to mixed broadleaved woodland.

Wild cherry (*Prunus avium*)
Two species of cherry are native to Ireland; the wild cherry *P. avium* and bird cherry *P. padus*. Wild cherry is a widespread species, usually occurring as individual trees or in small groups often on the margins of woods (Savill 1991). The trees habit of growth means that wild cherry occurs as colonies. Cherry has a strong apical dominance, and relatively weak phototropic tendencies, which usually results in the tree developing and retaining a single straight leading shoot. Most cherry in Ireland has arisen naturally as a minor component in existing woodland and as a valuable addition to a stand both for timber and as part of the landscape.

Common whitebeam *(Sorbus aria)*
Is a small tree that occasionally grows up to 20 m in height and of limited distribution. Localized in east, central and western part of the country. The European species of whitebeam are often very restricted in their geographical distribution, and are sometimes considered to represent 'micro species', or local races of widespread variable species. Irish whitebeam *S. hibernica* does not grow outside Ireland and is an excellent example of one of these local races. It is considered to be related to *S. graeca* from mainland Europe and to several of the English micro species.

Mountain ash (*Sorbus aucuparia*)
Sorbus aucuparia or Rowan is the most familiar and best known of the six native sorbus species. It is widely distributed throughout Ireland in woods, scrub and mountain areas and it will thrive at elevations up to almost 1000 m on sites where few other broadleaved trees will survive let alone grow. Rowan grows best on light textured brown earths and more fertile peats but does not tolerate waterlogged conditions. The species fruits regularly. Seed is widely dispersed by birds and natural regeneration is common. Young rowan trees grow fairly vigorously but the species rarely exceeds 15 m in height (Evans 1984).

Wych elm (*Ulnus glabra*)
The wych elm was once widespread throughout Ireland in woodlands, hedgerows and close to streams, but Dutch elm disease has eliminated most of the species. However, odd fine mature trees still thrive in some places, possibly because these trees were isolated and the disease-carrying beetle never reached them.

Distribution of introduced naturalized Noble Hardwoods

Sycamore (*Acer pseudoplatanus*)
Sycamore is a naturalized non-native species and although it is a common species for hedgerows and shelterbelts, stands of sycamore are relatively rare in Ireland. It is estimated that there are 3 18 ha of state and private broadleaved woodland in the Republic of Ireland but only 79 ha in pure stands (Binggeli and Rushton 1999). Sycamore accommodates itself to a wide range of site conditions and grows well on calcareous soils and on non-calcareous topsoils with an increasing pH inch depth (Joyce *et al*. 1998). It will not tolerate stagnant water conditions. It prefers a cool humid climate and is relatively tolerant of late spring frost. Like ash it is rarely found in pure stands of any extent; more usually it forms a component of mixed broadleaved woodland. It is a regular and prolific seeder and historical records suggest that it was very common and widespread at one point in time. It is thought to have

been introduced into Britain by the Romans (Fitzpatrick 1965) and was first recorded in Ireland in 1632. As there were no seed imports until 1964, all sycamore planted up to this date was of English provenances or home collected of English origin (Binggeli 1996). Two seedlots were imported in the 1960's from Northern Italy and Denmark. Home collection of sycamore continued on a minor scale in the 1970's and 1980's. Sycamore was only a minor constituent of our woodlands up to 1989. However under the Forest Operational Programme and the CAP reform grant scheme launched in 1989 it became the second most popular broadleaf species. Seed was again imported in 1993 and imports of transplants were used to satisfy the demand for this species. Evidence indicates that sycamore could have a significant role to play in Irish forestry. This species is valued for its ability to grow quickly on difficult exposed sites and sites affected by salt spray. It therefore warrants the same level of attention as accorded to ash, oak or beech.

No serious examination of sycamore provenances has been undertaken in Ireland. Perhaps it would be more correct to state that no serious silvicultural work of any type has been carried out in this country on sycamore. It appears from inspection of the best sycamore stands in the country that local provenances are giving good results. There are no examples of good stands from the imported seed lots of the 1960s. Indeed this may be partially due to the fact that the planned use was amenity. With the present level of sycamore planting, home seed collection will be inadequate for some years to come. To-date the shortfall has been made up with transplant imports from north European countries, but the target from 1996 onwards is to have sufficient home grown transplants of Dutch and Irish provenances available on a 50/50 basis. It appears from an examination of recently established plantations that both Irish and Dutch provenances are very promising at the initial stage. However it is desirable to pursue an evaluation of vegetative propagation of male clones as advocated by Binggeli (COFORD Research Programme 1994-1998).

Other introduced species

Most of the other species from the list of Noble Hardwoods are occasionally found as individual specimen trees in arboreta in Ireland but are generally of no importance economically or ecologically from a gene conservation viewpoint.

Genetic resources of Noble Hardwoods

Ex situ conservation

With an increasing interest in planting broadleaves in Ireland a number of our native broadleaved species are presently being evaluated. Birch, for example, long classified as a weed is now looked at in a more favourable light by Irish foresters. In 1999, an extensive provenance trial, containing 45 provenances of silver birch of Scottish and northern British origins was established near Macroom, Co. Cork, while presently a provenance trial containing two Irish, four Swedish, two Finnish and three Scottish provenance is in the process of establishment on an adjoining site.

In wild cherry, a seed collection of native provenances was made in the late 1980's but levels of germination were poor, resulting in a limited supply of material becoming available for provenance trials. As a result of this seed collection, a clonal test and progeny trial were established in Clonegal, Co. Wexford in 1990 and 1991. This trial was later destroyed by a late spring frost.

In common ash, a native seed collection was made in 1985 (Fennessy 1986). Seed was collected at 16 sites in the Irish Republic. The resulting plant material was later planted on a number of field trials at Clonegal, Co. Wexford (south east) and Drumsna, Co. Leitrim (north west) in 1989. The trial established in Clonegal has been lost to frost however the ash trial in Drumsna Co. Leitrim has survived. For all the other Noble Hardwoods no seed source or provenance studies have been undertaken to date.

In situ conservation

Research work on the conservation of genetic resources in Ireland is mainly concerned with conserving communities of rare or unusual flora and fauna, unique landforms and geology. The principal attempts to conserve our native broadleaved woodlands in the past were primarily in the context of establishing nature reserves under the 1976 Wildlife Act. Here, the underlying philosophy was to conserve the woodland ecosystem, rather than the trees, in order to maintain the genetic resource as represented by the flora and fauna (Cross 1987).

Of Ireland's broadleaved woodlands, today, not more than 6000 ha are protected for conservation, through state ownership or legislation in national parks and nature reserves. The process of designating lands for conservation is very active in Ireland, at present. Since 1992, two designations have been introduced, namely Natural Heritage Areas (NHAs), and Special Areas of Conservation (SACs). These represent a major new development, in that most of the land in NHAs and SACs is privately owned (O'Sullivan 1999). The development of the proposed NHA/SAC network is of major significance, as it greatly expands the area of protected semi-natural woodland in Ireland. The total area of woodland to be included within the network has not yet been quantified, but the National Parks and Wildlife Service are preparing figures.

Reproductive material

Since 1973 an official register, the National Catalogue of Seed Stands for all commercial tree species has been in place in Ireland. The phenotypically best and most productive stands are selected and registered under EU and OECD rules. At the end of 1998 the total area registered for Noble Hardwoods was 2 stands in common ash totalling 7.3 ha. It is anticipated that under new EU legislation all commonly planted broadleaved species will require seed stands.

Tree improvement programmes in Noble Hardwoods

Until recently, there has been little systematic improvement of any of the Noble Hardwoods, however since the early 1990s, programmes concentrating on species considered to be economically important are undertaken mainly by the Research and Development Unit of Coillte Teoranta—The Irish Forestry Board, through its Tree Improvement and Genetics Section. In common ash, sycamore and wild cherry elite phenotype selection has taken place to date in Coillte's forests and a number of individual trees have been selected (Table 6).

Table 6. Noble Hardwood plus trees selected in Ireland

Species	No. of plus trees selected
Common ash	85
Sycamore	92
Wild cherry	55

A programme of grafting has also been ongoing and many of these clones have been successfully grafted. In ash, an untested clonal seed production area has been established while for sycamore and cherry clone banks are being developed. Material from these selected trees has also been exchanged with interested parties in Ireland and overseas.

In 1998, a small scale programme of plus tree selection in sycamore was undertaken in Northern Ireland and 15 plus trees have been selected throughout the Region. A seed collection was made from each of these trees and a small progeny trial is planned (Binggeli and Blackstock 1998). In 1998, a study of sycamore and ash was undertaken and partially funded by COFORD (Bungelli and Rushton 1999). An improvement programme in birch commenced in 1998, partially sponsored by the Council for Forest Research and Development (COFORD) and undertaken by Teagasc in Cooperation with University College Dublin.

The seed stands have not yet been selected in any of the other Noble Hardwoods other than ash.

Conclusions

Prior to 1996, all Irish home collected seed either was processed by hand or sent abroad for processing. For this reason it was cheaper and easier to import seed than to use home collected material. Since 1996 a seed processing facility has been built and now with the ability to process more native material interest in using native seed sources has increased. For this reason the main priority for Ireland now is how to efficiently and effectively utilize the native Noble Hardwood resource.

Because most of the Irish forests, including the Noble Hardwood species, occur in small fragmented populations on the island, the first activity should be a detailed survey and inventory of native populations and their location. In spite of the small size of the country, no accurate, up-to-date information on the distribution or population size is available. Once this survey has been completed, the next step is to determine the patterns of variation in the species. Based on these results is should be possible to determine whether the entire Irish population of a particular species can be considered as one provenance or if it should be subdivided into smaller geographic regions. This question should be considered on a species by species basis.

The next step will be to develop seed production alternatives. Because many of the Noble Hardwood species do not occur in stands, but rather as individual trees, small groups and even in hedgerows it may not be possible to collect seed *in situ*. When and where this is possible such stands will be used, but in some species this will simply not be practical. For this reason we will need to resort to *ex situ* conservation methods. At present, ash is the only Noble Hardwood species where seed stands have been registered.

Future strategies call for the development of seed production areas for many of the more widely planted species. Based on the field survey of the country, the selection of phenotypically superior trees should be possible. Depending on whether a species will be divided into several provenances or not will determine whether one or more seed production areas will be necessary. The use of seed production areas should help overcome many of the problems associated with seed collection in native stands. To date one grafted ash seed production area based on 100 phenotypically selected individuals has been established.

Although some of the economically important Noble Hardwoods, such as ash cherry, are native to Ireland, no provenance experiments have been established to compare Irish with imported sources. Similarly, other naturalized non-native commercially important species, such as sycamore or sweet chestnut, have not been the subject of any provenance testing and the origin of material already growing here is generally unknown. Therefore Ireland would be interested in participating in joint provenance experiments that would be planned involving these species.

References

Anon. 1996. Growing for the future - A strategic plan for the development of the forestry sector in Ireland. Stationery Office, Dublin.

Anon. 1999. Forestry statistics. Forestry Yearbook 1999. The Irish Timber Growers Association, Dublin.

Binggeli, P. and P. Blackstock. 1998. Identification of 'plus' sycamore trees in the north of Ireland for seed procurement. School of Applied Biological and Chemical Sciences, University of Coleraine BT52 1SA, Northern Ireland. Unpublished.

Binggeli, P. and B.S. Rushton. 1999. Sycamore and ash - a review of aspects relevant to Irish Forestry. COFORD, Dublin.

Cross, J. 1987. Status and value of native broadleaved woodland. Irish Forestry Vol. 44(2): 81-88.

Evans, J. 1984. Silviculture of broadleaved woodland. Forestry Commission Bulletin 62. HMSO, London.
Fitzpatrick, H. M. 1965. Conifers: keys to the genera and species , with economic notes. Pp 67-192 *in* Scientific proceedings. Section A. Vol 2. No. 7. Royal Dublin Society, Dublin.
Hickie, D. 1990. Forestry in Ireland. An Taisce. Dublin. 32 p.
Joyce, P.M., J. Huss, R. McCarthy, A. Pfeifer, and E. Hendrick. 1998. Growing broadleaves - silvicultural guidelines for ash, sycamore, wild cherry and oak in Ireland. COFORD, Dublin.
Keogh, R.M. 1987 Letter to the Editor, Irish Forestry 44 (2):146-147.
Kilbride, C. 1997, Soils and site indicators for the production of high quality ash (*Fraxinus excelsior* L.), University College Dublin, Dublin.
Neff, M.J. 1974. Woodland conservation in the Republic of Ireland. Pp. 273-285 *in* Gehu, J.M. (ed.) Coloques Phytosociologues III: La Vegetation des Foréts Caducifoliees. J. Cramer. Vaduz.
Nelson, E.C. and W. Walsh. 1993. Trees of Ireland, Native and Naturalized. The Lilliput Press, Dublin.
Savill, P.S. 1991. The silviculture of trees used in British Forestry CAB International, UK.

Luxembourg

Myriam Heuertz
CREBS Research Unit, Centre de Recherche Public Gabriel Lippmann, Luxembourg

Occurrence of Noble Hardwood species

The priority species list for Luxembourg includes *Alnus glutinosa*, *Acer campestre*, *A. platanoides*, *A. pseudoplatanus*, *Betula pendula*, *Carpinus betulus*, *Fraxinus excelsior*, *Juglans regia*, *Malus sylvestris*, *Prunus avium*, *Pyrus pyraster*, *Sorbus aria*, *S. aucuparia*, *S. domestica*, *S. torminalis*, *Tilia cordata*, *T. platyphyllos*, *Ulmus glabra* and *U. minor*.

Only approximate data on the occurrence are available. More accurate data from the national forestry inventory which started in 1999 will be available by the end of 2000. The occurrence of Noble Hardwoods can be estimated on the basis of the 1985 forest inventory at approximately 4500 ha, which represents 5 % of the total forest area. The main species are *Carpinus betulus* (1300 ha), *Fraxinus excelsior* (330 ha), *Betula pendula* (320 ha), *Acer pseudoplatanus* (250 ha) and *Alnus glutinosa* (150 ha). *Carpinus betulus* is present in most even-aged oak stands on heavy clay soils. All other species have a very scattered distribution, except *Alnus glutinosa* and *Fraxinus excelsior* which can be found in more homogenous stands as shown in Figure 1.

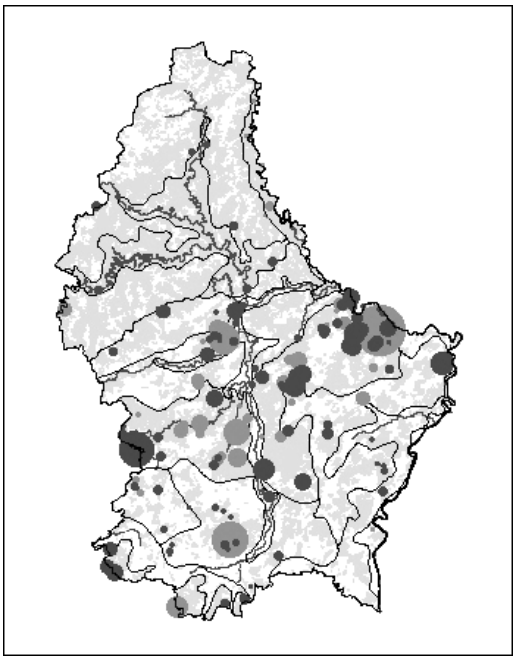


Fig. 1. Distribution of *Alnus* (dark grey points) and *Fraxinus* (light grey points) stands in Luxembourg (OBS, 1988) (areas from 20 to 2 ha).

Role and importance for the forestry sector and for other uses

The role of the Noble Hardwoods can be divided into three topics:

- high-quality wood production
- biodiversity
- landscaping.

The Ministry of Agriculture also supports plantation of Noble Hardwoods in private and commune forests for *Acer platanoides*, *A. pseudoplatanus*, *Carpinus betulus*, *Fraxinus excelsior*, *Juglans regia*, *Prunus avium*, *Tilia cordata*, *T. platyphyllos*, *Ulmus glabra* and *U. minor*.

Silvicultural approaches used

Basic short rotation silvicultural systems are used to manage Noble Hardwood stands. Special emphasis is placed on a method consisting of filling up wind-throw holes and natural regeneration holes with Noble Hardwoods in order to increase biodiversity of social broadleaf stands.

Health state and threats to the genetic resources of Noble Hardwoods

Since 1986 the health (defoliation and decolouration) of forest stands in Luxembourg has been monitored by a yearly inventory of plots within a 4×4 km grid on the basis of the European ICP forest standards. Between 1986 and 1998, their health steadily deteriorated, so that currently not more than ⅓ of the trees can be considered as being absolutely healthy. Since 1998 their state of health has remained fairly constant with a tendency to amelioration.

Because of the scattered distribution of the Noble Hardwoods, only 17 trees (*Acer* sp. (3), *Fraxinus* sp. (8), *Prunus avium* (5) and *Ulmus* sp. (1)) are monitored in Luxembourg every year. Four trees are without damage (class 0), 5 are slightly damaged (class 1) and 8 are damaged (class 2). There are no trees in the high damage classes 3 and 4.

Threatened species with regard to the small number of remaining individuals are *Sorbus domestica*, *Malus sylvestris*, *Pyrus pyraster* and *Ulmus* spp.

Conservation activities (in situ, ex situ)—constraints, challenges

Luxembourg has no *ex situ* conservation activities with Noble Hardwoods. Some species are included in the *in situ* conservation activities for seed production and for the protection of rare trees (*Sorbus domestica* and *S. torminalis*).

Research

The following research projects are currently ongoing:

- *In vitro* culture of *Sorbus domestica* for the production of reproductive material at the Centre de Recherche Public—Gabriel Lippmann.
- *In vitro* regeneration of seedlings and population genetics on *Fraxinus excelsior* at the Centre de Recherche Public—Gabriel Lippmann.
- Follow up of the yield of *Sorbus torminalis* stands in Ermsdorf by the University of Göttingen (Germany).

Use of genetic resources

Breeding activities for the production of reproductive material on *Sorbus* spp. and some other Noble Hardwoods are increasing in the regional nurseries of the state and commune forests, but the majority of the reproductive material of Noble Hardwoods is supplied from neighbouring countries.

Needs, capacities and priorities for international collaboration

The main needs can be summarized as follows:

- Better control systems of provenances of reproductive material (*Prunus avium*).
- Proposals and exchange of information on silvicultural approaches to *in situ* conservation and natural regeneration strategies of Noble Hardwoods in even-aged social broadleaf stands.

Institutions involved

Centre de Recherche Public—Gabriel Lippman;
University of Göttingen (Germany).

Norway

Tor Myking and Tore Skrøppa
Norwegian Forest Research Institute, Ås, Norway

Introduction

Norway is situated between latitudes 58° and 71°N and is surrounded by the North Sea, the North Atlantic and the Arctic ocean to the west and north, respectively. The Gulf Stream skirts along the west coast and has an extremely warming effect on the land. The warming causes the treeline to extend beyond 70°N, about 17 latitude degrees further north than in Labrador in Canada. Due to these climatic factors most of our native forest tree species reach the absolute northern distribution limit in Norway. This might also have an effect on the genetic constitution of the species and calls for responsible management. Because of the wide latitudinal extension (13 degrees), day length at the northern and the southernmost extremes varies extensively. The most outstanding topographic feature is the mountain chain running along the entire Scandinavian Peninsula with peaks of up to 2500 m in elevation (Johannessen 1970).

Species

In the present report we apply the list of the EUFORGEN Network, which includes 9 forest tree species occurring in Norway. Only five species are recognized as true Noble Hardwoods in Norway of which four are on the Network list (Table 1). Conventionally, the social broadleaves *Fagus sylvatica*, *Quercus robur* and *Q. petrea* are included because of their great summer temperature requirement. In the national plan for conservation *Alnus glutinosa*, *A. incana* and *Prunus padus* were also considered as Noble Hardwoods where they occur in stable communities on fertile soil (e.g. Fylkesmannen 1982). Thus, a total of 11 species of those included in the national conservation plan. Since *Betula pendula*, *Sorbus aucuparia*, *Malus sylvestris* and *Prunus avium* are not considered Noble Hardwood species in Norway they have a random occurrence in our forest reserves. It is important to note that the conservation plan was implemented and designed for conservation of forest communities and not genetic resources as such.

Table 1a. Noble Hardwood species in Norway according to the list of the Network, and summary of essential biological traits for each of the species

Species	Range size	Occurrence	Vector for pollination	Vector seed dispersal	Seed dispersal capability	Northern limit in Norway
Betula pendula	large	scattered/stand	wind	wind	very good	
Alnus glutinosa	small	scattered/stand	wind	wind water	very good	
Ulmus glabra[*]	small	scattered	wind	wind	good	x
Malus sylvestris	small	scattered	insects	mammals, birds	limited	x
Sorbus aucuparia	large	scattered	insects	birds, mammals	good	
Prunus avium	marginal	scattered	insects	birds	good	x
Acer platanoides[*]	small	scattered	insects	wind	good	
Tilia cordata[*]	small	stand/scattered	insects	wind	good	x
Fraxinus excelsior[*]	small	stand/scattered	wind	wind	good	x

[*] Species recognized as Noble Hardwoods in Norway

Table 1b. The evaluation of the genetic resources is based on composition of these traits since relevant genetic information is deficient or missing

Species	Conditions for genetic variability			
	Vital	**Uncertain**	**Exposed**	**Threatened**
Betula pendula	x			
Alnus glutinosa	x			
Ulmus glabra[*]				x
Malus sylvestris			x	
Sorbus aucuparia	x			
Prunus avium			x	
Acer platanoides[*]		x		
Tilia cordata[*]			x	
Fraxinus excelsior[*]		x		

[*]Species recognized as Noble Hardwoods in Norway

Occurrence and distribution

Approximately 37% (120 000 km^2) of the country is covered by forest, 57% of which is productive forest. About 25% of the forest area is situated above the conifer tree line, and this is composed mainly of *Betula pubescens* subsp. *czerepanowii*. Norway spruce and Scots pine constitute about 75% of the forest area below the conifer timberline. The rest is covered by deciduous species in which birches are the main component (Tomter 1994). Except from *Sorbus aucuparia*, the main distribution of the Noble Hardwoods is south of 64°N. Further north, the occurrences remain as isolated relicts or small populations (Fig. 1). In accordance with this distribution pattern the Noble Hardwoods constitute less than 10% of the standing volume of deciduous species (Table 2). The size of the forest reserves is correspondingly small, usually less than 3 ha. Conservation activities are coordinated by the Directorate for Nature Management organized under the Ministry of the Environment. However, the Ministry of Agriculture recently took initiatives for specific conservation of genetic resources of forest trees.

Legislation

A plan for conservation of Noble Hardwoods was initiated in the 1966, and during the following decades numerous areas were conserved as Nature Reserves according to the Nature Conservation Act (cf. Table 3). Nature Reserves are the most restrictive form of conservation, and they are still the backbone in the national network of conservation areas for Noble Hardwoods. A small share is conserved as Protected Landscapes according to the same act. They have less protection and management is in often included to maintain particular landscapes. All reserves conserved according to The Nature Conservation Act are marked on official maps of appropriate scales. In addition, information folders are usually available and information signs are placed on the border of the reserves to increase the public awareness about the ecological significance of Noble Hardwoods. The State Owned Land Company has established a few reserves on State property (administrative conservation), and these have a protection level comparable to Nature Reserves. Also the Planning and Building Act contributes, but to a very little extent. The Forest Act gives guidelines for forest management, but it has no significance for conservation.

Importance in forestry

The modest role of the Noble Hardwoods in Norwegian forestry is illustrated by the low standing volume and the low annual cut for sale (Table 2). However, there is a growing interest for Noble Hardwoods timber for use as panel, furniture and crafts. Most timber of Noble Hardwoods is imported, indicating that there is a potential for more intensive use of domestic resources.

Fig. 1. Northern distribution limits of Noble Hardwoods in Norway.

Table 2. Relative importance of Noble Hardwoods in Norwegian forestry. No data were available for *Malus sylvestris* and *Prunus avium*. *Picea abies*, the main forest tree, is included for comparison

	Standing volume	Mean annual increment	% of deciduous species	Annual cut
Alnus glutinosa	800 000	25 000	0.6	2000
Acer platanoides	570 000		0.4	< 50
Betula pendula	3 500 000	110 000	2.4	10 000*
Fraxinus excelsior	1 400 000	45 000	1	1000
Sorbus aucuparia	5 700 000		4.2	
Tilia cordata	560 000		0.4	
Ulmus glabra	700 000	20 000	0.5	<100
Total	**13 230 000**	**200 000**	**9.5**	**13 000**
Picea abies	**300 000 000**	**12 000 000**		**6 500 000**

All values are in m^3 (Kucera and Næss 1999)
*Including *B. pubescens*

Genetic knowledge

Only a few species have been studied in Scandinavia, and in this section we report primarily of studies of adaptive traits. *Betula pendula* has wide distribution and display clinal variations in growth rhythm characters along latitudinal, altitudinal and coastal-inland gradients (Håbjørg 1972, 1978, Eriksson and Jonsson 1986, Myking and Heide 1995, Myking 1997ab). Progeny trials reveal a great within-population variation in accordance with other wind-pollinated trees

(Langhammer 1981, Eriksson and Jonsson 1986, Skrøppa unpublished). *Sorbus aucuparia* has been studied with respect to crown architecture to see whether the different crown shapes in sheltered and wind-exposed stands could be due to genetic factors. However, it appeared to be exclusively an environmental effect, and as with many other tree species the within-population variation was larger than the between-population variability (Sæbø and Johnsen 2000). Håbjørg (1978) and Westergaard (1997) have reported of clinal variation in growth cessation in *Acer platanoides*. Such geographic trends may partly explain variable performance of widely different origins planted at the same site (Horntvedt 1981, Kerr and Niles 1998). Recently Baliuckas *et al.* (1999) reported a large variance at the family and population level in adaptive traits in Sweden, which is in agreement with observations of high population differentiation in marginal Finnish populations of *Acer platanoides* (Rusanen *et al.* 1996). Rather high population variance components were also found in *Fraxinus excelsior*, while in *Alnus glutinosa* they were comparatively low (Baliuckas *et al.* 1999). In *F. excelsior* a significant within-population variation has also been shown (Pliúra 1999). There is limited information on the genetic structure of *Tilia cordata*, but it is expected to have small within-population variation due to insect pollination, and scattered and small populations (Jensen and Canger 1999).

State of genetic resources

The limited knowledge about genetic structure in Noble Hardwoods is a problem for effective management and conservation of their genetic resources, particularly for rare and threatened species. However, certain life history traits affect their genetic structure, and educated guesses based on composition of these traits have been used to give a preliminary evaluation of the state of the genetic resources. Life history traits considered in the evaluation were:

- size and pattern of distribution (scattered, continuous) (Hamrick and Godt 1990)
- fragmentation (Boshier *et al.* 1995, Didham 1997)
- mode of reproduction - sexual and/ or vegetative (Hamrick and Godt 1990)
- efficiency of seed dispersal (seed size, dispersal vector) (Hamrick and Godt 1990, Boshier *et al.* 1995, Samuel *et al.* 1995)
- efficiency of pollen dispersal (pollination vector, wind or insects) (Fægri and van der Pijl 1971, Hamrick and Godt 1990, Bacilieri, *et al.* 1994, Samuel *et al.* 1995)
- diseases and herbivores
- the use of non-native provenances (Skrøppa and Dietrichson 1986, Skrøppa 1994)

Other important data, such as the effect of inbreeding, is missing for most species.

The state of the genetic resources was evaluated using the following scale; *vital*, *uncertain*, *exposed* and *threatened* (Table 1b).

Vital—Species characterized by wide and continuous distribution, successful sexual and vegetative regeneration, and effective dispersal of pollen and seeds. As shown in Table 1, this includes *Betula pendula*, *Alnus glutinosa* and *Sorbus aucuparia*. Though *S. aucuparia* is insect pollinated and birds serve as vector for seed dispersal, geneflow is probably adequate in this species, as extensive within-population genetic variation has been demonstrated (Sæbø and Johnsen 2000).

Uncertain—Species with small and scattered distributions, limited pollen- and seed-dispersal ability, and regeneration that is exposed to browsing. These are conditions that antagonize effective geneflow, and thus, might have a less genetic variation. Genetic resources of *Acer platanoides* and *Fraxinus excelsior* were considered uncertain.

Exposed—Species with marginal and fragmented distributions that share most of the characteristics with the former group. The condition is regarded as exposed for *Prunus avium, Malus sylvestris,* and for *Tilia cordata* owing to the unsuccessful seed set in Norway. This might reduce the genetic variability due to lack of recombination and loss of genetic variation when individuals/clones die.

Threatened—Declining species. The East-Norwegian *Ulmus glabra* population is severely attached by the Dutch elm disease and this may reduce the genetic variability of the species.

In situ *conservation and further recommendations*

A network of conservation areas intended for nature protection has been established for most Norwegian forest tree species (Table 3). However, an evaluation should be carried out on how well these protected areas fulfil the requirement for the conservation of the genetic resources. Also, protected areas selected for other purposes generally have inadequate distribution and coverage (Koski 1997).

Most conservation areas have been established for Norway spruce, Scots pine, Noble Hardwoods and Social Broadleaves. In addition, *Ilex aquifolium* and *Taxus baccata* have been conserved according to a separate conservation plan. Other species have a more or less random occurrence in the forest reserves, and several species, of which most are rare and endemic *Sorbus* species, have not been recorded in any conservation area. Irrespective of the state of a species' genetic resources, the fringe occurrences should always be managed with great care.

From a genetic point of view incomplete distribution and coverage of reserves is not considered a problem for species whose genetic resources are regarded as vital. In species with some degree of uncertainty connected to the genetic resources (Table 1), we suggest that the national network of reserves should be completed. According to this approach the conservation status is deficient in *Ulmus glabra*, *Malus sylvestris*, *Prunus avium*, *Fraxinus excelsior*, *Tilia cordata* and to some degree in *Acer platanoides.* There is a general deficiency of reserves in northern- and particularly in western Norway, mainly due to the fact that the conservation plans in these areas are not completed. In the extreme case of *Ulmus glabra*, *ex situ* conservation might be established north of the distribution of the *Ulmus glabra* bark beetle *Scolytus laevis*, the vector of the Dutch elm decease. We have also initiated collection of seeds to survey the genetic structure of *Ulmus glabra* because this influences the choice of conservation strategy.

Table 3. Number and distribution of forest reserves within each of four parts of Norway

Species	Dominating/ Associated	Number of reserves					
		West	East	Mid	North	Total	Total area (ha)
Betula pendula	*A*	9	76	2		87	
Alnus glutinosa	*D*	8	25			33	623
	A	9	43			52	
Ulmus glabra	*D*	25	59	22		106	2325
	A	5	36	2		43	
Malus sylvatica	*A*	4	7			11	
Sorbus aucuparia	*A*	27	124	36	5	192	
Prunus avium	*A*		30			30	
Acer platanoides	*A*		94			94	
Tilia cordata	*D*	16	54			70	1510
	A	15	37			52	
Fraxinus excelsior	*D*	9	31	1		41	686
	A	23	62	3		88	
Total		**150**	**678**	**66**	**5**	**899**	**5144**

Dark grey denotes common, and light grey denotes rare or isolated occurrence (cf. Hultèn 1971). *Dominating* refers to presence as dominant or co-dominant in a stable community. *Associated* refers to random or minor occurrence.

Research

A Nordic project to compare the genetic structure in *Betula pendula* and *Acer platanoides* was initiated in 1998. The main objective is to gain more information about insect pollinated species such as *A. platanoides*. Several provenance trials with *Betula pendula* were established many years ago and they will be used for estimating genetic variation within and among populations.

Collection of *Ulmus glabra* seeds from several stands in Norway has started to establish a field trial in 2000. It is of crucial importance for the choice of conservation strategy to have prior information about distribution of genetic variability. To our knowledge there are no studies of *U. glabra* with particular reference to adaptive traits. Seeds will be collected from three distinct populations in eastern, western and northern Norway.

In western Norway a field trial with *Sorbus aucuparia* has been established and the results have been outlined above.

A provenance trial with *Alnus glutinosa* has been established, and early results indicate that there are small provenance differences between origins from southern Norway.

A *Prunus avium* trial has been established with selected plus trees. The study also involves analysis of wood samples for technical characters from the plus trees, progeny testing and clonal propagation.

References

Bacilieri, R., T. Labbe and A. Kremer 1994. Intraspecific genetic structure in mixed populations of *Quercus petrea* (Matt.) Leibl and *Q. robur*. Heredity 73: 130-141.

Bosier, D.H., M. R. Chase and K. S. Bawa 1995. Population-genetics of *Cordia alliodora* (*Boranginaceae*), a neotrophical tree. III. Geneflow, neighbourhood, and population substructure. Am. J. Bot. 82: 484-490.

Baliuckas, V., I. Ekberg, G. Eriksson, and L. Norell. 1999. Genetic variation among and within populations of four Swedish hardwood species assessed in a nursery trial. Silvae Genet. 48: 17-25.

Didham, R.K. 1997. An overview of invertebrate responses to forest fragmentation. Pp. 303-320 *in* Forests and insects (A.D. Watt, N.E. Stork and M.D. Hunter, eds.). Chapham and Hall, London.

Eriksson, G. and A. Johnson 1986. A review of the genetics in *Betula.* Scand. J. For. Res. 1: 421-434.

Fylkesmannen 1982. Utkast til verneplan for edellauvskog i Buskerud fylke (Draft of conservation plan for noble hardwood species in Buskerudg county). Fylkesmannen i Buskerud. 44 p. (in Norwegian).

Fægri, K. and L. van der Pijl 1971. The principles of pollination ecology. Pergamon Press, Oxford. 291 p.

Håbjørg, A. 1972. Effects of photoperiod and temperature on growth and development of three altitudinal and three latitudinal populations of *Betula pubescens* Ehrh. Meld. Nor. Landbrukshøgsk. 57(2): 1-27.

Håbjørg, A. 1978. Photoperiodic ecotypes in Scandinavian trees and shrubs. Meld. Nor. Landbrukshøgsk. 57(33): 1-27.

Hamrick, J. L. J. and W. Godt 1990. Allozyme diversity in plants. Pp. 43-63 *in* Plant population genetics, breeding, and genetic resources (H. D. Brown, M. T. Clegg, A. L. Kahler and B. S. Weir, eds.). Sinauer Associates Inc. Publishers, Sunderland.

Horntvedt, S. 1981. Spisslønn (*Acer platanoides*). Sammenligning av frøkilder. (Norway maple (*Acer platanoides*). Comparison of seed sources). Gartneryrket 71: 781-782. (in Norwegian).

Hultèn, E. 1971. Atlas of the distribution of vascular plants in northwestern Europe. Generalstabens litografiske anstalts förlag, Stockholm. 531 p.

Jensen, J.S. and S. Canger 1999. Lime (*Tilia* spp.). Pp. 28-38 *in* Noble Hardwoods Network. Report of the third meeting, 13-16 June 1998, Sagadi, Estonia. (Turok, J., J. Jensen, Ch. Palmberg-Lerche, M. Rusanen, M. Russell, S. de Vries, and E. Lipman, eds.). International Plant Genetic Resources Institute, Rome, Italy.

Johannesen, T.W. 1970. The climate of Scandinavia. Volume 5. Pp. 23-62 *in* World Survey of Climatology (H.E. Landsberg, ed). Elsevier, Amsterdam.

Kerr, G. and J. Niles 1998. Growth and provenance of Norway maple (*Acer platanoides*) in lowland Britain. Forestry 71: 219-224.

Koski, V. 1997. *In situ* conservation of genetic resources. Pp. 5-13 *in* Technical guidelines for genetic conservation of Norway spruce (*Picea abies* (L.) Karst.) (V. Koski, T. Skrøppa, L. Paule, H. Wolf and J. Turok). International Plant Genetic Resources Institute, Rome, Italy.

Kucera, B. and R. Næss 1999. Tre - naturens vakreste råstoff (Wood – nature's most beautiful product). Landbruksforlaget, Oslo. 248 p. (in Norwegian).

Langhammer, A. 1982. Growth studies on *Betula pendula* (*Betula verrucosa* Ehrh) in Norway. Meld. Nor. Landbrukshøgsk. 61(23): 1-43.

Myking, T. 1997a. Control of dormancy and budburst in *Betula pendula* and *B. pubescens* ecotypes. Doctor Scientiarum Theses 1997:15. Agricultural University of Norway, Ås.

Myking, T. 1997b. Dormancy, budburst and impacts of climatic warming in coastal-inland and altitudinal *Betula pendula* and *B. pubescens* ecotypes. Pp. 51-66 *in* Phenology in Seasonal Climates I. (H. Lieth and M. D. Schwartz, eds.). Bachuys Publishers, Leiden.

Myking, T. and O. M. Heide 1995. Dormancy release and chilling requirement of buds of latitudinal ecotypes of *Betula pendula* and *B. pubescens*. Tree Physiol. 15: 697-704.

Pliúra, A. 1999. European long-term gene conservation strategies. Ash (*Fraxinus* spp.). Pp. 8-27 *in* Noble Hardwoods Network. Report of the third meeting, 13-16 June 1998, Sagadi, Estonia. (Turok, J., J. Jensen, Ch. Palmberg-Lerche, M. Rusanen, M. Russell, S. de Vries, and E. Lipman compilers). International Plant Genetic Resources Institute, Rome, Italy.

Rusanen, M., A. Mattila, P. Vakkari. 1996. Jalojen lehtipuden geneettinen monimuotoisuus-säyliytä ja käytä. Metsänt. Tied. 605: 45-52. (in Finnish).

Sæbø, A and Ø. Johnsen. 2000. Growth and morphology differ between wind exposed families of *Sorbus aucuparia* (L.). J. Arboricult. (in press).

Samuel, R., W. Pinsker and F. Ehrendorf 1995. Electrophoretic analysis of genetic variation within and between populations of *Quercus cerris*, *Q. pubescens*, *Q. petrea* and *Q. robur* (*Fagaceae*) form Eastern Austria. Bot. Acta 108: 290-299.

Skrøppa, T. and J. Dietrichson 1986. Winter damage in the IUFRO 1964/68 provenance experiment with Norway spruce (*Picea abies* (L.) Karst.). Com. Nor. For. Res. Inst. 39: 161-183.

Skrøppa, T. 1994. Impact of tree improvement on genetic structure and diversity on planted forests. Silva Fennica 28: 265-274.

Tomter, H. 1994. Statistics of forest conditions and resources in Norway. Norwegian Institute of Land Inventory. 103 p.

Westergaard, L. 1997. Genetic variation in seedling growth and phenology in four latitudinal provenances of *Acer platanoides* (*Acer platanoides* L.). Pp. 105-116 *in* Phenology in Seasonal Climates I. (H. Lieth and M. D. Schwartz, eds.). Bachuys Publishers, Leiden.

Turkey

Murat Alan
Forest Tree Seed and Tree Breeding Research Directorate, Ankara, Turkey

Introduction

In Turkey, forests cover 20.7 million ha or 26.6 % of the area of the country (77.9 million ha). Of these forests, 10 million ha (48.3 % of total forest land) are considered to be productive while the remaining 10.7 million ha are unproductive or highly degraded (Table 1).

Table 1. Area and quality of Turkey forests

Productive (million ha)			Degraded (million ha)			
High Forest	**Coppice**	**Total**	**High forest**	**Coppice**	**Total**	**Grand total**
8.2	1.8	10.0 (48.3%)	6.2	4.5	10.7 (51.7%)	20.7

Major forest species are *Quercus* spp., *Pinus brutia*, *Pinus nigra*, *Fagus orientalis*, *Pinus sylvestris*, *Abies* spp. and *Cedrus libani* (Table 2a,b)

Table 2a. Broadleaved species in Turkey

Species	Area (ha)	% of grand total
Acacia spp.	3481.2	0
Acer spp.	3069.0	0
Alnus spp.	109 398.4	1
Betula spp.	596.3	0
Carpinus spp.	1 000 631.5	0
Castanea sativa	99 538.7	0
Corylus spp.	40.6	0
Eucalyptus spp.	6669.2	0
Fagus spp.	1 335 527.4	6
Fraxinus spp.	11 671.0	0
Juglans spp.	201.4	0
Ostria carpinifolia	1957.4	0
Laurus spp.	2217.1	0
Liquidambar orientalis	3198.1	0
Oak spp.	6 068 920.1	29
Platanus spp.	1458.3	0
Populus spp.	28 737.4	0
Robinia pseudoacacia	259.0	0
Salix spp.	2192.6	0
Tilia spp.	5424.4	0
Ulmus spp.	139.6	0
Other	1 782 861.7	9
Total	**9 568 190.4**	**46**

In general, the Middle East is rich in flora and plant genetic diversity and Turkey has a number of plant species for which this is higher than all neighbouring countries. With its richness in genetic diversity, Turkey has a unique position. Two important gene centres (Near East and Mediterranean) described by Vavilov (1958) are located in the country. Besides these centres, Turkey is also a centre of diversity for many wild, transitional and cultivated forms of annual and perennial, herbaceous and woody plants.

Turkey is in the temperate climatic belt and has a large diversity of habitats due to diversity in its geomorphology, topography and climate (Fig. 1a, b, c).

Table 2b. Conifer species in Turkey

Species	Area (ha)	% of grand total
Abies spp.	627 143.4	3
Cedrus libani	343 032.4	2
Cupressus spp.	1375.3	0
Juniperus spp.	1 240 488.4	6
Picea orientalis	286851.1	1
Pinus brutia	4191460.1	20
Pinus halepensis	3793.2	0
Pinus nigra	3 328 730.9	16
Pinus pinaster	55 596.9	0
Pinus pinea	54 152.9	0
Pinus radiata	2522.3	0
Pinus sylvestris	1 037 751.3	5
Pseudotsuga menziesii	345.0	0
Other	21 814.6	0
Total	**11 195 057.8**	**54**

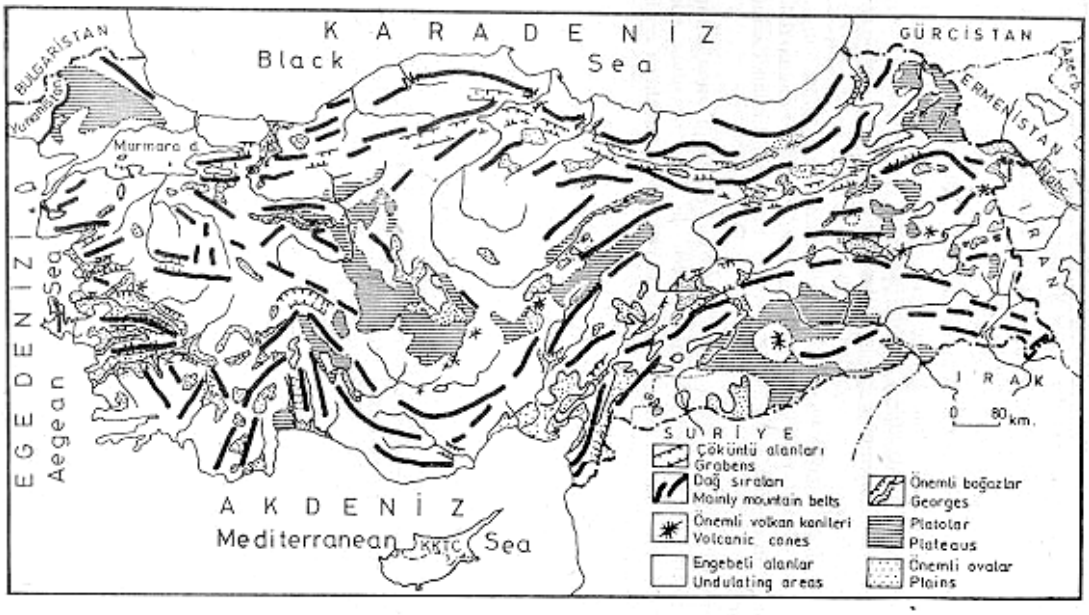


Fig. 1a. Physiographic map of Turkey (Atalay 1994).

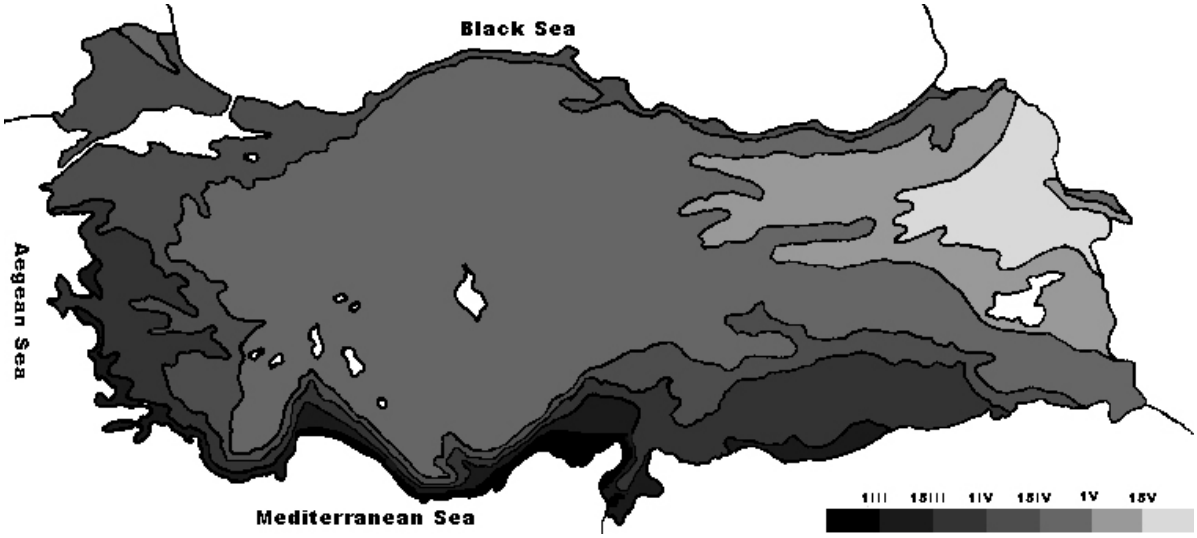


Fig 1b. Beginning of the vegetation periods on the basis of 8°C, in Turkey (Atalay1994)

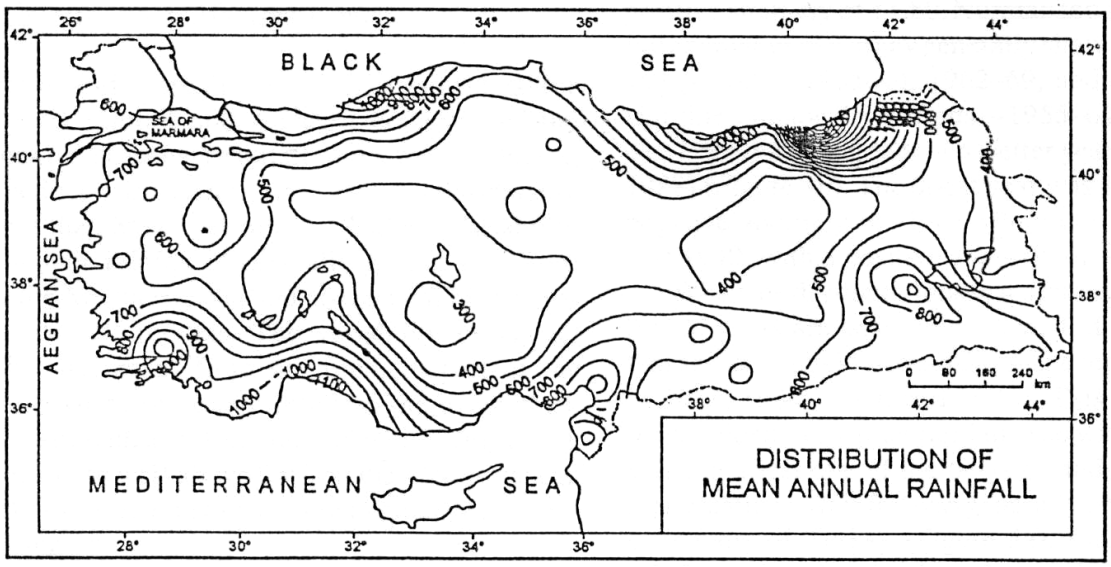


Fig. 1c. Distribution of mean annual precipitation in Turkey.

Studies have shown that there are 163 families (1225 genera and 8745 species) of vascular plants in Turkey and 2763 of these are endemic. Turkey is also a gene centre for some forest trees (fir, spruce, cedar, juniper, sweet gum etc.) and wild relatives of cultivated plants (wheat, barley, lentil, chickpea, apple, pear, cherry, walnut, pistachio, chestnut etc.), which are crop plants of worldwide importance.

Turkey has not only wide diversity in climate and geography but also is a bridge between the continents of Europe, Asia and Africa. The movement of different cultures and lifestyles between these continents in the past has not only brought many relatives of crop plants in cultivation today, but also fostered the distribution and evolution of many cultivated forms of crop species. As result of climatic diversity, different civilizations, migration and natural selection, many cultivated forms and landraces of crop species have evolved in Turkey (Kaya *et al*. 1998).

Turkey is divided into three main floristic regions: the Euro-Siberian, the Mediterranean and the Irano-Turanian (inner eastern and southwestern Anatolia) floristic region (Fig. 2).

Fig. 2. Floristic regions of Turkey: (I) Euro-Siberian, (II) Mediterranean and (III) Irano-Turanian (Kaya and Raynal, 2001)

- *Euro-Siberian Floristic Region*. The mean annual temperature varies between 10 and 14°C along the coastal belt Black Sea. The mean temperature ranges from 6 to 10°C between 1000 and 2000 m a.s.l. The average annual precipitation exceeds 1000 mm with precipitation distributed unevenly throughout the region.
- *Mediterranean Floristic Region*. The elevation ranges from sea level to up 4000 m. The mean annual temperature is approximately 17°C and the mean annual precipitation is about 870 mm (range 400-2000 mm).
- *Irano-Turanian Floristic Region*. Forests are present at the edge of plains and in tectonic depressions. Most basins support steppe vegetation. The mean annual temperature ranges from 4 to 18°C. The mean annual precipitation varies from 400 mm in central Anatolia to 600 mm in eastern Anatolia. However, mean annual precipitation is higher in the southeastern Taurus Mountains, about 1000 mm (Kaya and Raynal 2001).

Conservation studies

The National Tree Breeding and Seed Production Program started in 1994 (Koski and Antola 1993) and is implemented by the Forest Tree Seed and Tree Breeding Research Directorate. Intensive breeding activities, including seed stand selection and plus tree selection, seed orchard establishment, progeny testing and gene conservation concentrate mainly on five species: *Pinus brutia, P. nigra, P. sylvestris, Cedrus libani* and *Fagus orientalis*. Other species are subject to less intensive breeding activities including seed stand selection, seed orchard establishment, and gene conservation.

In the National Program, target species (*Pinus brutia, P. nigra, P. sylvestris, Cedrus libani* and *Fagus orientalis*) were divided into seed zones taking into consideration the geographical area in which ecological factors are similar. Main zones were also divided into subzones according to elevation (400 m interval). These subzones are considered breeding units.

Table 3. Target forest species for *in situ* conservation of genetic diversity in Turkey. (Revision of target species will be conducted during the implementation of national plan)

Species		Species	
Abies cilicica	Taurus fir	*Laurus nobilis*	Mediterranean laurel
Abies nordmanniana		*Liqudambar orientalis*	Sweet gum
subsp. *nordmanniana*	East Black Sea fir	*Olea europea*	Wild olive
subsp. *equi-trojani*	Kazdagı fir	*Pterocarya fraxinifolia*	Walnut
subsp. bormuelleriana	Uludagı fir	*Picea orientalis*	Oriental spruce
Alnus glutinosa	Red alder	*Pinus brutia*	Turkish Red pine
Alnus orientalis	Oriental alder	*Pinus halepensis*	Aleppo pine
Betula pubescens	Hairy birch	*Pinus nigra*	Black pine
B. medwediewi		*Pinus pinea*	Stone pine
Buxus sempervirens	Box tree	*Pinus sylvestris*	Scots pine
Castanea sativa	Anatolian chestnut	*Populus euphratica*	Euphrate poplar
Cedrus libani	Taurus cedar	*Populus tremula*	Trembling poplar
Ceratonia siliqua	Carob	*Pyrus eleagnifolia*	Wild pear
Crataegus azarolus	Azarole	*Quercus aucheri*	Oaks
Cupressus sempervirens	Cypress	*Quercus hartwissiana*	
Fagus orientalis	Oriental beech	*Quercus vulcanica*	
Fraxinus angustifolia	Ash	*Taxus baccata*	Yew
Fraxinus excelsior		*Tilia rubra*	Caucasus linden
Fraxinus ornus	Ornus	*Tilia tomentosa*	Silvery linden
Juglans regia	Walnut	*Ulmus campestris*	Elms
Juniperus drupacea	Junipers	*Ulmus carpinifolia*	
Juniperus excelsa		*Ulmus glabra*	
Juniperus foetidissima			

Each breeding unit selected for a target species should cover a minimum of 100 ha. For other species, the minimum stand area is also 100 ha if possible. According to the National Program when seed need is met from seed orchards, seed stands will be preserved as gene conservation forests. Therefore, seed stands are potential gene conservation forests.

Another important plan is the 'National Plan for *In Situ* Conservation of Plant Genetic Diversity in Turkey', which includes a forestry section prepared in 1998 (Kaya *et al.* 1998). However, the plan is not yet implemented and studies for its application are ongoing. This National Plan determined priority forest trees for conservation (Table 3).

The General Directorate of National Parks, Game and Wildlife is responsible for conservation through National Parks, Nature Parks, Nature Conservation Areas, and Nature Monuments. Nature conservation areas and nature monuments are particularly important for *in situ* gene conservation, because these areas sometimes aim to conserve species and single trees, respectively (Table 4).

Table 4. Some examples of nature conservation areas in Turkey

Name	**Area (ha)**	**Characteristics**
Kasnak megesi	1300.5	Pure endemic *Quercus vulcanica* stands
Sütçüler Sıla ormanı	88.5	Endemic *Liquidambar orientalis* has its optimum distribution here
Sırtlanda Halep Çamı	760	One of two places where *Pinus halepensis* is found in Turkey
Çamburnu	180	Low altitude *Pinus sylvestris* and habitats for migratory birds
Alacada	427	A rare ecosystem with more than 20 rare forest tree species, untouched natural structure and monumental trees

Turkey has many Noble Hardwood species (Table 5), some of which could be added to the Network's list: e.g. *Alnus orientalis, Liquidambar orientalis Pterocarya fraxinifolia, Platanus* spp., and *Pyrus eleagnifolia.*

Table 5. Noble Hardwoods in Turkey

Species	**Common name**
Acer spp.	
Alnus glutinosa	Red alder
Alnus orientalis	Oriental alder
Betula pubescens	Hairy birch
B. medwediewi	
Buxus sempervirens	Box tree
Carpinus spp.	
Castanea sativa	Anatolian chestnut
Ceratonia siliqua	Carob
Crataegus azarolus	Azarole
Corylus spp.	
Fraxinus angustifolia	Ash
Fraxinus excelsior	
Fraxinus ornus	Ornus
Juglans regia	Walnut
Laurus nobilis	Mediterranean laurel
Liquidambar orientalis	Sweet gum
Olea europea	Wild olive
Ostria carpinifolia	
Pterocarya fraxinifolia	Walnut
Platanus spp.	
Pyrus eleagnifolia	Wild pear
Tilia rubra	Caucasus linden
Tilia tomentosa	Silvery linden
Ulmus campestris	Elms
Ulmus carpinifolia	
Ulmus glabra	

Inventories

Not all Noble Hardwood species in Turkey are inventoried. Many of them are in fact categorized at the genus level (Table 6).

Table 6. Noble Hardwoods for which an inventory has been made

Species	Area (ha)
Acacia spp.	3.50
Acer spp.	3.00
Alnus spp.	109.40
Betula spp.	0.60
Carpinus spp.	1000.00
Castanea sativa	99.50
Corylus spp.	0.04
Fraxinus spp.	0.01
Juglans spp.	0.02
Ostria carpinifolia	2.00
Laurus spp.	2.20
Liquidambar orientalis	3.20
Platanus spp.	1.50
Tilia spp.	5.40
Ulmus spp.	0.10
Other	1782.90
Total	**3013.37**

Legislation

Although the Turkish Constitution does not directly refer to the conservation of plant genetic diversity, article 63 of the Constitution states that the government should protect its historical, cultural and natural values and resources as well a support and promote conservation efforts made by people. In addition to the articles present in the Constitution, the Law for Protection of Cultural and Natural values, the Environmental Law, the National Parks Law, the Bosphorus Law, the Law for Especially Protected Environmental Regions and the Forestry Law provide opportunities for protecting biological diversity, and facilitate activities related to conservation of plant genetic diversity.

Research

Research on Noble Hardwoods is quite limited. Most research activities are related to major commercial species: *Quercus* spp., *Pinus brutia, Pinus nigra, Fagus orientalis, Pinus sylvestris, Abies* spp. and *Cedrus libani*. However, a research project on breeding of *Alnus glutinosa* is underway.

Coordination at the national level

The Forest Tree Seed and Tree Breeding Research Directorate is responsible for conducting *ex situ* and *in situ* conservation of forest trees.

Public awareness

In Turkey, the public is not sufficiently aware of the importance of plant genetic resources and their conservation. Lately, the number of non- governmental organizations (NGOs) and their activities has increased. However, their contribution is limited due to budgetary problems. For Noble Hardwoods, awareness is also limited among foresters.

Summary tables of *in situ* and *ex situ* conservation activities and measures

	***In situ* measures**
Species	**Stands (ha/no.) 1999**
Alnus spp.	523/1
Castanea sativa	585/5
Corylus spp.	112/1
Fraxinus spp.	99/1
Liquidambar orientalis	60,5/1
Ostria carpinifolia	64,5/1
Platanus spp.	33/1
Tilia spp.	312/2

	***Ex situ* measures**			
Species	**Stands**	**Seed orchards and clone collections**		
		Number	**Ha**	**No. of clones/ families**
	1999*	**99**	**99**	**99**
Acer spp.	0.2/1			
Alnus spp.	9/1			
Fraxinus spp.	0.3/1			
Juglans regia	2/1	2	1.6	22
Liquidambar orientalis	0.2/1	1	2.2	30

*ha/number

References

Atalay, I. 1994. Vegetation Geography of Turkey. Ege Universitesi Basimevi, Izmir.

Kaya, Z., E. Kün, A Güner 1998. National Plan for *In Situ* Conservation of Plant Genetic Diversity in Turkey.

Kaya, Z., D. J. Raynal 2001. Biodiversity and Conservation of Turkish Forests. Biological Conservation 97(2001) 131-134.

Koski, V. and J. Antola 1993. National Tree Breeding and Seed Production Programme for Turkey. Prepared in cooperation with the Forest Tree Seed and Tree Breeding Research Directorate.

Vavilov, N. I. 1958. The Origin, Variation, Immunity, and Breeding of Cultivated Plants. The Chronica Botanica, Vol. 13 1/6 Waltham, MA, USA.

The role of hybridization in gene conservation

Discussion paper

Eric Collin
CEMAGREF, Nogent-sur-Vernisson, France

Introduction

The following presentation is a brief introduction to different aspects of hybridization in gene conservation. Whereas hybridization is often judged 'unnatural' and considered potentially detrimental to genetic resources, the past role of hybridization and the modern concept of species tell us that this phenomenon may also be viewed as a natural and a powerful factor for increasing genetic diversity and the adaptation of forest tree genetic resources to a changing environment. Consequently, gene conservation strategies should not be restricted to the protection of pure species from possible introgression risks, but they should also take into consideration the key role of species hybridization when their objective is to promote adaptation.

The role of hybridization in native European forest tree species

Asymmetric hybridization in oaks, as an example of the role of hybridization in adaptation

Genetic studies using chloroplast DNA molecular markers in European oak species in France have suggested that asymmetric hybridization has occurred between *Quercus petraea* and *Q. robur* (Petit *et al*. 1998). Hybridization occurs preferentially from *Q. petraea* (father tree) to *Q. robur* (mother tree). Successive unidirectional hybridization with *Q. robur* can be viewed as one of the mechanisms contributing to the enrichment of genetic diversity within *Q. petraea* (Bacilieri *et al*. 1996).

As *Q. petraea* is not as good as *Q. robur* for colonizing new sites, but more competitive in the long term and in lesser quality soils, hybridization can also be considered as one of the strategies for *Q. petraea* to colonize new sites.

The concept of 'species', and the possibility for gene exchanges between species

Very different approaches were used to define the concept of 'species':

- Morphological species (Linné)
- Biological species, which do not exchange genes (Mayr 1963)
- Ecological species, occupying different 'niches' (Van Valen 1976)
- Species complex, allowing for important gene exchanges (Pernès 1984)

We observe that, over time, the concept of 'species' has evolved from clear-cut differences between taxa to a more flexible notion acknowledging for important gene exchanges between them, such that a continuum is formed in 'species complexes'. The recent availability of molecular markers has enabled geneticists to revisit and to refine systematic units based on morphologic characters. Both approaches are definitely needed to provide a comprehensive understanding of the partitioning of genetic variation in forest tree species.

The role of hybridization and the recognition of 'species complexes' in Noble Hardwoods

Literature (e.g. Jeandroz *et al.* 1996) and discussions among Network members provide many examples of hybridization in European Noble Hardwoods*:*

Ulmus minor ⇔ *U. glabra*
Fraxinus excelsior ⇔ *F. angustifolia*
Tilia cordata ⇔ *T. platyphyllos*
Alnus glutinosa ⇔*A. incana & cordata*
Sorbus torminalis ⇔ *S. aria*

In some cases, for instance in the *Ulmus minor–Ulmus glabra* complex, the recognition of pure species becomes very awkward, and the conservation of their genetic resources has to be undertaken using an extensive notion of the diversity existing in the complex.

Introgression by introduced species and cultivated varieties of Noble Hardwoods

Introgression by introduced species: *Ulmus pumila* as an example

The 'Siberian elm' (*U. pumila* L.) was massively introduced in Italy in the 1930s, to be used as a living support for grapevine in replacement of the local Field elm (*U. minor* Mill.) victim of the Dutch elm disease (L. Mittempergher, pers. com.). It has also been widely planted as an ornamental tree in Spain, where it was first introduced in the 16th century (Cogolludo-Agustin *et al*. 2000).

As it is generally tolerant to Dutch elm disease, and it can crossbreed easily with the local Field elms and produce fertile hybrids, there is a possibility that the indigenous elm genetic resources in Spain and Italy are being introgressed to some unknown extent by *U. pumila*. Opinions on the extent (strong or negligible) and effect (beneficial with regard to tolerance to Dutch elm disease, detrimental with regard to wood quality) are extremely variable according to people's feelings. Facts, such as the spontaneous and frequent apparition of intermediate forms (e.g. *Siberian elm* seedlings showing typical *Ulmus minor* corky wings) tend to indicate that gene exchanges between the two species are becoming important in some places. However, a recent study (Cogolludo-Agustin *et al*. 2000) carried out with isozymes on 83 putative hybrids and 104 putative pure *U. minor* originating from different places of central Spain did not reveal any introgression evidence in the native *Ulmus minor* sample, and showed that hybridization is highly asymmetric due to preferential backcrossing of the hybrids with *U. pumila*.

Introgression by cultivated varieties: fruit trees and amenity plantings as examples

Discussions among Network members have revealed that it is not easy to tell if *Prunus, Malus or Pyrus* trees found in forest stands belong to the wild or to a cultivated or introgressed form of the species. Ancient cultivation of fruit trees in the vicinity of forests and woods, plus the recent development of amenity plantings along motorways or for the reconstruction of hedges, have provided many non-autochtonous sources of pollen.

Moreover, the evidence for long-distance pollination events tends to support the possibilities for such gene flow from cultivated trees to forest populations. It also questions the efficiency of the 'buffer zones' to be kept between conservation populations and planted domesticated forms.

Practical recommendations for the management of gene resources and conservation stands

Practical recommendations for the management of gene resources

With regard to ordinary 'planting practice', one of the main topics to discuss concerns the choice and availability of Forest Reproductive Material (seeds, planting stock). Should FRM regulation be adapted to strengthen the protection of forest gene resources ? Should awareness be raised among amenity and forest tree planters for a better choice of species and provenances?

Practical recommendations for the choice and management of gene conservation stands

With regard to genetic resources conservation activities, methods should match the two different kinds of objectives we want to reach when selecting populations for a European Noble Hardwoods conservation network:

(i) *prevent hybridization* when the objective is to preserve wild populations (e.g. *Malus*, *Pyrus*) from extensive introgression risks
(ii) *select 'hybridization conservation stands'* when the objective is to promote adaptation.

Network members and forest managers are aware of the need and conscious of the difficulty to implement the first objective. As a conclusion to this brief introductory talk on the role of hybridization in gene conservation, we can recommend that the second objective be also taken into consideration, and that a few populations where inter-specific hybridization takes place be selected in our 'Noble Hardwoods' genetic resources conservation networks.

Summary of the discussion among meeting participants

Participants observed that psychological factors depending on our 'cultural heritage' play a great role on the way people consider hybridization. Three different cases were observed for native, naturalized and recently imported species, the latter being considered the most 'dangerous'.

Other factors than time (i.e. ancient introduction) need in fact to be taken into consideration. Space (i.e. the distribution scale of the introduced species) is of course becoming very important due to the increasing role of man for mass seed transportation and habitat manipulation. Competitiveness of the introduced species or of its hybrids with the local resource, and their capabilities for pollen and seed dispersal are also key factors.

Participants mentioned the fact that 'moving provenances around' can be good for raising adaptive variation, and that provenance tests provide many examples of introduced species and provenances growing better than the local one.

With regard to practical recommendations, FRM regulations allowing possibilities for seed harvest in populations where hybrids can be found (e.g. for oaks, lime and birch) were briefly debated. Concern was expressed over the corridors possibly created by motorway amenity plantings. The need for research work on pollination distances and gene flow was emphasized. The proposal for selecting some populations within gene conservation networks, in which hybridization occurs and can be monitored over time, was accepted.

References

Allendorf F., R.F. Leary, P. Spruell and J.K. Wenburg. 2001. The problems with hybrids: setting conservation guidelines. Trends in Ecology and Evolution 16(11):613-622.

Bacilieri R., A. Ducousso, R.J. Petit and A. Kremer. 1996. Mating system and asymmetric hybridization in a mixed stand of European oaks. Evolution 50(2):900-908.

Cogolludo-Agustin M.A., D. Agundes and L. Gil. 2000. Identification of native and hybrid elms in Spain using isozyme gene markers. Heredity 85:157-166.

Jeandroz S., N. Frascaria-Lacoste and J. Bousquet. 1996. Molecular recognition of the closely related *Fraxinus excelsior* and *F. oxyphylla* (Oleaceae) by RAPD markers. Forest Genetics 3(4):237-242.

Mayr E. 1963. Populations, espèces et évolutions. Ed Hermann, Paris.

Pernès J. 1984. Gestion des ressources génétiques des plantes. Tome 2, Agence de coopération culturelle et technique, Paris.

Petit R.J., B. Pineau, B. Démesure, R. Bacilieri, A. Ducousso and A. Kremer. 1998. Chloroplast DNA footprints of postglacial recolonization by oaks. Proceedings of the National Academy of Sciences of the USA 94: 9996-10001.

Van Valen L. 1976. Ecological species, multispecies, and Oaks. Taxon 25:233-239.

Long-term conservation strategies

Juglans regia L. genetic resources conservation strategy

Josefa Fernández-López[1], Neus Aleta[2] and Ricardo Alía[3]

[1] *Centro de Investigacións Forestais de Lourizán, Pontevedra, Spain*
[2] *IRTA Mas Bové, Reus, Spain*
[3] *Departamento CIFOR-INIA, Madrid, Spain*

Introduction

The inclusion of walnut (*Juglans regia* L.) in the framework of the EUFORGEN Noble Hardwoods Network is based on some of its characteristics, such as the scattered distribution of the species in its western European range, the limited extension of the stands, in many occasions as isolated trees, and its precious timber, greatly appreciated for many uses. The main factors affecting the genetic resources of the species derive from the traditional plantation by man resulting in a complex pattern of native (if existing) and man-made stands, and the introgression of these cultivars with native trees. Recently, the use of cultivars of *Juglans regia* and *J. nigra* has become more important. Within the Noble Hardwoods Network, it shares some characteristic features of the strategies of genetic resource conservation with chestnut, mainly because of the multipurpose objectives of both species. However, the differences are quite high, due to the scarce presence and role of *Juglans* spp. in the forest. Walnut is usually found in stands of limited extension, in pure stands (the presence in Western Europe in mixed broadleaves stands is rare), and until recently cultivars had limited importance in the silviculture of the species.

Walnut grows as a wild species in mixed broadleaves forest from Southern Europe to India. It is found in the Balkan area (Hungary, former Yugoslavia, Bulgaria, Albania), Caucasus, Asia Minor (Turkey, North Iran and Iraq), Central Asia (the northern limit in Kyrgyzstan) and has its eastern limit in the North of India (Hemery 1998; Malvolti *et al.* 1997; Germain 1999). The natural area of the species is a matter of controversy, and little is known about the native area in Europe, and even in the Balkan area some authors consider it as an introduced species (Malvolti *et al* 1998). Central Asia, and more specifically the mountains of the West Himalayan chain in the Kashmir, Tajikistan and Kyrgyzstan, are considered to be the centre of origin of *J. regia* L. Surprisingly, in that area there are populations of *J. regia* with very different characteristics: some of them are formed of high trees with remarkable stem straightness and others include smaller trees that produce big crops of nuts and continuously flower during the growing season (Hemery 1998; Germain *et al.* 1997, 1999). Walnut has been cultivated since the Greek and Roman times all around the Mediterranean basin, where it is found as scattered individuals or groups of several trees on the borders of agricultural lands, orchards or by rivers, usually close to human settlements. The species was spread all around south Europe already in 1000 BC (Ducci *et al.* 1997). Thus, as a basis for the genetic resource conservation of the species, we can assume the existence of native trees all around the Western Mediterranean area.

It is a long-lived species, and it is not difficult to find 100-200 year old trees, and even some 1000 years old. There are some problems related to natural regeneration due to the fact that different animals eat the edible nuts. Walnut is found in all types of substrates, mainly in fresh, fairly rich, and loose soils, avoiding gypseous, compact, or dry ones. The optimum soil pH ranges from 6.5 to 7.5. It prefers mild to warm-mild climates, as late frost is an important limiting factor that affects both flowering and shoot development. In these climatic conditions, altitude is not an important limiting factor, and it can be found from low elevations up to 2500 m a.s.l. (Himalayas, Morocco) (Leslie and McGranahan 1988, 1997).

In Europe, walnut cannot be considered a social species, in the sense that there are no large monospecific stands and it is usually found as isolated trees with high spacing producing dense ground cover, or in small groups of trees.

Multiple use of the species

One of the main characteristics that has affected the present increase of the distribution area of the species is its multiple use. Walnut is planted for producing both nuts and timber. The ornamental value of the tree is of great importance in all of Europe, both in parks and in the countryside by houses. The wood is hard, homogeneous and heavy, with dark brown heartwood and with a highly appreciated pattern. By steaming, it produces a nice reddish colour or a black and red pattern of great beauty. Due to these characteristics and easy machining it is very appreciated in carpentry. It is used for veneer, fetching very high prices for furniture. Walnut timber is considered the most valuable European timber.

The fruit is edible and is highly appreciated for human consumption. As a result, many countries developed selection and breeding programmes for nut production. In Western Europe, new orchards are planted using grafted plants of cultivars issued from French and Californian breeding programmes, which have allowed a high improvement in orchard productivity (McGranahan 1997; Germain 1999). In Eastern Europe, plantations of clonal grafted varieties are not so common.

In general, European walnut production still largely depends on trees originated from seedlings. During the last 20 years, important work on seedling selection has been carried out in local populations of *J regia* throughout Europe. The characteristics of wild walnut trees have been described in Bulgaria, Germany, Greece, Hungary, Italy, Poland, Portugal, Romania, Slovenia, Spain and Ukraine (Germain 1992, Germain *et al.* 1983, 1997; Deaconu and Vasilescu 1997; Pielko 1989; Revin 1989; Solar 1989).

The trend in plantations and consequently in selection and breeding, is to separate the production of wood from the production of fruit. However, all genetic information obtained from walnut breeding programmes is also being used in current programs focused on wood production (FAIR III-CT-96-1887).

The clear separation that exists among breeding programs implies the necessity of including the two objectives in the genetic conservation of the species.

The area planted with *Juglans* species has recently increased, due to EU directive on afforestation of abandoned marginal lands (EU Directive 2078), and so has the use of interspecific hybrids that can be found in specialized nurseries (Becquey 1997).

At present, most of the nuts and the timber in Western Europe come from walnuts growing in the countryside; in France, however, most are produced in plantations.

Genetic knowledge

As this species is very sensitive to a number of abiotic and biotic factors, it is possible to suppose that natural selection is a very strong force in walnut populations, particularly in southwestern Europe. The most important abiotic factors are autumn frosts, which sometimes lead to tree death, and late spring frosts that have an effect on stem form. The main biotic damage factors are fungal attacks. *Armillaria mellea*, *Phytophthora cinamomii* and *P. cambivora* are important diseases affecting the root system while antracnosis (*Gnomonia leptostyla*) causes summer leaf fall. Bacterial diseases are also factors: *Xanthomonas arboricola* pv. *juglandis*, damages leaves and young shoots in humid and mild climate and after several rainy summers some trees might even die (Becquey 1997). *Erwinia* spp should also be considered as it damages bark and wood and although it might not kill the trees produces timber depreciation (Teviotdale *et al.* 1985; López *et al.* 1994).

Walnut is an anemophilous species, producing heavy pollen that spreads over 100 m. Although dichogamy is present there is autocompatibility (Germain *et al.* 1973). These factors and the scattered distribution of the species make it possible to suppose that the rate of

geneflow is low among stands. The presence of apomixis is reduced to cultivars from Central Europe and is highly influenced by the weather during the pollination period. Some Byelorussian, German and Hungarian origins have shown this phenomenon. In some conditions, up to 70% of apomixis has been described (Loiko 1989; Germain 1999).

According to Eriksson (1996, 1998), a very strong differentiation of adaptive traits can be assumed among populations located in different ecological conditions. This is due to the action of natural selection, the scant importance of geneflow and the very limited phenotypic plasticity of walnut. However, within a homogeneous ecological area, there are several populations subjected to the same natural selection processes (especially in relation to temperature and diseases) but between which there is no geneflow. Therefore, we can expect an important differentiation among these populations because of genetic drift and inbreeding within each one.

In fact, most authors consider that these SW European populations are adapted to local environments and the first results of provenance tests confirm this hypothesis. In Spain, for example, significant differences among populations have been detected in survival, height growth and heat sum to leafing out (Fernández and Pereira 1997), and in vigour, leaf fall and blight sensitivity (Aleta and Ninot 1997). Some variation in resistance to *Armillaria mellea* was met in *J. regia* progenies (Desray *et al.* 1997). The first results of different progeny tests developed in the European project showed a very important heritability for height and phenology (see first report of FAIR-III, CT-96-1887).

Twenty-six naturalized populations from Mediterranean and Asian origins were studied using isozymes (Malvolti and Fineschi 1987; Malvolti *et al.* 1997) and it was found that the values of polymorphism and heterozygosity (38.33-46.7 and 0.152-0.225, respectively) were lower than those reported for chestnut.

Malvolti *et al.* (1997) indicate that wild trees have arisen from genotypes that escaped cultivation, but in some areas the contribution of native residual germplasm cannot be excluded. These authors mention that despite the limited level of genetic variability within *J. regia*, two main factors have to be considered. Firstly, the presence of genotypes adapted to local environmental conditions, as deduced by the variation of *F* statistics among populations from different areas. Secondly, the occurrence of different alleles in populations from China and Europe suggest the existence of distinguished genepools.

As a result of exploration and selection in local populations, in many European countries there are several *J. regia* native germplasm collections. A list of this material and its localization will be available next year when FAO publishes the information in a specific publication of *J. regia* genetic resources (Germain, Coord., in preparation).

Threats to the genetic variability

The main threat to genetic variability, at least in South West Europe, is and was the felling of the best trees for wood production due to the high price of the timber.

Another threat is posed by the introgression of black walnut (*J. nigra*) or of grafted varieties for nut production. Many crosses are possible within the *Juglans* genus and interspecific hybridizations are very common. Particularly interesting for wood production are the hybrids *J. nigra* or *J. major* × *J. regia* (Becquey 1997). Sometimes F_1 hybrids are similar to *J. regia* particularly when trees are still in the nursery but morphological characteristics (such as cataphylar leaf distribution) or isozyme characterization can be used for identification (Arulsekar *et al.* 1985; Germain *et al.* 1993; Hussendörfer 1999).

Finally, the abandonment of the countryside could have a very strong influence on the naturalized populations.

Objectives of gene resource conservation

The main genetic resources to be conserved in SW Europe are the various small-sized (5 to 12 trees) scattered populations, that appear to be a long standing introduced genetic resource,

well adapted to the local environment. These may be considered as the gene resource population for selection of nut or wood varieties. The main South Western European germplasm collections conserve much more variability regarding nut production than forestry traits and usually the accessions are clonal selections, which means that population variability is not always preserved. However, a question that can be addressed is the genetic basis of these populations. At the moment, there is limited information on the amount of genetic diversity or the existence of founder effects in the Western European material. In this case, the introduction of new germplasm should be considered. This could be collected from areas where genetic variability is still high, e.g. Central Asia (Hemery 1998), or from countries where wild populations are widely present as they are the source of walnut timber for European manufacturers, e.g. Greece, Turkey or Iran (Jay-Allemand *et al.* 1996). Research programmes should clarify this last objective before taking any decisions.

Objectives of Walnut Forest Genetic Resources Conservation within the framework of the EUFORGEN Noble Hardwoods Network are based mainly on the multipurpose use of the species, and therefore, could be divided into three main objectives:

1. Conservation of the present genetic resource base, using the different collections of selected trees for wood or nut production with objectives of breeding.
2. Conservation of the present genetic base, taking into account the small size of populations in the European range of the species.
3. Dynamic conservation of the species by creating good conditions for future evolution of populations.

Suggested gene conservation methods

From a European perspective the gene conservation strategy of walnut should consider the following issues:

- As in Europe most of the trees are located in the countryside and not in the forest, which definition of population should be applied.
- How many populations and genetic entries should be included.
- How should populations be sampled.
- Which are the priority activities to be developed.

The following methods are suggested:

Ex situ conservation

Clonal archives of plus trees and valuable trees for fruit production already selected. As pointed out by Ducci *et al.* (1997), there are already some collections of great value that could be used for static conservation of genetic resources. Broad collections are currently found in France, Italy, Spain and Hungary.

Clonal seed orchards containing grafted plus trees provenance areas with 50 p.t. The promotion of planting with seedlings of such origin is a very effective way to increase genetic variability (Eriksson 1998) in Western Europe at a level that did not exist previously.

Dynamic conservation (MPBS) for conservation of wild populations

To establish a MPBS, according to the principles developed by Eriksson *et al.* (1993) and applied by Varela and Eriksson (1995), at least 20 populations of 50 genetic entries each must be chosen. In some situations the population size must be increased.

Ex situ managed plantations in SW Europe

Progeny tests of 50 trees collected in an ecologically homogeneous area. This can be especially interesting in areas where there is a breeding programme for forestry traits.

It is also necessary to identify methods to transform the progeny test into a conservation plantation, after progeny test evaluation and further stimulation of regeneration are completed.

In situ managed or unmanaged plantations

As was previously mentioned, in this species, the size of populations is quite limited. Therefore, these should be considered in a broad sense, in order to include at least 20 trees. Within these areas, natural propagation has to be promoted in order to increase the size. Due to the economic and social value of walnut management of these populations this is the only way to maintain and increase the size of the populations.

Selection of populations for conservation

Clonal archives of plus trees or clones selected for nut production and seed orchards will be maintained in each country interested in plantations and in genetic improvement.

In order to establish a dynamic conservation programme, populations should be selected throughout the entire European area and distributed among the different climatic zones: eight populations in the *true Mediterranean* (2 in Portugal, 3 in Spain, 2 in Italy, 1 in Turkey); two populations in the *atlantic temperate-humid zone* (1 in Turkey, 1 in Armenia); four populations in the *Atlantic-oceanic zone* (2 in Spain, 1 in France, 1 in UK); and seven in the *Atlantic middle European zone* (1 in France, 1 in Italy, 1 in Germany, 1 in Poland; 1 in Hungary, 1 in Bulgaria and 1 in Romania). Walter climatic classification was used (Allue Andrade 1990).

Research activities

Studies using different genetic markers (maternally and paternally inherited) to assess the migration pathways of the species, the role of native stands in Western Europe, and the mating system in different ecological conditions are needed.

Provenance tests, connected with the previous studies, to assess the adaptive variation of the species, including provenances from the entire distribution area are also required, together with a further evaluation of the interest of transfer of germplasm from SE Europe or Asia in SW Europe.

Bibliography

Aleta, N. and A. Ninot. 1997. Field evaluation of Juglans regia selected clones from seedling populations of Mediterranean and Atlantic Spanish Coast. In III International Walnut Congress. Alcobaça 1995. Gomes-pereira (ed). Acta Horticulturae 411: 63-67

Allue Andrade, J.L. 1990. Atlas fitoclimático de España. Ministerio de Agricultura, INIA, Madrid, 221 pp.

Arulsekar, S., D.E. Parfitt and G.H. McGranahan. 1985. Isozyme gene markers in *Juglans* species. Inheritance of GPI and AAT in *J. regia* and *J. hindsii*. J. of Hered. 76: 103-106

Becquey, J. 1997. Les noyers à bois. Ed. Institut pour le Développement Forestier (IDF). Paris. 144pp.

Deaconu, I. and V. Vasilescu. 1997. The contribution of the Romanian research to collecting and use of tree germplasm from walnut trees. III International Walnut Congress. Alcobaça 1995. Gomes-Pereira(ed). Acta Horticulturae 411: 271-276.

Desray, P., C. Jay-Allemand, B. Fady and J.J. Guillaumin. 1997. Susceptibility to *Armillaria mellea* of different progenies of *Juglans* spp. selected for timber. IUFRO Congress "Root and Butt rots", Carcans Mabuisson. In preparation.

Ducci, F., A. Rogatis and R. Proietti. 1997. Protezione delle risorse genetiche di *Juglans regia* L. Ann. Ist. Sper. Selv. 25/26: 35-55.

Eriksson, G. 1993. Dynamic gene conservation for uncertain futures. For. Ecol. Manage. 62:15-37.

Eriksson, G. 1996. Evolutionary genetics and conservation of forest tree genetic resources. Noble Hardwoods Network, Report of the First Meeting, EUFORGEN, IPGRI: 159-167.

Eriksson, G. 1998. Sampling for genetic resources populations in the absence of genetic knowledge. Noble Hardwoods Network, Report of the Second Meeting, EUFORGEN, IPGRI: 61-75.

Fernandez-Lopez, J. and S. Pereira. 1997. Genetic control of growth in *Juglans regia* seedlings from open families of different provenances. III international Walnut Congress. Alcobaça 1995. Gomes-Pereira (ed) Acta Horticulturae 411.69-75

Germain, E. 1992. Le noyer. In: Amélioration des espèces végétales cultivées: objectifs et critères de sélection. Gallais and Bannerot (eds). Ed. INRA: 620-632.

Germain, E., I. Hanquier and R. Monet. 1993. Identification of eight *Juglans* spp. and their interspecific hybrids by isozymatic electrophoresis. International Walnut Mmeeting, Reus 1991. Aletà, Tasias and Girona (eds). Acta Horticulturae 311: 73-85.

Germain, E., J. Jalinat and M. Marchou., 1973. Biologie florale du noyer (*J. regia* L.). Bull. Tech. Inf. 282: 662-673.

Germain, E., J.P. Prunet and A. Garcin. 1999. Le noyer. Ed. CTIFL. 279pp.

Hemery, G. 1998. Walnut (*J. regia*) seed-collecting expedition to Kyrgyzstan in Central Asia. Quaterly Journal of Forestry 92(2):153-157.

Germain, E, J. Jalinat, P. Léglise, A. Masseron, C. Tronel and A. Chartier. 1983. Le noyer: résultats de 20 ans d''expérimentation. Comportement dans le Sud-Ouest et la basse vallée du Rhône de 65 variétés d''origine française ou étrangère (2ème partie). L''Arboriculture Fruitière 356: 55-60.

Germain, E., N. Aletà, A. Ninot, D. Rouskas, G. Zakinthinos, J.A. Gomes-Pereira, F. Monastra and F. Limongelli. 1997. Prospections réalisées dans les populations de semis de noyer de l'Espagne, de Grèce, d''Italie et du Portugal. Caractérization des populations et description en collections d''études des préselections issues de ces prospections. Options Méediterranéennes Série B. Nº16. Ed. CIHEAM/CE.DGVI: 7-40.

Hemery, G.E. 1998. Walnut (*Juglans regia*) seed collecting expedition to Kyrgyzstan in Central Asia. Quarterly Journal of Forestry, 92,2: 153-157.

Hussendörfer, E. 1999. Short note: Identification of Natural Hybrids *Juglans* x *intermedia* Carr. Using Isoenzyme Gene Markers. Silvae Genetica 48: 50-52.

Jay-Allemand, C., B. Faby and J. Becquey. 1996. Walnut trees for woodland use in Mediterranean countries: Current situation and prospects. FAO-NUCIS Newsletter 5: 10-13.Aletà, N. 1997.

Leslie, C.E. and G.H. McGranahan. 1988. Native population of *J. regia*. Int. Conf. on Walnuts, Yalova, Turkey. Ataturk Central Horticultural Research Institute ed.: 111-124.

Leslie, C.E. and G.H. McGranahan. 19975. Origin of walnut. *In* Manual of Walnut Production. D. Ramos Ed. Univ. of California. Publication 3373: 3-7.

Loiko, R.E. 1989. Apomixis of walnut. I International Symposium on Walnut Production. Budapest 1989. Szentivanyi (ed). Acta Horticulturae 284: 233-236.

López, M.M., R. Marti, C. Morente, A. Ninot and N. Aletà. 1994. Bacterias fitopatógenas identificadas en nogal en España. Investigación Agraria. Fuera de Serie 2: 307-314.

Malvolti, M.E., E. Villani and F. Cannata. 1997. Genetic resources of multipurpose tree species in Mediterranean basin: the case of Juglans regia L. and Castanea sativa Mill. In C. Pichot (de). Resources Genetiques Forestieres. 2nd meeting. Avignon, 24-26 April. 1997. pp: 44-47.

Malvolti, M.E., N. Aletà, A. Ninot and M. Spada. 1998. Walnut (J. regia) genetic resources in Europe. *In* European development of walnut trees for wood and fruit production as an alternative and extensive system to agricultural crops. Ed. Jay-Allemand, CE-DG VI (Agriculture).

McGranahan, G.H., C.E. Leslie, H.A. Philips and A. Dandekar. 1997. Genetic Improvement. *In* Manual of Walut Production. D. Ramos Ed. Univ. of California. Publication 3373: 16-22.

Pieklo, A. and A. Czynczyk. 1989. Evaluation of selected types of walnuts in Poland. I International Symposium on Walnut Production. Budapest 1989. Szentivanyi (ed). Acta Horticulturae 284: 143-144.

Revin, A.A. 1989. Selection of walnut varieties in Crimea. I International Symposium on Walnut Production. Budapest 1989. Szentivanyi (ed). Acta Horticulturae 284: 157-158.

Solar, A. 1989. Phenological and pomological characteristics of walnut cultivars in Northeastern of Slovenia. I International Symposium on Walnut Production. Budapest 1989. Szentivanyi (ed). Acta Horticulturae 284: 167-174.

Teviotdale, B., M.N. Schroth and E.N. Mulrean. 1985. Bark, Fruit and Foliage diseases. In: Walnut Orchard Management. D. Ramos ed. Univ. of California. Publication 21410: 153-157.

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

Alnus spp. genetic resources conservation strategy

***Ante Krstinic*[1], *Joso Gracan*[2] *and Davorin Kajba*[1]**

[1]*Faculty of Forestry University of Zagreb, Zagreb, Croatia*
[2]*Forest Research Institute, Jastrebarsko, Croatia*

Foreword

At the second meeting of the EUFORGEN Noble Hardwoods Network held in Lourizán, Spain from 23 to 25 March 1997, it was concluded that is necessary to work on the European gene conservation strategy for the genus *Alnus*. This task was given to the participants from Croatia (Ante Krstinič and Joso Gračan).

Black alder (*Alnus glutinosa* L. Gaertn.) is a very important forest tree species in Croatia, especially in the floodplain ecosystems along the Sava and Drava rivers. Because black alder is a very variable and fast growing species found all over Europe, in our opinion it can be used as an example for conservation strategy models of gene resources for other species of the genus *Alnus*.

Introduction

The genus *Alnus* includes about 36 species mostly located in the Northern Hemisphere. Generally, alders grow in regions of floodplain forests, even though in the mountains of central Europe they occur along watercourses up to 2800 m a.s.l. Species of this genus grow either as bushes or high trees, showing great variability in their morphological and physiological properties.

Black alder is becoming an increasingly interesting forest tree species due to its multiple uses both in the forestry and wood industry. It is known as a fast growing and meliorative species, which has the ability of fixing atmospheric nitrogen. Black alder stands with longer rotations can produce logs of very good quality for the timber industry, but in short rotation (cycles) in so-called special-purpose plantations it is very desirable for biomass production (Krstinič 1994). The basic function of these black alder plantations is a reduction of the pressure on natural forests of valuable hardwoods species (oak, beech, ash, maple), conservation of genetic resources and a beneficial effect on global climate changes. Owing to these characteristics, black alder proved to be very suitable for tree cultivation either in the form of pioneer plantations or in mixed plantations with other coniferous and deciduous tree species which grow better than in monocultural plantations (Hansen and Dawson 1982; Heilman and Stettler 1983; Krstinič and Komlenovič 1986).

As the natural distribution of black alder is not compact but markedly disjunct and widely spread both in the horizontal and vertical directions, the natural populations of this species exist in different edaphic conditions, and it should be supposed that climatic, edaphic and altitudinal races are differentiated. This hypothesis is proved by the results of provenance research, which have shown very distinct genetic differences in survival and biomass production (Krstinič *et al.* 1992.). The genetic differences between provenances are found not only at the European level but also at a broader one. As a result, there is a need to protect existing biodiversity of natural populations and to spread the range of black alder by establishing plantations at suitable sites.

Distribution

Species of the genus *Alnus* are widely spread in the northern hemisphere from Northern Africa in the South up to 70°N in Europe and Asia. In South America, species of the genus *Alnus* occur south from the equator in Peru as well as in the northern part of Argentina up to a latitude of 25°S. They usually grow in cold and moderate climate conditions, but they can be also found in the warm regions of the Mediterranean. Alders grow on the banks of

streams and lakes in humid habitats, although their occurrence in dry sites has also been observed. Most species prefer rich, moist but well-drained soils with a high water table. Stagnant waters are tolerated well by some species only.

Black alder is spread all over Europe from Ireland in the west to Western Siberia in the east, as far as northern Africa in the south and up to 65° in the north. It has been introduced in the Azores and in the United States of America. Its range both in Europe and Africa is not compact but markedly disjunct. In the mountainous regions of the central Europe it reaches altitudes between 1500 and 1800 m. Its preferred climate is a moderate to cold one; it grows best in deep soils where the water table is high. The optimum amount of precipitation is from 800 to 860 mm per year. It does not tolerate stagnant water or high soil acidity (Fig. 1).

Alnus glutinosa /L./ Gaertn. belongs to the genus *Alnus*, of the *Betulaceae* family. Some 36 species of the genus *Alnus* are divided into various subgenera, subspecies or varieties.

In its natural range in Europe, black alder usually reaches a height of 25 m and in some rare cases up to 40 m. Diameters in old trees are normally between 35 and 40 cm, but a maximum diameter at chest height of 175 cm was found. Black alder is a highly variable forest tree species, therefore it has been the subject of much research.

Importance for forestry and environmental protection

Black alder is becoming an increasingly interesting forest species due to its multiple uses both in the forestry and timber industry. It is known as a meliorative species which, owing to a symbiotic actinomycete—*Frankia alni*—located in root nodules, has the ability to fix atmospheric nitrogen. The nodules act not only as nitrogen fixers but also as regulators of photosynthetic products (Wheeler and Lawrie 1976). This ability makes it very suitable for tree cultivation either in pioneer plantations or in mixed plantations with other coniferous and deciduous tree species which grow better than in monocultural plantations (Hansen and Dawson 1982; Heilman and Stettler 1983; Krstinič and Komlenovič 1986, and others).

Black alder may also be used as a pioneer species in establishing common oak plantations, common ash tree plantations and black poplar plantations. However, our experiences have shown that the establishment of mixed plantations with species mentioned is not easy since black alder fast outgrows common oak. Therefore, pioneer plantations for this purpose should be used mainly for biomass production and soil nitrogen enrichment that will then improve the growth of oaks and ash.

Black alder wood is used in mechanical and chemical processes. Thus, it is used in mining and hydraulic engineering, in production of veneers, utility plywood and joinery boards, and for the pulp and paper and furniture industries. It is also used in many crafts, musical instruments, models, toys, barrel stopcorks, wooden shoes, etc. Being very sensitive to the presence of sulphur dioxide, black alder may find an application as a bio-indicator of air pollution by this chemical compound. By cultivating black alder in mixed or pioneer plantations, the use of nitrogen fertilizers is avoided and the biological control of weed vegetation is ensured by shading thus making the application of herbicides unnecessary. In this way, it protects the soil and underground water (Trinajstic *et al.* 1991).

Growth of black alder is very intensive between the 5th and the 10th years, as well as between the 15th and 20th years (Mlinsek 1960, Ehrenberg 1979, Nemesszeghy 1986.). After reaching the age of 20, a stagnation of growth in height occurs while diameter growth remain satisfactory in old age. Table 1 gives data describing black alder production in Sweden, Germany and Croatia for various ages and different habitats according to several authors. Data show that the number of standing trees per hectare depends primarily upon the age (Schwapach 1902, Rauš 1971, Vidakovic and Krstinic 1984). According to some authors, at age 40 the number of trees per ha varies from 568 to 1352, but at age 60 from 363 to 595 trees/ha.

The annual average volume increment of black alder stands is lower in the north but becomes higher towards the south. The maximum volume increment per annum in Sweden is 3.9 m^3/ha, in Germany 6.4 m^3/ha, in Slovenia and Croatia from 7.7 to 9.7m^3/ha.

The first records of black alder plantations are found in eastern Germany (Ehrenberg 1979). Later, plantations of this species were also established in other countries where black alder is autochtonous as well as in countries where it is cultivated as an exotic species (USA, Canada). In order to improve its cultivation, special of black alder breeding have been prepared in several countries in Europe in the US and in Canada (Hall 1985). When establishing black alder plantations, it must be taken into consideration that this species is very sensitive to unsuitable sites (environmental stress) and to some arboricides (Tordon 10 k), it is also sensitive to salt (NaCl) and to herbicides.

Table 1. Black alder production (*Alnus glutinosa* /L./ Gaertn)

Country	Soil quality	Age (yrs)	Average height (m)	Average diameter at chest height (cm)	Number of strandings (trees/ha)	Wood stock (m^3/ha)	Average annual increase (m^3/ha)	Stand/plantation type	Author
Croatia	III	5	5	4	15 000	-	-	Posavina, pure, natural	Rauš (1971)
		10	11	8	5000	-	-		
		40	26	30	-	-	-		
Slovenia	I	21	17.0	15.6	1435	204	9.7	Pomurje, mixed, natural	Mlinšek (1962)
		40	21.0	28.0	670	365	9.1		
		59	23.0	34.0	595	521	8.8		
Croatia	I	48	20.0	25.5	500	250	5.2*	Natural popult., Podravina	Vidakovic and Krrtinic, (1984)
		70	28.5	36.0	400	538	7.7*		
	III	50	19.5	24.0	-	-	-	Natural popul., Posavina	
	IIII	75	21.2	29.6	-	-	-	Natural popul., Posavina	
Germany	I	20	14.5	11.7	1529	140	7.0	Natural stand	Schwappach (1902)
		40	20.9	21.7	677	281	7.0		
		60	24.1	27.4	476	359	6.0		
Germany	I	20	15.1	11.5	1.578	110	5.5	Pure plantation	Schober (1975)
	I	40	20.8	20.8	665	228	6.4		
	I	60	24.7	29.0	363	283	5.2		
	I	90	28.8	40.1	190	351	3.9		
Sweden	I	11	5	2.7	2168	4	0.4	Mixed stand with spruce	Erickon (1974)
	V	22	10.7	10.8	1656	86	3.9		
	I	40	13.1	14.6	1352	149	3.7		
	I	70	16.0	23.7	368	238*	3.4		

*Does not include wood from thinning

Genetics

Black alder has a very wide range of natural distribution. Such a large range in combination with relatively small isolated populations causes a very marked variability (Weisgerber 1974). Genetic differentiation of local populations occurs as a result of various selection pressures to which local populations are exposed, through strongly pronounced ecological differences (climatic, edaphic) and also as the result of inbreeding in small populations.

According to Weisgerber (1974), the genetic variability in natural populations of black alder, respecting the specific adaptation of natural populations, may be best demonstrated by difficulties encountered in raising these plantations in Germany caused by the phenomenon called 'dying of black alder plantations', that occurred at the beginning of this century. The causes of black alder dying have always been connected with the use of inadequate provenances in terms of its adaptation to local conditions

(Weisgerber 1974). The use of black alder autochtonous provenances well adapted to habitats has been recommended by many authors (Glavac 1962, Komlenovic and Krstinic 1987, and others).

According to Krstinic *et al.* (1992) and Krstinic and Kajba (1996), the provenance test covering 8 provenances (local populations from regions of Drava and Sava rivers) proved that at the ages of 15 and 20 years there is a provenance × site interaction indicating the genetic differentiation of local populations even in such narrow parts of the natural range in Croatia and suggests specific adaptation of these populations.

Genetic differentiation of black alder provenances indicate the possibility for fast genetic gains by selecting the best provenances and by establishing clonal seed orchards with selected plus trees (Krstinic and Kajba 1991).

According to some authors (Heitmüller 1957, Mejnartowitz 1972, Bialobok *et al.* 1980) the following hybrids are economically important: *A. incana* × *A. glutinosa, A. glutinosa* × *A. orientalis, A. rubra* × *A. glutinosa and A. glutinosa* × *A. inokumae.* It is considered that the most economically important would be hybrids between *A. rubra* and *A. glutinosa* (Bialobook *et al*. 1980). Spontaneous hybrids are also found between *A. glutinosa* and *A. cordata* (= *A. eliptica* Reg.).

According to Mejnartowitz (Bialobok *et al.* 1980), species of the genus *Alnus* most often have 28 chromosomes in somatic cells, while a few species have 42 chromosomes. The basic genome in species of the genus *Alnus*, consequently, contains 14 chromosomes.

Conservation methods of black alder gene resources

Gene conservation methods for black alder depend on the degree of threat or of damage, the economic importance as well as the ecological, genetic and silvicultural importance. These criteria are the basis for setting priorities for gene conservation methods and are influenced by the situation in various regions in Europe.

In situ *conservation*

It is well known that existing natural populations of black alder cannot last forever, and that natural regeneration is necessary. This natural regeneration of forests ensures the same gene and genotypes frequencies and can also ensure adaptation of the next generation. As black alder cannot be naturally regenerated as other broadleaved forest tree species, such as common oak, this raises the question of how to regenerate local populations artificially ensuring the same gene and genotypes frequencies in the next generation, as is the case for natural regeneration.

Seed germination lasts about 30 days and after germination the seedlings are cotyledons for another 30 days, and need nutrients, moisture and light for further development of leaves and stem. These conditions are not possible in natural stands of black alder because of the weed vegetation and of old tree canopies. Therefore, natural regeneration of black alder is successful only on light strips from which a humus layer is removed.

The artificial regeneration of black alder is possible by using intrapopulation diversity in two ways:

- by planting natural seedlings from above mentioned strips
- by planting artificially raised seedlings from local population.

For the cultivation of generative progeny from natural population, which will be genetically equivalent to generative progeny from natural regeneration, several conditions need to be fulfilled:

- That felling of mature trees in a given stand is synchronized with seed ripeness.
- That seed is collected and mixed from 10 to 50 representative trees on every 30 to 40 ha. The extracted seed should be stored at a temperature of +2°C.
- That good quality seedlings of 1+1 age, to be planted on a prepared site (3000-4500 plants/ha) are raised.

This method of regenerating black alder natural stands has been used in Croatia for more than 20 years, and has given satisfactory results both for silviculture and protection of intrapopulation variability of black alder.

In Croatia, the best black alder populations are found on clayey peat soils, but natural stands of this species also grow on floodplain clay.

Ex situ *conservation*

This method of conservation of genetic resources of black alder is useful if provenance tests are established in different edaphic, climatic and altitudinal (hypothetic) races, with representative samples planted at several locations in Europe. The establishment of these experiments in terms of seed collection, raising of seedlings, choice of experimental plots, measuring, and analysis of results should be uniform and carried out by the involved countries. These experiments should include local ecotypes, if they have already been tested in countries that have conservation programmes.

Conservation of black alder gene resources is possible through generative and clonal seed orchards. As black alder reaches reproductive maturity relatively early, the conservation of the gene pool by generative seed orchards would be possible if we use seed from 200 to 300 trees that are dispersed in all natural populations, which would each represent one seed unit or ecological race.

Clonal seed orchards are a second possibility for conservation of black alder gene resources through *ex situ* methods. For this method of conservation it is necessary to select about 100 normal and plus trees from each seed zone or region. Clonal seed orchards established with this method would represent 'breeding populations', and could be used for conservation as well as for breeding.

Conclusions

In future work on breeding and conservation of black alder it is important to use the best provenances and genotypes in Europe, particularly in the countries that are included in the Noble Hardwoods Network.

References

Bialobok, S. *et al*. 1980. Olsze - *Alnus* Mill., Polska akademia nauk, 351 p., Warszawa - Poznan.

Ehrenberg, C. 1979. Mini-monograph in *Alnus.* Tehnical Consultation in Fast growing Plantation Broadleaved Trees for Mediterranean and Temperate Zones, 16 p., Lisbon.

Glavaš V. 1962. [About the height gowth of black alder under the age 20]. Šumarski list 88 (11/12):408-414, Zagreb.

Hall, R.B. 1985. Breeding strategy for *Alnus*, *Populus* and *Salix*. Proceedings of the joint /IEA/ Forestry Energy Programme and FAO/Cooperative Network on Rural Energy Conference and Workshops on: Research in Forestry for Energy. Vol. I:78-95, Rungstedgaard-Garpenberg.

Hansen, A.E. and J.O. Dawson. 1982. Effect of *Alnus glutinosa* on Hybrids *Populus* Height Growth in a Short-Rotation Intensively Cultured Plantation.Forest Sci. 28(1):49-59.

Heilman, P. and R.F. Stettler. 1983. Phitomass Production in Young Mixed Plantations of *Alnus rubra* and Cottonwood in Western Washington. Canadian Journal of Microbiology 28 (8):1007-1013.

Heitmuller, H.H. 1957. Die Selbstungsanalyse als Möglichkeit der Kombinationsprüfung bei Krezungen innerhalb der Gattung *Alnus*. Silvae Genet. 6:158-159.

Komlenovic, N. and A. Krstinic. 1987. [Inter- and intrapopulation variability of some black alder (*Alnus glutinosa* /L./ Gaertn.) provenances in biomass production and nutrient accumulation]. Šum. list 10-12: 577-587.

Krstinic, A. and N. Komlenovc. 1986. The effect of Black Alder (*Alnus glutinosa* /L./ Gaertn) on the Growth of White Willow (*Salix alba* L.) Clones. 18 th IUFRO World Congress, Proc. Div. 1, Vol. II: 436-445.

Krstinic, A. and D. Kajba. 1991.[Possibilities of genetic gain for vigorous growth of black alder (*Alnus glutinosa* (L.) Gaertn.) by clonal seed orchard]. Sum.list 6-9: 261-271.

Krstinic, A. and D. Kajba. 1996. [Genetic variability of some local provenance of the black alder (*Alnus glutinosa* (L.) Gaertn.)]. Pp. 1-8 *in*: Mayer, B. (ed.), Unapredenje proizvodnje biomase sumskih ekosustava, Sumarski fakultet Sveucilista u Zagrebu & Šumarski institut, Jastrebarsko, Zagreb.

Krstinic, A., Ž. Borzan, J. Gracan, I.Trinajstic, D. Kajba, F. Mrva and M. Gradecki.1992. [Forest tree breeding]. Pp. 109-120 i*n* Raus, D. (ed.) Sume u Hrvatskoj, Graficki zavod Hrvatske, Zagreb.

Krstinic, A., Komlenovic, N. and M. Vidakovič. 1992. Selection of white willow clones (*Salix alba* L.) suitable for growing in mixed plantations with black alder (*Alnus glutinosa* (L.) Gaertn.). Annales Forestales, 15/2: 17-36, Zagreb.

Krstinic, A. 1994. Genetics of Black Alder (*Alnus glutinosa* /L./ Gaertn.), Annales Forestales, 19/2:33-72, Zagreb.

Mlinsek, D. 1960. [Growth and economic value of black alder]. Pomurske tiskarne u Murskoj Soboti, 32 p.

Nemesszeghy, L. 1986. [Black alder in Prekmurje]. Pomurska zalozba, 89 p.Murska Sobota.

Raus, D. 1971. [Black alder (*Alnus glutinosa* (L.) Gaertn) in the forests in Posavina. Savjetovanje o Posavini III:353-362, Zagreb.

Schwapach. 1902. Untersuchung uber Zuwach und Form der Schwarzerle. 7-38, Neudamm.

Trinajstic, I., N. Komlenovic, A. Krstinic and D. Kajba. 1991. [Dinamics and significance of weed vegetation in plantations of white willow (*Salix alba* L.) and black alder (*Alnus glutinosa* (L.) Gaertn) on peat-clay soils in Podravina]. Fragmenta herbologica 20(1-2):35-47, Zagreb.

Vidakovic, M. and A. Krstinic. 1984. [Clonal seed orchards in Republic of Croatia]. Sumarski pregled 1-4:41-63, Skopje.

Weisgerber, H. 1974. First Results of Progeny Test with (*Alnus glutinosa* (L.)(Gaertn.) after Controlled Pollination. Proceedings, Join IUFRO Meeting, SO2. 04. 1-3 Session VI, 423-438, Stockholm.

Wheeler, C.T. and A.C. Lawrie. 1976. Nitrogen fixation in root nodules of alder and pea in relation to the supply photosynthetic assimilates. Pp 497-510 *in* P.S. Nutman (ed.) Symbiotic nitrogen fixation in plants. Cambridge University Press.

Strategies and guidelines for the conservation of the genetic resources of *Ulmus* spp.

Eric Collin
CEMAGREF, Nogent-sur-Vernisson, France

Introduction

Why should gene conservation of elms be treated differently from that of other common Noble Hardwood species? The sole answer that readily comes to mind is: "because elms are endangered species, due to Dutch elm disease". As a matter of fact, the two Dutch elm disease (DED) pandemics that spread across Europe this century have caused dramatic mortality in elm populations, and the disease still represents a great threat for each individual elm tree. However, the statement that "elms are endangered species" needs to be scrutinized and the situation of each elm species must be considered separately. Factors of importance in elm gene conservation must be discussed before practical recommendations for the implementation of elm gene conservation can be made, in the light of the principles and methods defined for the other common Noble Hardwoods.

Are the European elms an 'endangered species'?

This is a twofold question: how many elm species are there in Europe, and are they in danger of extinction or at least under threat of severe genetic depauperation?

Because the taxonomy of elms has always been a bone of contention among botanists, it is difficult to give a simple answer to the first question. Some botanists consider that there are only three elm species in Europe (Richens 1983), and that major variants in these species must be given the rank of varieties or sub-species. Others (Melville 1940, 1957) advocate the recognition of species when regional forms display a very distinctive habit (e.g. *Ulmus plotii* Druce in the English Midlands) or conspicuous characters such as leaf hairiness (e.g. *U. canescens* Melville in the Eastern Mediterranean region) or seed hairiness (e.g. *U. elliptica* Koch in the Caucasus). Little information is available about *U. celtidea*, an endemic Russian species differing from the European white elm (*U. laevis* Pall.) in tree size and form of the samaras (Yarmolenko 1936).

The second question can be answered more easily: elms are not endangered at specific level, except if one takes the 'species' concept in an extremely narrow sense. For instance, because of its status as an endemic, *U. plotii* is listed in the *UK Biodiversity action plans* as a species of high conservation importance. However, such a narrow 'species' concept may prove misleading, as demonstrated by recent molecular work (Coleman *et al.*, in press) showing that *U. plotii* is in fact composed of a single widespread clone mixed with a number of morphologically similar but genetically unrelated entities. Conversely, some rare forms and marginal populations of European elms are indeed in serious danger because of DED and/or the destruction of their habitats. More generally, there are risks that repeated tree losses and the reduction in the number of genets effectively contributing offspring might result in genetic depauperation in the long term. Besides, as stated by Millar and Libby (1991), perhaps the greatest challenge to conservation biologists is not only to "rescue species from the brink of extinction" but also "prevent currently healthy taxa from ever becoming endangered".

From a practical point of view, we suggest that the European elms be regarded as three 'large species' (see section below) with different biological and ecological features, and thus requiring different gene conservation strategies. The present knowledge on the taxonomic and geographic partitioning of genetic variation within each of these large species is fragmentary and sometimes controversial. However, it provides a basis for the implementation of a pragmatic combination of *in situ* and *ex situ* conservation measures as well as indications for further research. For instance,

regardless of names and putative taxonomic ranks ('*U. glabra* Huds. var. *trautvetteri* Johansson' as opposed to '*U. elliptica* Koch'), one should investigate the genetic diversity in the distinctive Caucasian form of Wych elm (*U. glabra*) and its genetic distance from the type devoid of hair on the seed. Similarly, even if one may doubt that the Mediterranean forms of Field elm (*U. minor* Mill.) with densely hairy leaves really compose a genetic entity, it is certainly worth while to preserve in *ex situ* collections clones representative of the small populations of *U. canescens* that still can be found in Malta and other places.

We do not think that the principles of elm gene conservation differ fundamentally from the general guidelines proposed for the other common Noble Hardwoods (Jensen *et al.* 1999). In all cases, rarity and endangerment do not occur at the species level but rather at intraspecific level. Just as for other common Noble Hardwoods, our goal is to ensure the conservation of the evolutionary potential of the elm species rather than strictly preserve the present state of their gene pools. The only difference is not in terms of goals but in terms of difficulties encountered. From this point of view, Dutch elm disease poses probably the most critical problem, but certainly not the only one. As will be discussed below, habitat fragmentation is also a major issue in the conservation of marginal populations of the European white elm (*U. laevis*). Ancient transfers by humans and a good ability for vegetative propagation have combined their effects to render sampling for conservation particularly difficult in countryside Field elms (*U. minor* Mill.). So, the case study of elms should certainly not be reduced to its pathological component but rather be viewed as a condensed example of the many kinds of difficulties that can be met when undertaking the genetic conservation of forest tree species.

Present state of the elm resource in Europe

Ulmus glabra

Wych elm (*U. glabra* Huds. = *U. montana* With. = *U. scabra* Mill.) is native to most European countries. It thrives at northern latitudes, but also occurs in the montane forests of southern Europe. As latitudinal variation is strong in *U. glabra,* Uotila (1997) suggests two subspecies, a northern one and a southern one. Apart from the case of *U. elliptica* already discussed (see above), interesting taxonomic variants with a corky rhytidom were described in Rumania (Borlea, 1995) and a distinctive form of *U. glabra* with long leaf stalks occurs in northern Spain (Richens, 1983). In Sweden and Norway, rare relict populations of *U. glabra* can be found not very far from the Arctic Circle (L Ackzell, pers. com.).

Ulmus glabra is very susceptible to DED, but remains unaffected at the northernmost latitudes where no efficient insect vector is available. The threat to its genetic resources in the central part of its natural range is still debated among specialists. In some areas, it is not considered endangered because it regenerates easily from seed. In other regions, foresters report that, because *U. glabra* does not set seed regularly, the trees that die of DED are often not replaced by younger ones. Moreover, whenever seedlings appear, they are likely to be destroyed by deer and other game.

In Germany, foresters have started implementing practical preservation measures such as fencing seedling patches. If natural regeneration is missing, then they plant material obtained from seed lots harvested locally. The situation of small marginal populations requires special care because they could be devastated by DED in a very short time. This seems to be the case in Sicily (L. Mittempergher, pers. com.).

The main ecological characteristic of *U. glabra* to consider in a sampling strategy for conservation purposes is its ability to form fairly large sexually reproducing populations. Because it is a wind-pollinated species, geneflow and random mating are expected to be important, so the risks of inadequate sampling are probably limited due to the large ratio of within- to among-population variation. However, at the margin of its distribution, *U. glabra* is scattered, and its conservation should be targeted with a greater precision.

Ulmus laevis

The European white elm (*U. laevis* Pall. = *U. effusa* Willd. = *U. pedunculata* Foug.) belongs to section *Blepharocarpus*, which also includes its American relative, *U. americana* (American elm). *Ulmus laevis* probably does not hybridize with *U. glabra* and *U. minor* (Mittempergher and La Porta 1991). It has a definite eastern European distribution, but it reaches eastern and central France. There are even a few relict populations in southern France (Timbal and Collin, in press.). *Ulmus laevis* is a component of riparian forests along large rivers such as the Rhine, the Elbe, and the Danube. It is one of the rare European tree species that thrive in damp soils flooded at some periods of the year.

U. laevis is susceptible to the fungal agent of DED (*Ophiostoma novo-ulmi*), but, at least in western Europe, its populations are generally not severely damaged by the epidemics. Experiments with captive elm bark beetles (*Scolytus scolytus* and *S. multistriatus*) allowed to feed on different elm species have shown that *U. laevis* is far less attractive for the elm bark beetles than *U. minor* (Sacchetti *et al.* 1990; Webber 1999; D Piou, pers. com.). As long as the insect vectors do not change their feeding preferences, the genetic resources of *U. laevis* are not really endangered by DED. In fact, *U. laevis* is certainly more seriously threatened by the destruction of the riparian forests where it can be found. Major changes in the landscape are likely to happen along the banks of large rivers, especially when the land can be drained and reclaimed for agriculture. The changes in land ownership in many east European countries with economies in transition have also threatened riparian woodlands. Thus, conservation of the genetic resources of *U. laevis* should concentrate on marginal populations (e.g. in southern France) and on remarkable floodplain communities in danger of deforestation. It could be undertaken either *in situ*, when some kind of legal protection of habitat is available, or *ex situ* as a complementary measure.

Ulmus laevis is often found in fragmented populations of limited size that may be subject to serious risks of genetic drift. Studies conducted in Finland with isoenzyme markers (Mattila and Vakkari 1997) have suggested that random genetic drift may have caused substantial differentiation among the small populations of *U. laevis* at the northern fringe of its range. Hence, sampling for adaptedness should be carried out very carefully and focus on populations with a large genetic diversity. On the other hand, populations that are likely to have encountered high levels of genetic drift should also be targeted in order to maximize the capture of allelic diversity.

Ulmus minor

Field elms have been given so many Latin names (Richens 1976) that some preliminary explanations need to be given here. In theory, the binomial *U. campestris* L. should be rejected because it is an ambiguous name since Linné did not make distinctions between Wych elm and the Field elms (Melville 1938); however, it is still popular among botanists and foresters. The binomial *U. carpinifolia* Gled. is frequently used to designate the diverse forms of Field elms that are common on the European mainland; it does not include the English Elm (*U. procera* Salisb.). Following Richens (1968), we favour the enlarged circumscription of the binomial *U. minor* Mill. *sensu latissimo*, which covers the Field elm complex in its totality; in this treatment, forms with distinctive branching habits and leaf shapes are given a varietal rank. The many other Latin names that were given to Field elms, such as *U. nitens* Moensch. and *U. foliacea* Gilibert, are liable to bring more confusion than clarity and should not be used anymore.

Ulmus minor differs from *U. glabra* and *U. laevis* in many respects. First, *U. minor* is adapted to warmer climates. Its distribution is clearly south European, but also occurs in Algeria, Turkey and northern Iran. It is probably not native in England and northern countries, and its status on the Baltic islands is problematic (Richens 1983). The second specificity of *U. minor* is due to the role of humans (Heybroek 1990, 1993b). Whereas *U. glabra* and *U. laevis* are mainly found in natural woodlands, *U. minor* has been widely propagated

and planted during the last two thousand years, and probably even earlier. For instance, according to Richens (1983), the regional variety known as Cornish elm (var. *cornubiensis*, syn. *U. stricta*) was introduced from western Brittany into Cornwall before the ninth century. Similarly, the English elm (var. *vulgaris*, syn. *U. procera*) may have been introduced from the Iberian Peninsula into Britain in the Later Bronze Age. The third major difference between *U. minor* and the two other European elm species is its large variability and taxonomic complexity. An illustration of the biosystematic and nomenclatural difficulties that arise in the *U. minor* complex is given by the conflicting treatments proposed by eminent elm specialists for the different kinds of *U. minor* found in Britain (Armstrong and Sell 1996). Whereas Melville (1975, 1978) recognized them as five different species, several varieties and many complex hybrids, Richens (1968, 1980) pooled them into a single large species with four varieties. In the microspecies approach adopted by Armstrong (1992) they are described under about 40 binomials, most of them new ones. The complexity in the present day distribution of the British elms is partly due to their ancient introduction and cultivation by humans. However, natural variability in *U. minor* is particularly high and poorly known. Richens (1980) mentions a longitudinal pattern of variation which could be explained by northwards migrations from "a chain of distinct Mediterranean refugia during the last Glaciations". Hopefully, molecular markers should help clarify this taxonomic chaos (Hollingsworth *et al.* 1999) and provide evidence on ice refugia and possible re-colonization routes followed by the elms.

Ulmus minor hybridizes easily in nature with other elm species and varieties (apart from *U. laevis*). Its hybrids with *U. glabra* compose a very large and diverse group of intermediate forms commonly referred to as *U.* × *hollandica*, - i.e. the Dutch hybrid elms. It seems that, in Spain and Italy, *U. minor* is now being introgressed by the introduced Asian species *U. pumila*. This very recent introgression process may be regarded as a potential asset as far as tolerance to DED is concerned, but people fear that it could also be detrimental to the quality of wood.

Another feature of major importance for conservation biologists is the excellent ability of *U. minor* to produce root suckers and to re-sprout from the stump. The first consequence of this ability is that *U. minor* can colonize new sites by seed and then rapidly reproduce by root suckers, eventually forming thickets with little or no genetic variation. Another consequence is that vigorous suckering and re-sprouting occur very frequently in countryside elm hedges after they have been devastated by DED. Thus, in spite of the heavy losses due to the disease, the genetic resources of the common varieties of Field elms are probably not as threatened as thought at the peak of the epidemics when all mature trees were dying so quickly.

Because of the taxonomic confusion in the *U. minor* complex, the occurrence of clonal-patches in natural or sub-spontaneous stands, and the gene transfers caused by its ancient cultivation, sampling for genetic diversity in *U. minor* is particularly difficult. Different measures should be applied in the case of riparian natural stands *versus* the more common situation of elm landscapes largely influenced by human activity.

Past and current activities in elm research and conservation

A detailed review of the results of research work carried out on elm biology, biosystematics and genetics cannot be presented here, but fields of major activity will be briefly highlighted.

Variation in macroscopic characters

In the period 1940-1980, extensive studies of leaf variation in *U. minor* were made in several western European countries by two English botanists who had divergent views on the taxonomy of elms. Unlike Melville who employed a traditional approach of classification, Richens in collaboration with Jeffers developed a numeric method based on computer-aided multivariate analysis of measurements of leaves. Richens and Jeffers published their results for England (1978; Jeffers and Richens 1970), northern France (1975), Wales (1985) and

northern Spain (1986). Richens was working on the interpretation of the results for former Yugoslavia when he died. In Spain, Ipinza (1989) employed the same method as Richens and Jeffers, whereas in Britain, Armstrong (1992) adopted a microspecies approach of British elms. In a recent paper (1999), Jeffers recalls Richens' wish that their data (either the complete set obtained from over 2000 trees, or the 'reference collection' composed with a subset from 66 trees representing the full range of variation) be re-analyzed by other scientists with today's computers and programs.

Apart from foliar traits, botanists have paid attention to a large array of characters such as: flower, fruit (e.g. size of samara, position of seed, form of seed notch, pubescence), bark and cork. However, no extensive collections of data were made at an international scale for such characters. Branching habit and aspect of rhitydom have been studied and illustrated for the most distinctive British varieties (Jobling and Mitchell 1974).

Associated species

Richens (1963, 1983) considered that monophage species associated with elms, such as *Stigmella* sp. (Lepidoptera), could provide information on post glacial-migration. Similarly, he regarded the gall mites *Eriophyes* sp. as valuable indicators of the origins of the diverse local forms of elms transported by man in historic or prehistoric times.

Variation in microscopic characters

The observation of chromosomes shows that the American elm (*U. americana*) is tetraploid whereas the other elm species are diploid. This last assumption was challenged by Machon *et al.* (1995) who concluded from isoenzymes profiles that the three European elm species must be segmental tetraploids; however, other explanations were recently proposed for such profiles (Hollingsworth *et al.* 1999; M.A. Cogolludo, pers. com.).

Pollen lots of four European 'species' of elms (*U. procera* included) were discriminated under electronic microscopy by Stockmarr (1970, 1974), using the different frequencies in number of pores per grain observed in each lot; *U. procera* was the less difficult to discriminate from the other species, even from *U. minor*. In the same study, fossil pollen from Lithuania indicated that *U. laevis* was the first elm species to re-colonize this part of Europe after the glaciations. However, according to Richens (1976), such investigations were based on too small samples to allow secure conclusions on the nature of palynological variation within the field elm generally.

Biochemical and molecular markers

Variation in elms, and particularly European elms, has been analyzed using flavonoids (Bate-Smith and Richens 1973; Heimler *et al.* 1990, 1993), isozymes (Machon *et al.* 1995, 1997), RAPDs (Coleman 1998, Coleman *et al.* in press), chloroplast and nuclear encoded ribosomal DNA restriction site analysis (Wiegrefe 1992; Wiegrefe *et al.* 1993). A brief review of some of these studies can be found in Hollingsworth *et al.* (1999). More research is being carried out in the RESGEN 78 project funded by the European Union (see infra) as well in the frame of the Spanish national program. A PhD study focused on marginal populations of *U. laevis* is starting in Sweden and should involve the development of microsatellite markers for elms. A comprehensive review of the results obtained with biochemical and molecular markers needs to be made in the next few years.

Biologic traits and adaptative markers

Botanists (Richens 1983) have reported phenologic differences in bud burst and leaf fall between the early flushing English elm and other varieties of *U. minor* (such as the late flushing var. *cornubiensis*) in Britain. Breeders (Heybroek 1993a and 1999; Mittempergher and La Porta 1991) have collected observations on the flowering and crossing ability of a large and diverse array of elm clones, and systematically investigated their susceptibility to DED

in artificial inoculation trials. A few provenance tests were planted for Asian elm species of interest in breeding, but none for European elm species. Phenologic notations will be carried out in clonal banks and clonal tests in the frame of the EU RESGEN 78 project, and the Swedish PhD research mentioned above should include a greenhouse experiment allowing measurements of open progenies of *U. laevis* obtained from Sweden, southern France and a place in central Europe.

Pollen and seed dispersal, as well as self-sterility, are of major importance in the definition of gene conservation strategies for the species concerned. According to Walter (1931) and Daumann (1975), the three European elm species are normally wind pollinated but honeybees contribute to pollen dispersal and their role might be not negligible in the absence of wind. Elm seed is attached to a winged samara and thus easily dispersed by the wind. The samara is of medium size in the case of *U. minor*, larger in *U. glabra* and smaller in *U. laevis*. Heybroek (1993) reports that "elms are mostly to highly self sterile" and that "generally, random parents give better germinating seeds and more seedlings per pollination bag in crosses than in selfings, on average 23 times as many. Relations vary strongly from year to year however, and certain clones are relatively self-fertile". Heybroek does not give separate figures for the European species and the Asian species, and his data probably include clones with a complex parentage involving many species.

Archeology, linguistics

Richens (1983; Richens and Jeffers 1978) made use of archeological findings and places names to trace the introduction of elms. For instance, he established links between the distribution of distinctive forms of *U. minor* and the narrow occurrence of a particular kind of coinage used among ancient tribes in northern France and southern England. He also paid much attention to the period of time when places received a name meaning 'elm' (indo-european '*lm-', as in 'elm', 'ulm', 'olm', 'alm'…and '*wig-', as in 'wice', 'wych').

Breeding

In Europe, elm breeding was mainly achieved in the Netherlands. The Dutch breeding program was continued without interruption over a period of 64 years (1928-1992) and was headed by three persons only (Heybroek, 1993a). In the first phase of the program, elm clones were collected in different European countries, and exotic material was introduced from Asian and American sources. Next phases involved screening for tolerance to DED, crossing selected parents, selecting in the offspring and field testing. Among the hybrid clones obtained by Heybroek, several were released for trade in the Netherlands and others are about to be released in other European countries. Elm breeding has also been undertaken in Italy (Mittempergher *et al.* 1998) and Spain (Solla 1999a,b) but these programs are younger than the Dutch one; one hybrid clone obtained by Mittempergher has been released and others are being field-tested. Besides, screening for tolerance to DED in local material is under way in many European countries; common protocols for inoculation and symptoms scoring were recently defined in the frame of the EU RESGEN 78 project. A review of the breeding/screening activity carried out in central and eastern European countries would be very helpful when little information is available in the international literature.

The development of biotechnologies and genomics has deeply changed perspectives in breeding work. It is too early to assess the consequences of this change in the case of elms. Several teams have undertaken the genetic transformation of elms, and important progress was made recently (Gartland *et al.* 1998, 1999).

Gene conservation

Due to the dramatic consequences of DED pandemics, many European countries have allocated important efforts to the *ex situ* conservation of their native elm material. This activity is principally built upon vegetative propagation (by grafting and cuttings) and aims

at the creation of clonal banks and/or grafted seed orchards. It is often associated with improvement goals such as selection for tolerance to DED and good phenotype. Conservation of seed lots and *ex situ* planting of progenies has also been carried out, but to a much smaller extent. In addition, the cryopreservation of elm explants in liquid nitrogen has successfully been experimented in the prospect of long-term static conservation purposes (Pâques 1997). However, the different national programs were defined without any coordination at an international level, and no common protocol was available for the characterization, evaluation, rationalization and long-term management of the collections. Fortunately, the creation of the 'Noble Hardwoods' Network in 1996 and the launching of the RESGEN 78 EU project in 1997 have reversed this trend (Collin *et al.* 1999). The 5-year project supported by the European Union is coordinated by Cemagref (France) and involves 17 institutes in 9 west European countries. It is based on the large clone collections existing in several countries and complements them with material originating from partner countries where conservation actions have not yet begun. The clones in these collections will be registered in a common database and characterized with molecular markers applied to nuclear and chloroplast DNA. Their conservation will be optimized in the framework of a European core collection reflecting the geographic partitioning of genetic variation. Conservation methods will associate sustainable field clonal banks (low hedges unattractive for the vector of DED) and cryopreservation of buds in liquid nitrogen. Evaluation will consist of clonal screening for low susceptibility to DED (tolerance to the fungal agent and/or to the insect vector) and good horticultural traits. Despite the fact that this project aims at the rationalization of existing clone collections, and not at the completion of genetic studies based on an independent sampling strategy, it should bring out genetic knowledge of interest for the conservation elm genetic resources throughout Europe.

In the case of *U. laevis* and some natural stands of *U. minor*, *in situ* conservation is often associated with the preservation of riparian ecosystems. In the case of *U. glabra*, it is often linked with the selection of phenotypically remarkable individual trees by foresters. Such 'preservation' approaches are not necessarily sufficient to capture enough genetic variability in the population and thus maintain its evolutionary potential.

More information on elm conservation activities in different European countries can be found in the national presentations published in the meeting reports and on the Web page of the Noble Hardwoods Network.

Factors of importance in elm gene conservation

What are the consequences of DED on the effective size of populations (*Ne*)?

The number of parents effectively contributing offsprings is crucial for the maintainance of genetic diversity and additive variance in a population. If this number becomes too low, genetic drift is likely to cause genetic depauperation and loss of ability to adapt to environmental changes. This is why we need to assess the effect of DED on the effective size of elm populations. As *U. laevis* is generally not severely damaged by the DED pandemics, and as *U. minor* is not commonly found in large natural populations reproducing sexually, we shall focus on the situation of *U. glabra*.

The distribution and dynamics of DED in Europe

First, we need to scrutinize the different factors acting upon the intensity of the pressure exerted by the disease. It is certainly a misleading simplification to speak about DED as if its causal agent was exactly the same everywhere and forever. Brasier has shown (for a synthetic presentation, see Brasier, 1999a) that the fungus *Ophiostoma novo-ulmi* responsible for the second epidemics (ca. 1970) in Western Europe was not the same and more aggressive as for the first epidemics (ca. 1920). In addition, two different races (the north American – NAN- and the east-Euroasian -EAN-) exist in Europe and have followed different routes across the continent. Besides, the epidemic process has its own complex dynamics, with

phases of low activity when the populations of elms and beetles have decreased in number, and secondary epidemic phases when the surviving young elms have grown to a size allowing a new start in the DED cycle. Moreover, some kind of biological control of the pathogen may be exerted by mycoviruses referred to as 'd. factors' (Brasier 1999b). The role of the insect vectors (different species of bark beetles, with different requirements in the size of the elm trees where they breed, and different efficiencies in inoculating the pathogen to elms) as well as their adaptation to present day climate and adaptability to climatic changes also need to be taken in consideration. For all these reasons, the gravity of the situation is liable to differ among regions and vary considerably over time.

The effect of DED on population size, age classes, genetic diversity and effective population size

People tend to react emotionally to the visible effects of DED. For instance, in the case of *U. minor*, the general public in western Europe in the late 1970s had acquired the feeling that elms were bound to disappear; 15 years later, the same people were prone to consider that elms had made a spectacular 'come-back' in the landscape and that DED was no more a problem. The first feeling and the second consideration are equally wrong and only prove our common failure to estimate properly the excellent regeneration capability of *U. minor* and the cyclic return of epidemic phases of DED.

Are today's forest managers in a better position to describe objectively the present situation of *U. glabra*? When no precise inventories exist, can they totally resist the fallacious impressions they may get from a limited number of observations made by chance (e.g. coming across abundant regeneration of some elm trees in a particular area of the forest)? In the absence of genetic data (e.g. studies with isoenzymes), no one can monitor possible changes in the genetic diversity in the stand after a large proportion of the mature elms are lost to DED? Besides, the desequilibrium in age classes resulting from losses to DED may also considerably decrease the buffer effect that was provided by overlapping generations. Even if an apparently sufficient number of trees are left, is it reasonable to suppose that most of them will survive and equally contribute offspring? Such questions are not trivial when one thinks that the mean effective population size (*Ne*) to be considered over several generations is not the arithmetic mean of the *Ne* in each generation, but their harmonic mean "which is always less than the arithmetic mean because it is particularly sensitive to the smallest number of the set" (Lawrence and Marshall, 1997). Thus, special care must be taken to avoid catastrophic reductions in population sizes.

There are very few examples of epidemics causing similar damage and threat to a forest tree species. In the case of sugar pine (*Pinus lambertiana*), a northern-American species endangered by blister rust (*Cronartium ribicola*) introduced from Europe in 1910, Millar (1999) has highlighted the paradox that "a large portion of genetic diversity in sugar pine populations will be lost even though the population recover in size". This paradox is due to a strong selection pressure in favour of a major gene for resistance to the pathogen. To counteract this trend, Millar has recommended keeping the diseased trees (many take years to die) in the stands, so that they "contribute genes through pollen to resistant mother trees" and "also can bear resistant seeds themselves through pollination from resistant father trees". The situation with elms is probably different from the situation with sugar pine because, as observed by Heybroek (1999), full resistance in elms "is apparently determined by many small genes" and "had been gleaned from many sources and accumulated over generations of breeding and selecting in the Dutch breeding program". In the case of the American chestnut (*Castanea dentata*), a species of the eastern United States devastated by chestnut blight (*Endothia parasitica*) introduced in 1906, Hamrick and Godt (1996) indicate that no resistance has been found in the species.

In the case of elms and DED, diseased trees generally die in less than 2 or 3 years, so it is unlikely that they contribute seedlings between the moment they show DED symptoms and

the moment they die. This situation is particularly bad for *U. glabra*, which lacks the excellent capability of *U. minor* for producing root-suckers and re-sprouting from the stump. Moreover, the forest manager cannot really predict when a particular stand will be swept by an active epidemic phase, nor how many trees will remain unaffected, nor why some remain unaffected and others die. Individual elms, which are scattered in the forest are more likely to be unnoticed by the insect vectors. It is also possible that others remain uncontaminated just by chance, or because they are unattractive to *Scolytus* sp. for some unknown reasons (smell; aspect and taste of bark) or because they have particular characteristics (phenological lag unfavourable to the development of the inoculum in the sap flow; small diameter of vessels; induced resistance resulting from another pathologic experience) which enable them to resist a moderate contamination. For all these reasons, it is not possible to predict how many trees will contribute seedlings, nor whether some long lasting individuals will regularly produce huge quantities of pollen and thus be over-represented in terms of genetic contribution. In order to maintain *Ne* as high as possible, it would be wise to act preventively, i.e. ensure the natural regeneration of a large number of mature elms before an active epidemic phase occurs or reappears. This precaution is of particular interest in stands that have not yet been severely hit by the epidemics. The difficulty in this task is that it requires a careful silviculture looking after single trees or small patches of trees. There is also a risk that, by giving them more light, the seed trees become more visible to *Scolytus* sp.; this risk can be viewed as another reason for undertaking natural regeneration in the stand well before the development of a local epidemic episode.

As the overall state of effective population size in forest elm stands may be considered 'uncertain' rather than clearly good or bad (in particular in the case of *U. glabra*), two courses of action are needed. One is: develop tools to monitor changes, i.e. make periodic inventories in several populations in different regions of Europe, and characterize the genetic diversity in some of them. The other is: take precautionary measures in stand management, i.e. facilitate flowering, seed production and germination, and protect seedlings. These general recommendations do not apply in the case of small marginal populations where urgent and more intensive *ex situ* and *in situ* conservation measures may be needed to preserve a rare resource. For budget and continuity reasons, inventories and genetic studies are more likely to be undertaken in forests depending from forestry schools or research institutes. Care for elm regeneration requires a precise silvicultural management and creates additional costs (e.g. soil preparation for seed germination; protection and possibly fencing of seed patches), but it can certainly be implemented in some state-owned forests or by private owners who have a special interest in elm conservation.

What is the amount of geneflow in the case of small fragmented riparian populations?

For *U. laevis*, the major cause of endangerment results probably not from DED but from habitat destruction. As the natural habitat of this species is riparian forests, and as the remaining stands of *U. laevis* are generally small (e.g. a few ha and no more than 20 mature trees), one can wonder whether *in situ* conservation is really feasible in such cases due to severe risks of genetic drift. However, such remaining stands are often not very distant (1-10 km) from other populations or even isolated individuals belonging to the same species. What we need to know is whether geneflow occurs between such populations, and whether it is likely to counterbalance the effect of genetic drift. Geneflow may be obtained through pollen clouds and/or seeds carried by the stream when the riversides are flooded.

The best way to answer the question is to employ molecular markers and assess the genetic diversity within and between populations along the river. In addition, a detailed analysis of the mating pattern in a population would provide valuable general guidelines for the *in situ* conservation in similar cases.

A practical manner of dealing with the problem in the absence of genetic knowledge would be to reinforce the population in size and in genetic diversity by planting material

(seedlings or clones) obtained from populations in the same fluvial basin. Such reinforcement can be viewed as reintroduction of autochtonous material and reestablishment of continuity between relicts of a formerly unique entity, which was fragmented due to human impact. The preservation and reinforcement of several 'micro-populations' along the river may also provide corridors for long-term geneflow in a stepping stone effect.

Another and more radical approach would be to consider that, due to genetic drift, the genetic diversity and evolutionary adaptability in the populations have become too low to ensure their long term *in situ* conservation. The solution proposed would be to sample trees over the whole ecogeographic area, propagate them vegetatively (by grafts or cuttings) and pool their clonal copies in an artificial breeding population. Then, two options are available. One is: create a seed orchard, which will ultimately produce the planting material to be reintroduced in the original stands. The other is: create immediately a *pseudo in situ* plantation with plantlets obtained by cuttings (i.e. grown on their own roots, as opposed to grafted plantlets) and planted in the same area and kind of environment as the original stands. In the first option, management is carried out *ex situ* and artificially, and no output is immediately available *in situ*. In the second option, *pseudo in situ* plantation is undertaken two years only after the collection of cuttings, and the stand can be further managed just like a natural stand (i.e. allowing trees to grow to their full size and be submitted to natural selection and silvicultural thinnings). The goals and by-products of these two conservation schemes are not identical: in the first case, seed production is clearly targeted and may provide a commercial output; in the second case, immediate conservation in the original habitat is emphasized, while seed production becomes optional. Conversely, conservation of associated biodiversity and landscape value may be not negligible.

What are the consequences of human factors on the resources of *U. minor*?

The strongest consequence of human impact on the resource of *U. minor* is undoubtedly the catastrophic damage due to the introduction of a new pathogen in Europe! Paradoxically, the former effects of human activities were extremely beneficial to *U. minor*, which had been extensively propagated and planted (some may say 'overplanted') in many countries and many kinds of environments (including urban).

What we need to assess now is: (i) what are the present consequences of ancient plantings on the geographic partitioning of genetic variation in *U. minor* (ii) what are the possible effects of genetic improvement programs on the gene pool of *U. minor.*

Is there an architecture behind chaos?

As discussed above, the notion of population is not always easy to delineate practically in the case of sexually reproducing 'wild' species of elms such as *U. laevis* and *U. glabra*. In the case of the suckering 'semi-cultivated' and taxonomically complex Field elms, the definition of populations may become extremely awkward, if not hopeless. Long distance transfers of planting material by humans, combined with natural vegetative propagation in hedgerows have probably produced a complex pattern of variation, eventually complicated by subsequent hybridization between varieties of *U. minor* and/or introgression by *U. glabra*. The occurrence of sexual reproduction in *U. minor* varies considerably according to regional climate. In Great Britain, it is so rare that populations of Field elm can be regarded as principally composed of a diverse array of clonal material. In southern Europe, *U. minor* sets seed abundantly and frequently, but the notion of population is still complicated by the effect of natural suckering and human management.

This situation may lead to broaden the notion of 'population' when defining geographical units for conservation activities or the computation of among-units differentiation. In France, the unit scale pragmatically chosen for such activities and computations was the size of a large geographical region (Machon 1997). This choice may be rejected from a biological point

of view; it can also be regarded as an acceptable form of stratified sampling based on historic and ecogeographic entities. Many other alternatives are available, and different situations in different countries may lead to completely different approaches. In particular, if some riparian or island populations have not been subject to extensive anthropogenic management, their conservation could be treated in a manner very similar to *U. laevis* and *U. glabra*, provided that special attention is paid to the presence of clonal patches in the stand.

Use of exotic species, hybrid cultivars and transgenic material

The debate about the introduction of 'alien' gene resources in agriculture is both technical and ethical. In the case of elms, it would be relevant to collect all kinds of data of interest in the technical part of the debate. For instance, isozyme studies are carried out in Spain to recognize and assess the introgression of local *U. minor* by the introduced Asian species *U. pumila*. Ethical debates about 'genetic pollution' and discussions about the benefits (improved tolerance to DED) and dangers (deterioration of wood quality) of such introgression may be viewed as mere 'exercises of style' as long as no quantitative data are available to describe the reality and possible evolution of this phenomenon. The same kind of concern exists in the case of hybrid material released for trade in several European countries. Cultivars obtained from crosses of Asian species (e.g. 'Sapporo Autumn Gold') are widely planted, not only in cities but also for the reconstruction of countryside hedges, and are likely to shed large quantities of pollen. Before debating about the consequences of this situation, it would be necessary to gather precise data on such plantations and the possible lag between the flowering periods of those cultivars and the local elms.

Genetic engineering and risks of 'gene escape' are issues that may arise in a near future in the case of elms. A clone of English elm (*U. minor* var. *vulgaris*, syn. *U. procera*) is being genetically modified for resistance to DED (Gartland *et al.*, 1999). One argument that may be used in favour of its possible release is that, at least in Great Britain, *U. procera* does not flower, or very seldom, which provides a certain guarantee against 'gene escapes'.

In the case of elms, regulations about the use of cultivars are mainly taken in the scope of urban plantings. They can be regarded as maladapted to plantings in other situations (forestry, reconstitution of countryside hedgerows, etc.).

What should be the aim of *ex situ* sampling strategies?

As indicated by Eriksson (1996) and other authors (Brown and Briggs 1991), alleles that occur in intermediate frequencies (say 10-90%) are the most interesting in an evolutionary perspective. According to the logarithmic relationship expressed by Brown, there is "a strong law of diminishing (genetic) returns on sample size in terms of the allele richness of the sample. The first 10 organisms randomly sampled from a population are as important as, if not more important than, the additional 90" (Brown and Briggs 1991). This law of 'diminishing returns' suggests that we devote *ex situ* collection efforts to taking few samples in many populations in different ecogeographic zones rather many samples in few populations.

In addition to alleles randomly sampled, should we also care about genotypes, or 'genets', deliberately chosen? This is not justified if conserving additive variance is our sole goal but it might be of interest to capture genotypes when some kind of tolerance to DED or other valuable traits are likely to be gleaned. In the case of mature elms that have survived the epidemics, such captures will be vain if the tree survived just by chance, but they may also bring out a character of interest in selection and breeding work.

What should be the role of *ex situ* conservation as opposed to *in situ* conservation?

Ex situ conservation must be regarded as complementary to *in situ* conservation. In the case of elms, it will mainly consist in the preservation of clonal copies (obtained using cuttings or grafts) of genotypes, and be employed when emergency measures are needed for rare

endangered populations (e.g. *U. glabra* in Sicily) and when populations are too small to be managed *in situ* (e.g. risks of genetic drift). It will also be convenient for *U. minor*, which does generally not form real 'populations' but complex mixtures of clonal populations in which taxonomic diversity and tolerance to DED can be targeted using stratified sampling methods. In addition, *ex situ* conservation is an excellent means for building collections easily available for research work.

What needs to be defined is whether *ex situ* measures should also be applied for populations in which *in situ* conservation is carried out, and whether there should be many more *ex situ* than *in situ* conservation units. Millar and Libby (1991) give positive answers to both questions, such that clinal and ecotypic diversity can be properly sampled. As one may doubt that enough money and manpower will be available for such an extensive sampling, an alternative solution would be to schedule the 'two-stage sampling' scheme proposed by Jain (cited in Brown 1992), "where diversity studies of the first round of samples are used to improve the second round".

How to save and utilize past breeding and conservation work?

A large amount of clonal material and genetic knowledge has already been accumulated in the frame of past conservation and/or breeding programs, and it is important not to loose it when people retire and/or institute policies change. Heybroek (1999) has witnessed such difficulties, and other experiences show that 'orphan' clone collections become very fragile. International projects and networks provide good opportunities for reviving old collections and facilitating their characterization and use. For instance, the RESGEN78 EU project has enabled the duplication of the material collected by Melville in the 1970s and stimulated its use for research on *U. plotii*. Several *ex situ* collections of elm clones in Europe are probably in great need of inventory and rejuvenation.

How to pool research and conservation efforts?

Foresters and forest geneticists must develop synergies with other specialists of elms (botanists, breeders, pathologists and epidemiologists, etc.) as well with conservationists and elm enthusiasts. For instance, conservationists who take care of natural reserves along large rivers can play a major role in the discovery, inventory, preservation and regeneration of *U. laevis*. Raising awareness is a major issue, especially among conservationists who may be more interested in habitat preservation than in the dynamic management of infra-specific gene resources. Exchanges of information among managers of gene conservation stands is crucial for the implementation of efficient regeneration methods; dissemination of information can be facilitated by the Noble Hardwoods Network, but direct exchanges among managers through the Internet needs to be encouraged. A Website should be made available such that managers of sites not officially selected by the network can be associated in the conservation effort and informed of progress and experience in other places.

The need for a comprehensive strategy

The different issues discussed above show that research, breeding, conservation and forest management should not be considered independently but that progress in one of these activities enables some progress in the other fields as well. The link between research and conservation activities should particularly be emphasized, so that sampling for conservation and genetic studies are coordinated and reinforce each other. The same situation applies in terms of geographic scale. Gene conservation programs can be undertaken separately in different countries, but they are certainly more efficient when coordinated. For instance, if research and conservation work is to be undertaken on the gene resources of *U. laevis* in the Rhine valley or the Danube basin, the sampling should be organized in the different countries along the rivers and genetic analyses should be carried out with the same protocol.

Defining comprehensive research and conservation strategies, and providing help for coordination of national projects are two major tasks of the EUFORGEN Noble Hardwoods Network.

Suggested activities to be carried out in the Network are:

- contribution to the rationalization of sampling throughout the distribution range
- holding record of all relevant data on conservation units and persons involved
- identification of research fields of major importance
- contribution to the preparation of proposals for research and conservation programs
- making recommendations as regards the regulations on the transfer of planting material (provenance of forest reproductive material; use of ornamental cultivars in natural areas).

Practical recommendations for the implementation of in situ conservation

Sampling

General indications for sampling for *in situ* conservation of common Noble Hardwoods have been discussed by Jensen *et al.* (1999): select at least 30 populations/species over the distribution area; effective size of each population (*Ne*) must be greater than 50; in the centre of the distribution area, give preference to large gene reserves (*Ne*>150); in marginal areas, select a larger number of conservation units of smaller size.

Additional remarks for elms are as follows:

- sampling for *in situ* conservation should be stratified and based upon environmental factors (ecogeographic zones, habitats) and genetic factors (subspecies, varieties, ecotypes, major genetic differentiation revealed with markers); special attention should be given to populations at the southern margin of the distribution area.
- requirements as regards the number of populations/species should be put up for *U. minor* and *U. glabra* because of the occurrence of regional forms of high taxonomic rank (variety, sub-species or even 'species').
- requirements as regards the effective size of population (*Ne*=50) should be interpreted according to risks of losses (due to DED) and possibilities for geneflow.
- emergency measures should be rapidly taken for the preservation of endangered rare populations (e.g. risks of habitat destruction or maladapted management).
- in all other cases (i.e. larger and less threatened populations), conservation units should be selected only when all relevant documents and inventories are available; in addition to environmental factors and genetic factors, selection criteria should include guaranties for a sustainable and precise management; preference should be given to stands where joint conservation with another species in the EUFORGEN programme is possible (e.g. *U. laevis* with *Populus nigra* or *Alnus sp*. in riparian forests; *U. glabra* with *Acer sp. or Tilia sp.* in montane stands); attention should also be paid to associated biodiversity (e.g. rare species of lichens in the case of *U. glabra*).
- the notion of population might be maladapted to *U. minor* due to anthropic management and/or extensive vegetative propagation; in such cases, *ex situ* conservation may be preferred to *in situ.*

Management

General indications for *in situ* management have also been given by Jensen *et al.* (1999): stimulate natural regeneration, plant local material when natural regeneration is not sufficient, avoid contamination with pollen from external sources, practice weeding, clearing and thinning. Additional remarks for elms are as follows:

- in the case of small fragmented populations of *U. laevis*, reinforce the size and diversity of the population by planting material obtained from the same fluvial basin and environmental conditions
- in the case of *U. glabra*, stimulate natural regeneration as a precautionary measure, such that seedlings are in place before the mother trees become diseased
- in the case of *U. minor*, cut the diseased trees and protect their re-sprouts, stimulate root-suckering if necessary
- when an active epidemic phase arises, practice sanitation (prophylactic cuttings and pruning, trap and destroy bark beetles,…) in the conservation unit and in its vicinity.

Practical recommendations for the implementation of ex situ *conservation*

Sampling

General indications for sampling for *ex situ* conservation of common Noble Hardwoods have been discussed by Jensen *et al.* (1999) and above (under 4).

Additional remarks for elms are as follows:

- *ex situ* conservation will mainly—but not only—be employed when population size is too small to allow *in situ* conservation; it is an excellent tool for the conservation of *U. minor*, which is highly variable and shows very complex patterns of geographic variation; *ex situ* conservation will also be convenient to capture genotypes of interest for research and breeding work
- sampling for *ex situ* conservation should be stratified and based upon environmental factors (ecogeographic zones, habitats) and genetic factors (subspecies, varieties, ecotypes, major genetic differentiation revealed with markers); special attention should be given to populations at the margins (in particular the southern one) of the distribution area as well as to individual trees that may own some tolerance to DED
- the number of populations per species where *ex situ* conservation should be undertaken depends on whether *ex situ* measures can take place in units where *in situ* conservation is already being carried out; if funds allocated enable such a complementary approach, *ex situ* conservation will be used for building collections easily available for research and breeding work
- preference will be given to the collection of cuttings or grafts, but seed and seedlings can be used as an alternative solution
- the number of individuals to sample per population should be about 10; a higher number can be sampled if this is not detrimental (in terms of funds and manpower available) to sampling in another population in a different ecogeographic zone
- emergency measures should be rapidly taken for the preservation of endangered rare populations (e.g. mortality due to DED, risks of habitat destruction)
- sampling for allelic diversity within a stand should be carried out randomly; in addition, sampling for valuable genets can be specifically targeted in the case of trees with a remarkable phenotype or which have survived a very severe epidemic phase of DED; trees with particular botanic or phenologic traits should be sampled too
- a minimum distance of 50 m between trees to sample is needed in the case of *U. minor*, which often forms clonal patches (this precaution is not needed when phenotypic or phenologic differences are obvious).

Management

- material to be made available for research and breeding work should be preserved in collections built and managed as low hedges (less attractive to insect vectors of DED); a small subset of the collection can be cryopreserved (buds) if such facility is available at a reasonable cost and with good chances of subsequent regeneration; existing collections should be described (and characterized if possible) and rationalized to ensure their conservation in the long term (duplication, constitution of core collections)
- as suggested by J. Kleinschmit (pers. com.), material for seed production should be assembled in grafted seed orchards comprising at least 30 genotypes from the same ecogeographic zone; size of orchard should be at least 1 ha; spacing 5×5 m with a possibility to enlarge it later to 5×10 m.
- material for *pseudo in situ* conservation should be obtained from seed and/or cuttings and be composed of at least 30 genotypes or 20 progenies from the same small ecogeographic zone (e.g. fragmented populations belonging to the same riparian ecosystem); after plantation in the original habitat, management is as indicated for *in situ* conservation.

Conclusions

Two different and complementary courses of actions are urgently needed: (i) collect and improve genetic knowledge on elms; (ii) implement and rationalize conservation activities in a pan-European perspective. Such actions need to be decided and carried out at country level, but it is the task of the EUFORGEN Noble Hardwoods Network to identify need and indicate priorities.

In spite of today's facilities for exchange of information, existing knowledge is not always fully valorized. Translations and literature reviews are necessary, and can be encouraged by the Network. Research fields of major importance must be highlighted, and submission of projects in international calls for proposals facilitated. Applied research, such as the development of resource inventories and monitoring of changes in genetic diversity, should be promoted too. Independently from the Network, meetings such as 'The International Elm Conference' are likely to provide excellent opportunities for collecting and exchanging information. In addition, results from diverse ongoing research projects should also become available in the next few years

It is the role of the Network to contribute to the rationalization of sampling throughout the distribution range and to hold record of all relevant general data on conservation units and contact persons or services. Besides, links with other EUFORGEN Networks (in particular *Populus nigra*) should be encouraged for the development of a common 'habitat' approach. Awareness must also be raised through publications and the Internet.

At country level, research and conservation activities must necessarily be a compromise between the need already identified and the funds allocated to the projects. Priorities should be given to preserving endangered natural populations and existing *ex situ* collections (if any). Inventories and pre-selection of conservation units should come next, together with raising awareness about genetic conservation methods among forest managers and environmentalist organizations. If possible, this preliminary phase should include studies of genetic variation. Finally, long-term conservation management should be ensured in carefully selected populations, representative of a significant portion of elm diversity in the country and from a European perspective.

Acknowledgements

Appreciation is greatly expressed to many people, and particularly Drs S. Wiegrefe and N. Machon, who have facilitated my access to literature sources.

References

Armstrong, J.V. 1992. Taxonomy of British elms. PhD. University of Cambridge.

Armstrong, J.V. and P. D. Sell. 1996. A revision of the British elms (*Ulmus* L., Ulmaceae): the historical background. Botanical Journal of the Linnean Society 120: 39-50.

Bate Smith, E.C. and R.H. Richens. 1973. Flavonoid chemistry and taxonomy in Ulmus. Biochemical Systematics 1: 141-146.

Borlea, G.F. 1995. The elm species in Rumania. Pp. 407-411 *in* P. Baradat, W. T. Adams and G. Muller-Starck, eds. Population genetics and genetic conservation of forest trees. SPB Academic Publishing, Amsterdam, The Netherlands.

Brasier, C.M. 2000a. Intercontinental spread and continuing evolution of the Dutch elm disease pathogenes. Pp. 61-72 *in* C. P. Dunn, ed. The Elms: breeding, conservation and disease management. Kluwer Academic Publishers, Boston, MA, USA.

Brasier, C.M. 2000b. Viruses as biological control agents of the Dutch elm disease fungus *Ophiostoma novo-ulmi*. Pp. 201-212 *in* C. P. Dunn, ed. The Elms: breeding, conservation and disease management. Kluwer Academic Publishers, Boston, MA, USA.

Brown, A.H.D. 1992. Human impact on plant gene pools and sampling for their conservation. Oikos 63: 109-118.

Brown, A.H.D. and J.D. Briggs. 1991. Sampling strategies for genetic variation in ex situ collections of endangered plant species. Pp. 99-119 *in* D. A. Falk and K. E. Holsinger, eds. Genetics and conservation of rare plants. Oxford University Press, New York.

Coleman, M. 1998. The elm problem: a molecular and morphological case study. M.Sc. degree in Plant Taxonomy and Biodiversity. Edinburgh University and the Royal Botanic Garden Edinburgh.

Coleman, M., M.L. Hollingsworth and P.M. Hollingsworth. in press. Application of RAPDs to the critical taxonomy of the English endemic Ulmus plotii Druce. Botanical Journal of the Linnean Society.

Collin, E., I. Bilger, G. Eriksson and J. Turok. 2000. The conservation of elm genetic resources in Europe. Pp. 281-293 *in* C. P. Dunn, ed. The Elms: breeding, conservation and disease management. Kluwer Academic Publishers, Boston, MA, USA.

Daumann, E. 1975. Ein rudimentares Blutennektarium und unterschiedliche Pollenkittreste bei der Ruster (Ulmus). [A rudimentary floral nectary and various pollen-adhesive residues in the elm (Ulmus)]. Preslia (Prague) 47: 14-21.

Eriksson, G. 1996. Evolutionary genetics and conservation of forest tree genetic resources. Pages 159-167 in J. Turok, G. Eriksson, J. Kleinschmit and S. Canger, compilers. EUFORGEN Noble Hardwoods Network: report of first meeting, Escherode, Germany, 24-27 March 1996. International Plant Genetic Resources Institute, Rome, Italy.

Gartland, J.S., T.M. Fenning, C.M. Brasier, A.T. McHugh, K.M.A. Gartland, M.R. Davey, P.G. Alderson, K.C. Lowe and J.B. Power. 1998. Transformation studies with *Ulmus* species. Pages 285-290. Tree biotechnology: towards the millennium. Nottingham University Press, Nottingham.

Gartland, K.M.A., J.S. Gartland, T.M. Fenning, A.T. McHugh, R.J. Irvine, G.D. Main and C. M. Brasier. 2000. Genetic manipulations with elms. Pp. 259-270 *in* C. P. Dunn, ed. The Elms: breeding, conservation and disease management. Kluwer Academic Publishers, Boston, MA, USA.

Hamrick, J. L. and M. J. Godt. 1996. Conservation genetics of endemic plant species. Pp. 281-304 *in* J. C. Avise and J. L. Hamrick, eds. Conservation genetics: case histories from nature. Chapman and Hall, New York (USA).

Heimler, D., L. Mittempergher, P. Buzzini and V. Boddi. 1990. Quantitative HPTLC separation of flavonoid glycosides in the taxonomy of elm (*Ulmus* spp.). Chromatographia 29: 16-20.

Heimler, D., A. Pieroni, L. Mittempergher and P. Buzzini. 1993. The use of flavonoid glycosides for the identification of elm hybrids. Canadian Journal of Forest Research 23: 611-616.

Heybroek, H.M. 1990. Los olmos, compañeros de la humanidad. [The elms, companions of Man]. Pp. 17-25 *in* L. Gil, ed. Los olmos y la grafiosis en España. [The elms and Dutch elm disease in Spain]. ICONA, Madrid.

Heybroek, H.M. 1993a. The Dutch elm breeding program. Pp. 16-25 *in* M. B. Sticklen and J. L. Sherald, eds. Dutch elm disease research: cellular and molecular approaches. Springer-Verlag, New York, USA.

Heybroek, H.M. 1993b. Why bother about the elm? Pp. 1-8 *in* M. B. Sticklen and J. L. Sherald, eds. Dutch elm disease research: cellular and molecular approaches. Springer-Verlag, New York, USA.

Heybroek, H.M. 2000. Notes on elm breeding and genetics. Pp. 249-258 *in* C.P. Dunn, ed. The Elms: breeding, conservation and disease management. Kluwer Academic Publishers, Boston, MA, USA.

Hollingsworth, P.M., M.L. Hollingsworth and M. Coleman. 2000. The European elms: molecular markers, population genetics and biosystematics. Pp. 3-20 *in* C. P. Dunn, ed. The Elms: breeding, conservation and disease management. Kluwer Academic Publishers, Boston, MA, USA.

Ipinza, R. 1989. Contribucion a la taxonomia numerica de los olmos ibericos a través de algoritmos de classificacion jerarquica. [Contribution to the numeric taxonomy of the Spanish elms using hierarchical classification algorithms]. PhD thesis. University of Madrid.

Jeffers, J.N.R. 1999. Leaf variation in the genus Ulmus. Forestry 72: 183-190.

Jeffers, J.N.R. and R.H. Richens. 1970. Multivariate analysis of the English Elm population. Silvae Genet. 19: 31-38.

Jensen, J.S., M. Rusanen and A. Pliura. 1999. Gene conservation of Noble Hardwoods in situations where they occur widespread. Background document for the Fourth meeting of the EUFORGEN Noble Hardwoods Network, Gmunden, Austria, 3-7 Sept. 1999. 10 p.

Jobling, J. and A.F. Mitchell. 1974. Field recognition of British Elms. HMSO. Forestry Commission Booklet no. 42, London.

Lawrence, M.J. and D.F. Marshall. 1997. Plant population genetics. Pp. 99-113 *in* N. Maxted, B.V. Ford-Llyod and J.G. Hawkes, eds. Plant Genetic Conservation. Chapman & Hall.

Machon, N., M. Lefranc, I. Bilger and J.P. Henry. 1995. Isoenzymes as an aid to clarify the taxonomy of French elms. Heredity 74: 39-47.

Machon, N., M. Lefranc, I. Bilger, S.J. Mazer and A. Sarr. 1997. Allozyme variation in *Ulmus* species from France: analysis of differentiation. Heredity 78: 12-20.

Mattila, A. and P. Vakkari. 1997. Genetic variation of Quercus robur and Ulmus laevis in Finland. Pp. 63-68 *in* M. Kurm and U. Tamm, eds. Metsa geneetiliste ressursside sailitamine. Conservation of forest genetic resources. Eesti Pollumajandusulikool. Estonian Agricultural University, Tartu.

Melville, R. 1938. Is *Ulmus campestris* L. a nomen ambiguum? J. Bot. : 261-265.

Melville, R. 1940. Contributions to the study of British Elms. III. The Plot Elm, Ulmus plotii Druce. J. Bot. 78: 181-192.

Melville, R. 1957. *Ulmus canescens*: an eastern Mediterranean Elm. Kew Bull.: 499-502.

Melville, R. 1975. *Ulmus*. Pp. 292-299 *in* C. E. Stace, ed. Hybridization and the flora of the British Isles. Academic Press, London.

Melville, R. and R.H. Richens. 1978. On the discrimination of species in hybrid swarms with special reference to *Ulmus* and the nomenclature of *U. minor* Mill. and *U. carpinifolia* Gled. Taxon 27: 345-351.

Millar, C.I. 1999. Genetic diversity. Pp. 460-494 *in* M. L. J. Hunter, ed. Maintaining Biodiversity in Forest Ecosystems. Cambridge University Press, Cambridge, UK.

Millar, C.I. and W.J. Libby. 1991. Strategies for conserving clinal, ecotypic and disjunct population diversity in widespread species. Pp. 149-170 *in* D. A. Falk and K. E. Holsinger, eds. Genetics and conservation of rare plants. Oxford University Press, New York.

Mittempergher, L., A. Fagnani and F. Ferrini. 1998. Gli olmi e la grafiosi in città oggi. [Elms and Dutch elm disease in town today]. Informatore fitopatologico 6: 34-39.

Mittempergher, L. and N. La Porta. 1991. Hybridization studies in the Eurasian species of elm (*Ulmus* spp.). Silvae Genetica 40: 237-243.

Paques, M., M. Poissonnier, E. Dumas, V. Monod, A. Altman and M. Ziv. 1997. Cryopreservation of dormant and non-dormant broad-leaved trees. Proceedings of the third international ISHS symposium on *in vitro* culture and horticultural breeding, Jerusalem, Israel, 16-21 June, 1996. Acta Horticulturae. 1997, No. 447, 491 497.

Richens, R.H. 1963. Monophage analysis of Elm populations. FAO World Consult. For. Genet., Stockholm 1963 No. FAO/FORGEN 63/-6b/4.

Richens, R.H. 1968. The correct designation of the European field elm. Feddes Repertorium: 1-2.

Richens, R.H. 1976. Variation, cytogenetics and breeding of the European field elm (*Ulmus minor* Miller *sensu latissimo* = *U. carpinifolia* Suckow). Anali za Sumarstvo. Annales Forestales (Zagreb) 7:107-145.

Richens, R.H. 1980. On fine distinctions in *Ulmus* L. Taxon 29: 305-312.

Richens, R.H. 1983. Elm. Cambridge University Press, Cambridge.

Richens, R.H. and J.N.R. Jeffers. 1975. Multivariate analysis of the elms of northern France. I. Variation within France. Silvae Genetica 25: 141-150.

Richens, R.H. and J.N.R. Jeffers. 1978. Multivariate analysis of the elms of northern France. II. Pooled analysis of the elm populations of northern France and England. Silvae Genetica 27: 85-95.

Richens, R.H. and J.N.R. Jeffers. 1985. The elms of Wales. Forestry 58: 8-25.

Richens, R.H. and J.N.R. Jeffers. 1986. Numerical taxonomy and ethnobotany of the elms of northern Spain. An. Jard. Bot. Madr. 42: 325-341.

Sacchetti, P., R. Tiberi and L. Mittempergher. 1990. Preference of *Scolytus multistriatus* (Marsham) during the gonad maturation phase between two species of elm. Redia 73: 347-354.

Solla, A., Y. Menendez, M. Buron, S. Iglesias and L. Gil. 2000a. Programa español para la conservacion y mejora de *Ulmus minor* Miller. [Spanish program for the conservation and improvement of Ulmus minor Miller]. Montes : 5-12.

Solla, A., Y. Menendez, M. Buron, S. Iglesias and L. Gil. 2000b. Spanish program for the conservation and breeding of elms against DED. Pp. 295-304 *in* C. P. Dunn, ed. The Elms: breeding, conservation and disease management. Kluwer Academic Publishers, Boston, MA, USA.

Stockmarr, J. 1970. Species identification of Ulmus pollen. Danmarks Geologiske Undersoegelse, IV 4: 1-19.

Stockmarr, J. 1974. Sem studies on pollen grains of North European Ulmus species. Grana 14: 103-107.

Timbal, J. and E. Collin. in press. L'orme lisse (Ulmus laevis Pall.) dans le sud de la France: répartition et stratégie de conservation des ressources génétiques. [The European White Elm (*Ulmus laevis* Pall.) in southern France: distribution and genetic resources conservation strategy]. Revue Forestière Française .

Uotila, P. 1997. Jalavan suku sekä lehto- ja vuorijalavan taksonomia. [The genus *Ulmus* and the taxonomy of *U. minor* and *U. glabra*]. Sorbifolia 28: 5-16.

Walter, H. 1931. Ulmaceen. Pp. 639-719 *in* O. V. Kirchner, E. Loew and C. Schröter, eds. Lebensgeschichte der Blütenpflanzen Deutschlands, Leipzig (Germany).

Webber, J. 2000. Insect vector behavior and the evolution of Dutch elm disease. Pp. 47-60 *in* C. P. Dunn, ed. The Elms: breeding, conservation and disease management. Kluwer Academic Publishers, Boston, MA, USA.

Wiegrefe, S.J. 1992. Molecular genetic variation in the Ulmaceae: phylogenetic implications. PhD. thesis. University of Wisconsin-Madison.

Wiegrefe, S.J., R.P. Guries, E.B. Smalley and K.J. Sytsma. 1993. Genetic diversity in elms: what molecular data tell us. Pp. 227-238 *in* M. B. Sticklen and J. L. Sherald, eds. Dutch elm disease research: cellular and molecular approaches. Springer-Verlag, New York, USA.

Yarmolenko, A.V. 1936. Urticales Lindl. Pp. 283-296 in V. L. Komarov, ed. Flora of the USSR, Moskva-Leningrad.

Agenda

Fourth EUFORGEN Noble Hardwoods Network meeting
Gmunden, Austria, 4-6 September 1999

Friday 3 September
Arrival, transfer from Vienna Airport to Gmunden, registration, dinner

Saturday 4 September

1. Opening of the meeting
   Welcome (Host country and Chair of the Network)
   Introduction and format of the meeting (EUFORGEN Coordinator)
   Adoption of the agenda and nomination of rapporteurs

2. European long-term gene conservation strategies on Noble Hardwoods
   Presentation of *Alnus* spp. strategy (J. Gracan)
   Presentation of *Juglans regia* strategy (R. Alía)
   Discussion

3. Technical Guidelines for gene conservation and management of Noble Hardwoods
   Discussion of the draft text in chapters:
   Introduction (G. Eriksson, J. Kleinschmit and J. Turok)
   Evolutionary genetics and forest tree gene conservation (G. Eriksson)
   Gene conservation of Noble Hardwoods in situations where they occur widespread (M. Rusanen, A. Pliura and J. Jensen)
   Gene conservation of Noble Hardwoods in situations where they occur rarely (B. Demesure, R. Stephan and J. Kleinschmit)
   Case study: Multipurpose Noble Hardwoods – chestnut and walnut (J. Fernández and R. Alía)
   Case study: Gene conservation of elms and possibly other species that require special treatment (E. Collin)
   Descriptors (J. Jensen)
   Conclusion (G. Eriksson, J. Kleinschmit and J. Turok)

4. Network's Bibliography - review of the progress made

Sunday 5 September

5. Field trip

6. Public awareness
   Brief round-the-table updates on public awareness activities in each country
   Joint public awareness initiatives of the Network

Monday 6 September

7. Progress made in the national gene conservation strategies
   Brief round-the-table country updates
   Introductory reports from newly attending countries

8. Inventories and documentation of Noble Hardwoods genetic resources
   Brief round-the-table updates on national inventories and databases/ documentation systems
   Development of the Network's Internet home page; Internet resources; common minimum information standards

9. Research
   Overview of ongoing research projects (A. Prokazin)
   Collaboration with other international projects and activities on Noble Hardwoods
   Development and submission of project proposals for funding to the EU Fifth Framework Programme
   Discussion: Identification of common research needs

10. Miscellaneous
    Distribution of Network publications
    Date and place of next meeting
    Any other business

11. Conclusions

Tuesday 7 September

Departure of participants

Fifth EUFORGEN Noble Hardwoods Network meeting Blessington, Ireland 17-19 May 2001

Wednesday 16 May

Arrival of participants to Dublin and transfer to Blessington

Thursday 17 May

1. Opening of the meeting:
1.1. Welcome (Host country and Chair of the Noble Hardwoods Network)
1.2. Introduction (IPGRI)
1.3. Adoption of the agenda and nomination of rapporteurs

2. Country reports
2.1. Country updates (brief highlights)
2.2. Introductory country reports from newly attending countries

3. Seminar: The role of species hybridization in gene conservation
3.1. Presentation
3.2. Discussion

4. European long-term strategies for gene conservation and management of Noble Hardwoods
4.1. Harmonization of existing strategies
4.2. Adoption at the national level
4.3. Effective dissemination and implementation at the European level

Friday 18 May

5. Technical guidelines
5.1. Results of the InterNetwork meeting
5.2. EUFORGEN general principles of Forest Gene Conservation
5.3. Noble Hardwoods "case studies"

6. Inventories and Documentation
6.1. Application of minimum information standards
6.2. Information platform on the Internet
6.3. Bibliography

7. Public awareness
7.1. Current EUFORGEN public awareness initiatives
7.2. Public awareness activities of the NH Network

8. Research
8.1. Overview of ongoing projects and their results
8.2. Research needs
8.3. Role of the network in the dissemination of results

Saturday 19 May

Morning:

9. Field trip

Afternoon:

10. Adoption of the report
11. Date and place of next meeting
12. Any other business

Sunday 20 May

Transfer to Dublin and departure of participants

List of participants*

Mr Karen Ter Ghazaryan (Gmunden only)
Forest Research and Experimental Center
15 Lusarovich Street
4th floor, GARUN
Yerevan 370015
Armenia
Tel: +374 2 562974
Fax: + 1 978 926 64 76 (US)
Email: freenet.am

Mr Ferdinand Müller
Institute of Silviculture
Federal Forestry Research Center
Hauptstrasse 7
1140 Wien
Austria
Tel: +43 1 87838 2206
Fax: +43 1 87838 2250
Email: ferdinand. bva.bmlf.gv.at

Mr Bart De Cuyper
Institute for Forestry & Game Management
Duboislaan 14
1560 Hoeilaart
Belgium
Tel: +32 2 6570386
Fax: +32 2 6579682
Email: bart. in.vlaanderen.be

Mr Emil Popov (Blessington only)
Forest Research Institute
Kliment Ohridski Blvd. 132
1756 Sofia
Bulgaria
Tel: +359 2 9620442
Fax: +359 2 9620447
Email: bulnet.bg

Mr Davorin Kajba (Gmunden only)
Faculty of Forestry
Svetosimunska 25
10 000 Zagreb
Croatia
Tel: 385-1-230 22 68
Fax: 385-1-218 616
Email: davorin. zg.tel.hr

Mr Joso Gracan (Blessington only)
Forest Research Institute
Cvjetno naselje 41
10 450 Jastrebarsko
Croatia
Tel: +385 1 6381022
Fax: +385 1 6281493
Email: jaska.sumins.hr

Mr Václav Buriánek (Gmunden only)
Forestry and Game Management Research Institute
Strnady
15604 Praha 4
Czech Republic
Tel: 420-2-57921643
Fax: 420-2-57921444
Email: vulhm.cz

Mr Lubomir Salek (Blessington only)
LESPROJEKT Kromeriz s.r.o.
Kotojedska 1044
76701 Kromeriz
Czech Republic
Tel: +420 634 335547
Fax: +420 634 333828
Email: lesprojekt km.cz

Mr Jan Svejgaard Jensen
Forest and Landscape Research Inst
Hørsholm Kongevej 11
2970 Hørsholm
Denmark
Tel: +45 45 763200
Fax: +45 45 763233
Email: fsl.dk

Mr Ülo Tamm
Forest Research Institute
Kreutzwaldi 5
51014 Tartu
Estonia
Tel: +372 7 422346
Fax: +372 7 421053
Email: eau.ee

Ms Mari Rusanen
Forest Research Institute
Box 18,
01301 Vantaa
Finland
Tel: +358 9 8570 5542
Fax: +358 9 8570 5711
Email: mari. metla.fi

Ms Brigitte Demesure
Conservatoire Génétique des Arbres
Forestiers, ONF
Centre INRA
45160 Ardon
France
Tel: +33 2 38414808
Fax: +33 2 38417879
Email: orleans.inra.fr

*Participants to both meetings unless otherwise stated

Mr Jochen Kleinschmit (Gmunden only)
Lower Saxony Forest Research Institute
Dpt Forest Resources
34355 Escherode
Germany
Tel: 49-5543-940810
Fax: 49-5543-940861
Email: nfv- t-online.de

Mr Richard Stephan (Blessington only)
Institute for Forest Genetics and Tree Breeding
Sieker Landstrasse
22927 Grosshansdorf
Germany
Tel: +49 4102 696144
Fax: +49 4102 696200
Email: holz.uni-hamburg.de

Mr László Nagy
Forest Research Institute
Várkerulet 30/A
9600 Sárvár
Hungary
Tel: 36-95-320 070
Fax: 36-95-320 252
Email: reemail.c3.hu
avaria.hu

Mr Michael Lally (Gmunden)
Coillte Research & Development
Newtown Mount Kennedy
Co. Wicklow
Ireland
Tel: 353-1-2011111
Fax: 353-1-2011199
Email: lally_ coillte.ie

Mr John Fennessy (Blessington only)
Coillte Teoranta
Tree Improvement Center
Kilmacurra Park
Kilbride, Wicklow Park
Ireland
Tel: +353 404 482 82
Fax: +353 404 483 77
Email: fennessy_ coillte.ie

Mr Alfas Pliûra
Lithuanian Forest Research Institute
4312 Girionys Kaunas reg.
Lithuania
Tel: +370 7 547245
Fax: +370 7 547446
Email: mi.lt

Ms Myriam Heuertz
CREBS Research Unit
C.R.P. Gabriel Lippmann
162 av. de la Faïencerie
1511 Luxembourg
Luxembourg
Tel: +352 470261439
Fax: +352 470261389
Email: crpgl.lu

Mr Gheorghe Postolache (Blessington only)
Institute of Botany
Padurii 18
2002 Chisinau
Moldova
Tel: 373-2- 523553
Email: asm.md

Mr Sven M.G. de Vries
ALTERRA Green World Research
PO BOX 47
6700 AA Wageningen
Netherlands
Tel: +31 317 477 841
Fax: +31 317 424 988
Email: s.m.g. alterra.wag ur.nl

Mr Tor Myking
Norwegian Forest Research Institute
Hoegskoleveien 12
1432 Aas,
Norway
Tel. +47 64 949043
Fax +47 64 949280
Email: tor. nisk.no

Mr Adolf F. Korczyk
Forest Research Institute
Park Dyrekcyjny 6
17 230 Bialowieza
Poland
Tel: +48 85 68 12 396
Fax: +48 85 68 12 203
Email: as.ibl.bialowieza.pl

Ms Maria Carolina Varela
Estação Florestal Nacional, INIA
Edificio do Procalfer Quinta do Marquês
2784 505 Oeiras
Portugal
Tel: +351 1 4415763
Fax: +351 1 4415660
Email: mariacarolina lix.pt

Ms Natalia Demidova
Northern Research Institute of Forestry
Nikitov 13
Arkhangelsk 163062
Russian Federation
Tel: +7 8182 416246
Fax: +7 8182 412587
Email: forestry.sts.ru

Mr Roman Longauer (Blessington only)
Forest Research Institute
T.G. Masaryka 22
96092 Zvolen
Slovakia
Tel: +421 855 5314327
Fax: +421 855 5321883
Email: roman. ris.sk

Ms Hojka Kraigher
Slovenian Forestry Institute
Vescna Pot 2
1000 Ljubljana
Slovenia
Tel: + 386 1 2007820
Fax: +386 1 2573589
Email: hojka. gozdis.si

Ms Josefa Fernández López (Gmunden only)
Centro de Investigaciones Forestales de Lourizán
Apartado 127
36080 Pontevedra
Spain
Tel: +34 986 85 64 00
Fax: +34 986 85 64 20
Email: nia.es

Mr Gösta Eriksson (Gmunden only)
Department of Forest Genetics
Swedish University of Agric. Sciences
Box 7027
750 07 Uppsala
Sweden
Tel: +46 18 671240
Fax: +46 18 672718
Email: gosta. sgen.slu.se

Mr Peter Rotach
Swiss Federal Institute of Technology
Ramistrasse 101
8092 Zürich
Switzerland
Tel: +41 1 6323210
Fax: +41 1 6321033
Email: waho.ethz.ch

Mr Murat Alan (Blessington only)
Forest Tree Seed and Tree Breeding Research Directorate
PO Box 11
06560 Gazi , Ankara
Turkey
Tel. +90 312 2126519
Fax +90 312 2123690
Email: yahoo.com

Ms Olga S. Mazhula (Gmunden only)
Laboratory of Forest Tree Breeding
Ukrainian Research Institute of Forestry
310024 Kharkiv
Ukraine
Tel: 380-572-431549
Fax: 380-572-432520
Email: u-fri.kharkov.com

Mr Roman Volosyanchuk
Ukrainian Research Institute of Forestry & Forest Melioration
Pushkinska, 86
Kharkiv 61024
Ukraine
Tel : +380 572 431549
Fax: +380 572 432520
Email: uriffm.com.ua

Ms Karen Russell
Horticulture Research International
East Malling
West Malling
Kent ME 19 6BJ
United Kingdom
Tel: +44 1732 843833
Fax: +44 1732 521557
Email: karen. hri.ac.uk

EUFORGEN Secretariat/IPGRI

Mr Jozef Turok
Via dei Tre Denari 472/a
00057 Maccarese (Fiumicino)
Rome, Italy
Tel: +39 066118250
Fax: +39 0661979661
Email: j. cgiar.org

Mr Simone Borelli (Blessington only)
Via dei Tre Denari 472/a
00057 Maccarese (Fiumicino)
Rome, Italy
Tel: +39 0661182
Fax: +39 0661979661
Email: s. cgiar.org

Observers

Mr Eric Collin
CEMAGREF
Groupement de Nogent-sur-Vernisson
Domaine des Barres
45290 Nogent-sur-Vernisson
France
Tel: 33-2-38 95 03 55
Fax: 33-2-38 95 03 46
Email: eric. nogent.cemagref.fr

ISBN 92-9043-496-1

Cover photo: Simone Borelli