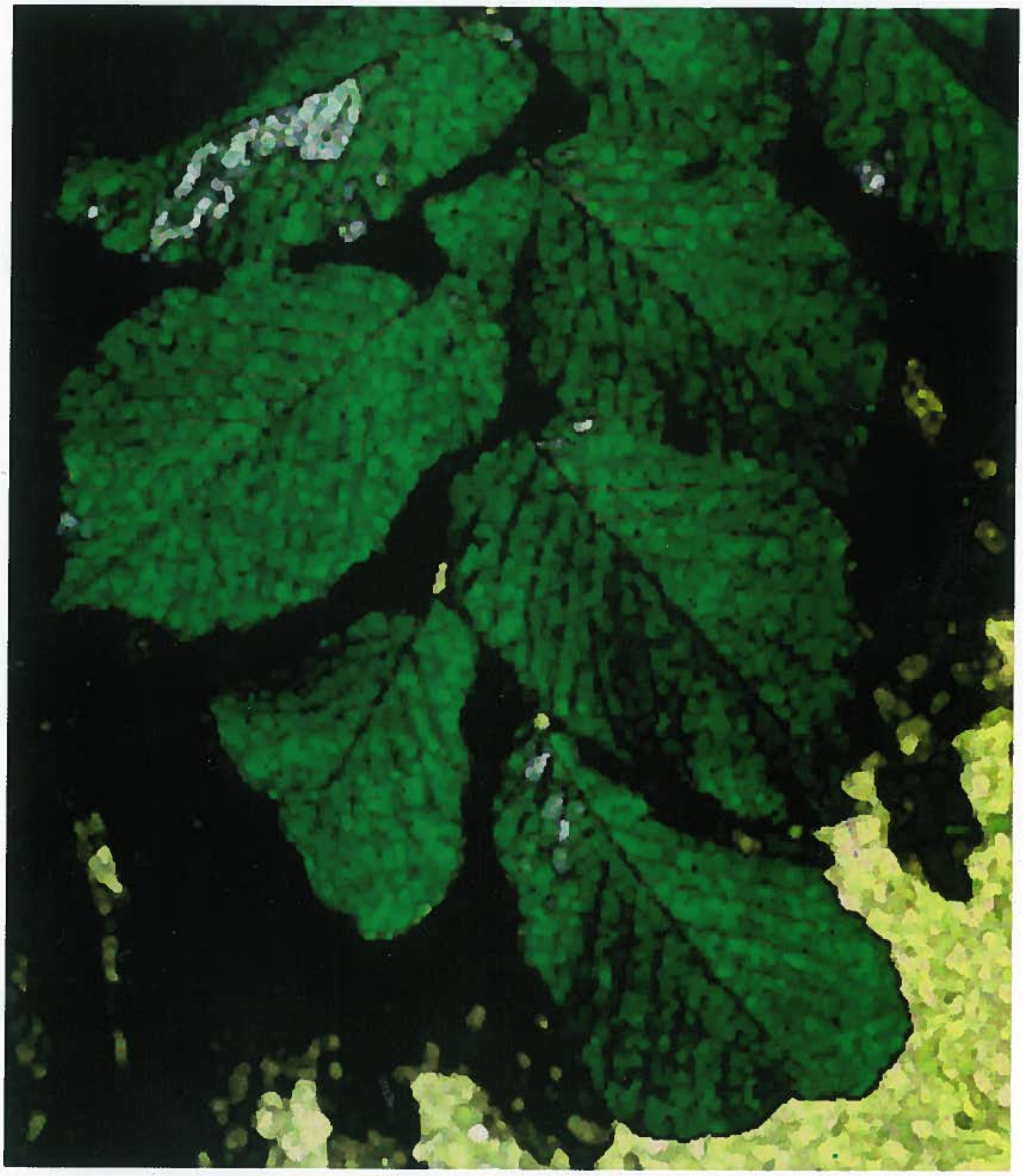
EUROPEAN FOREST GENETIC RESOURCES PROGRAMME (EUFORGEN)

Noble Hardwoods Network

EUFORGEN

Report of the second meeting
22-25 March 1997
Lourizán, Spain

J. Turok, E. Collin, B. Demesure, G. Eriksson, J. Kleinschmit, M. Rusanen *and* **R. Stephan,**
compilers



International Plant Genetic Resources Institute
IPGRI

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

EUROPEAN FOREST GENETIC RESOURCES PROGRAMME (EUFORGEN)

Noble Hardwoods Network

Report of the second meeting
22-25 March 1997
Lourizán, Spain

J. Turok, E. Collin, B. Demesure, G. Eriksson,
J. Kleinschmit, M. Rusanen *and* **R. Stephan,** *compilers*

International Plant Genetic Resources Institute
IPGRI

The International Plant Genetic Resources Institute (IPGRI) is an autonomous international scientific organization, supported by the Consultative Group on International Agricultural Research (CGIAR). IPGRI's mandate is to advance the conservation and use of plant genetic resources for the benefit of present and future generations. IPGRI's headquarters is based in Rome, Italy, with offices in another 14 countries worldwide. It operates through three programmes: (1) the Plant Genetic Resources Programme, (2) the CGIAR Genetic Resources Support Programme, and (3) the International Network for the Improvement of Banana and Plantain (INIBAP). The international status of IPGRI is conferred under an Establishment Agreement which, by January 1998, had been signed and ratified by the Governments of Algeria, Australia, Belgium, Benin, Bolivia, Brazil, Burkina Faso, Cameroon, Chile, China, Congo, Costa Rica, Côte d'Ivoire, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, Greece, Guinea, Hungary, India, Indonesia, Iran, Israel, Italy, Jordan, Kenya, Malaysia, Mauritania, Morocco, Pakistan, Panama, Peru, Poland, Portugal, Romania, Russia, Senegal, Slovak Republic, Sudan, Switzerland, Syria, Tunisia, Turkey, Uganda and Ukraine.

Financial support for the Research Agenda of IPGRI is provided by the Governments of Australia, Austria, Belgium, Brazil, Bulgaria, Canada, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, F.R. Yugoslavia (Serbia and Montenegro), Finland, France, Germany, Greece, Hungary, Iceland, India, Ireland, Israel, Italy, Japan, Republic of Korea, Latvia, Lithuania, Luxembourg, Malta, Mexico, Monaco, the Netherlands, Norway, Pakistan, the Philippines, Poland, Portugal, Romania, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Turkey, the UK, the USA and by the Asian Development Bank, Common Fund for Commodities, Technical Centre for Agricultural and Rural Cooperation (CTA), European Union, Food and Agriculture Organization of the United Nations (FAO), International Development Research Centre (IDRC), International Fund for Agricultural Development (IFAD), International Association for the promotion of cooperation with scientists from the New Independent States of the former Soviet Union (INTAS), Interamerican Development Bank, United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP) and the World Bank.

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

Citation: Turok, J., E. Collin, B. Demesure, G. Eriksson, J. Kleinschmit, M. Rusanen and R. Stephan, compilers. 1998. Noble Hardwoods Network. Report of the second meeting, 22-25 March 1997, Lourizán, Spain. International Plant Genetic Resources Institute, Rome, Italy.

ISBN 92-9043-363-9

IPGRI, Via delle Sette Chiese 142, 00145 Rome, Italy

Contents

Introduction 1

Workplan 2

Introductory country reports

Conservation of forest genetic resources in Romania with special reference to Noble Hardwoods
Ioan Blada 6

Noble Hardwoods in Ukraine: distribution and conservation of genetic resources
Olga S. Mazhula, Igor N. Patlaj and Svitlana A. Los 17

Conservation of Noble Hardwoods in Poland
Adolf Korczyk 22

Noble Hardwoods in Russia: conservation of genetic resources
Andrey Prokazin, Iliodor Routkowsky and Nadezhda Shchegunova 27

Conservation of Noble Hardwood genetic resources in Sweden
Lennart Ackzell and Gösta Eriksson 36

European gene conservation strategy for Noble Hardwoods in the long term 39

Norway maple (*Acer platanoides*) and sycamore (*Acer pseudoplatanus*)
Mari Rusanen 40

Elm (*Ulmus* spp.)
Eric Collin 44

Mountain ash (*Sorbus* spp.)
Brigitte Demesure 48

Wild fruit trees (*Prunus avium, Malus sylvestris* and *Pyrus pyraster*)
Jochen Kleinschmit and Richard Stephan 51

Sampling for genetic resources populations in the absence of genetic knowledge
Gösta Eriksson 61

Evaluation of genetic resources in Noble Hardwoods
Bart A. de Cuyper 76

Common minimum descriptors for Noble Hardwoods
Jan Sveigaard Jensen 82

Overview of ongoing research projects
Andrey Prokazin 86

Literature review: *Ulmus* spp.
Eric Collin 91

Programme 100

Participants 101

Introduction

The second EUFORGEN Noble Hardwoods Network meeting was held from 22 to 25 March 1997. It was hosted by the Centro de Investigaciones Forestales in Lourizán, Galicia, Spain. Participants from 22 countries attended the meeting (see list of Participants). Representatives of a further three countries (Malta, Norway and Portugal) were unable to attend.

Guillermo Vega, director of the Centro, expressed his satisfaction with hosting this EUFORGEN meeting on Noble Hardwoods in Lourizán and wished the participants a pleasant stay and successful meeting.

The Chair of the Network, Gösta Eriksson from Sweden, welcomed all participants to the meeting. He stressed the importance of further developing the Network's principal task, i.e. the European long-term gene conservation strategy for Noble Hardwoods. Four draft components for the strategy, developed during the period since the first Network meeting, were going to be presented and discussed. G. Eriksson introduced the agenda of the meeting which was endorsed with modifications (see Programme of the meeting).

Jozef Turok, EUFORGEN coordinator, mentioned some recent circumstances in the development of a general framework for forest genetic resources activities (FAO Committee on Forests), and emphasized the importance of regional collaboration ongoing in Europe at a time when no political commitment to the conservation of forest genetic diversity could be reached globally. He also informed about activities in the other EUFORGEN Networks and wished the participants a very fruitful meeting.

The Workplan established at the previous meeting (held in Escherode, Germany, in March 1996) was revised during the working sessions of the meeting. The updated Workplan (see below) was endorsed following the discussions, and then distributed at the end of the meeting. It has provided guidance for completing Network tasks and activities after the meeting.

The individual activities listed in the Workplan resulted in outputs such as the European gene conservation strategy for four genera and groups of species, the common list of descriptors, literature reviews, overview of ongoing research projects, summary of the evaluation methods for genetic resources and a public awareness leaflet. Most of these outputs are provided in this volume and are also available electronically on the Internet[1].

G. Eriksson on behalf of all participants thanked the host of the meeting for the excellent organizational arrangements. The next Network meeting will be held in Sagadi, Estonia, 13-16 June 1998.

[1] URL: http://www.cgiar.org/ipgri/euforgen/networks/noble.htm.

Workplan

Conservation strategy for Noble Hardwoods from a European perspective

Five documents based on the plan to define a minimum long-term European strategy for genetic conservation of Noble Hardwood species, as agreed at the last Network meeting, were presented and discussed (see Report of the last meeting, page 5). The strategies on *Ulmus* spp., *Prunus avium, Malus sylvestris* and *Pyrus pyraster, Acer platanoides* and *Acer pseudoplatanus*, and *Sorbus* spp. were endorsed by the participants and will serve as basic reference documents for future activities. The remaining strategy on *Fraxinus* spp. should be further developed. A strategy on *Castanea sativa* and *Juglans regia, Alnus* spp. and *Tilia* spp. will be prepared for discussion at the next Network meeting.

Action to be taken and deadlines

After having reviewed the comments and suggestions provided by the Network, Eric Collin, Brigitte Demesure, Jochen Kleinschmit, Mari Rusanen and Richard Stephan will submit the four final strategy papers to J. Turok, before 1 July 1997, for inclusion in the Report of the meeting (to be published and distributed in September-October 1997). Václav Buriánek and Alfas Pliura will improve the strategy on *Fraxinus* spp. and prepare it for discussion at the next meeting. The strategies on *Castanea sativa* and *Juglans regia* (Ricardo Alia), *Alnus* spp. (Joso Gracan) and *Tilia* spp. (Jan Sveigaard Jensen) will also be prepared for the next Network meeting. They will be circulated among Network members 1 month before the meeting.

Inventories of genetic resources

It was recognized that inventories are the prerequisite of gene conservation strategies for Noble Hardwood species. Reliable data are needed regarding the ecogeographic distribution of individual species. The next fundamental step will be the inventory of information on genetic and phenotypic traits. Basic requirements for inventories of genetic resources at the level of populations, used in forestry practice, were presented by J. Kleinschmit. These inventory requirements were then broadly discussed and will be further developed. A more general presentation was given by G. Eriksson on the sampling for genetic resources in the absence of genetic knowledge.

Action to be taken and deadlines

G. Eriksson will send his paper on sampling strategies to J. Turok by 1 July 1997. Jochen Kleinschmit, Richard Stephan, Csaba Mátyás and Fulvio Ducci will prepare a paper on inventory requirements for the next meeting (to be circulated 1 month prior to the meeting).

Coordination of databases and descriptors

Several models of databases and descriptor lists used in various projects on forest genetic resources were briefly presented and discussed from a technical point of view. The type and structure will differ according to the groups of species. A decentralized structure should preferably be used. IPGRI was asked to assist with the organization of the databases and their possible connection through the Internet.

Action to be taken and deadlines

Jan S. Jensen to produce and circulate a simple, minimum list of descriptors to all Network members by 1 May 1997. Network members to send comments and suggestions to J.S. Jensen by 1 June 1997. J.S. Jensen to send the agreed descriptors to J. Turok for inclusion in the Report of the meeting by 1 July 1997. Brigitte Demesure to prepare a concept note on the principles of databases at a national level for the next meeting (to be circulated 1 month before the meeting).

Overview of current gene conservation measures and ongoing activities

All the countries gave very brief updates of the current situation and the activities that have taken place since the last meeting. It was noted that a number of activities on genetic resources have been initiated or further developed and that contacts between the Network members and relevant institutions in their countries have been improved. Introductory country reports on the conservation of genetic resources in agreed Noble Hardwoods species from Romania, Ukraine, Poland, Russian Federation and Sweden were provided and will be published in full.

An overview table showing the relative importance of individual Noble Hardwoods in the national gene conservation programmes at the level of species and populations was updated (see Table 1).

Insufficient coverage of many Noble Hardwood species by the current legal regulations on the movement of reproductive material was emphasized as a common and continuous concern. The application of minimum standards for source-identified reproductive material for trade was outlined as the main objective to be pursued. The formulation of a letter reflecting this position will give the Network members the possibility to address their national authorities concerning legislation on forest reproductive materials.

Action to be taken and deadlines

Introductory country reports to be submitted by Romania, Ukraine, Poland, Russian Federation and Sweden to J. Turok by 1 June 1997. Sven de Vries and J. Turok to formulate and circulate among all Network members a letter with recommendations regarding the agreed position of the Network on seed legislation by 1 May 1997.

Literature reviews

The literature reviews developed so far on individual species and groups of species were presented. It was noted that this task could not be finalized owing to the short time. All references which are relevant from each Network member's perspective should be included. The Network members were encouraged to compile literature reviews on behalf of and in collaboration with all national institutions. It was agreed to concentrate on 'grey literature' but references from refereed international journals may be included as well. Regarding accessibility of the literature included, the source (originating institute) should always be cited, in addition to the information agreed upon at the last meeting. Any original literature should be kept by the compilers of the reviews for individual species and groups of species.

Action to be taken and deadlines

Countries which have not yet sent the national lists of references to the compilers will do so before 1 August 1997. Compilers of individual species and groups of species will finalize and send their reviews to J. Turok by 1 October 1997. J. Turok will ensure publication of the reviews by IPGRI, both in hard copy and on the Internet, before the end of 1997.

Research coordination

A number of EU-funded research projects were mentioned and briefly described by the involved participants. They concern different species of Noble Hardwoods and comprise, to a greater or lesser extent, tasks related to genetic resources. Eric Collin was commended for the successful preparation of the project on elms. A questionnaire aimed at producing an overview of the ongoing projects at a national level was circulated, which should improve the information flow and facilitate research contacts among countries.

Action to be taken and deadlines
Countries which could not provide this information during the meeting will send the completed form (preferably by Email) by 1 May 1997 to Andrey Prokazin, who will submit the overview, for inclusion in the Report of the meeting, by 1 July 1997.

Evaluation of genetic resources

Bart de Cuyper presented the results of a survey made on the evaluation of genetic resources in individual countries during the year. Besides giving an overview of the current situation, it aims at elaborating a uniform, efficient and feasible methodology for the characterization of genetic resources.

Action to be taken and deadlines
Countries which have not yet sent a reply will contact B. de Cuyper and send him the required information and any illustrations by 1 June 1997. J. Turok to contact IUFRO and provide information already produced by the relevant Working Groups to B. de Cuyper by 1 June 1997. Eric Collin to send relevant information to B. de Cuyper by 1 June 1997. B. de Cuyper to incorporate the comments and suggestions and finalize the document by 1 July 1997. J. Turok to include the paper in the Report of the meeting and under the EUFORGEN Internet homepage.

Public awareness

The Network considered it essential to increasingly contribute to raising awareness about the genetic resources of Noble Hardwoods. Two levels of public awareness were recognized: the professional forestry community and the general public. It was decided that a public awareness leaflet as a joint Network publication would be produced and distributed along with the Report of the meeting. The target group will be forestry officers in all European countries. This will give the Network members the opportunity to distribute the leaflet in the most appropriate way within their countries (along with an accompanying letter/translation).

Action to be taken and deadlines
Ferdinand Müller to formulate and send the text to J. Turok by 1 July 1997. All Network members to send illustrations/photographs they wish to be included in the leaflet to F. Müller by 1 June 1997. F. Müller and J. Turok to prepare the leaflet for publication along with the Report of the meeting.

Practical management guidelines

Recognizing the guidance provided by the strategy documents for promoting an integrated conservation and use of genetic resources at a national level, it was suggested to produce practical guidelines for the management of Noble Hardwoods genetic resources at the level of forest stands. This issue was very briefly discussed but no unanimous agreement reached. The development of such guidelines should be made according to the strategies for individual Noble Hardwood species.

Action to be taken and deadlines
Peter Rotach agreed to write a draft and circulate it among Network members in preparation of the next meeting (1 month before the meeting).

Table 1. Noble Hardwood species considered very important (shaded) and important for genetic resources conservation in European countries at the level of SPECIES (S), or populations (p).

Species	AUT	BEL	HRV	CZE	DNK	FIN	FRA	DEU	HUN	ITA	LVA	LTU	MLT	NLD	POL	ROM	RUS	SVK	ESP	SWE	CHE	UKR
Alnus cordata							p			p												
Alnus glutinosa	p	p	p	p	p	p	S	p			p	p		p				p	p			
Acer campestre	S				p			p						p	p		p	p	p	S		p
Acer lobelii										S												
Acer platanoides	S		p	p	p	p		p		p	p	p					p	p	p	p		p
Acer pseudoplatanus	p	p	p	p	p		S	p		p				S		p	p	p	p	p		p
Betula pendula				p				p		p	p	p					p		p			
Carpinus betulus	p				p			p			p	p		S						p		
Castanea sativa			p				S	p		p									S		p	
Fraxinus angustifolia			p	S			S			p			S					p				S
Fraxinus excelsior	p	p	p	p	p	p	S	p		p	p	p		S	p	p	p	p	p	p		p
Juglans regia	S		S				S	p	p	S							p		S		p	
Malus sylvestris	S	S		p	p		S	p	p		S	p		S				S		p	S	
Prunus avium	S	p	S	p	p		S	p	p	p	p	p		S		p		p	S	p	S	
Pyrus amygdaliformis													S									
Pyrus pyraster	S			p	p		S	p	p		S	p		S				S			S	
Sorbus aria	S			S	p			p		S					S			S				
Sorbus aucuparia	p			p	p	p	p	p	S	p	p					S		p				
Sorbus domestica	S			S			S	p		S	S							S			S	
Sorbus torminalis	S			p	S		S	p		p					S			p			S	S
Tilia cordata	p		p	p	p	p	S	p		p	S	p		p		p	p	p		p	S	p
Tilia platyphyllos	p		p	p	S			p			S			S	p	p		p		p	S	p
Ulmus canescens													S									
Ulmus glabra	p	S	p	p	p	S	S	p	p	p	S	p		S	S	p	p	p	S	p		p
Ulmus laevis	p	S	p	p	p	S	S	p	p	p	S	p		S	S	p	p	S		p	S	S
Ulmus minor	S	S	p	p			S	p	p			p		S	S	p		p	S	p		
Ulmus procera																p						

AUT=Austria, BEL=Belgium, HRV=Croatia, CZE=Czech Republic, DNK=Denmark, FIN=Finland, FRA=France, DEU=Germany, HUN=Hungary, ITA=Italy, LVA=Latvia, LTU=Lithuania, MLT=Malta, NLD=the Netherlands, POL=Poland, ROM=Romania, RUS=Russian Federation, SVK=Slovakia, ESP=Spain, SWE=Sweden, CHE=Switzerland, UKR=Ukraine.

Introductory country reports

Conservation of forest genetic resources in Romania with special reference to Noble Hardwoods

Ioan Blada
Forest Research and Management Institute, 72904 Bucharest, Romania

Introduction

Romania is located in the southeastern part of Europe between 43°30′- 48°20′ N latitude and 19°50′- 29°00′ E longitude. The country elevation ranges between 0 and 2542 m above sea level. The Carpathians with their Pre-Carpathians hills, the Transylvanian and Moldovan plateaux, as well as the southern Romanian lowlands, represent the most prominent parts of the country.

The climate is a typical temperate continental one, i.e. with heavy winters and hot summers, but mild springs and autumns. Rainfalls are normal at higher elevations and more or less poor at lower ones.

Because of the favourable geographic and climatic conditions, the Romanian forest flora is very rich (Table 1). But since the late 1970s a heavy drought has been the main characteristic of the weather. Such dry weather, combined with local and overall pollution, as well as some pests and diseases, is causing serious negative effects on several trees and shrubs (Blada 1995).

Forest genetic resources including Noble Hardwoods

After agriculture, forests represent the most valuable natural resource in Romania. According to the Romanian Forest Inventory (Anonymous 1986), forest represents about 27% of the country's area. Table 2 shows that out of 6 341 472 ha of total forest land, 6 223 416 ha represent forest-covered areas while 118 056 ha represent other forest lands. The afforested areas include broadleaved species (4 312 650 ha or 69.3%) and conifers (1 910 766 ha or 30.7%).

The major indigenous broadleaved species are *Fagus sylvatica* (1 909 187 ha or 30.7%) and different *Quercus* species (1 142 500 ha or 18.4%) while the most widespread conifer species is *Picea abies* (1 431 670 ha or 23%), followed by *Abies alba* (311 452 ha or 5%). The major indigenous species which can be found within virgin or virgin-like natural forests are: *Fagus sylvatica, Picea abies, Abies alba, Larix decidua, Pinus nigra* subsp. *banatica* and *Pinus cembra.*

Other economically and ecologically important species (*Quercus petraea, Q. petraea* subsp. *dalechampii, Q. petraea* subsp. *polycarpa, Q. robur, Q. pedunculiflora, Q. frainetto, Q. pubescens, Q. virgiliana, Q. cerris, Populus alba, P. nigra, Salix alba,* etc.) have in the past been components of the virgin forests; unfortunately, especially owing to man's destructive activity, these forests no longer maintain their natural state.

Conservation of genetic resources

According to the Romanian Forest Law (1996) all forests are managed taking into consideration:

- sustainable, close-to-nature and multifunctional forest management according to the principles of dynamic gene conservation
- active protection and conservation of biological diversity of forests
- support of the biological and economic stability and continuity of forests by promoting natural regeneration and by improving the planting stock
- natural regeneration supported in all forests, where possible; if seedlings are used, they should derive from adequate seed sources, and only suitable species/provenances can be used.

Table 1. The main trees and shrubs of Romania

Conifers	
Picea abies	*P. strobus*†
Abies alba	*Pseudotsuga menziesii*†
Larix decidua	*P. glauca*†
Pinus sylvestris	*Juniperus sabina*
P. nigra subsp. *banatica*	*J. communis*
P. cembra	*Taxus baccata*
P. mugo	

Broadleaved‡	
Fagus sylvatica	***A. incana***
F. orientalis	***A. viridis***
Quercus robur	***Sorbus aucuparia***
Q. petraea	***S. domestica***
Q. petraea subsp. *dalechampii*	***S. torminalis***
Q. petraea subsp. *polycarpa*	***S. aria***
Q. pedunculiflora	*Crataegus monogyna*
Q. frainetto	*C. pentagyna*
Q. pubescens	*Laburnum anagyroides*
Q. virgiliana	*Robinia pseudoacacia*†
Q. cerris	*Amorpha fruticosa*
Q. rubra†	*Cotinus coggygria*
Carpinus betulus	*Euonymus europaeus*
Populus alba	*E. verrucosa*
P.nigra	*Rhamnus catharticus*
P. tremula	*R. tinctoria*
Salix alba	*Frangula alnus*
Salix sp.	*Elaeagnus angustifolia*
Acer platanoides	*Hippophae rhamnoides*
A. pseudoplatanus	*Cornus mas*
A. campestre	*C. sanguinea*
A. tataricum	*Syringa vulgaris*
A. monspessulanum	*Sambucus nigra*
Ulmus minor	*Sambucus racemosa*
U. glabra	*Viburnum lantana*
U. procera	*V. opulus*
U. laevis	*Lonicera nigra*
Fraxinus excelsior	***Castanea sativa***
F. ornus	***Juglans regia***†
F. angustifolia	***J. nigra***†
Prunus avium	*Morus alba*†
P. mahaleb	*M. nigra*†
P. padus	*Celtis australis*
Tilia cardata	*Ribes* spp.
T. tomentosa	***Platanus acerifolia***†
T. platyphyllos	***Malus sylvestris***
Betula pendula	***Pyrus pyraster***
Alnus glutinosa	

† Non-native species.
‡ Noble Hardwoods in bold.

Table 2. Noble Hardwoods in Romania (According to Romanian Forest Inventory, 1986)

Species	Area(ha)	%
Acer spp.	44 636	0.72
Fraxinus spp.	56 872	0.91
Prunus avium	7 922	0.13
Juglans nigra	6 350	0.10
Other, minor hardwood species	581 326	9.34
Tilia spp.	100 626	1.62
Total broadleaved species	4 312 650	69.30
Total conifers + broadleaved spp.	6 223 416	100.00
Other forest land	118 056	
Total forest land	6 341 472	

Why the need for conservation ?

There are several reasons why there is a need for forest genetic resources conservation in Romania:

- for maintaining, at least, the present genetic diversity of all native species
- because, according to the monitoring data, the health state of Romanian forests is negatively influenced, mainly by combined effects of drought and pollution
- because, according to long-term prognoses and owing to the climate change, a desertification process will take place in the southern part of Romania; consequently, ecosystems including many tree species (i.e. *Quercus* spp., *Populus alba, Populus nigra, Acer* spp., etc.) are already in danger
- because all species of *Ulmus* have been seriously damaged by *Ophiostoma ulmi* for about seven decades; because of this disease and perhaps other causes, most of the *Ulmus* populations disappeared.

In situ *conservation*

Selected seed stands

About three decades ago, the Forest Research and Management Institute, together with the forestry authorities, started an extensive programme aimed at selecting the best seed stands within both natural and artificial populations. According to the Seed Stand Catalogue (Enescu 1986) the selected seed stands are as follows (Table 3):

- total number of seed stands: 2912, of which 1555 (53%) were conifers and 1357 (47%) broadleaved species
- total (conserved *in situ* + *ex situ*) seed stands area: 70 178.7 ha, of which 32 886.0 ha (47%) were conifers and 37 292.7 ha (53%) broadleaved species
- total area of seed stands conserved *in situ*: 61 705.2 ha, of which 26 302.2 ha (43%) were conifers and 35 397.0 ha (57%) broadleaved species
- according to the national regulations (Enescu *et al.* 1988), all the seeds for reforestation of commercial stands have to be collected from approved seed stands and seed orchards.

It must be stressed that some very valuable Noble Hardwood species, such as *Acer campestre, A. platanoides, A. pseudoplatanus* and *Prunus avium,* had no selected seed stands yet. Some other important Noble Hardwoods species, e.g. *Ulmus* spp., *Malus sylvestris, Pyrus pyraster* and *Sorbus* spp., could not have designated seed stands because they are found in general only as scattered trees. Other species like *Carpinus betulus* and *Betula pendula,* though widely spread, have little potential silvicultural and industrial importance. For this reason, selection for most Noble Hardwood species has not taken place yet.

It must also be stressed that, at present, the new inventory of the seed stands (and other forest genetic resources) is ongoing in Romania, and in 1999 a new catalogue will be released.

Table 3. Selected seed stands by area and species (According to the Seed Stands Catalogue, 1986)

Species	No. of stands	Total area (ha)	*In situ* (ha)	*Ex situ* (ha)
Tilia cordata	31	396.1	396.1	–
Tilia platyphyllos	13	171.4	171.4	–
Tilia tomentosa	47	708.7	708.7	–
Fraxinus excelsior	69	820.4	793.2	27.2
Alnus glutinosa	9	74.9	54.0	20.9
Castanea sativa	28	197.2	52.7	144.5
Total broadleaved species		2368.7	2176.1	192.6
All species including conifers	2912	70178.7	61705.2	8473.5

Natural forest reserves

An inventory was started in 1993 and should be finished in 1998. However, the main results, by counties, were presented at the end of 1996 (Lalu and Nicolescu 1996) (Table 4). It is a special category of natural populations with high genetic variability and economic value, and also comprising numerous seed stands, where finally natural regeneration is desirable. The major criteria for selection were origin, wood production, wood quality, adaptability to the environment and natural pest resistance. Such forest reserves consist of the main productive species, and include Noble Hardwoods from the following genera: *Picea, Abies, Larix, Pinus, Fagus, Quercus, Acer, Ulmus, Fraxinus, Prunus, Tilia, Alnus, Sorbus, Castanea, Malus, Pyrus, Populus.* Many other, less productive species, including shrubs, are also covered.

Table 4 shows that selection of forest reserves was made in 42 counties with the following results (Lalu and Nicolescu 1996):

- there are 347 delineated units, each unit consisting of a 'core' and a 'buffer zone' surrounding each core
- the total core area at the country level was 11 304 ha, with an average of 33 ha per core
- the proportion of the genetic reserves from the total national forest land was 0.17%.

At the completion of inventory, probably in 1998, a catalogue with Natural Forest Reserves by counties, species and area, including Noble Hardwoods, will be released. All these forest reserves fall into the IUCN IVth category.

Protected areas: national parks and biosphere reserves

According to Toniuc *et al.* (1992), in Romania there are 586 protected areas. From the forestry viewpoint 13 national parks representing a total of 397 761 ha are the most important. Almost all tree species, including Noble Hardwoods, could be found in these areas. Unfortunately, detailed information on their tree species composition cannot be given here.

Table 4. Natural forest reserves in Romania by counties (According to Lalu and Nicolescu 1996)

County	Forest units (no.)	Area of forest units: Core (ha)	Area of forest units: Buffer zone (ha)	Proportion of county area (%)
Alba	11	409	778	0.19
Arad	11	297	1533	0.13
Arges	4	95	277	0.03
Bacau	8	188	966	0.07
Bihor	13	469	1218	0.24
Bistrita-Nasaud	7	245	597	0.13
Botosani	3	89	322	0.16
Brasov	17	531	1450	0.28
Braila	5	43	86	0.20
Buzau	7	198	415	0.13
Caras-Severin	19	606	1467	0.16
Calarasi	2	41	152	0.17
Cluj	10	277	554	0.18
Constanta	2	36	109	0.16
Covasna	16	546	953	0.34
Dambovita	7	136	462	0.11
Dolj	6	93	200	0.12
Galati	8	258	508	0.71
Giurgiu	6	139	188	0.34
Gorj	6	125	302	0.05
Harghita	15	663	1091	0.29
Hunedoara	14	326	870	0.11
Ialomita	2	38	45	0.15
Iasi	5	107	422	0.11
Maramures	14	753	1330	0.28
Mehedinti	8	150	363	0.10
Mures	9	360	531	0.17
Neamt	7	330	761	0.13
Olt	8	182	329	0.33
Prahova	15	528	962	0.36
Satu Mare	7	211	763	0.32
Salaj	3	52	102	0.05
Sibiu	14	434	926	0.23
Suceava	17	1072	1527	0.25
Teleorman	2	37	55	0.13
Timis	8	175	922	0.18
Tulcea	4	119	242	0.18
Vaslui	5	127	553	0.18
Valcea	6	133	481	0.05
Vrancea	3	45	169	0.03
Bucuresti	3	79	152	0.31
ICAS	10	562	672	–
Total	347	11304	25805	0.17

Ex situ *conservation*

Artificial seed stands

The total area with planted seed stands is 8473.5 ha, i.e. 12% of total selected stands; out of which 6577.9 ha (78%) consist of conifers and 1895.6 ha (22%) of broadleaved species. Broadleaved species conserved in *ex situ* conditions are mainly represented by *Quercus petraea* (352.6 ha), *Quercus robur* (535.7 ha), *Fraxinus excelsior* (27.2 ha), *Alnus glutinosa* (20.9 ha) and *Castanea sativa* (144.5 ha). Even though these stands have good phenotypic characteristics, their origin is unknown.

Seed orchards
According to Enescu *et al.* (1989), 1004 ha of clonal and seedling seed orchards of phenotypically selected plus trees were established in Romania, but only 972.8 ha remain at present. Table 5 shows that:

- out of 972.8 ha, 375.0 ha (39%) are broadleaved and 597.8 ha (61%) are conifer species
- out of the 375.0 ha of broadleaved species, *Quercus* spp., *Prunus avium*, *Fraxinus excelsior*, *Tilia* spp., *Acer pseudoplatanus* and *Castanea sativa* represent 66%. From conservation and utilization viewpoints, the following Noble Hardwood species would have to be taken into consideration for the future establishment of additional seed orchards: *Acer* spp., *Fraxinus excelsior*, *Prunus avium*, *Tilia* spp., *Ulmus* spp. and *Juglans regia*.

Table 5. Seed orchards

Broadleaved species	Area (ha)	Fructification
Acer pseudoplatanus	7.0	+
Robinia pseudoacacia	126.7	+
Tilia spp.	32.3	
Fraxinus excelsior	49.9	+
Quercus spp.	87.0	+
Prunus avium	67.1	+
Castanea sativa	5.0	+
Total	375.0	

Present status of Noble Hardwoods in Romania

Species

At present, 23 species are considered Noble Hardwoods in Romania (Table 6). Beech and oaks are considered among the most important Noble Hardwoods in our country, but they belong under the scope of the 'Social Broadleaves Network' and are therefore not dealt with here (see Table 7). According to the author, some softwood species, such as *Betula pendula* and *Tilia* spp. cannot be called "Hardwoods" even if they fulfill the criteria to be "Noble"; it seems that the designation of "Hardwoods" is not suitable for such species.

A special remark should be made regarding *Juglans regia* which is neither a native nor a typical forest species but produces the best veneer for the furniture industry. For its extremely valuable timber, it should be recommended for further introduction into the forestry practice.

According to their occurrence and population size, four categories of Noble Hardwoods (including oaks and beech) were established (Table 6), such as large, medium, small populations and scattered trees.

The first category comprises species with large population sizes like *Fagus sylvatica*, *Quercus* spp., and the last one comprises species that have more or less only scattered trees like *Ulmus* spp., *Pyrus pyraster*, *Malus sylvestris*, etc. Within the first category the best interpollination occurs, while the highest self-pollination and hence inbreeding could be found within the species that have only scattered trees or small populations.

Table 6. Main Noble Hardwoods, oaks and beech according to the population size

	Population size			
Species	**Large**	**Medium**	**Small**	**Scattered trees**
Native species:				
Acer campestre			+	
Acer platanoides			+	
Acer pseudoplatanus			+	
Alnus glutinosa		+		
Betula pendula	+			
Carpinus betulus	+			
Castanea sativa			+	
Fagus sylvatica	+			
Fraxinus excelsior		+		
Malus sylvestris				+
Prunus avium	+			
Pyrus pyraster				+
Quercus petraea	+			
Quercus robur	+			
Sorbus aucuparia			+	
Sorbus domestica				+
Sorbus torminalis				+
Tilia cordata		+		
Tilia platyphyllos			+	
Tilia tomentosa	+			
Ulmus glabra				+
Ulmus minor				+
Non-native species:				
Juglans regia				+

Economic importance

Noble Hardwood species are very important for the national economy: in the wood-processing industry, other industrial sectors, silviculture and various other purposes (Table 7). The wood-processing industry uses Noble Hardwoods mainly for furniture, e.g. maple, ash, lime, wild cherry, alder and, of course, walnut produces high-quality veneer. Some other industrial sectors, such as paper, colouring and even the food industry, use Noble Hardwood products as raw materials. For example, alder wood is used for colouring, and walnut and chestnut nuts and wild cherries are used in the food industry.

Almost all Noble Hardwoods are used or should be intensively used in silviculture in establishing mixed stands, as associated species with the principal ones.

Threats

Similarly to other tree species, Noble Hardwoods have been affected by several damaging agents, such as drought, pollution (and other adverse human activities), vascular diseases, defoliators, seed predators, genetic drift and inbreeding (Table 8).

Elms (*Ulmus minor, U. glabra, U. laevis* and *U. procera*) are the most endangered species; in Romania they have been attacked by *Ophiostoma ulmi* since 1924 (Georgescu *et al.* 1958). As a result, most of the populations have disappeared, and at present, only scattered trees could be found. Because of this situation, the genetic diversity within elms has been severely reduced. Research on the breeding of elms for *Ophiostoma* resistance is ongoing in Romania (Borlea 1997).

To prevent losses of genetic diversity in Noble Hardwoods, conservation combined with breeding and use, according to the genetic principles, is compulsory.

Table 7. Main Noble Hardwoods, oaks and beech according to their commercial use

	Present major use in:				Future major use in:			
Species	**Wood industry†**	**Other industries‡**	**Silvi-culture**	**Other uses§**	**Wood industry**	**Other industries**	**Silvi-culture**	**Other uses**
Native species								
Acer campestre	+		+	+	+		+	+
Acer platanoides	+		+	+	+		+	+
Acer pseudoplatanus	+		+	+	+		+	+
Alnus glutinosa	+	+	+		+	+	+	
Betula pendula			+	+	+	+	+	+
Carpinus betulus				+	+		+	+
Castanea sativa		+	+			+	+	
Fagus sylvatica	+	+	+	+	+	+	+	+
Fraxinus excelsior	+		+	+	+		+	+
Malus sylvestris		+			+	+	+	
Prunus avium	+	+	+		+	+	+	+
Pyrus pyraster					+	+	+	+
Quercus petraea	+	+	+	+	+	+	+	+
Quercus robur	+	+	+	+	+	+	+	+
Sorbus aucuparia				+			+	+
Sorbus domestica				+			+	+
Sorbus torminalis				+			+	+
Tilia cordata	+		+	+	+		+	+
Tilia platyphyllos	+		+	+	+		+	+
Tilia tomentosa	+		+	+	+		+	+
Ulmus glabra					+		+	+
Ulmus minor					+		+	+
Non-native species								
Juglans regia	+	+			+	+	+	+

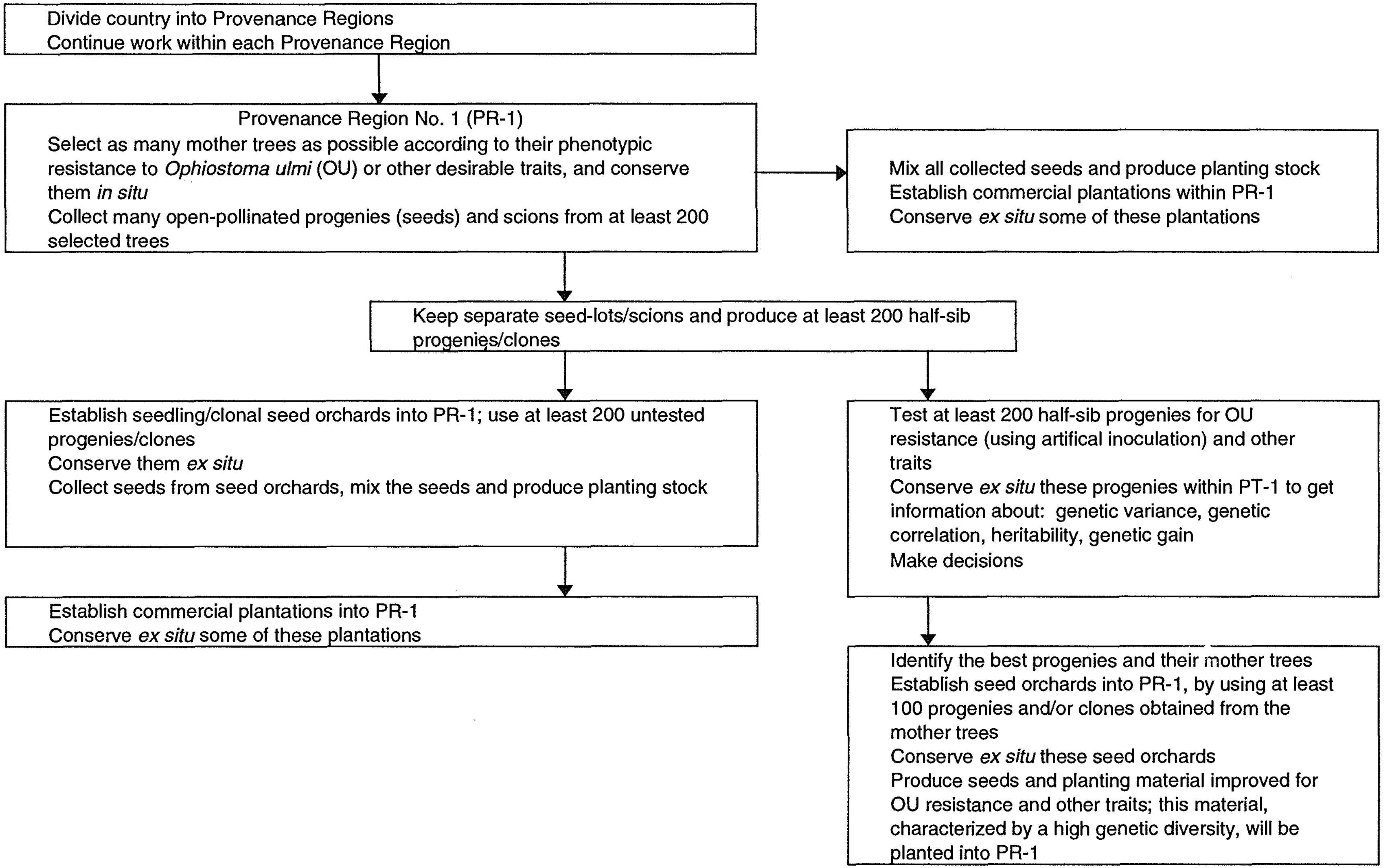
† Furniture (mainly) and other processing.
‡ Paper, food colouring, etc.
§ House construction, fuel, handicrafts, landscaping, etc.

Proposals for dynamic breeding, conservation and utilization of Noble Hardwoods

Noble Hardwoods usually grow either in association with major species within mixed populations or as scattered trees. Range fragmentation gives rise to insufficient geneflow. Genetic drift and inbreeding followed by an inadequate use in forest plantations lead to a gradual loss of genetic diversity. To avoid such undesirable phenomena, the genetic structure of planting material has to comprise as many genes as possible. To meet this requirement, two breeding/conservation/utilization schemes are proposed (Fig. 1).

According to these schemes, the country is divided into several provenance regions, and the work should be done separately for each of them. The basic principle of both schemes consists of: (a) combining *in situ* with *ex situ* conservation, but using predominantly planting material from populations conserved *ex situ*; (b) joint breeding, conservation and utilization by maintaining as broad a genetic diversity as possible, i.e. a dynamic conservation by breeding and use which is in accordance with other authors' opinions (Kleinschmit 1994; Eriksson 1996). The planting stock produced by using these two schemes will be characterized by high genetic variability.

In Romania, special attention should be given to elms, where *Ophiostoma ulmi* has caused loss of most of the populations. Therefore, the dynamic conservation according to these two schemes, is strongly recommended.


Divide country into Provenance Regions
Continue work within each Provenance Region
Provenance Region No. 1 (PR-1)
Select as many mother trees as possible according to their phenotypic resistance to *Ophiostoma ulmi* (OU) or other desirable traits, and conserve them *in situ*
Collect many open-pollinated progenies (seeds) and scions from at least 200 selected trees
Mix all collected seeds and produce planting stock
Establish commercial plantations within PR-1
Conserve *ex situ* some of these plantations
Keep separate seed-lots/scions and produce at least 200 half-sib progenies/clones
Establish seedling/clonal seed orchards into PR-1; use at least 200 untested progenies/clones
Conserve them *ex situ*
Collect seeds from seed orchards, mix the seeds and produce planting stock
Establish commercial plantations into PR-1
Conserve *ex situ* some of these plantations
Test at least 200 half-sib progenies for OU resistance (using artifical inoculation) and other traits
Conserve *ex situ* these progenies within PT-1 to get information about: genetic variance, genetic correlation, heritability, genetic gain
Make decisions
Identify the best progenies and their mother trees
Establish seed orchards into PR-1, by using at least 100 progenies and/or clones obtained from the mother trees
Conserve *ex situ* these seed orchards
Produce seeds and planting material improved for OU resistance and other traits; this material, characterized by a high genetic diversity, will be planted into PR-1

Scheme 1

Scheme 2

Divide country into Provenance Regions
Continue work separately within each Provenance Region

↓

Provenance Region No. 1 (PR-1)
Select as many parent trees as possible, according to their phenotypic resistance to *Ophiostoma ulmi* (OU) or other desirable traits, and conserve them *in situ*

Perform half-diallel† crosses to obtain full-sib progenies

↓

Test full-sib progenies for OU resistance (using artificial inoculation) or other traits to get basic information about:

- general combining ability of the parents (GCA effects)
- specific combining ability of the parents (SCA effects)
- additive and non-additive genetic variance
- genetic correlation among traits
- narrow and broad-sense heritabilities
- genetic gain

Make decisions

↓

Identify parents with the best GCA for OU resistance or other traits

Establish seed orchards into PR-1 by using at least 100 parents with a good GCA for OU resistance or other traits

Conserve *ex situ* the above-mentioned seed orchards

Produce seeds and planting material improved for OU resistance or other traits; this material, characterized by a high genetic diversity, will be planted into PR-1

† A tester design could also be used.

Fig. 1. Two schemes proposed for dynamic breeding/conservation/utilization of elms (and other Noble Hardwoods) by using controlled cross-fertilization.

References

Anonymous. 1986. Romanian Forest Inventory (Unpublished).

Blada, I. 1995. Conservation of Romanian forest genetic resources. ITC/PGR Country report to IPGRI, 11 p. (Unpublished).

Borlea, F. 1997. Testarea in culturi multistationale de genotipuri de ulm rezistente la *Ceratocystis ulmi* si multiplicarea lor. Manuscris ICAS (Unpublished).

Enescu, V. 1986. Seed stands catalogue. ICAS Bucuresti, 467 p.

Enescu, V., N. Donita *et al.* 1988. Zonele de recoltare a semintelor forestiere in Romania. ICAS, Seria II-a, Bucuresti, 61 p.

Enescu, V. *et al.* 1989. Ameliorarea prin selectie si incrucisare a arborilor plus si crearea plantajelor pentru producerea semintelor genetic ameliorate de foioase si rasinoase. Manuscris ICAS (Unpublished).

Eriksson, G. 1996. A policy suggestion for conservation of Noble Hardwoods genetic resources in Sweden. Pp. 147-154 *in* Noble Hardwoods Network. Report of the first meeting, 24-27 March 1996, Escherode, Germany (J. Turok, G. Eriksson, J. Kleinschmit and S. Canger, compilers). International Plant Genetic Resources Institute, Rome, Italy.

Georgescu, C.C. *et al.* 1958. Bolile si daunatorii padurilor. E.A.S., Bucuresti,638 p.

Kleinschmit, J. 1994. Waldumbau - neue züchterische Strategien - Erhaltung forstlicher Genresourcen. Schriftenr. Sächs. Landesanst. Forst. Heft 1:57-76.

Lalu, I. and L. Nicolescu. 1996. Catalogul national al resurselor genetice forestiere. Partea I. Manuscris ICAS, 187 p. (Unpublished).

Toniuc, N. *et al.* 1992. List of protected areas in Romania (1932-1991). Ocrotirea Naturii si Mediului Inconjurator 36 (1):22-33.

Noble Hardwoods in Ukraine: distribution and conservation of genetic resources

Olga S. Mazhula, Igor N. Patlaj and Svitlana A. Los
Department of Forest Tree Breeding, Ukrainian Institute of Forestry, 310024 Kharkóv, Ukraine

Introduction

In Ukraine the total area covered by forests is about 8 600 000 ha with an average proportion of forest coverage of 14.3%. The total growing stock is about 1319.9 million m^3 (as in 1989). The forest cover is higher in the following regions: Carpathians (39.9%), Crimea (30%), Polissya (29.8%). According to general information on the state forest fund of Ukraine, coniferous stands cover 47% of the territory occupied by forests, hardwoods 42% and softwoods 11%.

Methods of conservation of genetic resources for forest tree species

Since the beginning of the century, activities for the conservation of forest genetic resources have been carried out. The long-term programme for conservation of genetic diversity of natural forests in Ukraine has, in fact, been operational for 70-80 years. It foresaw selection, conservation and reconstruction of valuable genetic resources. According to this programme, mature populations were selected for *in situ* conservation in the more widespread type of forest gene reserves. They preserved the typical characteristics of the occurring forest type. In general, these are highly productive stands where plus and other best-performing trees were selected and registered. The gene reserves with a high proportion of rare species sometimes have lower productivity. Provenances trials, clonal archives, seed orchards and seed plantations also belong to gene conservation units.

Most gene conservation units contain the principal forest-forming species: *Pinus sylvestris, Quercus robur* and others. Rare and Noble Hardwoods species are present in several units.

Distribution and main characteristics of Noble Hardwoods

The stands in which Noble Hardwoods predominate (species of the genera *Betula* L., *Alnus* Mill., *Carpinus* L., *Fraxinus* L., *Ulmus* L., *Acer* L., *Tilia* L.) occupy about 12% of the territory covered by forests. At the same time Noble Hardwoods are disseminated in the hardwood forests almost everywhere, and *Betula* in coniferous forests, with a range from single occurrence to 40% of the species composition.

Characteristics of the Noble Hardwoods stands, some results of breeding and methods of conservation for each species are given below.

Betula pendula Roth (*verrucosa* Ehrh.)

This species is one of the most important and widespread in the forests of Ukraine. It often grows in mixture with *Betula pubescens* Ehrh. *Betula pendula* requires more light than *B. pubescens* and grows worse on soils with high water content. The stands in which these two species predominate occupy 290 200 ha (Table 1). There are many geographical, ecological and morphological forms (intraspecific variation) of *B. pendula* in Ukraine. Two gene reserves of *B. pendula* were chosen, one in Polissya forest zone and one in forest-steppe zone (Table 2).

Table 1. Characteristics of Noble Hardwoods in Ukraine

Species	Distribution†	Area (ha)	Area (%)	Growing stock ('000)
Betula spp.	M;D	290 200	4.7	29 410
Alnus glutinosa	D;M	233 100	3.9	26 810
Carpinus betulus	M;D	116 200	1.9	16 900
Fraxinus spp.	M;D	78 800	1.3	12 420
Ulmus spp.	M;D	12 200	0.2	540
Acer spp.	M;D	7 700	0.1	620
Tilia spp.	M;D	8 800	0.1	1 190
Juglans spp.	I	–	–	–
Malus sylvestris	I	–	–	–
Sorbus aucuparia	I	–	–	–
Sorbus torminalis	I	–	–	–

† D = stands with predominance of this species; M = mixed with other species; I = individual trees.

Table 2. Present situation of the genetic conservation of Noble Hardwoods

	In situ			*Ex situ*	
	Seed stands			Seed orchards	
Species	Number	Area (ha)	Plus trees	Number	Area (ha)
Betula pendula	2	36.5	5		
Alnus glutinosa	15	192.1	8		
Carpinus betulus	3	67.8			
Fraxinus excelsior	7	177.8	31	3	6.8
Fraxinus angustifolia	1	86.5	9	1	1.9
Acer platanoides	1	3.2	1		
Acer pseudoplatanus			4	1	2.0
Sorbus torminalis	1	6.1		2	4.3

Alnus glutinosa Gaertn.

It is the main species in damp and excessively moist places. *Alnus glutinosa* forms pure stands of high productivity or grows in an admixture with birch, poplar and other species. Middle-aged stands are predominant. There are geographical and phenological forms of alders in Ukraine. Gene reserves are situated in the Carpathians, Polissya and forest-steppe zones.

Carpinus betulus L.

It spreads mainly in the basins of rivers Dnieper and Tisa. *Carpinus betulus* grows most often in an admixture with oak and beech and this species predominates in large areas of stands (116 200 ha). Middle-aged stands are predominant. Not much attention has been paid to *C. betulus* breeding in Ukraine and only three gene reserves were chosen.

Fraxinus L.

The stands in which the species predominate occupy 78 800 ha. Middle-aged stands are predominant. *Fraxinus excelsior* L. is the most abundant and at the same time the most valuable species of the genus *Fraxinus* in Ukraine. Three natural zones of occurrence of this species are known in Ukraine: west, middle-east and south. The presence of stable climatic and edaphic ecotypes of *F. excelsior* is proven by studies conducted in plantations. The most interesting of these plantations (a provenance experiment) was established in 1930 under the guidance of V.N. Andrejev and V.V. Gurskiy in the Trostyanetz forest office in forest-steppe of the northeastern part of Ukraine. There are ash trees from 51 forest districts of Ukraine in this plantation. The performance of the ash trees from forest-steppe provenance is the best, the growth of ash trees from Polissya is good, the growth of the steppe ash trees is almost like that of the native forest-steppe provenances but its stem form is worse. Trees from Polissya have the best stem form and are considerably more resistant against early frost.

Edaphic conditions of the stand essentially influence the growth performance of ash. Forms which need much water perform worse in dry valleys than drought-resistant forms. All this proves that ash, like other similar tree species, requires a good understanding of seed behaviour and good choice of planting sites.

Numerous forms of ash differ by volume and morphology of fruits and winged seeds. During the planting of the above-mentioned provenance collection a special trial was established with seeds of different size. Individuals from big, middle-size and small seeds do not differ significantly with regard to tree height, diameter, resistance and productivity.

Ashes with seeds of narrow-shovel, sharp-pointed and narrow-winged linear forms are the most widespread in the forests of Ukraine. Dependence of the growth performance and productivity on the form of seeds was not observed.

To conserve and study ash stands, seven reserves with predominance of *F. excelsior* were chosen in different regions of Ukraine (Table 3). The genetic diversity of *Fraxinus* is also conserved in the mixed oak-ash stands. Fifty-one reserves of the European oak with a total area over 1500 ha are now designated in nine regions of Ukraine. Ash makes up 10-50% of their composition (Table 4). Altogether 31 plus trees of *F. excelsior* and 9 plus trees of *F. angustifolia* were selected. Clonal seed orchards were established from cuttings of *F. excelsior* (total area 6.8 ha) and *F. angustifolia* (1.9 ha). *Fraxinus angustifolia* Wahl. grows naturally in Crimea. It is less investigated.

Table 3. Taxation data from *Fraxinus excelsior* gene reserves

Region	Forestry Regional Office	Area (ha)	Species† composition (%) 1	2	3	4	5	6	7	8	Age (yr)	Height (m)	Diam. (cm)	Mean stock (m^3/ha)
Volynska	Volodymyr-Volynsky	13.0	60	10	20	10	–	–	–	–	60	25	26	280
Ternnopilska	Ternnopilsky	4.4	60	30	–	10	–	–	–	–	45	18	19	200
	Buchatsky	1.3	40	–	20	–	–	–	30	20	50	20	22	170
Rivnenska	Dubnivsky	11.0	50	–	–	20	20	–	–	10	70	28	32	330
	Ostkivsky	5.4	40	20	–	–	30	–	10	–	75			170
Zakarpatska	Volovecky	19.7	70	–	–	–	–	20	10	–	120	29	44	290
	Velyko Bychkivsky	137.0	70	–	–	–	–	30	<10	–	120	32	40	380
Total	7 reserves	177.8												

† 1 = *Fraxinus excelsior*, 2 = *Quercus robur*, 3 = *Alnus glutinosa*, 4 = *Betula pendula*, 5 = *Carpinus betulus*, 6 = *Fagus sylvatica*, 7 = *Acer* spp., 8 = *Salix*/*Populus*.

Ulmus L.

Stands of elms occupy 12 200 ha. The sapling, pole and middle-aged stands predominate. *Ulmus* L. trees most often grow in admixture with oak, beech and other principal forest-forming species. Two species – *Ulmus glabra* Huds.(*scabra* Mill.) and *Ulmus laevis* Pall. – grow everywhere. Both species are subject to strong 'graphiosis' disease (*Ophiostoma ulmi*); at the same time individual trees have been found showing high resistance. This phenomenon has been observed in the Carpathian mountain forests, the Trans-Carpathian forests and in other regions. There are no old-growth *Ulmus* L. stands nor are there any gene reserves of elms.

Table 4. Gene reserves of European oak mixed with *Fraxinus* L.

Region	No. of reserves	Area (ha)	Proportion of ash in stand composition (%)
Dnipropetrovsk	1	10.2	50
Charkivsk	18	622.3	10-40
Vinnizk	14	499.5	10-50
Volinsk	1	48.5	20
Lvivsk	1	18.0	10
Poltavsk	13	91.5	10-30
Kirovogradsk	3	143.3	20-40
Sumsk	6	62.3	10-30
Tsherkassk	4	35.8	10-40
Total	51	1531.4	10-50

Tilia L.

Tilia L. often grow in an admixture with oak, locally forming almost pure lime stands (8 800 ha). These are mainly middle-aged stands. *Tilia cordata* Mill. and *T. platyphyllos* Scop. are the most widespread species of the genus *Tilia* in Ukraine. *T. platyphyllos* grows in the forests of the western part of Ukraine. Lime is less investigated and not included in any breeding programme. There are 20 gene reserves of European oak with the proportion of *Tilia* from 10 to 50% (Table 5).

Table 5. Gene reserves of European oak mixed with *Tilia*

Region	No. of reserves	Area (ha)	Lime share in stand composition (%)
Kijvsk	4	197.9	20
Kharkivsk	1	5.9	10
Vinnizk	15	472.8	10-50
Total	20	676.6	10-50

Acer L.

Acer L. mainly occurs in stands as an admixed species, stimulating the growth of the dominant species, i.e. oak or beech. It seldom forms pure stands. The area of stands, in which this species occurs is 7700 ha. Sapling and pole stands predominate. *Acer platanoides* L. and *Acer campestre* L. have the broadest ranges of distribution. *Acer pseudoplatanus* L. spreads mainly in the western part of Ukraine and in Podoliya. There is one gene reserve with 40% *A. platanoides* share in composition, and 15 reserves of European oak mixed with *Acer* L. (Tables 6 and 7).

Table 6. Taxation data on *Acer platanoides* gene reserves

Region	Forestry Regional Office	Area (ha)	Species[†] composition (%) 1	2	3	4	Age (yrs)	Ht. (m)	Diameter (cm)	Mean stock (m^3/ha)
Ternnopilska	Kremencky	3.2	40	40	10	10	80	26	32	300

[†] 1 = *Acer platanoides*, 2 = *Fraxinus excelsior*, 3 = *Carpinus betulus*, 4 = *Acer pseudoplatanus*.

Table 7. Gene reserves of European oak mixed with *Acer* L.

Region	No. of reserves	Area (ha)	Maple share in stand composition (%)
Kharkivsk	1	7.4	10
Vinnizk	3	54.0	10
Donetsk	1	12.0	10
Lvivsk	1	29.0	10
Poltavsk	2	80.7	10
Rivensk	1	53.0	10
Sumsk	6	79.2	10
Total	15	315.3	10

Sorbus L.

Sorbus aucuparia L. grows as single trees everywhere. *Sorbus torminalis* (L.) Crantz. is a species with early occurrence, mainly in the north-western regions. There is one gene reserve with 10% share in the species composition of the stand (Table 8).

Table 8. Taxation data on *Sorbus torminalis* gene reserves

Region	Forestry Regional Office	Area (ha)	Species† composition (%)† 1	2	3	4	Age (yrs)	Height (m)	Diameter (cm)	Mean stock (m³/ha)
Ternnopilska	Buchatski	6.1	10	50	10	30	25	8	60	80

† 1 - *Sorbus torminalis*, 2 - *Quercus robur*, 3 - *Picea abies*, 4 - *Carpinus betulus*.

Malus sylvestris (L.) Mill.

Malus sylvestris grows widely as individual trees.

Juglans regia

European walnut breeding in Ukraine for winter hardiness and high fruit quality has been the object of investigations since the 1930s. During that period genetic forms have been developed withstanding low temperatures as low as –35 to –37°C practically without damages, affecting the degree of yield. These trees do not compare unfavourably with the best foreign breeds. For example, the protein content in the nut kernels can be up to 21-24%, and the fat content reaches as much as 70% and higher.

During the last 25 years in European walnut breeding, the species' ability for apomixis resulted in autonomous and induced parthenogenesis and pseudogamy.

In the mentioned cases the developing ovicell nucleus reduces a diploid set of chromosomes during one of the first divisions, causing homozygosity of the plant, i.e. lines appearance. The plants having lethals and semilethals are rejected. Among the remaining forms of the increased genetic level the fast-growing forms are isolated, having fruits of high quality, some of which possess increased winter hardiness. Some forms have been further improved, with average fruit (nuts) mass 23 g and average kernel yield 7.5 g.

Methods of vegetative propagation of the European walnut have been developed for the steppe conditions, by summer inoculations with ennobled planting material up to 84-86% as well as by indoor winter grafting into a small stem and root. The survival of planting material is up to 79% and 60%, respectively.

When different *Juglans* species are crossed among themselves, including European walnut, forms with heterosis growth are selected. For example the volume of a decorative wood suitable for veneering wood manufacture for one tree at the age of 42 years was 6 m^3.

Prospects

In Ukraine, long-term breeding programmes are designed for the development of further improved genetic material and include the conservation of genetic resources of natural Noble Hardwood stands. Genetic investigations of these species and their populations should be intensified. Unfortunately, breeding research is considerably reduced owing to lack of financial support. Taking into account the increasing importance of Noble Hardwoods, additional programmes on these species are necessary. They must include detailed information on their distribution, the objectives of genetic resources conservation, and studies of their morphological and genetic diversity.

Conservation of Noble Hardwoods in Poland

Adolf Korczyk
Forest Research Institute, 17230 Bialowieza, Poland

Introduction

The area of forests in Poland amounts to 8 732 000 ha, representing 27.9% of the total country area. There are public and private forests. The area of public forests is 7 240 000 ha, wherein 7 164 00 ha are state property (6 855 000 ha are under State Forest Service administration), and local communities own 76 000 ha. Private forests cover 1 492 000 ha, wherein 1 394 000 ha are the property of individual persons.

The average age is 50 years (in the State Forest Service 55 years and in private forests 36 years). Almost 96% of the forests are artificially regenerated, while only 4% naturally. The forest health condition is constantly deteriorating. The percentage of damaged deciduous tree species is growing and it has reached the proportion of 51.3%, while the respective proportion for coniferous tree species is 55.4%.

National strategy for the conservation of forest genetic resources

In Poland, the only law in force defining the methods for the *in situ* preservation of plants and animals is the Nature Protection Law of 16 October 1991 (Anonymous 1991a). It also prescribes the penalties for its infringements. The Nature Protection Law comprises the following forms of protection:

- national park
- nature reserve
- landscape park
- protected landscape area
- plant and animal species protection
- nature monument
- ecological grounds.

The Forest Law of 28 September 1991 mentions the necessity of gene resources conservation (Anonymous 1991b). The background of this issue was more widely elaborated in the report published in December 1994: 'The Polish policy concerning the broad preservation of forest resources' (Rykowski 1994; Grzywacz 1994).

The Forest Research Institute, under the responsibility of the State Forest Service, creates and carries out the forest tree breeding and gene resources conservation programmes, and coordinates the activities with other collaborating institutions. Until 1990 some of our activities concerning gene conservation were carried out under the actual breeding programme (1975-90). One of the main aims of this programme was to conserve, mainly *in situ*, economically important species, populations and trees. In January 1993 the 'Programme of gene conservation and tree breeding' was formally confirmed for the period 1991-2010 (Matras and Korczyk 1993).

Noble Hardwood species in Poland

There are 31 native broadleaved species occurring in Poland's forests. Only a few of them are economically important, because of their wide distribution and wood quality (Table 1).

Table 1. Native broadleaved tree species in Poland

Native species	Distribution	Economic importance†	Native species	Distribution	Economic importance
Acer campestre	+++	–	*Prunus avium*	++	–
Acer platanoides	+++	+++	*Quercus pubescens*	+	++
Acer pseudoplatanus	++	++	*Quercus petraea*	+	++
Acer tataricum	+	–	*Quercus robur*	+++	+++
Alnus glutinosa	+++	+++	*Robinia pseudacacia*	++	++
Alnus incana	++	+	*Salix alba*	++	+
Betula carpatica	+	–	*Sorbus aria*	+	–
Betula obscura	+	–	*Sorbus aucuparia*	+++	++
Betula oycoviensis	+	–	*Sorbus intermedia*	+	–
Betula pendula	+++	+++	*Sorbus torminalis*	+	–
Betula pubescens	++	+++	*Tilia cordata*	+++	+++
Carpinus betulus	+++	++	*Tilia platyphyllos*	++	++
Fagus sylvatica	+++	+++	*Ulmus campestris*	+	+
Fraxinus excelsior	++	+++	*Ulmus laevis*	+	+
Malus sylvestris	+	–	*Ulmus glabra*	++	+++
Populus tremula	+++	+++			

† Estimation of species (economic) importance: – none, + low, ++ moderate, +++ high.

At the end of 1994, the total area covered by broadleaved species amounted to 1 924 000 ha, i.e. 22.1% of the total forest area in Poland. The proportion of individual species areas including most important Noble Hardwoods is as follows: *Fagus sylvatica* - 4.1%; *Quercus robur* and *Q. petraea, Fraxinus excelsior, Acer platanoides* and *A. pseudoplatanus* and *Ulmus* spp. - 6.0%; *Betula pendula* and *B. pubescens* and *Robinia pseudoacacia* - 5.8%; *Alnus glutinosa* and *A. incana* - 5.3%; *Populus tremula, Tilia cordata* and *T. platyphyllos* and *Salix* spp. - 0.4%; *Carpinus betulus* - 0.3%; *Populus* hybrids - 0.2%.

In situ conservation activities

Forests under legal protection represent 41.5% of the total forest area in Poland. They include:

- 22 national parks – 284 811 ha (of which forests 64.2%), 0.9% of the whole country area
- 524 forest reserves – 38 200 ha (0.44% of the forest area), 0.38% of whole country area
- 96 landscape parks – 1 860 500 ha (of which forests 56.6%), 6.0% of the whole country area
- 231 protected landscapes – 5 257 500 ha (of which forests 44.7%), 16.8% of the whole country area.

Additionally there are *in situ* and *ex situ* conservation units, which are chosen for tree breeding purposes (Table 2).

Table 2. Overview of *in situ* and *ex situ* tree breeding units for Noble Hardwood species

Species	Seed stands: area (ha)	Plus trees: number	Clonal seed orchards (ha)	Seedling seed orchards (ha)
Acer pseudoplatanus	1.63	4	–	–
Alnus glutinosa	409.70	266	24.87	–
Betula pendula	161.63	165	33.07	7.39
Fraxinus excelsior	95.73	62	–	–
Tilia cordata	78.48	33	27.83	–
Total broadleaves	14408.34	988	94.23	7.39

In 1996 a new type of *in situ* gene conservation units was started. A number of 'protective tree stands' were designated. Fragments of old-growth, natural or semi-natural stands were selected, using the criteria of threat level. Seeds harvested from these stands are maintained for long-term storage in the Gene Bank. Only sanitary fellings are allowed in the category of the protective tree stands. The first stands were designated in the state forest of the region Bialystok where four *Fraxinus excelsior* stands (total area 39.73 ha) and five *Quercus robur* stands (46.98 ha) were selected.

Breeding and genetic research

The following research programmes are carried out:

- Interspecific variability of common oak. Forest Research Institute. Collaborators: Laboratoire de Génétique et Amélioration INRA (France); Institute of Dendrology Kornik, Agricultural University of Cracow and Poznan. Ten Polish provenances included. (Coordinated by Gerard Burzynski).
- Variability among populations of *Fagus sylvatica* L. in Poland. Forest Research Institute. Collaborators: Institute of Dendrology Kornik, Warsaw Agricultural University, Agricultural University of Cracow and Poznan. In 1992 two experimental areas (IUFRO 1992) with 48 provenances; and in 1996 five experimental areas with 30-40 provenances were established. (Coordinated by Jan Matras).
- *Betula pendula* variability, its growing capacities and breeding properties. Forest Research Institute. In 1997, 20 Polish and 5 foreign provenances, and 45 progenies from three provenances were studied. (Coordinated by Jan Matras).
- *In situ* preservation of native populations and old trees in the north-western part of Poland. Forest Research Institute. (Coordinated by Adolf Korczyk).

Bibliography on Noble Hardwoods in Poland

Anonymous. 1991a. [Nature Protection Law of October 16, 1991]. Dz.U. Nr. 114, poz. 492. [Polish].

Anonymous. 1991b. [Forest Law of September 28, 1991]. Dz.U. Nr. 101, poz. 444, z dnia 8 listopada 1991r. [Polish].

Anonymous. 1996. [Foundations of the Polish Government Forest Policy]. Ministerstwo Ochrony Srodowiska, Zasobów Naturalnych I Leśnictwa, Warszawa 1996. 58 p. [Polish].

Barzdajn, W. 1993. Preliminary results of an experiment with Polish provenances of pedunculate oak (*Quercus robur* L.) and sessile oak (*Quercus petraea* [Matt.] Liebl.). Ann. Sci. For. 50,1: 222s-227s.

Bednarz, Z. 1994. [Water deficit limits tree-ring widths of oak (*Quercus robur* L.) in the Niepołomice Forest, Southern Poland]. Sylwan. CXXXVIII,10: 29-41. [Polish, with English summary].

Boratyński, A. 1994. [Outline of Oak taxonomy]. Sylwan.CXXXVIII,10: 73-88. [Polish, with English summary].

Denisiuk, Z. 1995. [The European ash (*Fraxinus excelsior*) in the system of nature conservation in Poland]. *In* Jesion wyniosły. *Fraxinus excelsior* L. (W. Bugała, ed.), Nasze drzewa leśne ed., vol. 17. Sorus, Poznań-Kórnik 1995 [Polish, with English summary].

Filipek, Z. 1992. [The content of tannins in the heartwood of sessile oak trees (*Quercus petraea* Liebl.) of different ages]. Sylwan. CXXXVI(4): 45-55. [Polish, with English summary].

Fober, H. 1994. [International provenance experiment with *Quercus petraea* (Matt.) Liebl.]. Arbor. Kór. XXXIX: 109-124. [Polish, with English summary].

Forest Biodiversity Protection Project, Warsaw.
Glaz, J. 1986. [Elm in the State Forests]. Sylwan. CXXX(1): 23-33. [Polish, with English summary].
Grzywacz, A. 1994. [The Polish policy concerning the broad preservation of forest resources. Synthesis] . *In:* The Polish policy concerning the broad preservation of forest resources. Report, vol. II. Fundacja "Rozwój SGGW", Warsaw. [Polish].
Helinska-Raczkowska, L. and E. Fabisiak. 1995. [Duration of the juvenile period in diameter growth of birch (*Betula pendula* Roth.) Trees]. Sylwan. CXXXIX,12: 77-84. [Polish, with English summary].
Korczyk, A. 1980. [Morphological variability of *Tilia cordata* Mill. and *Tilia platyphyllos* Scop. in the Forests of Poland]. Frag. Flor. Geobot. XXVI,1: 5-48. [Polish, with English summary].
Korczyk, A. 1987. [Preservation of natural gene resources of native species of forest trees]. Sylwan. CVVVI,9: 31-38. [Polish, with English summary].
Korczyk, A. 1992. [The necessity of old trees preservation in order to restore the native forest trees populations]. *In* Problematyka genetyki i selekcji drzew leśnych (SITLiD, ed.), Postepy techniki w leśnictwie ed., vol. 51. Wydawnictwo Swiat, Warszawa.
Korczyk, A.F. 1995a. Protection and conservation of gene resources of forest trees in the Białowieza Forest. *In:* P. Paschzlis, K. Rykowski and St. Zajączkowski (eds.) Protection of forest ecosystems biodiversity of Białowieża Primeval Forest. Grant GEF 05/21685 Pol. Forest Biodiversity Protection Project, Warsaw.
Korczyk, A.F. 1995b. Risk assessment of pollution load on reproductive systems in forest tree. *In:* P. Paschalis, K. Rykowski and St. Zajączkowski (eds.) Protection of forest ecosystems biodiversity of Białowieza Primeval Forest. Grant GEF 05/21685 Pol.
Kraj, W., A. Dolnicki and B. Pilczuk. 1995a. [Growth and frost-resistance of two-year-old beech (*Fagus sylvatica* L.) Seedlings grown from seed soaked in solutions of growth regulators]. Sylwan. CXXXIX,12: 91-96. [Polish, with English summary].
Kraj, W., A. Dolnicki and B. Pilczuk. 1995b. [Growth and frost-resistance of one-year-old beech (*Fagus sylvatica*) seedlings grown from seed soaked with solutions of growth regulators]. Sylwan.CXXXIX,10: 103-113. [Polish, with English summary].
Matras, J., A. Korczyk *et al.* 1993. [The programme of the forest gene resources conservation and tree breeding in Poland, in the years 1991-2010]. Dyrekcja Generalna Lasów Państwowych, Instytut Badawczy Lesnictwa. [Polish].
Mejnartowicz, L. 1980a. [Studies on racial variation of black alder in Poland]. Arbor. Kór. XXV: 167-180. [Polish, with English summary].
Mejnartowicz, L. 1980b. [Provenance experiment on black alder (*Alnus glutinosa* (L.) Gaertn.) established in 1968]. Arbor. Kór. XXV: 161-166.[Polish, with English summary].
Pacyniak, C. 1995. [The age of the oldest and monumental ash trees in Poland]. *In* Jesion wyniosły. *Fraxinus excelsior* L. (W. Bugała, ed.), Nasze drzewa leśne ed., vol. 17. Sorus, Poznań-Kórnik 1995. [Polish, with English summary].
Rykowski, K. 1994. [Research programme: "The model for the multifunctional forestry". *In:* The Polish policy concerning the broad preservation of forest resources. Report. Vol. II. Fundacja "Rozwój SGGW", Warszawa. [Polish].
Rzeźnik, Z. 1976. [Investigations of Polish beech provenances (*Fagus sylvatica* L.)]. Rocz. AR Pozn., Leś. 72: 5-37. [Polish].
Rzeźnik, Z. 1988. [Volume and quality of beech stands of Polish provenances aged 20 years]. Sylwan. CXXXII(8): 9-20. [Polish, with English summary].
Rzeźnik, Z. 1989. [Investigations on leaf mutability of beech (*Fagus sylvatica* L.) on the experimental provenances areas in Poland]. [Polish, with English summary].

Sabor, J. 1993. Conditions for oak selection in Poland. Ann. Sci. For. 50,1: 452s-455s.

Sierocinska-Jędra, A. 1994. [Variability of biometric parameters in leaves of common maple (*Acer platanoides* L.) as an indicator of environmental conditions in the city of Warsaw]. Sylwan. CXXXVIII,12: 89-96. [Polish, with English summary].

Siwecki, R. 1989. A decline of oak forests caused by abiotic and biotic factors and attempts at biological research on this syndrome. Arbor. Kór. XXXIV: 161-169.

Siwecki, R. 1994. [Oak (*Quercus* sp.) decline related to global climate change]. Sylwan. CXXXVIII,10: 43-59. [Polish, with English summary].

Sułkowska, M. 1994. [Conservation of common beech (*Fagus sylvatica* L.) gene resources in Poland]. Sylwan. CXXXVIII,1: 43-48. [Polish, with English summary].

Suszka, B. 1993a. [The Forest Gene Bank in Kostrzyca - Vision and Reality]. Sylwan. CXXXVII,11: 17-27. [Polish].

Suszka, B. 1993b. Wissenschaftliche Grundlagen der Bucheckern- Langzeitlagerung. AFZ Waldwirts. Umweltvor. 18: 922-926. Only in German

Suszka, B. and A. Kluczyńska. 1980. Seedling emergence of stored beech (*Fagus sylvatica* L.) seed chilled without medium at a controlled hydration level and pre-germinated in cold-moist conditions. Arbor.Kór. XXV: 231-267.

Suszka, B. and T. Tylkowski. 1980. Storage of acorns of the English oak (*Quercus robur* L.) over 1-5 winters. Arbor.Kór. XXV: 199-299.

Szczygieł, K., E. Borkowska and O. Baziuk. 1994. [Micropropagation of selected clones of aspen (*Populus tremula* x *P. tremuloides*) using tissue cultures]. Sylwan. CXXXVIII,10: 97-107. [Polish, with English summary].

Tylkowski, T. 1987. Storing of Russian elm (*Ulmus laevis* Pall.) seed over many years. Arbor. Kór. XXXII: 297-305.

Tylkowski, T. 1988. Storage of stratified seeds of European ash (*Fraxinus excelsior* L.). Arbor.Kór. XXXIII: 259-266.

Tylkowski, T. 1994a. [Pre-sowing treatment of dormant seeds by cyclically repeated soaking in water. I. European ash, *Fraxinus excelsior* L.]. Sylwan. CXXXVIII,11: 53-59. [Polish, with English summary].

Tylkowski, T. 1994b. [Adaptation of dormant seeds to sowing by cyclically repeated soaking in water. II. Small-leaved lime, *Tilia cordata* Mill.]. Sylwan. CXXXVIII,12: 67-72. [Polish, with English summary].

Tylkowski, T. 1995. [Physiological aspects of dormancy receding in ash (*Fraxinus excelsior*) seeds]. Sylwan. CXXXIX,9: 53-59. [Polish, with English summary].

Walczak, M., T. Lubelska, J. Radziejowski and M. Smogorzewska. 1993. [Protected areas in Poland]. Dzial Informacji i Wydawnictw Instytutu Ochrony Srodowiska, Warszawa. 229 p. [Polish].

Noble Hardwoods in Russia: conservation of genetic resources

Andrey Prokazin, Iliodor Routkowsky and Nadezhda Shchegunova
Russian Tree Breeding Centre, 141200 Pushkino, Russian Federation

Introduction

Hardwoods grow all over the territory of Russia, from the Kola Peninsula in the north to the Caucasus in the south, and from western frontiers as far as the Far East. There are dozens of species, and they prevail on an area of more than 120 million ha. The most widespread are oak, beech, maple, lime, birch and aspen (Table 1 and Fig. 1). Although most deciduous forests are situated in the Asian part of Russia, they also cover a significant area (more than 40 million ha) in the European-Urals region. The above species are of economic importance and are used intensively (especially in the regions with developed infrastructure). Considering a huge growing stock of deciduous forests (of which more than 13 billion m^3 belong to the six above species), a difficult economic situation in Russia, as well as relatively high profitability of woodworking industries, one may predict maintenance of or increase in the exploitation of hardwood species. It should be noted that those species are especially endangered which produce a highly valuable timber. In this connection, the efforts aimed at study and conservation of the rich genetic diversity of Russian deciduous hardwood forests would be timely.

Table 1. Hardwood species† in Russia: area (thousand ha) and growing stock (million m^3).

Region	Oak	Beech	Maple	Lime	Birch	Poplar
European-Urals						
Area	1345.4	701.3	269.8	2217.7	31641.6	7274.8
Stock	209.6	175.0	30.3	351.0	3550.4	1108.8
Asian part						
Area	2462.6	–	28.6	800.7	64430.8	11633.1
Stock	244.0	–	2.5	121.3	5713.7	1632.5
Total in Russia						
Area	3808.0	701.3	298.4	3018.4	96072.4	18907.9
Stock	453.6	175.0	32.8	472.3	9264.1	2741.3

† Oak = *Quercus robur, Q. petraea, Q. mongolica, Q. dentata*; Beech = *Fagus sylvatica, F. orientalis*; Maple = *Acer platanoides, A. pseudoplatanus, A. campestre, A. tataricum, A. mandschuricum, A. ginnala, A. mono, A. tegmentosum, A. ukurunduense* and others; Lime = *Tilia cordata, T. begoniifolia, T. sibirica, T. amurensis, T. mandshurica, T. taquetii* and others; Birch = *Betula pendula, B. pubescens, B. krylovii, B. lanata, B. dahurica, B. platyphylla, B. cajanderi, B. costata, B. schmidtii*, and others; Poplar = *Populus tremula, P. alba, P. tomentosa, P. nigra, P. suaveolens, P. laurifolia* and others.

As is evident from the previously published EUFORGEN Noble Hardwoods Network materials, the discussion of the criteria for assignment of particular hardwoods to the Noble Hardwoods group is not completed yet. However, the Network participants are using the two following criteria: the species must be local (not introduced), and it must produce either highly valuable or extensively used merchantable wood. The Noble Hardwoods also include endangered species, as well as species which must be preserved because of their ecological significance and scattered distribution patterns.

If the forest fund in Russia (characterized by a very rich diversity of site conditions) is viewed in this context, it may be concluded that all main hardwood species may be classified as Noble Hardwoods, depending on specific regions of

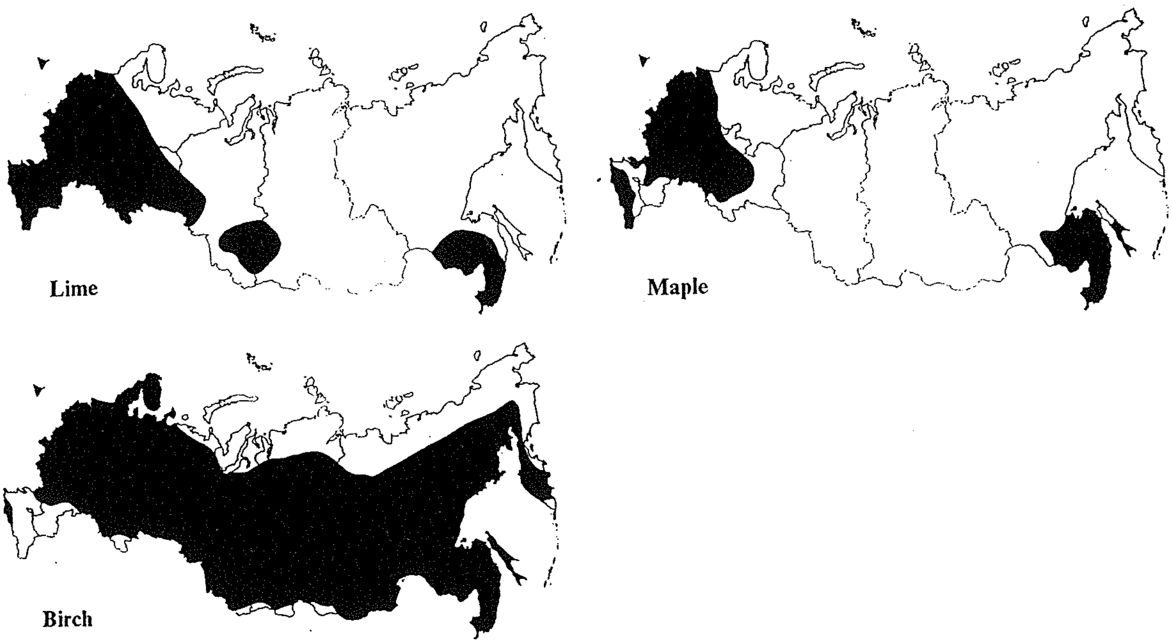


Fig. 1. Distribution of main Noble Hardwood species in Russia.

their distribution, with the areas covered being comparable with those of some European countries. The species in question, with their stands covering (depending on a region) hundreds of thousands, or millions of hectares, may produce high-quality (oak, beech) or extensively used merchantable wood (birch, poplar); they may be of major environmental importance, or may be used in protection forestry (maple, lime); finally, those species may not comply with the above criteria for belonging to the Noble Hardwoods group. For instance, *Quercus robur* is considered a Noble Hardwood species in the North Caucasus, whereas it does not belong to the Noble Hardwoods group within its northern range because of the frost damages preventing a widespread use of *Q. robur* wood. In some regions, *Populus tremula* is not susceptible to rot attacks and produces valuable raw materials for the pulp and paper industry, and it is commonly used for establishing water conservation and soil protective stands; hence, it belongs to Noble Hardwoods. In other regions, this species does not belong to the Noble Hardwoods group and is of minor importance.

The authors of this report follow the species list adopted by the Network member countries and conventionally attributed to the group of Noble Hardwoods. Consequently, the situation of genetic conservation of oak, beech and poplar is not described here.

Description of main Noble Hardwood species

Maple and sycamore(*Acer*)

Acer platanoides and *A. pseudoplatanus* occur in the European-Urals part of Russia. The most widely distributed is *A. platanoides*, as a component of stands mixed with oak, ash, birch and other species, within forest, forest-steppe and steppe zones. Maple is used in protection forests. *Acer ukurunduense* (with the most extensive range), *A. mandschuricum*, *A. ginnala*, *A. mono*, *A. tegmentosum* and others are found in the Far East. The stands of *A. mono* occur within river terraces, those of *A. mandschuricum* in valleys. As a result of *A. platanoides* breeding, ornamental types of maple were selected, featuring a globe-shaped or pyramidal crown, cut white-motley and red leaves, various texture of wood. Crossing of *A. platanoides* with other species made it possible to obtain fast-growing hybrids (especially valuable ones as a result of crossing with *A. negundo*). At the foothills of the southern Urals, maple is of particular importance for its soil-protecting, water-regulation and water-storage role.

Lime (*Tilia*)

The most widely distributed species is *Tilia cordata*, of which virtually pure stands are found in Bashkorostan, Chuvashia and Tatarstan, with the mean growing stock of 80-year-old stands being about 350 m^3/ha. This species occurs everywhere in the forest-steppe zone of European Russia. *Tilia sibirica*, a relict species of Siberian broadleaved forests, occurs at the foothills of the Kuznetsk Ala Tau ('Lime island' of 400 km^2) and in the neighbourhood of Krasnoyarsk. *Tilia amurensis* is often found in the Far East, within river valleys and in mountain broadleaved forests.

Less distributed are *T. mandshurica* and *T. taquetii*. During selection of *T. cordata* within natural stands of the central Urals, the ornamental types were selected with a wide column-shaped, oval or weeping crown, as well as other phenological types. As a result of remote crossing, a number of ornamental and stable types of lime was obtained. Lime is introduced in artificial stands mixed with oak, pine and larch; it is used for planting of greenery and in protection forestry, and is also a good melliferous species. The light and soft lime wood is used in the production of plywood, turnery and fretwork.

Birch (*Betula*)

There are about 50 species of birch in Russia. However, only two main species of long-boled, white-barked birch – *Betula pendula* and *B. pubescens* – prevail over the major part of the territory, with the exception of the extreme north and south regions. Both species are often found in the same stand, although *B. pendula* prefers drier and higher sites. Birch forests come third in area behind larch and pine stands, respectively. Growing conditions being favourable, the productivity of birch stands may reach 350 m^3/ha by the age of 50. The extensive areas of West Siberia are covered with *B. krylovii*. The most widely distributed in East Siberia and in the Far East are the dark-barked *B. lanata* and *B. dahurica*, as well as the white-barked *B. platyphylla*. A small range in the East Sakhta is occupied with *B. cajanderi*. *Betula costata* occurs to the south of the Lower Amur (the Far East), and *B. schmidtii*, which was entered in the Red Data Book, is distributed over dry rocky slopes in the extreme south of the Primorski Territory. As a result of breeding carried out with *B. pendula* and *B. pubescens*, a considerable number of morphological types were selected, differing in the rate of growth, and the structure of bark and crown; a long-boled variety of *B. pendula* f. *carelica* was also selected. Within forest and forest-steppe zones, birch is introduced in the artificial stands of pine and spruce, with the purpose of raising their tolerance and productivity; birch is also used in protection forests and amenity planting, and is of great environmental and recreational value. Pure birch stands may produce high-quality wood for diverse uses.

Genetic structures and tree seed zones

Despite a long history of hardwood breeding in Russia, we have so far only a vague idea of their genetic structure. Moreover, genetic distinctions between some species are not clear. This problem is very complicated and hardly studied, for the following reasons: the research work mostly involves conifers which are the main timber species of the highest economic value; extensive ranges of hardwoods that make it necessary to collect considerable quantities of experimental data; small number of scientists who are sufficiently skilled in applying sophisticated research methods; high prices for the preparations which are indispensable for carrying out genetic research. Today, the progress in studies of hardwoods' genetic structure in Russia could be achieved only on the condition that some external financial sources be available. Thus, the term 'ecotype', or 'climatype', is widely used now by Russian breeders when considering intraspecific structure of hardwoods, as applied to stands within a certain administrative region. For instance, the "Moscow climatype" refers to stands growing within the bounds of the Moscow Region.

Lack of systematic research into this problem, as well as no distinct ideas available concerning the genetic structure of hardwoods, could not leave unaffected the regulations of the 'Division of the main forest timber species in the USSR into tree seed zones' that was issued as early as 1982. Pursuant to that document, the boundaries of tree seed zones should run along the administrative boundaries. However, such a condition does not lessen the significance of that document which was developed from the results of a large-scale evaluation of provenance trials of main timber tree species, and paved the way for the regulation of seed utilization.

Organization of work on forest gene reserves

The first basic document on the conservation of national forest genetic resources is 'The Regulations on designation and conservation of tree species genepools in the forests of the USSR which have been in force since 1982. This document determines the main directions of the work to be performed and the criteria for designation of forest gene reserves, as well as the relevant procedures to be followed.

The designation of forest gene reserves in Russia takes into consideration specific features of the national forest legislation which divides all forests into three groups. The group I forests (20%) perform mainly water-storage, protective, sanitary and other ecological and social functions. In the group II forests (5.5%) forest exploitation is permitted with certain restrictions; those forests are located in densely populated, or in sparsely forested regions. The group III forests (74.5%) are of mainly exploitable, commercial value. Accordingly, particular forest management rules are specified for each group, the group I forests being managed most carefully.

The group I forests comprise several protection classes, including reserve forests, national and natural parks, etc. Forest gene reserves are thereby referred to the protection class of "forests of scientific or historical value".

The special protected forest areas (SPFA) are to be allocated within each group of forests. In this connection, forest gene reserves may be considered as "special protected forest areas of particular economic value". Generally, only relatively small forest gene reserves are assigned to SPFAs. SPFAs are not allocated within those of the group I forests which are referred to protection classes with similar or even more strict forest management regime.

It is permitted to transfer the forest areas which were assigned formerly to gene reserves within the group II and III forests, to the group I forests.

Pursuant to the current rules, the gene reserves may be allocated in:

1. the forests of protected reserves, national and natural parks (group I forests), without transferring to another forest group or protection class (the decision must be made by forest management bodies of the Russian Federation's regions);
2. the group I forests, with transferring to the protection class "forests of scientific or historical value" (the decision must be made by the authorities of the Russian Federation's regions);
3. in the forests of all groups, with assigning to "special protected forest areas of particular economic value" (to be decided upon exactly as in 2);
4. in the groups II and III forests, with transferring to the group I forests and assigning to "forests of scientific or historical value" (the decision must be made by the Federal Forest Service of Russia).

Accordingly, each of the above alternatives requires a particular set of necessary source documents (application to be submitted by a relevant organization, expert's conclusion, cartographic materials, silvicultural characterization of areas, etc.), as well as specific procedures for considering, coordinating and approving a decision on the designation of gene reserves.

The lines of work aimed at genepool conservation

One can point out roughly three lines of work relating to the conservation of hardwood genepools *in situ* and *ex situ*. The first one comprises conservation of genepool by means of breeding. Seed stands and plus trees are selected, and seed orchards, provenance trials, progeny trials and clonal archives established. This work is carried out most broadly and systematically owing to financial support of the Federal Forest Service of Russia under the coordination ensured by the Russian Tree Breeding Centre. It should be noted that Russian forest legislation also binds forest owners and users with an obligation to carry out tree breeding work.

The second group of activities aimed mainly at genepool conservation envisages designation of forest gene reserves according to the criteria determined above. Generally, this scope of work is carried out from scientists' own initiative, without any coordination at a national level or financial backing.

The third line of work aimed mainly at the conservation of forest ecosystems includes the establishment of national parks and reserves, as well as forest reserves and other specially protected areas intended, in addition to their main function, for genepool conservation. This work is performed, as a rule, on the initiative of administrations of the Russian Federation's regions, and is not in progress at the present time.

This report comprises the information on gene conservation units which either exist naturally or have been established artificially when carrying out work within the framework of the first two directions.

Institutions involved

The above system on gene conservation in the forests, as well as the lines of that work, allows to specify a list of participating institutions.

The breeding work is performed, principally, by Russian forest management units under the guidance of regional forest management bodies, and, methodically, with the participation of research institutes.

Designation of gene reserves is carried out on the initiative of the following research institutions, subordinate to the Federal Forest Service of Russia and the Russian Academy of Sciences (RAS):

- Research Institute of Forest Genetics and Tree Breeding (Voronezh)
- Forest Institute of RAS Siberian Branch (Krasnoyarsk)
- Forest Institute of RAS Urals Branch (Ekaterinburg)
- Forest Institute of the Karelian Research Centre of RAS (Petrozavodsk)
- The Institute of Biology of RAS Scientific Centre of the Komi Republic (Syktyvkar)
- All-Russian Research Institute of Forest and Forestry Mechanization (Pushkino, Moscow Region)
- Arkhangelsk Institute of Forest and Forest Chemistry (Arkhangelsk)
- St. Petersburg Forest Research Institute (St. Petersburg)
- The Far East Forest Research Institute (Khabarovsk)
- Research Institute of Mountain Forestry and Forest Ecology (Sochi)
- Russian Tree Breeding Centre (CENTRLESSEM) (Pushkino, Moscow Region) and the network of 34 directly subordinated zonal seed testing stations.

The above-mentioned zonal seed testing stations are entrusted with a task of gathering the regional data on the available gene conservation units in the Russian forests, while the staff of CENTRLESSEM is responsible for keeping a summary national register of those units.

Main results of the efforts on the conservation of genetic resources of Noble Hardwoods

The main results of activities on the conservation of genetic resources of hardwood species in Russia are presented in Table 2. Forest gene reserves with a total area of 6725.7 ha are designated for one species of Noble Hardwoods only – birch in the European-Urals part of Russia. The absence of forest gene reserves for lime and maple can be explained because, similarly to the other Hardwoods, they are not considered the most valuable species (compared with oak and beech). There is a relatively low interest of scientists in studying their genetic diversity and safeguarding their genetic resources. Maples along with other broadleaved species occur in forest gene reserves designated for other, principal species with a total area of 3067.1 ha (Kostroma and Orenburg regions, Karachaevo-Cherkesia, North Osetia). Furthermore, the function of gene reserves for maple, lime and birch is also fulfilled by some of the nature protected areas: nature reserves, national parks, botanical gardens and others.

Results of breeding of Noble Hardwoods (Table 2) can be viewed as insufficient for the Russian Federation. The isolated areas of seed stands are minimal. Selected plus trees, with rare exceptions, are not regenerated in the seed orchards.

But the necessity of saving the genetic resources of the mentioned species is also defined by their extensive intraspecific variability and the presence of valuable forms. For example, 13 decorative forms of *Acer platanoides* were selected, differentiating from each other by the shape of crown and the leaf colour. They bear significant value for amenity forestry. In Russia the following forms of Norway maple are known:

- *Acer platanoides* f. *columnare* – with columnar crown and reddish by the foliation leaves
- *A. p.* f. *globosum* – forms dense and globular crown, especially by cutting in young age; grows more in width than in height
- *A. p.* f. *laciniatum* – hollows between the leaf blades are very deep, lobes are narrow, with very long narrow and thin-pointed to othes and lobes of the second order; leaf blade commonly with the down wrapped edges
- *A. p.* f. *palmatifidum* – leaves symmetric nearly to base divided, lobes deep and thinly cut, often recovering each other by the edges
- *A. p.* f. *Stollii-Schwerin* – leaves are clean-3-lobed, from time to time slightly 5-lobed, lobes are intact, base is cut or shallow-heart-shaped, sometimes crater-shaped; leaves are by development reddish; it grows slower as the typical form and has more raised branches
- *A. p.* f. *crispum* – the edges of leaves are more or less turned up inside, wavy; leaf blade is bent-folded
- *A. p.* f. *variegatum* – leaves are with white spots, pinkish by leaves development
- *A. p.* f. *Schwedleri* – leaves by development bloody-red, later becomes olive; petioles stays red; this form is particularly beautiful in spring
- *A. p.* f. *rubrum* – leaves are reddish-green, sometimes with more dark red spots, in late summer becomes black-red colour till autumn.

Table 2. Gene conservation units of Noble Hardwood species

Federal Forest Service of Russia by 'economic areas'			
Noble Hardwood species	**Plus trees**	**Seed stands (ha)**	**Seed orchards (ha)**
1. North			
Betula carelica	100	2.1	2.5
Alnus glutinosa		2.0	
2. Central			
Betula carelica	–	–	5.8
Betula pendula	38	–	6.2
Tilia cordata	1	–	–
3. Volgo-Vyatka	0	0	0
4. Central-Chernozem	0	0	0
5. Volga	0	0	0
Fraxinus lanceolata	120	–	–
Fraxinus excelsior	45	–	–
Acer albenskii	14	–	–
Ulmus laevis	11	–	–
Ulmus pinato-ramosa	41	–	3.5
Ulmus pumila	20	–	–
Betula carelica	–	–	12.5
Betula pendula	45	–	–
Tilia cordata	6	–	–
Juglans regia	50	–	–
6. North Caucasus			
Fraxinus excelsior	11	–	–
Ulmus pinato-ramosa	10	–	–
Juglans regia	176	–	12.0
Juglans nigra	53	2.9	–
Castanea sativa	41	–	–
7. Urals			
Betula pendula	104	61.5	–
Tilia cordata	130	108.5	–
8. West Siberia			
Betula pendula	88	1.5	1.0
9. East Siberia	0	0	0
10. Far East	0	0	0
11. Northwest			
Acer platanoides	–	–	2.2
Acer negundo	–	–	2.0
Ulmus glabra	–	–	4.0
Betula carelica	–	–	8.0
12. Kaliningrad Region			
Fraxinus excelsior	10	–	–
Alnus glutinosa	5	–	–

Sycamore is an excellent species for parks and amenity forests of big groups, making background for lesser groups and solitary trees with more light or bright-orange (in autumn) leaves. It looks well in alleys in gardens and parks, in row street, boulevard and road stands too, has many forms with different colour of leaves. In Russia the following forms are known:

- *Acer pseudoplatanus* f. *variegatum* – leaves are dense covered with white spots and points of different sizes, in the spring leaves are yellow-pink
- *A. psp.* f. *flavo-variegatum* – leaves are with yellow spots

- *A. psp.* f. *Worleei* – leaves are deep-dissected, light-cupidate, by development deep-orange, later gold-yellow, in shade more greening
- *A. psp.* f. *Leopoldii* – leaves are by development intense-pink from dense spots of different sizes, later becoming white, as in *A. psp.* f. *variegatum*
- *A. psp.* f. *purpureum* –it has purple from below leaves
- *A. psp.* f. *euchlorum* – leaves are from above brightly-green, and from below whitish
- *A. psp.* f. *erythrocarpum* – fruits are coral-red.

For *Tilia cordata*, growing in different forest zones, individual variability and isolation of ecological forms are frequent. In Russia the principal forms are:

- *Tilia cordata* f. *ovalifolia* – differing from the usual *T. cordata* by the more or less oblong leaves, sidelong-cut by the base, rounded or even slightly wedge-shaped, as a rule smaller than in the typical form
- *T. c.* f. *pendula* – differing by pendent branches
- *T. c.* f. *aureovariegata* – it has golden-variegated leaves of very different forms
- *T. c.* f. *vulgaris* – it is, probably, the hybrid of *T. cordata* x *T. platyphyllos*, raised artificially, occupies intermediate status between these species; leaves are from below with brownish and whitish furrows of straight hairs in corners of veins, the plates are gentle-haired, with the faint ribs or without them.

The mentioned forms of maple and lime are broadly used in amenity forestry in cities, and these plantings can be seen as a kind of saving the intraspecific diversity *ex situ*.

Development of activities for studying genotypic variation of Noble Hardwoods, broadening the scale of gene conservation measures and their long-term maintenance can be fulfilled only by the establishment of respective federal programmes.

Problems and research priorities

The prospects for the development of work aimed at gene conservation in Russian Federation's forests will involve the question of financial support and coordination at the federal level: one needs a national, well-supported development programme. Unfortunately, all efforts of the Russian scientists along this line have gone unrewarded. One of the most urgent tasks is the creation of a computer-aided database on the units of gene conservation in the Russian forests. Another problem of no less importance is the organization of systematic research into the genetic structure of principal tree species in Russia by application of modern methods of biochemical genetics. Without having comprehensive information of the genetic structures and creating an up-to-date database on the units available for gene conservation, it is hardly possible to develop scientific and practical aspects of further work.

The participation of Russia in international cooperative programmes is of particular importance for solving those problems. Some approaches have now been found for the methodological and even financial problems related to the creation of a database on the units of genepool conservation in the Russian forests, the coordination of activities has been promoted also among the former USSR countries, and the scientists from Russian research institutes have obtained access to the information on how similar work is organized and what methods are applied in other European countries and in the rest of world.

Conclusions

The work on gene conservation in Russia needs further development, more dynamic approaches, coordination and financial support. Complicated economic situation in forestry relegates the problem of gene conservation to the background. There are not more than 10 highly skilled scientists in Russia who can handle this problem. Without any specialists and funds available, some regional research institutions have curtailed the efforts. Many of the formerly established units of *ex situ* conservation may be lost because proper tending and protection practices were ceased. The lack of any economic incentives is also a problem.

On the one hand, the huge efforts of Russián scientists are essential in working out a clear governmental commitment to solving the problems of forest gene conservation in general, and hardwood species in particular. On the other hand, it is necessary to increase the pressure of the international community on those authorities which are responsible for the development and implementation of such a commitment. Of no minor importance would be also direct financial backing of the most urgent lines of work aimed at conservation of a very rich genepool of Russian forests.

Conservation of Noble Hardwood genetic resources in Sweden

Lennart Ackzell[1] *and Gösta Eriksson*[2]
[1] National Board of Forestry, 551 83 Jönköping, Sweden
[2] Department of Forest Genetics, SLU, 750 07 Uppsala, Sweden

Introduction

There are many types of genetic resources populations, from cryopreserved tissue cultures to large *in situ* forest gene conservation stands comprising a few hundred hectares, all with their specific merits. A scrutiny of the merits of different units was carried out by Varela and Eriksson (1995). As regards the Noble Hardwood species there is no intensive breeding programme in Sweden. Owing to their comparatively low economic importance, the gene conservation programme has to rely on low-cost measures like approved seed stands, existing seed orchards and genetic field trials. Before a detailed description is given, a brief presentation of Noble Hardwoods distribution, forest policy, and the Swedish programme on forest genetic resources is presented.

Occurrence and distribution of broadleaved tree species in Sweden

Sweden is situated at the northern fringe of the distribution area of Noble Hardwoods. Their northern limit of distribution constitutes the border line between the boreal zone (>latitude 60°N) and the more southern nemoral or hemiboreal zone. Interesting relict stands or groups of trees are found as north as 65°N latitude (*Ulmus* spp.). Other interesting populations on the borderline of the species distribution with an endemic character are the populations found on the major islands in the Baltic sea.

According to the National Inventory the broadleaved species are dominated by *Betula*, with 262 million m^3 standing volume, followed by *Populus* 34, *Quercus* 24 and *Fagus* 17 million m^3. The sum of the other broadleaved species, among which the Noble Hardwoods, according to EUFORGEN's definition, dominate is 56 million m^3 standing volume.

Forest policy

Since the early 1980s the National Board of Forestry has the responsibility for forest gene conservation in Sweden. According to the resolutions from the Ministerial Conference in Helsinki, in 1993, long-distance transfer of forest reproductive material should be avoided. The National Board of Forestry has performed an investigation about the availability of forest reproductive material for broadleaved species within Sweden. Because of our climatic conditions, seed crops from domestic sources are frequently outcompeted by less expensive seeds from warmer regions. This has a great impact on the seed material used in reforestation. Our objective is to inform landowners about proper silvicultural measures in seed stands and seed orchards, and to facilitate the availability of the needed amount of well-adapted, tested seed material on the market. This aspect of gene conservation is particularly interesting for rare species with populations unevenly distributed, as is the case for some of the Noble Hardwoods species.

Swedish Forest Tree Gene Resource Programme

Since the early 1980s the Programme has carried out activities mainly on *Picea abies* and *Pinus sylvestris*. During the 1990s, work with broadleaved species was initiated. For *Quercus*, which in the Swedish forestry is considered a Noble Hardwood species, six plantations with more than 20 000 seedlings from 513 open-pollinated families of autochthonous origin were established (*ex situ*).

The gene conservation programme for Noble Hardwoods

With regard to species included in the Network's definition as Noble Hardwoods, we are participating in the EU project on *Ulmus* conservation with Eric Collin (CEMAGREF, France) as project coordinator. The task for the Swedish partner in this project is to collect and regenerate material from approximately 10 populations including relict populations from latitudes between 64° and 65°N. The material will then be allocated to several clonal archives.

For seed and plant trade purposes, selected stands have been approved (Table 1). Each seed stand must have at least 100 trees able to participate in the matings within the stand. These stands constitute the genetic resources used for artificial forest regeneration and are part of the overall gene conservation programme. Some of them might be included in a European network consisting of multiple populations according to the suggestions by Namkoong (1984), if such a network is established.

Table 1. Selected seed stands of Noble Hardwood species

Species	Number of selected stands
Acer platanoides	6
Acer pseudoplatanus	9
Alnus glutinosa	47
Alnus incana	3
Carpinus betulus	7
Fraxinus excelsior	33
Prunus avium	2
Tilia cordata	20
Ulmus glabra	9
Ulmus laevis	2

A few approved seed orchards exist for Noble Hardwood species (Table 2). Normally these seed orchards contain 100 selected plus trees each and the clones are represented by 20-60 grafts. All orchards are located in the southernmost province of Sweden. The Forestry Research Institute of Sweden (SkogForsk) is responsible for these activities.

Table 2. Approved seed orchards of Noble Hardwood species

Species	Number of seed orchards
Acer platanoides	1
Alnus glutinosa	2
Fraxinus excelsior	2
Prunus avium	1
Tilia cordata	2

The Department of Forest Genetics, Swedish University of Agricultural Sciences (SLU), has established two progeny trials (between 56° and 59°N latitudes) with several populations of both *F. excelsior* and *P. avium*. Each population is represented by up to 30 open-pollinated progenies.

Another indirect measure of gene conservation is to withdraw forest management from certain areas. Nature reserves or national parks are examples of this. In the three southern provinces of Sweden, 55% of the protected areas (5500 ha) are Noble Hardwood forests (however, including *Quercus* and *Fagus* as per the Swedish definition) and in the rest of the hemiboreal zone 11% of a total area of 44 500 ha.

References

Namkoong, G. 1984. Strategies for gene conservation in forest tree breeding. P. 79–89 in Plant Gene Resources: a Global Imperative. AAAS Selected Symp. 87. Eds C.W. Yeatman, D. Kafton, and G. Wilkes. Westview Press, Boulder, CO.

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

European gene conservation strategy for Noble Hardwoods in the long term

Further to the main goal of the Network, agreed as being the "identification of minimum gene conservation activities from a European perspective in the long term", it was decided at the first meeting to develop a joint gene conservation strategy. It was agreed to structure the strategy according to genera and groups of species as follows (see Report of the last Network meeting and updated Workplan in this volume):

- *Acer: Acer platanoides* and *Acer pseudoplatanus*
- *Ulmus* spp.
- *Sorbus* spp.
- rare wild fruit trees: *Prunus avium, Malus sylvestris* and *Pyrus pyraster*
- *Fraxinus* spp.
- *Castanea sativa* and *Juglans regia*
- *Alnus* spp.
- *Tilia* spp.

The first four strategies, developed by members of the Network and endorsed at the Network meeting, are provided below. The remaining four strategies will be presented and discussed during the third Network meeting.

The strategies aim at providing guidance to Network members and stimulate activities at a national level. They will also serve as a basis for developing concise, practically oriented recommendations ('technical guidelines') for gene conservation of Noble Hardwoods. The strategies, concentrating on the various Noble Hardwoods genera and groups of species, illustrate that different options and approaches are possible.

Some species are rare under almost all conditions whereas others are rare close to the margin of their distribution area. This means that gene conservation to be applied for a species in its marginal areas may be different from the methods in the areas in which it is common. Therefore, general principles for gene conservation, with population size as a critical starting point, will be elaborated and included in the guidelines.

For forest managers who implement gene conservation at a practical level it will be useful to obtain some basic knowledge in evolutionary genetics. The technical guidelines for gene conservation of European Noble Hardwoods to be produced by the Network will also be complemented with a chapter providing such basic overview of forest genetic concepts.

Both Norway maple and sycamore flower regularly in their central distribution area, and even in the margin the seed production is not a limiting factor. Often the seed production is abundant and germination is good. There is wide variation in both the morphology and function of flowers in the genus *Acer*. The proportion of insect- and wind-pollination is difficult to estimate and probably varies according to the external conditions. The role of self-pollination is not known, but isolated trees have been known to produce seed, which suggests at least partial self-fertility (de Jong 1976).

It is necessary that knowledge on the genetic variation, in both neutral and adaptive characters of insect-pollinated species like maples, be widened by further research at the European level.

Suggested gene conservation methods

In order to preserve sufficient genetic variability to maintain the adaptive potential of Norway maple and sycamore in Europe it is necessary:

1. To conserve and enhance variability in small local populations

In situ gene conservation stands should be selected throughout the distribution area. This could be linked to seed stands as many countries have already chosen to do. The structure of the *in situ* network of gene conservation stands would be based on the following guidelines.

- The essential *in situ* network of populations is situated in the natural distribution area.
- In order to cover the variability of adaptive characters, the network should be structured according to climatic variation.
- The network should consist of at least 20 stands to ensure sufficient coverage. The absolute minimum number of regularly flowering and seed-producing trees in a gene conservation stand should be 20 trees.
- Marginal areas of the natural distribution area must be covered. Another option would be to limit the network in the centre of the distribution area, assuming that most of the variability can be found within the centre. However, since the data to support this assumption seem to be inadequate, a safer strategy would be to include the margins in the network.
- In many cases it is not reasonable to aim at pure stands; the efforts should be combined for including several species.

The *in situ* network could be complemented with *ex situ* collections, which would be designed to serve provenance research at the same time. The material would include the whole geographic variation of the species and it would be planted throughout the distribution area. Since not all of the material would have good prospects in all places, the collections would finally serve conservation of only part of the originally planted material. A disadvantage would be that these populations could not be used for seed production because the variation in the next generation might be too wide and unpredictable.

Local *ex situ* collections can be established to serve both conservation and seed production. They should be designed to enhance variability within a region of provenance and to avoid inbreeding. Thus they would improve the genetic quality of the seed material. In some special cases the variability of a natural stand may need to be enhanced with controlled seed transfers.

2. To ensure that afforestation material is used in a proper way and that the regeneration methods, as well as used seed sources, are well documented

The trade with maple seed as well as other Noble Hardwoods reproductive material is generally under weak control compared with more important forest species. In addition, maples are regularly used for non-forestry purposes like horticulture and landscaping, where the tradition for controlling and documenting seed sources is recent or non-existent. The present EU directive does not cover maple species and in many countries the national legislation is limited to the principal species.

It is essential that maples moving in trade be properly documented and that the users are guided to select suitable material according to their conditions. Any long-distance transfers should not be encouraged unless they are based on knowledge from long-term provenance trials. At the moment this knowledge is generally not available. Seed transfers are usually not necessary since in most cases the seed crops are regular and abundant.

3. To protect the species in areas where the whole species is threatened

Although Norway maple and sycamore are generally not endangered as such on the European level, some countries have indicated that heavy forest utilization and management practices threaten these species and that they should be protected by appropriate measures.

Conclusions

Maples have several biological and cultural features which make their populations rather vulnerable to threats. However, it seems clear that neither Norway maple nor sycamore has high priority in the conservation programmes of most European countries. As resources are limited, it is probably wise to ensure a minimum conservation level through actions which do not demand high economic inputs or which can be integrated to the conservation of other species. The main approach will be to establish a network of a minimum of 20 *in situ* gene conservation stands. In addition, local *ex situ* collections may be combined with seed production and a few collections can be established to serve provenance research. The use of maples as forestry species should be promoted and special actions to be taken to ensure wise use of certified reproductive material.

References

de Jong, P.C. 1976. Flowering and sex expression in *Acer* L. A biosystematic study. Mededelingen landbouwhogeschool Wageningen 76-2, 201 p.

Hamrick, J.L., M.J.W. Godt and S. Sherman-Broyles. 1992. New Forests 6:95-124. Kluwer Academic Publishers, The Netherlands.

Håbjørg, A. 1972. Effects of photoperiod and temperature on growth and development of tree latitudinal and tree altitudinal populations of *Betula pubescens* Ehrh. Institute of Dendrology and Nursery Management, Agric. College of Norway, Report No. 44.

Koski, V. and R. Sievänen. 1985. Timing of growth cesseation in relation to the variations in the growing season. Pp. 167-193 *in* Crop Physiology of Forst Trees (P.M.A. Tigerstedt, P. Puttonen and V. Koski, eds.). University of Helsinki.

Kriebel, H.B. and C.-W. Wang. 1962. The interaction between provenance and degree of chilling in bud-break of sugar maple. Silvae Genet. 11:125-130.

Perry, D.J. and P. Knowles. 1989. Allozyme variation in sugar maple at the northern limit of its range in Ontario, Canada. Can. J. For. Res. 19:509-514.

Rusanen, M., A. Mattila and P. Vakkari. 1996. Jalojen lehtipuiden geneettinen monimuotoisuus-säilyatä ja käytä. Metsäntutkimuslaitoksen tiedonantoja 605, pp. 45-52.

Turok, J., G. Eriksson, J. Kleinschmit and S. Canger (compilers). 1996. Noble Hardwoods Network. Report of the first meeting, 24-27 March 1996, Escherode, Germany. IPGRI, Rome, Italy. 172 p.

Westergaard, L. and N.E. Eriksen. 1997. Autumn temperature affects the induction of dormancy in first-year seedlings of *Acer platanoides* L. Scand. J. For. Res. 12:11-16.

Elm (*Ulmus* spp.)

Eric Collin
CEMAGREF, 45290 Nogent sur Vernisson, France

The need for a pragmatic 'step by step' strategy

Before defining a long-term gene conservation strategy, it is necessary to take into account the following factors and particular features of *Ulmus* species and their populations:

- the drastic decrease in elm populations, mainly due to Dutch elm disease (DED) and to the disappearance of characteristic riparian ecosystems
- the taxonomic complexity within the genus, especially within *U. minor* (Mill.) *sensu lato*
- the different population types and regeneration modes of the species concerned (*U. minor* is a scattered species with excellent capability to form rootsuckers, whereas *U. glabra* can be found in large stands and reproduces sexually; the former can be propagated by cuttings and preserved in clonal, 'hedge' banks, whereas the latter is more easily conserved *in situ* or grafted for the establishment of seed orchards. It seems that *U. laevis* is well adapted to the different types of conservation).

Current situation in the gene conservation of elm species in European countries:

- altogether 9 European Union (EU) member countries participate in a 5-year (1997-2001), EU-funded project for the 'Conservation, characterization, collection and utilization of genetic resources of European elms'
- many other countries are currently taking measures to preserve elms *in situ* and/or *ex situ*, and opportunities exist for central and eastern European countries to apply for EU grants in the framework of an extension programme to the above mentioned EU project.

This very brief characterization indicates that we should not launch a 'monolithic' European programme but coordinate a 'step by step' approach, adapted to the research and conservation opportunities in each country and to the extent of threats to the local genetic resources of elms. Moreover, the results obtained by research conducted in some countries should be transferred to others in the short term.

Preliminary steps (1997-99)

In the framework of EUFORGEN

1. Evaluation of the present range of elm species and identification of most endangered resources

A questionnaire should be sent to the researchers specialized in elm studies through EUFORGEN participants and Network members. This would allow us to acquire a better knowledge of the present situation of indigenous elm species in different parts of Europe and to identify the most endangered resources. When necessary, emergency preservation measures should be discussed in the Network and practical recommendations should be proposed.

2. Emergency preservation measures which might include:

- protection of habitat (e.g. population of a major riparian species *Ulmus laevis* directly threatened in their existence by deforestation)
- *in situ* conservation (e.g. facilitating and monitoring the natural regeneration of *Ulmus glabra* in a mountain forest where all large elm trees are dying, or will be felled)

- *ex situ* conservation (e.g. collection of germplasm in a major population before the area is deforested).

3. Inventory of *in situ* conservation stands (database)
Several countries have already started selecting *in situ* conservation stands. A database and a map are necessary to give an overall view of the number and location of such stands.

In the framework of the EU project
4. Inventory of *ex situ* clone collections (database)
All clones in the collections held by partner institutes should be recorded in a database with common standards for passport data (e.g. accession number, location of collection site, latitude, longitude, altitude, population type, environment type, diameter class of the original tree).

5. Acquisition of material from the margins of the distribution area (within the EU)
About 300 new clones should be acquired and most of them should originate from the margins of the elm distribution area in the member states of the European Union (e.g. Sweden, Greece, Portugal, southern Italy).

6. Evaluation of natural genetic variability with molecular markers
By the end of 1999, a sample of over 700 clones should have been characterized with molecular markers (cpDNA and microsatellites), and the geographic structure of genetic diversity assessed.

7. Evaluation of tolerance to DED (susceptibility to the pathogen and attractiveness for the vector)
A sample of about 300 clones whose original trees are assumed not to have died from natural infection will be screened for their susceptibility to *Ophiostoma novo-ulmi* in inoculation tests. Besides this, about 24 clones will be evaluated for their attractiveness to *Scolytus* spp. Two experimental designs will be used: (1) a net tent covering the experimental plot where captive *Scolytus* will fly and feed on young elms in large pots; and (2) a 2-way air box allowing the captive *Scolytus* to choose between the scent of two clones, produced by twigs and leaves placed in the ventilation system.

Suggestion for research without known international framework or available funding
8. Study of the mating system in natural stands
Based on the application of molecular markers, such study would be crucial for the definition of efficient *in situ* management rules. Most trees of a population and a sample of their progenies (e.g. 30 seedlings per tree) need to be analyzed. This kind of study could be applied to several populations of both *U. glabra* and *U. laevis*.

Implementation of clonal conservation strategies (1998-2002)

In the framework of the EU project
9. Definition of a core collection representative of the elm resources in the EU
A core collection composed of over 800 clones (one half being *Ulmus minor*, and the rest *U. glabra* and *U. laevis*) will be conserved in the long term.

The selection of the material will be based on different criteria such as:

- clones representative of taxonomic units (species, subspecies, microspecies)
- provenances representing a wide range of habitats

- provenances recognized of particular interest in studies carried out on the phylogenetics of elms and the partitioning of genetic diversity
- clones representative of the polymorphism revealed by molecular markers
- clones showing valuable phenotypic traits
- different natural and artificial hybrids.

Conservation methods will associate cryopreservation of buds and plantation of sustainable field clonal banks.

10. Maintenance of the core collection in field clonal banks
As the pathological pressure is still strong throughout Europe, the best solution is to have the whole collection spread in several field clonal banks, with duplicates stored in at least two different field clonal banks. Duplication of the clones will be achieved through cuttings or grafting. Each partner will be in charge of the conservation of a part of this core collection: his own material and some other, exchanged with partners. The field clonal banks will be maintained as low hedges, which has proven to be an efficient method to protect them from the *Scolytus* vector and subsequent contamination by DED. All clonal banks should be planted by 2001.

11. Cryopreservation of part of the collection (450 clones)
Cryopreservation of dormant buds sent by partners will be carried out in two different sites (France and Germany) between 1998 and 2000. Collaboration between the two teams will result in exchange of cryopreserved buds, so that the complete 450 subsample will be held in both places.

12. Establishment of a long-term plan for the conservation of elm genetic resources in Europe
At the end of the EU-funded project in 2001, conclusions will be drawn and perspectives will be discussed in collaboration with EUFORGEN Network.

Suggestions for additional research (with possible EU-funding)
Opportunities exist for central and eastern European (CEE) countries to apply for EU-funding in the framework of an extension of the existing elm project. Such an application could take place in 1998 or 1999, in close collaboration with the coordinator of the currently ongoing EU project.

The following steps would follow the same procedures as those described above.

13. Inventory of *ex situ* clone collections in CEE (database)
14. Evaluation of natural variability in CEE with molecular markers
15. Definition of a core collection representative of the elm resources in CEE
16. Conservation of the core collection in field clonal banks
17. Cryopreservation of part of the collection (in the EU and in CEE).

Implementation of dynamic conservation strategies (1998-2002)

In the framework of the EU project
18. Extensive use of the elm clones selected in the EU collection
The screening of existing collections for low susceptibility to DED and good landscaping traits will provide native material for prudent reconstitution of countryside elm landscapes. Such clones could be used, mixed with other tree species, for amenity planting and afforestation. At the same time, this would contribute to the preservation of the adaptive potential of elms.

In the framework of EUFORGEN

19. Guidelines for elm stand management and *in situ* conservation in Europe

Silvicultural practices have major consequences on genetic conservation, both from quantitative (success of regeneration) and qualitative (genetic diversity) points of view. Guidelines for elm stands management should be based on silvicultural observations and the genetic studies mentioned under **8.**

20. Guidelines for the management of elm seed orchards

Unlike the above-mentioned gene conservation measures (clonal *ex situ* conservation and *in situ* stand management), elm seed orchards can provide many possibilities for truly dynamic genetic conservation and the realization of crossings. Such possibilities should be discussed in relation to the main goal of the Noble Hardwoods Network being promotion and creation of good conditions for future evolution.

Suggestions for additional research

21. Linking of conservation strategies with breeding and genetic transformation strategies

Several countries are currently working on elm genetic transformation research programmes. It would be interesting to discuss the theoretical aspects and possible practical links between conservation, breeding and genetic transformation.

Mountain ash (*Sorbus* spp.)

Brigitte Demesure
Conservatoire Génétique des Arbres Forestiers ONF, Centre INRA, 45160 Ardon, France

Introduction and objectives of gene conservation

The genetic resources present in the thousands of useful tree species on the earth constitute an intergenerational resource of vast social, economic and environmental importance. Most of the forest species are characterized by extensive natural range and high levels of diversity. This high genetic variation at the level of individual trees, within and among the populations, enables adaptation to the environmental conditions they face during the very long life cycle of forest trees and forest stands. Nevertheless, many tree species are considered to be threatened because of global climate change, pollution, reduction of the forest and uncontrolled seed transfer, and require the intensification of joint efforts for genetic conservation. These efforts must be based on a better knowledge of the diversity and the genetic structure of the species. This strategy emphasizes the preservation of genetic variation and hence evolutionary adaptability of populations to a changing environment over generations, as the main goal of gene conservation. The preservation of genetic variation is also crucial for its effective use for human needs in the future. From a more practical point of view, the conservation of forest genetic resources must be taken into consideration not only for timber and other forest products, but also for a whole range of values provided by forest ecosystems, including the ecological and social benefits not limited by national boundaries.

The genus *Sorbus* complex (*Sorbus torminalis, Sorbus aria, Sorbus aucuparia* and *Sorbus domestica*) belongs to the Rosaceae family. This indigenous genus exists in Europe from temperate to boreal countries and from mountain to plains. These widespread species typically grow in mixed hardwood forests. They are characteristic of ancient and undisturbed lowland. Despite their weak competitive ability they are mostly to be found in extreme sites where their competitors do not survive. Most of the *Sorbus* species are interfertile, even sometimes with related species of *Malus* and *Pyrus*. In most countries represented in the Noble Hardwoods Network, *S. torminalis* and *S. aria* are not considered to be really threatened as species, but sometimes as populations. On the contrary, *S. domestica* is considered under threat by most of the countries. The countries in which *Sorbus* species are considered to be threatened are shown in Table 1C.

The main causes contributing to the endangerment of *Sorbus* are:

- extensive cutting for commercial purposes
- narrow genetic base for small effective population sizes
- lack of natural regeneration
- competition with other species
- inadequate silvicultural management
- uncontrolled seed transfer.

Some countries have already developed gene conservation programmes on *Sorbus*, but most have only just started.

Forestry

Sorbus species flower regularly everywhere in their distribution area and seed production is not a limiting factor. Although seed production is often abundant, germination and regeneration are frequently low, especially for *S. domestica*. For the time being, it seems that the species are only insect-pollinated. New studies on *S. aucuparia* seem to show that self-pollination is not possible (O. Raspe, pers.

comm.). Nevertheless, partial self-pollination for isolated individuals cannot be excluded.

For *Sorbus*, vegetative regeneration is important. Moreover, these species are very sensitive to competition; pure stands are non-existent. Isolated trees or small patches are most common.

Because of the high economic value of timber and especially for *S. torminalis*, the increasing demand on the market, uncontrolled seed production and uncontrolled seed transfer takes place. Indeed an early exploitation of stands before their regeneration may promote plantation with uncontrolled material. Seed transfers occur among provenances and countries. For these species the demand for afforestation material is higher than the supply. The seed transfers may pose a threat to local populations because of introgression with other populations which can be genetically very different. The other species less intensively used for wood production are in the same situation, for example *S. aucuparia* used for landscaping. Important seed transfer occurs across Europe for ornamental plantations.

Genetic structures

For a realistic programme of gene conservation, one of the key issues is to gain better knowledge of the genetic variability of *Sorbus*. Very little is known about these species. Some countries are starting to undertake research on this topic (Table 1D). The first results of genetic analyses indicate that *S. torminalis* has relatively high population differentiation compared with other disseminated species and especially *Prunus avium*. But the geographical structure seems to be very weak (Prat and Daniel 1993). New studies must be carried out with more populations all over the range and with more markers including adaptive traits which are an important component of the diversity. Moreover, these characters are often strongly linked with genetic structure. The characterization of all aspects of diversity is necessary for an efficient strategy or a policy of gene conservation.

Future activities

1. To preserve sufficient genetic variability to maintain the adaptive potential of *Sorbus*, it is necessary to:
   - identify and protect very small autochthonous populations[2] under threat because of their small effective size
   - protect and conserve the genetic variability of autochthonous populations.

2. *In situ* conservation
   In situ methods, the main component of gene conservation, maintain the genepool of natural populations and species over many generations. *In situ* conservation, where evolutionary forces in populations are very close to natural conditions, is appropriate for saving populations and maintaining their genetic adaptability within individual species. The following guidelines can be given:
   - network of gene conservation stands must be sufficient to cover spatial variation of the species
   - effective population size must be maintained for a good system of regeneration
   - the regeneration stock must originate from matings within each population
   - if artificial regeneration is necessary, seeds must come from the same stand or neighbouring stands in the same area
   - adequate forest management must be promoted.

---

[2] Population: viewed as at least 20 individual trees, more than 50 m apart from each other and distributed over an area not exceeding 15-20 ha.

3. *Ex situ* conservation
   Ex situ methods aim at maintaining the material from endangered stands (destruction by natural or anthropic effects, or lack of regeneration) with no influence of evolutionary forces on the collections. This is the case with clone collections or seed banks. The main aim for *ex situ* conservation will thus be to maintain or enhance the existing genetic structures (and thus the existing adaptability). *Ex situ* conservation can also be used to develop breeding programmes for high-quality wood.

   Ex situ conservation is complementary to *in situ* methods and is especially important when the conditions for *in situ* conservation cannot be applied. Indeed it can be recommended for:
   - Endangered populations: within the distribution range of *Sorbus* the further existence of small populations under threat, and especially when the efficient size of the populations is too low. The populations can be easily maintained by planting or grafting.
   - Establishment of clone collections: the material must come from the whole range and must be planted in different areas. The different species of *Sorbus* must be conserved separately in order to avoid hybridization. The collection can serve for static conservation and also for seed production; for its establishment it would be recommended to:
     - sample with respect to genetic variation within and between the stands
     - sample at least 10 stands within each region of provenance
     - collect seeds in a year of abundant seed crop and from 20-30 trees well distributed in the population and 30-50 m apart
   - Establishment of seed banks: Gene conservation can be achieved through the storage of bulked seed lots with precise identification of sampled individuals in a region of provenance. An adapted procedure of seed drying methods can be used. Temperature above zero (2-4°C) can be recommended for short-term storage. Another purpose for seed storage can be to ensure good supply of afforestation material. For the time being, only the principal forestry species benefit from national and international rules on seed transfer. No long distance transfers should be encouraged.

The conservation strategy for the genus *Sorbus* can not be considered as a whole and has to differentiate among the needs of individual species. It seems that *S. domestica* is more endangered than the other species, few populations remain and the recommendations for this species are more focused on *ex situ* conservation than *in situ*. On the contrary, S. *torminalis* and S. *aria* populations are not threatened and *in situ* conservation is more suitable for them.

Of course all these required activities are implemented on a voluntary basis. It is clear that Noble Hardwoods conservation is just beginning, and no programme is totally sufficient at the moment.

Reference

Prat, D. and C. Daniel. 1993. Variatilité génétique de l'alisier torminal et du genre *Sorbus*. Rev. For. Fr. XLV(3):216-228.

Wild fruit trees (*Prunus avium, Malus sylvestris* and *Pyrus pyraster*)

Jochen Kleinschmit[1] *and Richard Stephan*[2]
[1] Niedersächsische Forstliche Versuchsanstalt, Abt. Forstpflanzenzüchtung, 34355 Staufenberg - Escherode, Germany
[2] Bundesforschungsanstalt für Forst- und Holzwirtschaft, Institut für Forstgenetik, 22927 Großhansdorf, Germany

Distribution

Wild cherry (*Prunus avium* [L.] L.), wild apple (*Malus sylvestris* [L.] Mill.), and wild pear (*Pyrus pyraster* [L.] Burgsd.) belong to the plant family Rosaceae. These insect-pollinated species are autochthonous in nearly all European countries, but with a very scattered occurrence. They are generally rare species in mixed hardwood forests. *Prunus avium* still exists in natural populations of limited size, e.g. in France, Italy and Germany, although most of the trees occur as single individuals or in small groups. Owing to their weak competitive ability, *M. sylvestris* and *P. pyraster* exist mostly at the edge of forests, in hedges on farmland or on very extreme sites where the stronger competitors do not survive either. Even there they occur only as single individuals or very few trees in small groups.

All three wild fruit tree species are native to central, western and southern Europe. *Pyrus pyraster* does not occur naturally only in the north European countries. *Malus sylvestris* and *P. avium* were introduced into new areas where they can be grown. Nevertheless, the knowledge about autochthonous origin is often insufficient. Therefore, it is necessary to prepare a survey of the natural range in Europe and to improve the information about the occurrence of autochthonous stands, groups or individual trees of the pure species not contaminated by domesticated cultivars or originating from those. This should be done in close cooperation between research institutions. The results of such surveys can be shown in maps as, for example, the occurrence of *M. sylvestris* (Fig. 1) or of *P. pyraster* (Fig. 2) in northern Germany. Each occurrence was registered by its geographical data and additional information was assessed.

In comparison with other tree species, one can also assume that these tree species migrated into southern refugia during the different glacial periods, e.g. into areas south of the Alps. There are also several closely related species, e.g. *Pyrus nivalis* in southeastern Europe or *Pyrus amygdaliformis*, which occurs only in southern Europe (e.g. Malta and Slovenia). *Malus sylvestris* has a great intraspecific variability where several varieties can be differentiated. The intraspecific variability should be maintained by suitable conservation methods.

Forestry

The three minor Noble Hardwood species are important from an ecological as well as from an economical point of view. They are growing in mixed hardwood forests, often at the margins of forest stands due to competition for light. In mixed hardwood stands with beech as a major component thinning usually favours the minor Noble Hardwood species in order to prevent heavy competition and to reach sufficient size for an economically interesting utilization.

Prunus avium has been planted extensively in the past in many European countries. *Pyrus pyraster* and *M. sylvestris* only survived occasionally on very wet or very dry sites due to the competition with beech. Plantation of these species was very rare and only inreased in recent years slightly due to more public concern about their endangered status. However, seed from suitable sources is mostly missing due to the lack of sufficiently large breeding populations.

Both *Prunus avium* and *Pyrus pyraster* can reach considerable size and diameter of high quality stems. Their wood is highly valued on the market. These two species are also very interesting for afforestation of marginal farmland for the production of valuable timber in mean (50-70 years) rotation time.

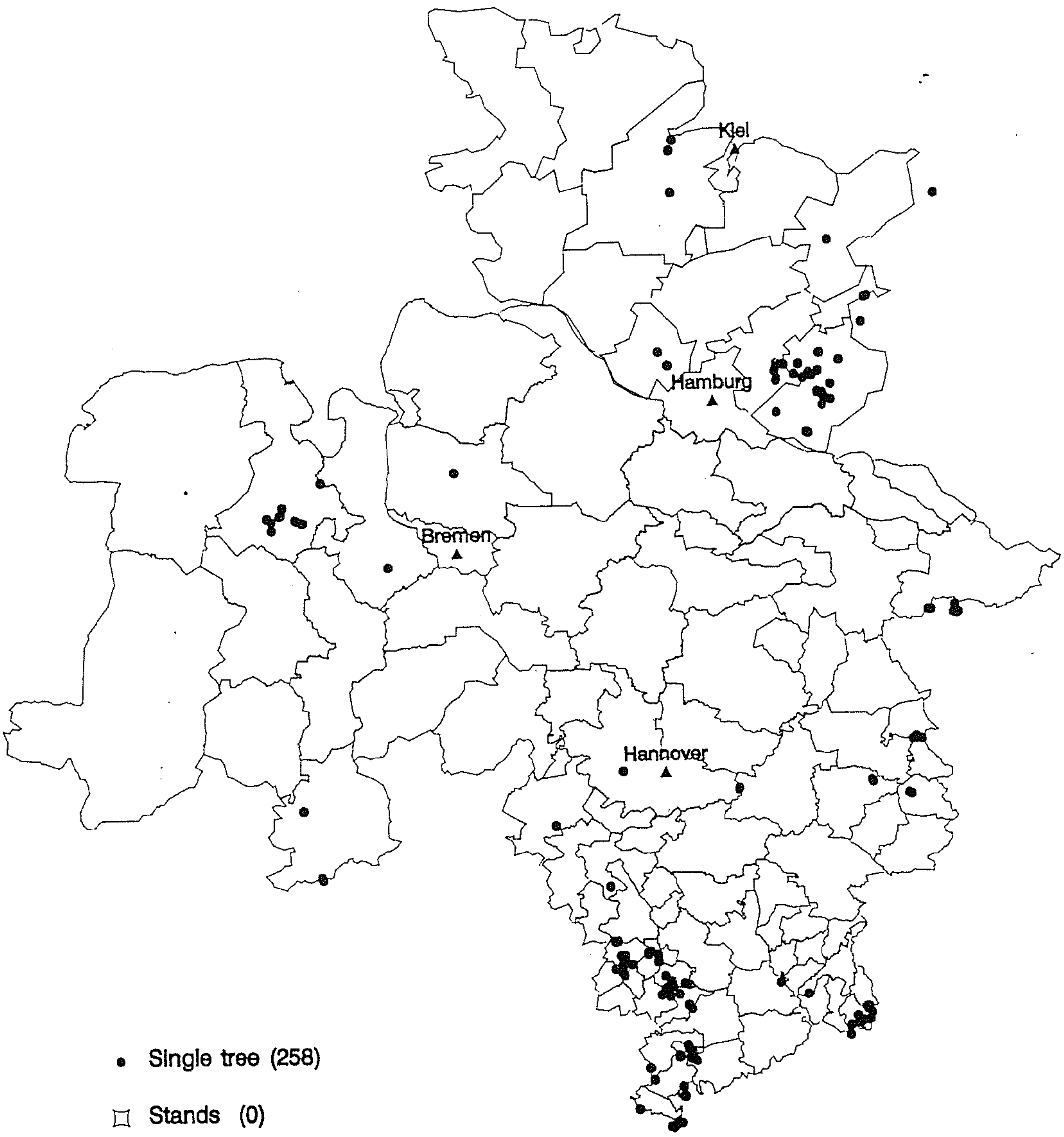


Fig. 1. Conservation of *Malus sylvestris* genetic resources in Lower Saxony and Schleswig-Holstein.

Genetic knowledge

The variability and genetic structure of *P. avium, M. sylvestris* and *P. pyraster* is not yet known in detail and should be investigated intensively. All three species show great phenotypical variation. One can assume that various ecological types can be distinguished due to the large natural distribution area, and the fact that populations or individual trees of the same species are growing under different environmental conditions, e.g. on calcareous or siliceous soils.

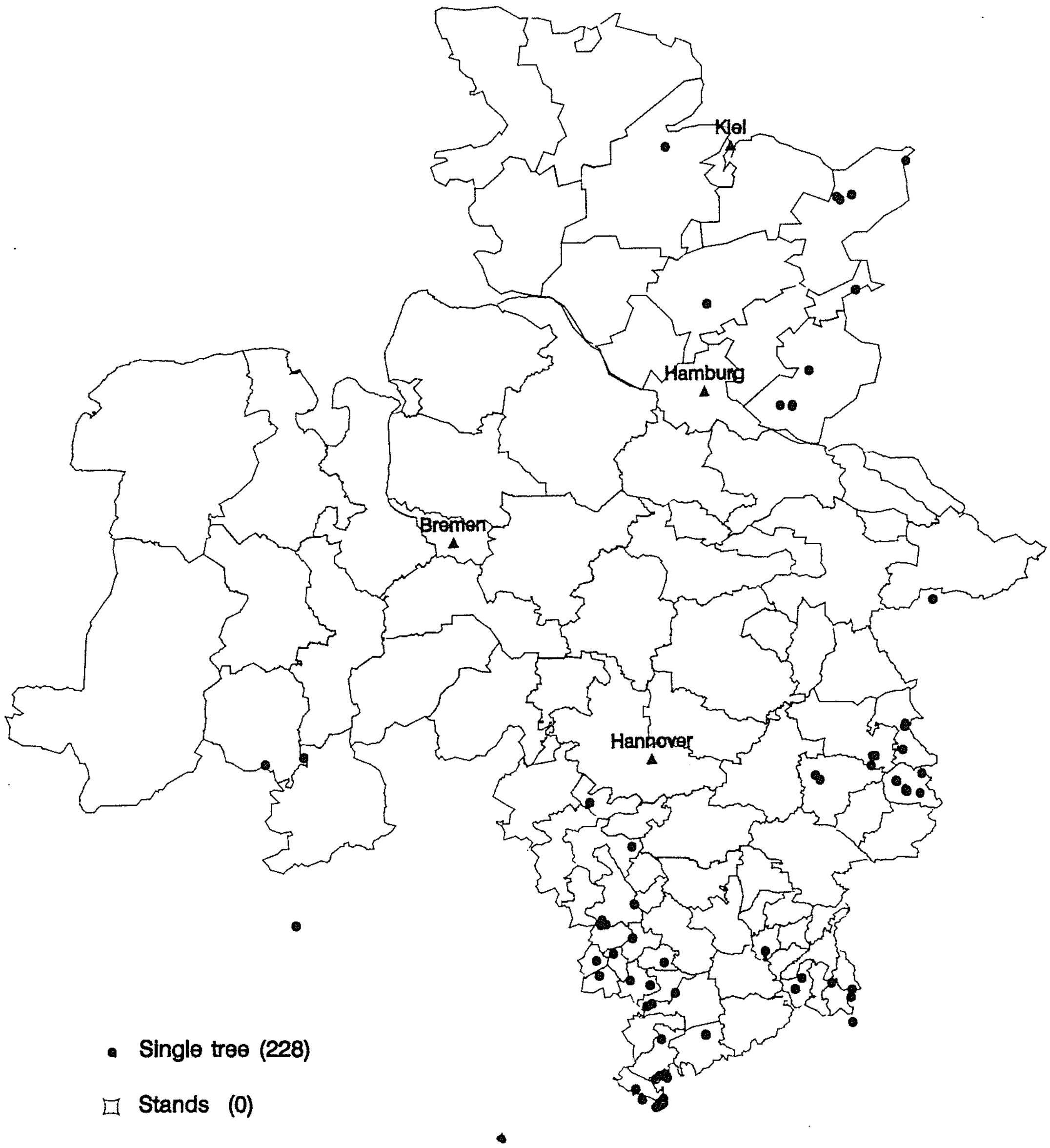


Fig. 2. Conservation of *Pyrus pyraster* genetic resources in Lower Saxony and Schleswig-Holstein.

Rangewide provenance experiments on *P. avium* do not yet exist. Only regional provenance/progeny and clonal tests have been performed. They show considerable variation in morphological and phenological traits (Weiser 1996; Meier-Dinkel *et al.* 1997; Santi, pers. comm.; Kleinschmit, unpublished). Santi and Lemoine (1990a) studied the inheritance and linkage of isoenzyme loci and described variation in isoenzyme patterns. They use these patterns to discriminate between *Prunus cerasus* and *Prunus cerasus* x *P. avium* (Santi and Lemoine 1990b).

Studies conducted at seven isoenzyme systems in 14 Italian *P. avium* populations showed a higher intrapopulation variability in the northern areas of the natural range, where the distance between populations is low. The interpopulation variability was higher in the Tuscany region and in the central southern Apennines, where the distance between populations is large. The lowest degree of polymorphism was found in isolated populations (Ducci and Proietti 1997).

Treutter and Feucht (1985) showed differences in phenolic composition of *P. avium* clones.

For fruit juice colour and albinism, Watkin and Brown (1956) found simply inherited dominant-recessive pairs of alleles. The gametophytic incompatibility 5 locus is polymorphic with at least 6 alleles (Berger 1963).

Many of the data concerning genetic traits in fruit trees are from cultivars. It is supposed that there is no difference between the technique to separate isoenzymes from cultivated or wild fruit trees (Chevreau, pers. comm.).

Many analyses have been carried out on apple, mainly in domesticated varieties. *Malus* is a genus of the northern temperate zone with 25-35 species that are difficult to circumscribe due to lack of distinguishing traits. Reasons for taxonomic confusions may be:

- widespread crossability
- transportation by people to distant habitats
- escapes from cultivation
- introgression
- considering selections with horticultural value as species.

In the apple industry, a reliable verification of the cultivar being grown is also of great importance, particularly for nurserymen and growers. Isoenzyme analysis offers a possible method for cultivar identification which has been successfully applied to several other crops. Previous isoenzyme studies in *Malus* focused on:

- Identifying apple cultivars and rootstocks: Weeden and Lamb (1985) characterized 54 apple (*Malus domestica* Borkh.) cultivars and found out that intercultivar polymorphism at 6 isoenzyme systems was sufficient to permit reliable and unambiguous identification of nearly every cultivar
- Identifying genetic markers linked with horticultural traits: no correlation could be established between the inheritance of an isoenzyme and a resistant (apple scab, cedar-apple rust, fire blight) phenotype of the populations investigated (Weeden and Lamb 1987)
- Isoenzyme inheritance (Chevreau and Laurens 1987; Manganaris and Alston 1988)
- Extraction techniques (Korban and Bournival 1987)
- Grouping *Malus* x *domestica* accessions by using isoenzyme markers
- Using phenotypes to identify closely related forms.

Isoenzyme analyses at the species level in *Malus* are limited. Recent investigations deal with the isoenzyme diversity in North American *Malus* species (Dickson *et al.* 1991) and in wild populations of *Malus sieversii* (Ledeb.) M.J. Roem. (Lamboy *et al.* 1996).

Malus sieversii, native to Central Asia, is thought to be the primary progenitor of the cultivated apple *M. domestica* Borkh. and therefore important in apple breeding, genetics, evolution and germplasm conservation.

Until now the method has failed to distinguish *M. sylvestris, M. pumila, M. orientalis, M. asiatica* and *M. sieversii* from each other or these closely related wild species from *M. domestica* using isoenzyme polymorphisms. The level of genetic diversity is very high in all these species and is very similar to that found in the domesticated apple. So there is one hypothesis that interspecific hybridization is so rampant among these forms that they actually constitute one panmictic species. The mentioned species are perhaps not distinct, but form one large panmictic population with an extension from western China to Europe. Analyses of many more samples of the other close relatives of apple (others than *M. sieversii*), especially of *M. sylvestris*, could result in a rejection of that hypothesis as long as species-specific alleles can be identified.

Genetic analyses based on DNA markers may provide better information regarding the immediate ancestors of cultivated apple and pear. So there is a second chance to at least partially reject the hypothesis, but the experiments for using DNA markers have yet to be performed (Weeden, pers. comm.).

There is little information about pear. To work with isoenzymes in pear is much more difficult than working with apple. In Europe experiences with pear do exist at INRA Angers.

Objectives of gene conservation

The genetic resources of *P. avium, M. sylvestris* and *P. pyraster* are seriously endangered, mainly for the following reasons:

- Extensive felling for commercial purposes. Rare occurrence and a narrow genetic base cause genetic drift due to small numbers of mother trees and large distances between adult, reproducing trees.
- Natural regeneration is not guaranteed and, if it occurs, it is endangered by grazing. Hybridization with cultivated forms of cherry, apple or pear is a main obstacle. The identification of the wild fruit tree species is difficult, especially for *M. sylvestris* and *P. pyraster,* but suitable identification keys have been developed (Wagner 1995; Müller and Litschauer 1996).
- Uncontrolled seed transfer. In EU countries *P. avium, M. sylvestris* and *P. pyraster* are not included under national legislation for forest reproductive material. Therefore, seed of unknown origin (even residuals from distilleries) is used for plantations or for afforestation purposes in the landscape and along highways. Also clonal plantations are established through vegetative propagation of selected material from unknown origin.
- Several diseases, especially viral diseases, have contaminated the three wild fruit tree species and may endanger their existence in some areas.

Present and suggested gene conservation activities

Measures must be taken for the conservation of genetic resources of the three rare Noble Hardwood species. Activities concerning collection and study of the existing material is already underway in some countries. But Europe-wide activities or projects are still lacking. Regarding *P. avium, M. sylvestris* and *P. pyraster,* the following overview informs about the actual situation and possibilities of conservation measures in European countries. Most of the information was presented at the first meeting of the EUFORGEN Noble Hardwoods Network (Turok *et al.* 1996).

Prunus avium: Conservation measures of different intensity are carried out in 13 European countries (Table 2). The main activities cover *in situ* conservation of selected stands and single trees, as well as *ex situ* conservation of clones or families in seed orchards and clonal archives. Other *ex situ* conservation measures have obviously had no importance until now. In some areas the trees are contaminated by viral diseases. Nevertheless, wild cherry is used for plantations or afforestations in several countries. Forestry practice is now interested in planting wild cherry because of the high value of its timber.

Malus sylvestris and ***Pyrus pyraster***: Although wild apple and wild pear are autochthonous in several European countries, intensive conservation measures are still lacking with the exception of Germany, where for both species conservation programmes have been carried out by federal-state institutes for several years. These programmes concentrate on seed orchard establishment to restore breeding populations of sufficient size. The necessity of a Europe-wide cooperation programme for the conservation of genetic resources of these two valuable wild fruit tree species needs to be emphasized.

1. In situ *conservation*

The natural situation of the rare fruit tree species restricts the possibilities for implementing *in situ* conservation strategies. In only a few cases, e.g. *Prunus avium,* natural stands with a minimum number of 30 to 50 individual trees can still form *in situ* conservation populations. If such stands exist, they should be designated for this purpose and naturally regenerated. However, due to the high value of the timber, it will be difficult to maintain such stands in private ownership over a long time, especially since *P. avium* tends to decay from an age of 80 years onwards. Therefore, the selection of *in situ* conservation stands is probably restricted to public ownership where the necessary measures for natural regeneration can be taken. One has to take into account that *P. avium* propagates vegetatively by adventitious shoots from roots. Therefore, monoclonal stands occur.

2. Ex situ *conservation*

For all three species the establishment of *ex situ* conservation seed orchards seems to be the most suitable and efficient conservation measure. Grafting is not difficult in any of the three species. *Prunus avium* can also be propagated by tissue culture methods (Meier-Dinkel *et al.* 1997). Seed orchards can be relatively easily established. They should be regionally structured due to the ecological conditions. A minimum of 50 clones per seed orchard should be aimed at. Especially in *M. sylvestris* and *P. pyraster,* new interbreeding populations can be established when individual specimens, scattered over a large, but ecologically similar area, are collected and planted together in a seed orchard. Because regular and sufficient seed crop is hardly possible in natural populations, the establishment of seed orchards is also a necessity for ensuring seed procurement.

Seedling seed orchards seem to be less suitable owing to the danger of pollen contamination from cultivated forms within the seedlings and the risk of inbreeding when only one or few trees are left for seed harvest as a base for the seedling seed orchard. For *P. avium,* however, seedling seed orchards may be a solution in those cases where sufficiently large populations are available.

As far as possible, seeds of the three species should be stored. The methods for long-term storage need to be improved or further developed.

Outlook

Investigations about naturally occurring populations, groups or individuals of the three wild fruit tree species should be started with joint forces. Significant occurrences of the species, e.g. *P. avium,* should be protected *in situ* as gene conservation stands. Small groups or individuals should be grafted and planted in clone collections for further use. Those materials should be tested to verify whether or not they are contaminated by diseases (virus, bacteria, fungi).

Research about intraspecific variation and genetic structure by using, among others, molecular markers, as performed by Santi and Lemoine (1990a, 1990b) for *P. avium,* must be intensified in cooperation between the European countries.

The establishment of clone collections or archives and the exchange of those materials and information between the Noble Hardwood Network members will facilitate conservation and propagation of the three species. Suitable clones can be used for the establishment of seed orchards, from which one can expect genetically variable and valuable seed material for plantations. Such plantations should guarantee a type of "pseudo *in situ* conservation". The combination of gene conservation and utilization is in the long term the only viable and meaningful method of conservation, since without utilization the conservation strategy would lead to a dead end.

References

Berger, K. 1963. Fertilitätsuntersuchungen an der Wildkirsche *Prunus avium* L. var. *avium*. Kulturpflanze 11:358-375.

Chevreau, E. and F. Laurens. 1987. The pattern of inheritance in apple (*Malus x domestica* Borkh.): Further results from leaf isozyme analysis. Theor. Appl. Genet. 75: 90-95.

Dickson, E.E., S. Kresovich and N.F. Weeden. 1991. Isozymes in North American *Malus* (*Rosaceae*): Hybridization and species differentiation. Syst. Botany 16:363-375.

Ducci, F. and R. Proietti. 1997. Variabilità alloenzimatica nel ciliegio selvatico (*Prunus avium* L.) in Italia (Genetic variability of wild cherry [*Prunus avium* L.] in Italy). Ann. Ist. Sper. Selv. 25: 81-104.

Korban, S. and B.L. Bournival. 1987. Catalase, esterase and peroxidase enzymes in seeds and leaves of *Malus x domestica* Borkh. Scientia Horticulturae 32:213-219.

Lamboy, W.F., J. Yu, P.L. Forsline and N.F. Weeden. 1996. Partitioning of allozyme diversity in wild populations of *Malus sieversii* L. and implications for germplasm collection. J. Am. Soc. Hort. Sci. 121:982-987.

Manganaris, A. and F.H. Alston. 1988. The acid phosphatase gene ACP-1 and its linkage with the endopeptidase ENP-1 and the pale green lethal gene 1 in apple. Acta Hort. 224:177-184.

Meier-Dinkel, A., J. Svolba and J. Kleinschmit. 1997. Selektierte, mikrovermehrte Vogelkirschen-Klone. Allg. Forstz./Der Wald 52:963-964.

Müller, F. and R. Litschauer. 1996. Unterscheidung zwischen Wildobstarten und verwilderten Kulturformen. Österreichische Forstzeitung 107:21-22.

Santi, F. and M. Lemoine. 1990a. Genetic markers for *Prunus avium* L.: inheritance and linkage of isozyme loci. Ann. Sci. For. 47:131-139.

Santi, F. and H. Lemoine. 1990b. Genetic markers for *Prunus avium* L. 2. Clonal identifications and discrimination from *P. cerasus* and *P. cerasus x P. avium*. Ann. Sci. For. 47:219-227.

Treutter, D. and W. Feucht. 1985. Art- und klonspezifische Polyphenolmuster des Phloems von *Prunus avium* und *P. cerasus*. Mitt. Klosterneuburg 35:256-260.

Turok, J., G. Eriksson, J. Kleinschmit and S. Canger (compilers). 1996. Noble Hardwoods Network. Report of the first meeting, 24-27 March 1996, Escherode, Germany. International Plant Genetic Resources Institute, Rome, Italy. 172 pp.

Wagner, I. 1995. Identifikation von Wildapfel (*Malus sylvestris* [L.] Mill.) und Wildbirne (*Pyrus pyraster* [L.] Burgsd.). Forstarchiv 66:39-47.

Wagner, I. 1996. Zusammenstellung morphologischer Merkmale und ihrer Ausprägung zur Unterscheidung von Wild- und Kulturformen des Apfel- (*Malus*) und des Birnbaumes (*Pyrus*). Mitteilungen der Deutschen Dendrologischen Gesellschaft 82:87-108.

Watkin, W. and A.G. Brown. 1956. Genetic response to selection in cultivated plants: Gene frequencies in *Prunus avium*. Heredity 10:237-245.

Weeden, N.F. and R.C. Lamb. 1985. Identification of apple cultivars by isozyme phenotypes. J. Am. Soc. Hort. Sci. 110:509-515.

Weeden, N.F. and R.C. Lamb. 1987. Genetics and linkage analysis of 19 isozyme loci in apple. J. Am. Soc. Hort. Sci. 112:865-872.

Weiser, F. 1996. Ergebnisse einer 33-jährigen Einzelbaum-Nachkommenschaftsprüfung nach freiem Abblühen von Vogelkirsche, *Prunus avium* L. var. *avium*. Silvae Genet. 45:260-266.

Table 1. Survey of the threats and conservation activities in the selected Noble Hardwood species (based on information obtained from countries)

A. Are the species considered to be threatened?

	Acer pseudoplatanus		*Acer platanoides*	
Country	**Species**	**Population**	**Species**	**Population**
Austria	No	No	No	No
Belgium	No	No	No	No
Bulgaria	No	No	No	No
Croatia	Yes		Yes	
Denmark	* No	* No	No	
Finland	*	*	No	Yes
France	No	No	No	No
Germany	No	No	No	Yes
Hungary	No	Yes	No	No
Italy	No	No	No	No
Lithuania	*Yes	* No	Yes	No
Netherlands	No	No	*	*
Poland	No	Yes	No	Yes
Portugal	No	Yes	* No	* Yes
Romania	No	No	No	No
Russia	No	Yes	No	Yes
Slovakia	No	No	No	Yes
Spain	No	Yes	No	Yes
Sweden	* No	* No	No	No
Switzerland	No	No	No	Yes
Ukraine	No	Yes	No	No

* The species is not native.

B. Are there any gene conservation programmes for the species?

	Acer pseudoplatanus		*Acer platanoides*	
Country	***In situ***	***Ex situ***	***In situ***	***Ex situ***
Austria	started	started	No	No
Belgium	started	started	No	No
Bulgaria	started	No	started	No
Croatia	No	No	No	No
Denmark	* No	* No	started	started
Finland	*	*	started	started
France	No	No	No	No
Germany	started	started	started	started
Hungary	No	No	No	No
Italy	No	No	No	No
Lithuania	*planned	*planned	started	No
Netherlands	started	planned	*	*
Poland	No	No	No	No
Portugal	No	No	* No	* No
Romania	started	No	started	No
Russia	No	No	No	No
Slovakia	started	started	planned	planned
Spain	No	No	No	No
Sweden	* No	* started	started	started
Switzerland	No	No	No	No
Ukraine	started	started	started	No

* The species is not native.

C. Are the *Sorbus* species considered to be threatened?

Country	*S. torminalis*	*S. aria*	*S. domestica*	*S. aucuparia*
Austria	Yes	No	Yes	No
Belgium	–	–	–	No
Croatia	No	No	Yes	No
Czech Republic	No	No	Yes	No
Denmark	locally threatened	No	–	No
Finland	–	–	–	No
France	locally threatened	No	Yes	No
Germany	locally threatened	locally threatened	Yes	No
Hungary	No	Yes*	Yes	No
Italy	No	No	Yes	No
Latvia	–	–	–	No
Lithuania	–	–	–	No
Netherlands	–	–	–	No
Poland	Yes	Yes	Yes	No
Portugal	–	–	–	–
Romania	locally threatened	No	Yes	No
Russia	–	–	–	No
Slovakia	Yes	No	Yes	No
Slovenia	locally threatened	No	No	No
Spain	No	No	No	No
Sweden	–	–	–	No
Switzerland	Yes	No	Yes	No
Ukraine	locally threatened	–	locally threatened	No

* A number of taxa related to *S. aria* x *S. torminalis* are regarded as threatened.
– Species does not occur.

D. Are there any gene conservation programmes (research/applied) for *Sorbus* species?

Country	*S. torminalis*	*S. aria*	*S. domestica*	*S. aucuparia*
Austria	Yes	No	Yes	No
Belgium	–	–	–	Yes
Croatia	No	No	No	No
Czech Republic	No	No	No	No
Denmark	No	No	–	No
Finland	–	–	–	Yes
France	Yes	No	Yes	No
Germany	Yes	No	Yes	Yes
Hungary	No	Yes	No	No
Italy	No	No	No	No
Latvia	–	–	–	No
Lithuania	–	–	–	No
Netherlands	–	–	–	Yes
Poland	No	No	No	No
Portugal	–	–	–	–
Romania	No	No	No	No
Russia	–	–	–	No
Slovakia	Yes	No	Yes	No
Slovenia	No	No	No	No
Spain	No	No	No	No
Sweden	–	–	–	No
Switzerland	Yes	No	Yes	No
Ukraine	Yes	–	No	No

– Species does not occur.

Table 2. Conservation measures in *Prunus avium* summarized from the country reports. Only those countries which have started conservation activities are mentioned.

	A[†]	B	CR	D	DK	E	F	H	IT	NL	P	S	SK
Conservation measures	native	native	native	native	introd.	native	native	native	native	native	native	introd.	native
In situ conservation:													
selected stands		2	1	34	11-15		102					10	
single trees		121		1164		93	400	180			X		X
Ex situ conservation:													
conservation stands				48	4							1	
single trees									>350				
seed orchards	3	4+2		17			X	1		1			X
families				1					70				
clones	157	79+97		700		51			150	X			
clonal archives	X	1		4	1	1		2					
seed storage				X									
pollen storage				X									

[†] A = Austria; B = Belgium (Flanders + Wallonia); CR = Croatia; D = Germany; DK = Denmark; E = Spain; F = France; H = Hungary; IT = Italy; NL = Netherlands; P = Portugal; S = Sweden; SK = Slovakia. Introd. = introduced; X = details of the measure cannot be given.

Sampling for genetic resources populations in the absence of genetic knowledge

Gösta Eriksson
Department of Forest Genetics, SLU, 750 07, Uppsala, Sweden

Introduction

Sampling of the existing adaptedness is a central element of any forest gene conservation programme. This sampling may be simple if all variation exists within populations and not between them. Then, conservation must only ensure that sufficient population sizes are included and any one population or any mixture of populations would be as good as any other for those purposes. However, if variation exists among populations, the apportioning and design of population sampling, as well as sample sizes within them, becomes a problem. Therefore, the existing variation in adaptedness should be seen as a means to capture maximum variance rather than as a final goal of conservation. Sampling of the present state does not necessarily oblige a conservation programme to freeze the available structure but should instead be seen as a starting point for continued evolution (Eriksson *et al.* 1995).

For the majority of tree species there are limited or no solid facts on among-population genetic variation in adaptedness. This means that sampling, at best, will be informed guesses about existing structure. The purpose of this paper is to discuss how such guesses might be derived from expected among-population genetic differentiation, with the main emphasis on random mating populations.

Evolutionary forces

The effects of the evolutionary forces: mutation, genetic drift, natural selection, and geneflow are discussed in textbooks in population genetics and evolutionary genetics. It is well documented that geneflow is a strong force to prevent fixation of neutral alleles. Similarly, genetic drift is a strong evolutionary force in small populations, though unlike geneflow it causes fixation of alleles. According to the survey on the strength of natural selection in the wild carried out by Endler (1986), natural selection can vary from weak to as strong as inbreeding. Mutation frequencies are mostly regarded to be low in individual loci amounting to approximately 10^{-5}. However, the pooled mutation frequency in loci influencing a trait may be considerably higher, $10^{-2}/10^{-3}$ (Lande and Barrowclough 1987). Kärkkäinen *et al.* (1994) reported a mutation frequency for chlorophyll mutants in *Pinus sylvestris* of 10^{-2} based on data published by Eiche (1955). Phenotypic plasticity which might be regarded as a disguise of the genotype has not been discussed much as an opposing force to natural selection.

The relationship between these forces and the among-population differentiation is illustrated in Figure 1. It should be noted that natural selection should here be understood as disruptive. The action of these forces on within-population variation is illustrated in Figure 2. Geneflow, genetic drift and inbreeding constitute the forces making up the mating pattern. The latter is here defined as the matings realized in the population. The mating pattern creates the raw material that the stabilizing natural selection can act upon. Under the assumption that geneflow brings in migrants from other populations with other gene frequencies, geneflow is the only force that causes an increase of the genetic variation within a population. Similarly, new mutations will increase the within-population variation. Note that in Fig. 1 it is assumed that mutations increase the differentiation among populations. The contradiction that might appear from a comparison of Figs. 1 and 2 is due to the assumption that individual mutations are of such a low frequency that different populations will get different mutations and in this way they will contribute to a small extent to population differentiation; simultaneously each new mutation will increase the genetic variation within a population.

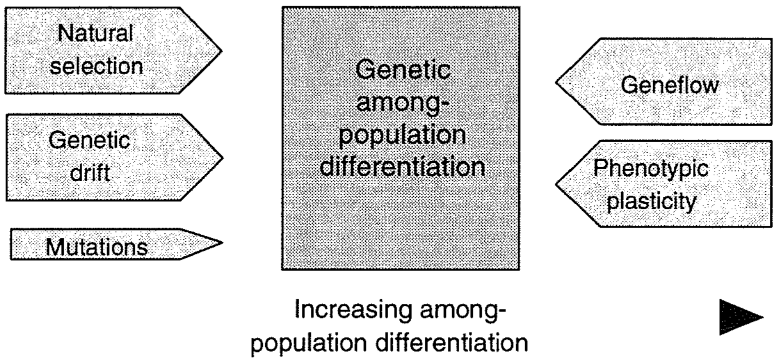


Fig. 1. Schematic illustration of the evolutionary forces that tend to increase and decrease the differentiation among populations. Phenotypic plasticity is looked upon as an evolutionary force since it might be regarded as a disguise of the genotype which makes natural selection less efficient in its presence. Natural selection should in this case be understood to be disruptive.

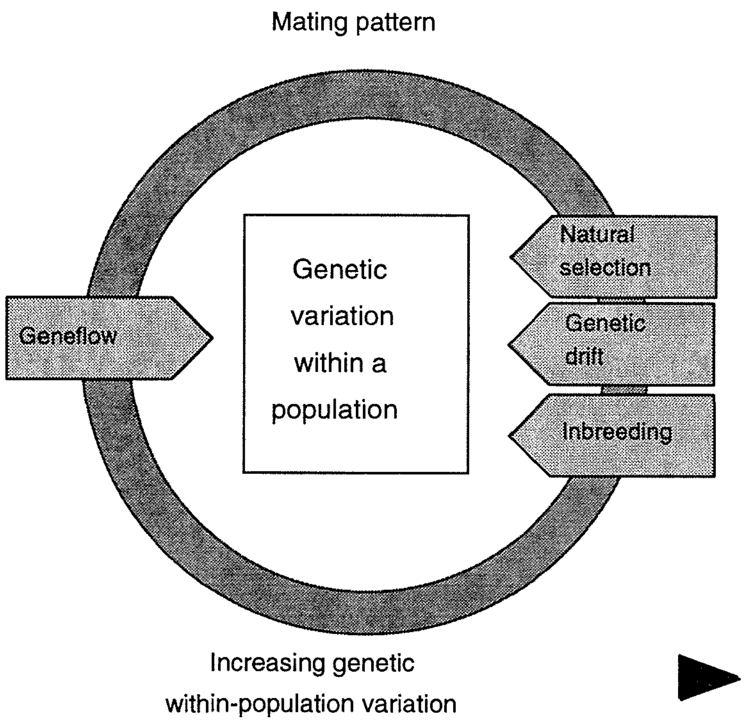


Fig. 2. Schematic illustration of the forces influencing the genetic variation within a population. The mating pattern, defined as the matings realized in a population, is a consequence of geneflow, genetic drift and inbreeding in that population. The mating pattern creates the raw material that natural selection will act upon. Natural selection should in this case be understood as stabilizing.

Random mating populations

In populations with a large effective population size (*Ne*), the effect of genetic drift is negligible. Nor will mutations influence the structure to any great extent in large populations. Therefore, the discussion of the interaction between disruptive natural selection and geneflow in development of among-population genetic differentiation will be the main focus. Some comments on phenotypic plasticity will be given.

Selective environmental neighbourhoods

A prime prerequisite for among-population differentiation is that the environment occupied by a species is experienced as heterogeneous by this species. A second prerequisite is that there is some consistency in this heterogeneity over generations. The concept of **selective environmental neighbourhood** (SEN) introduced by Brandon (1990) is useful for a discussion of this prerequisite. Within a SEN there is no ranking change of the genotypes with respect to fitness, conferring a degree of homogeneity to a SEN. Thus several SENs are required for among-population differentiation. Stabilizing selection within each of several populations in different SENs will be experienced as disruptive selection among populations. Besides, the geographic extension of the SEN over generations must not vary too much, otherwise natural selection will not have enough time to bring about a differentiation.

A SEN should be regarded as a genetic delimitation rather than a geographic one, which means that a SEN may contain non-contiguously growing populations (Fig. 3). As one example of this, populations at each of the two slopes of a valley may physically not grow adjacent to each other but still be parts of one SEN. As the environment changes the physical shape of a SEN may change or even merge with another SEN. One physical population constituting one single SEN remains so until environmental changes cause ranking shifts of fitness in this population. It should be noted that SENs are trait-specific. Within a certain geographic area one trait may contribute to fitness whereas another does not. In another area both traits may contribute to fitness and the SENs for the two traits may in the extreme case be identical. Thus different traits may have different numbers of SENs within a species. Differences in the physical area of different SENs among traits are dependent upon the contribution to fitness of the trait and its correlation with other fitness-contributing traits.

With high probability a wide climatic distribution of a species will give rise to numerous SENs and adaptation to different climatic zones (= among-population differentiation) may take place. Other abiotic and biotic elements of site conditions may also be suspected to give rise to different SENs, although much less is known about adaptation to such environmental variables (e.g. Jonsson and Eriksson 1989; Weiser 1995). In summary, a prerequisite for a species to consist of one single SEN is that it grows under homogeneous conditions both in space and time.

As long as there is additive variance for fitness of a trait, disruptive natural selection may cause a trait differentiation among populations inhabiting different SENs. A large difference between two SENs will give rise to a stronger disruptive selection than when the difference is small. Even if there are large differences and ample additive variance is present, among-population differentiation may be absent owing to substantial geneflow among individuals of different SENs as will be discussed in the next section.

Geneflow among different selective environmental neighbourhoods

If there is no intermating among selectively divergent populations, evolution can be expected to eventually lead to speciation, but with complete intermating, then every generation would re-establish the original Hardy-Weinberg frequencies regardless of the intensity of selection. For most forest trees, however, populations are neither completely isolated nor completely intermating, and in these cases, the outcome of the balance between selection and migration is not clear. When the population structure is one in which a very large central population (a continent) exists and small islands are attached by isolated migrants only to that continent, it does not take more than one migrant per generation to prevent strong divergence from evolving. However, if populations are only partially isolated, and particularly if migration is limited to only a few adjacent populations of similar size (a stepping stone model), then the same exchange rate may allow a wide distribution of allele

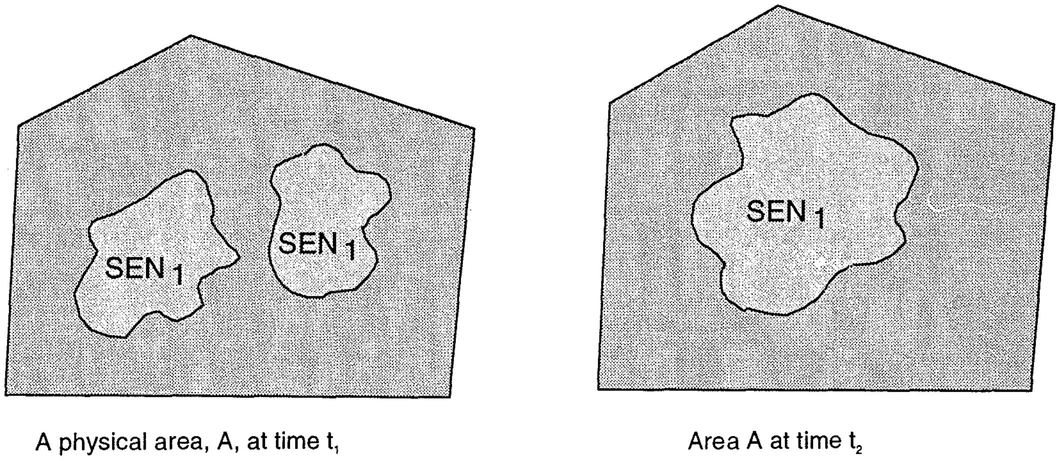


Fig. 3. Schematic illustration of the geographic extension of a selective environmental neighbourhood at two different times. Within a selective environmental neighbourhood the genotypes do not change rank with respect to fitness (cf. Brandon 1990).

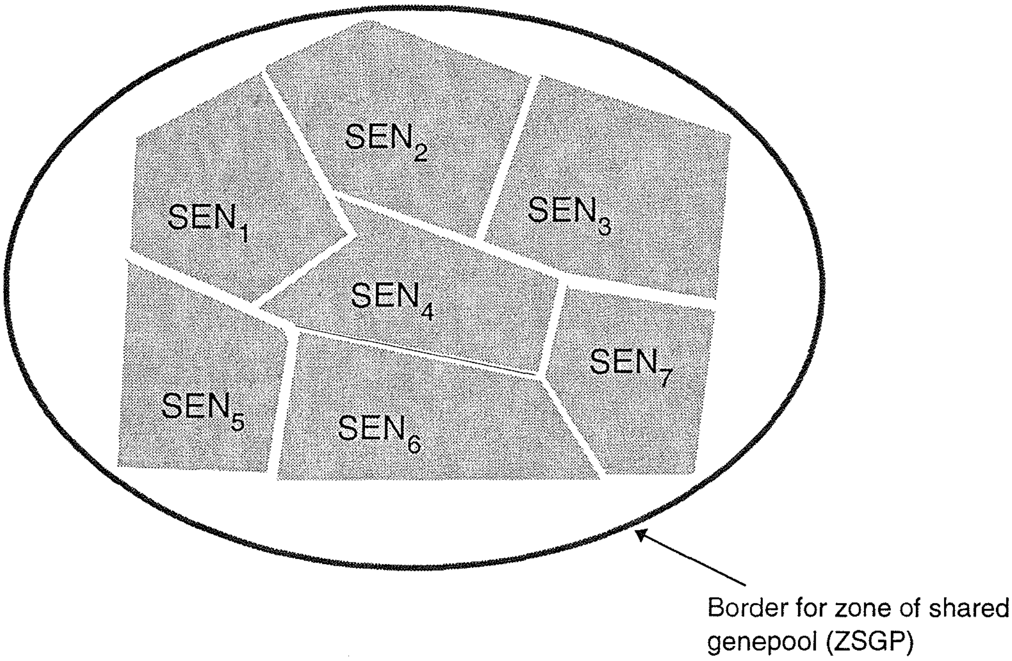


Fig. 4. Schematic illustration of seven selective environmental neighbourhoods among which there is free intermating.

frequencies to evolve among the populations, even if no speciation occurs (Hedrick 1988). Even if selection was not divergent among the populations, local mutations may still lead to the existence of genetic variations if migration was at a low rate (Phillips 1996). Forest trees might also differ among the sexes in their rates of migration, with sometimes, pollen or seed being less mobile than the other, and the effect of the less mobile sex may allow for more variations to evolve than if an average migration rate were computed (Gregorius and Namkoong 1983; Namkoong and Gregorius 1985).

The consequences of interpollination among different SENs will be discussed with the help of the schematic illustrations in Figures 4-6. An example for a species with a continuous distribution is given in Fig. 4. Pollen of wind-pollinated tree species may be transported over large distances (Koski 1970). The share of such distant pollen in the formation of a new generation in a SEN might be considerably less. In conclusion, intermating among different SENs is in many cases a strong and preventive force operating against genetic differentiation. Therefore, the mere occurrence of swamping of pollen from other SENs may prevent or strongly reduce the among-population differentiation even if there are several SENs. Therefore, the degree to which there is interpollination among different SENs will be important for the possibility to develop among-population differences. Transfers of seeds and other propagules will also reduce the possibilities for differentiation. It is therefore relevant to introduce the concept of a zone of shared genepool (ZSGP). ZSGP will mostly be different from *Ne* and may vary from one extreme of total random mating within the ZSGP (ZSGP = *Ne*) to exchange of one single migrant among different subzones of a ZSGP. Therefore, the strength of the geneflow (SGF) among SENs will influence the amount of differentiation that may take place. The degree of genetic differentiation will depend on the relationship between disruptive selection and SGF.

If the trees in the seven SENs of Fig. 4 can be regarded as members of one randomly mating population (i.e. ZSGP = *Ne*), natural selection must be extremely strong to give rise to among-population differentiation. A contrasting case is given for a species with a scattered distribution in Figure 5. In this case the two populations (SEN1 and SEN2) are growing at some distance from each other and there is no exchange of pollen or propagules between the two SENs. Such a situation is a good starting condition for specific adaptation to varying site conditions. In such a case ecotypic differentiation of a species may take place. A situation intermediate to the two described above is shown in Figure 6. This is the situation for many wind-pollinated and continuously distributed species where there is an overlap of the zones of shared genepool along an environmental gradient. This would in itself favour the development of clinal variation and isolation by distance (cf. Wright 1943).

In lowland forests it is highly likely that a SEN covers a huge area. Within this area species represented by a few sexually mature individuals per hectare may be characterized by a meta-population structure with most of the pollinations within each subpopulation (Fig. 7). If each subpopulation is small ($Ne<20$), this may lead to pronounced allele fixation by genetic drift.

Differentiation in large populations

The effect of the interaction between disruptive selection and the SGF is illustrated in Figure 8. It is assumed that there is a stability of the geographic extension of SENs over generations. For random reasons there may be some among-population variation in absence of strong disruptive selection (position 1). In absence of substantial geneflow and by increasing strength of the disruptive selection (i.e. moving from position 1 to position 2) the among-population differentiation will increase. As the geneflow increases along the line between positions 1 and 3, the probability of differentiation decreases rapidly in the case of weak disruptive selection (position 3). A large swamping of pollen will eradicate most of the among-population variation. However, in the presence of strong disruptive selection, substantial among-population variation can still exist in spite of the strong geneflow (position 4).

Informed guesses about the ratio SGF/SDS (strength of disruptive selection) in a species can be obtained from its type of distribution and type of pollination. A wide distribution as compared to a limited distribution mostly means that there are several SENs, especially when the distribution covers large climatic ranges. The SGF is also dependent on the type of pollen vector. Wind-pollinated species will

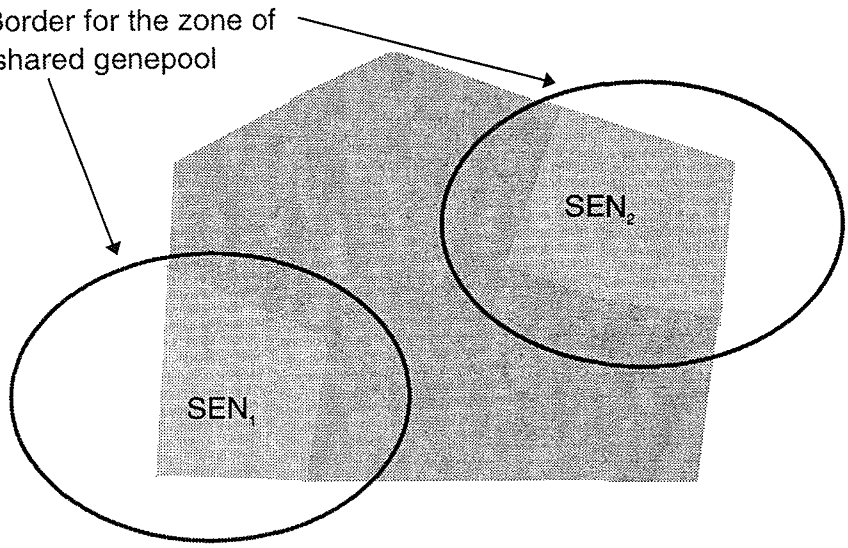


Fig. 5. Schematic illustration of two selective environmental neighbourhoods between which there is no intermating.

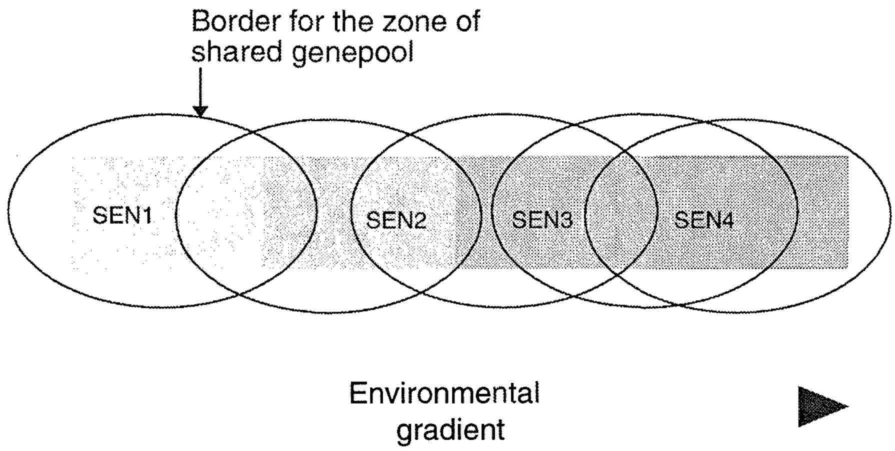


Fig. 6. Schematic illustration of four selective environmental neighbourhoods along an ecological gradient with intermating among adjacent selective environmental neighbourhoods.

have larger SGFs than species with other types of pollen vectors since the pollen distribution by insects, bats and birds is assumed to be over shorter ranges. If there are physical obstacles between disjunct populations this will reduce the geneflow among populations, with a reduced SGF as a consequence.

The expectations concerning among-population differentiation in cases of instability of the SENs is illustrated in Fig. 9. The situation at stability of SENs (the line connecting positions 1 and 2) will be the same as the corresponding positions in Fig. 8. Instability of SEN means that selection may operate in different and sometimes contrasting directions during different generations. This will lead to a low among-population differentiation (positions 3 and 4). As a consequence of the latest disruptive selection a slightly larger among-population differentiation may be observed if this selection was strong (position 4).

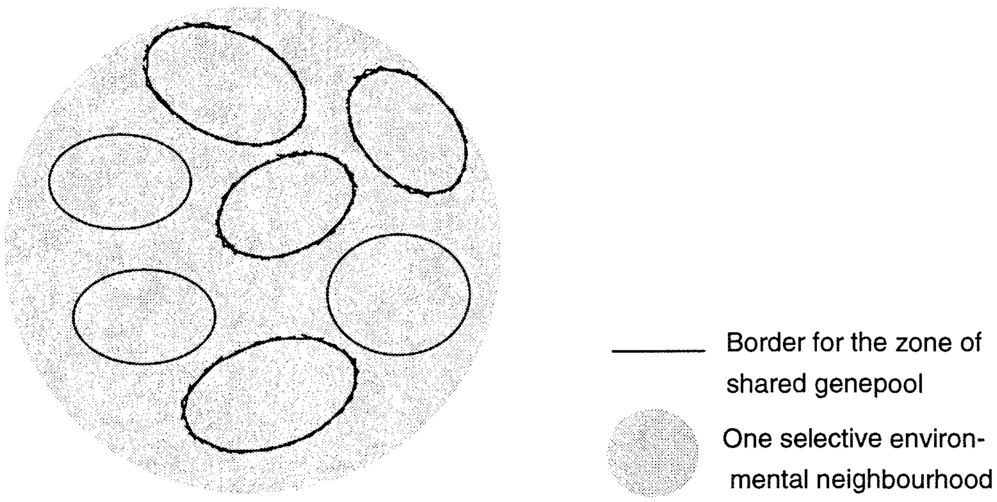


Fig. 7. One selective environmental neighbourhood in which intermatings occur within certain isolated groups.

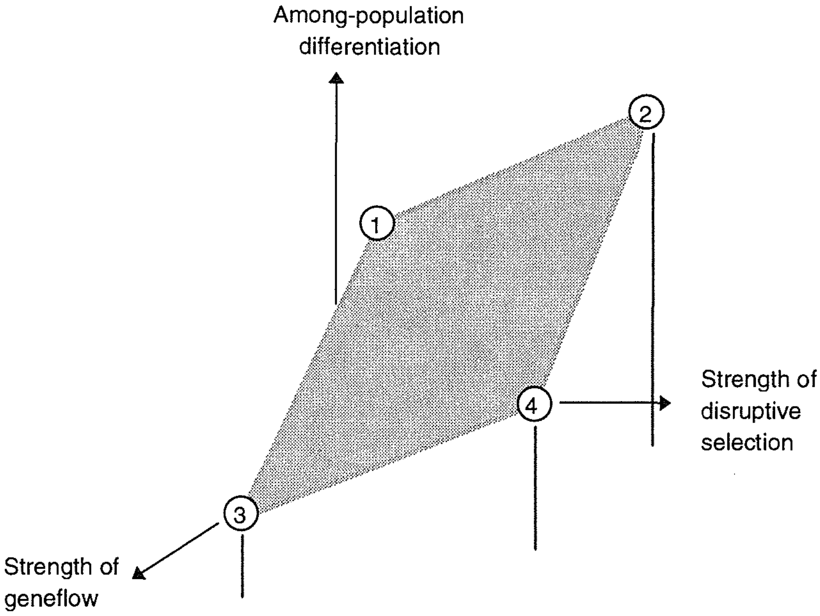


Fig. 8. Schematic illustration of the expected among-population differentiation as a result of interaction between geneflow and disruptive natural selection. Random mating and a certain stability in the direction of the disruptive selection are assumed.

Within- and among-population variation

In case of non-disruptive natural selection the ratio is only influenced by random processes which in large populations would lead to the largest ratio of within- and among-population variation (Fig. 10, position 1 and 3). This ratio will be lowest at strong disruptive selection combined with a limited geneflow (position 2, Fig. 10). At high SGF a strong disruptive selection will reduce the W/A ratio to some extent as indicated in Fig. 10 (position 4). Fig. 10 is a reflected image of Fig. 8.

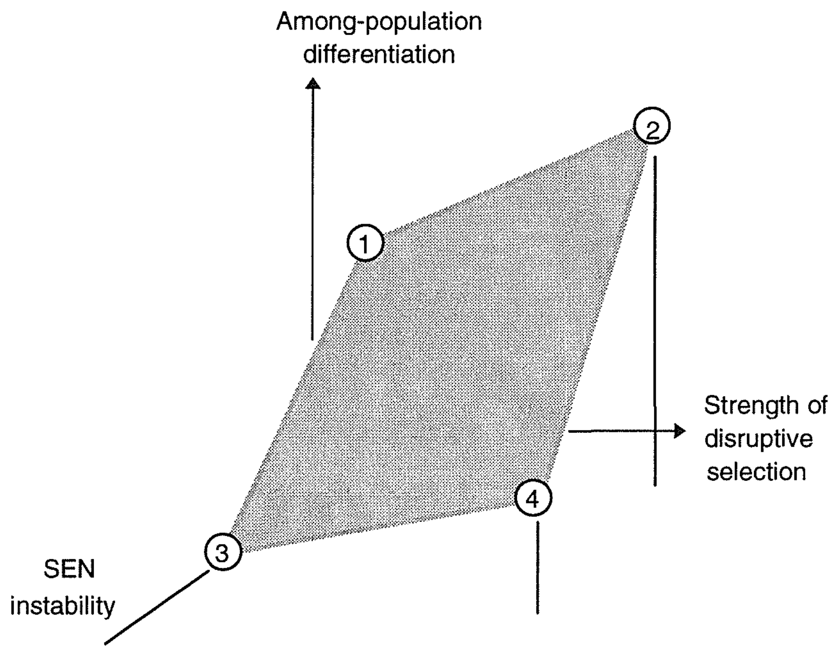


Fig. 9. Schematic illustration of the expected among-population differentiation as a result of interaction between geneflow and stability of the disruptive natural selection under situations of random mating.

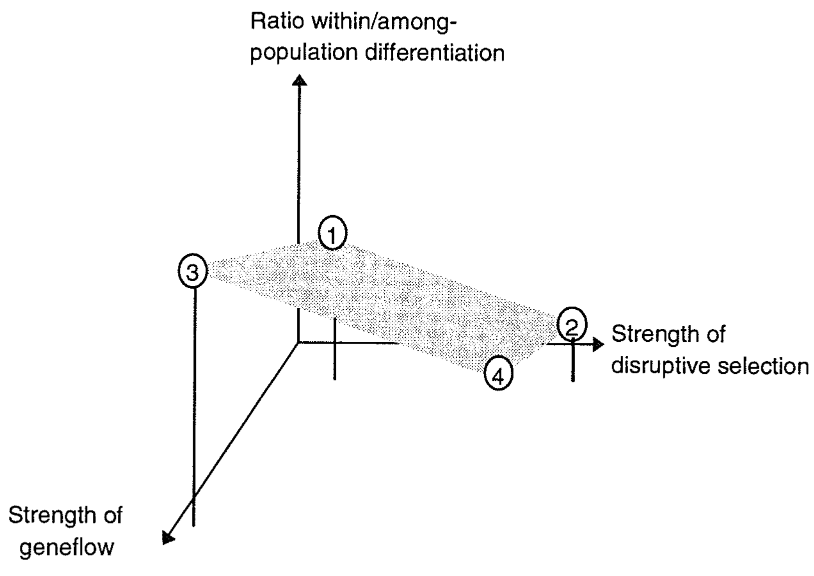


Fig. 10. Schematic illustration of the expected ratio of within- to among-population genetic variation. Random mating and a certain stability in the direction of the disruptive selection are assumed.

Phenotypic plasticity

A species with a short generation turnover can respond to changed directions of selection by adaptation via natural selection, presupposed that the species contains enough additive genetic variance. On the other hand a species with a long generation turnover cannot during its lifetime respond to the multitude of directions of selection that the environment may provoke. Rather it is probable that a certain degree of phenotypic plasticity would be evolutionary advantageous (Fig. 11). If the situation for a tree is that of Fig. 4, the tree might spread its genes over all seven SENs. Then it would be an advantage for that tree, to give rise to a progeny that performs well in all SENs, i.e. to have a large phenotypic plasticity. In other words phenotypic plasticity confers fitness to its carrier. The larger the SGF, the higher the probability that phenotypic plasticity would confer fitness in species with long generation turnover.

Research observations

Some examples from tree species will be given to illustrate observations about among- and within-population variation. Pine and spruce species are wind-pollinated with pollen flights over wide areas (Koski 1970; Savolainen 1991). Many species also occupy wide, continuous, and climatically variable areas which would indicate firstly that they have a large number of SENs and secondly that the geneflow is considerable among different SENs. In agreement with this, estimates of *Ne* are high, amounting to several thousand trees (Schoen and Brown 1991; Yang and Yeh 1995).

Of particular interest is the investigation of among- and within-population variation in *Pinus sylvestris* in Finland by Karhu *et al.* (1996) since it treats one adaptive trait, bud set, and several molecular markers in the same populations. There was a 21 days difference in bud set between the most southern (latitude 60°) and the most northern population (latitude 70°). All the molecular markers showed limited among-population variation while the within-population was large. The results presented clearly demonstrate that the number of SENs varies from trait to trait. Markers like isoenzymes, RAPDs, and RFLPs are assumed to be neutral (cf. Kimura 1983). Therefore, we expect that there is just one SEN for each of them (see position 1 in Fig. 8).

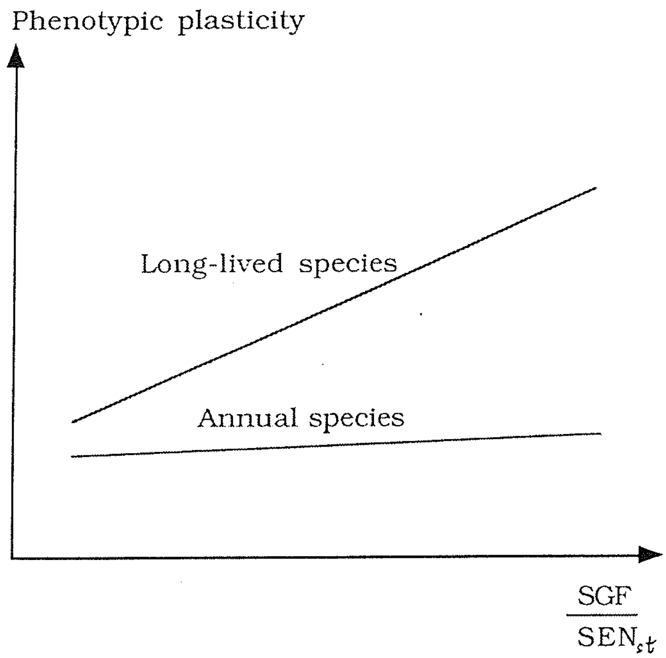


Fig. 11. Schematic illustration of the expected phenotypic plasticity in short- and long-term generation species, respectively, plotted against the ratio of the strength of the geneflow over disruptive natural selection.

Pinus sylvestris in the northern part of its distribution in Sweden (latitudes 61-68°) shows a steep clinal variation in tree survival (Eiche 1966). There is also a large within-population variation in survival (Eriksson *et al.* 1980). At different latitudes an adaptation to a growth period that matches the climate at this latitude is taking place. This matching is to the largest extent exerted by the photoperiodic conditions at different latitudes. The night length triggers the onset of hardening. With a too late onset of hardening the trees suffer from severe frost damage. The observation on survival in *Pinus sylvestris* fits the anticipation that the among-population variation in survival would be large since a strong disruptive selection counteracts the swamping of pollen into several different SENs (see position 4 in Fig. 8). The disruptive selection thus causes a clinal variation of the means of the populations. The large variation within the populations could mainly be explained by swamping of pollen among populations (see position 4 in Fig. 10).

In Sweden south of latitude 59° there is good survival among all *Pinus sylvestris* populations (Johnsson 1971). With respect to survival it is probable that there is just one SEN in this part of the country, which explains the absence of variation in this trait (below point 3 in Fig. 8). In contrast there is a clinal variation in stem volume all over Sweden (Johnsson 1971; Eriksson *et al.* 1980). Again there is an adaptation going on of the duration of the growth period to different latitudes. This is triggered by the night length as regards the cessation part of the growth period. Less growth is accomplished during a short growth period than during a long growth period. With respect to growth we have different SENs not only in northern Sweden but also in the southern part of the country.

In *Picea abies* steep clines have been reported for bud flushing (Eriksson *et al.* 1974), bud set (Holzer 1966; Dormling 1979) and stem volume (Persson and Persson 1992) as well as large within-population variation for growth and growth rhythm traits (Ekberg *et al.* 1985). It is probable that there are several SENs for each of these traits. In spite of a large geneflow among SENs the disruptive selection has caused a population differentiation (position 4 in Fig. 8). The large W/A ratio (position 4 in Fig. 10) must be attributed to pollen swamping.

Several conifer species from North America show similar results to those found for *Picea abies* and *Pinus sylvestris* from the Old World (Rehfeldt 1970, 1980, 1982; Conkle 1973; Campbell 1979). There are a few exceptions to this, *Pinus monticola* and *Pinus resinosa* being two of them. In *P. monticola* most genetic variation in growth and phenology traits remains within populations and only small differences are found among populations, though with a sharp border between south and north in central Oregon (Campbell and Sugano 1989 and lit. cit.). Similarly there is some variation among populations of *Pinus resinosa* without any clear clinal pattern of variation (Overton and Johnson 1985 and lit. cit.).

As regards *Pinus monticola*, Campbell and Sugano (1989) discuss a few evolutionary explanations for the limited among-population variation for a large area of its distribution in northwest USA. They rule out phenotypic plasticity as the major reason for this since the large genetic variation among trees should contradict such an explanation. Another possible explanation is that the species does not experience the environment as heterogeneous; with the terminology of Brandon (1990) there is just one single SEN for the species north of central Oregon (see position 1 in Fig. 8). In support of this it seems to occupy a specific habitat and is evidently outcompeted by other species in other habitats. Still another explanation would be that the environment changes strongly over time, preventing any stabilizing selection within certain areas. SENs thus should vary strongly over time (position 3 in Fig. 9). However, it remains to be proven why *P. monticola* experiences the environment as very variable while other conifers experience the same environment as fairly stable.

Pinus resinosa grows predominantly on xeric sites in a band approximately 700 kilometres wide from south eastern Manitoba and Minnesota to the Atlantic coast. The east-west distribution of the species covers different climatic zones which presumably should give rise to several SENs. As a consequence of that, one would expect adaptation to these different SENs as long as large random mating populations exist. It has repeatedly been reported that it has low genetic diversity (see Mosseler 1995) and the species does not suffer from much inbreeding depression (Fowler 1964, 1965). This has given rise to speculations that the species has passed through several bottlenecks after the last glaciation and in this way lost genetic diversity. However, as stated by Overton and Johnson (1985), *P. resinosa* is not devoid of genetic variation in quantitative traits but the variation is less than in other comparable pine species. One possible explanation for the limited genetic variation is that SENs of this species do not differ as much as for other species. The emphasis that *P. resinosa* predominantly grows on xeric sites (Mosseler 1995) supports that view. The larger genetic variation in *P. strobus* might be attributed to its occupation of a wider range of site conditions and accompanying larger differences in its SENs.

In agreement with the observations by Karhu *et al.* (1996) many earlier separate analyses of isoenzyme variation revealed a much larger within-population variation than among-population variation (e.g. Bergmann 1973; Rudin and Lundkvist 1977; Wheeler and Guries 1982). Sometimes clines are observed (Bergmann 1978; Lagerkrantz and Ryman 1990) but never as steep as for metric traits. The clinal variation observed for some isoenzyme markers is most likely a consequence of isolation by distance (cf. Wright 1943) and not a consequence of disruptive selection since it takes a long time to reach the same frequency of a new mutant allele in all subpopulations. The absence of marker differences among *P. resinosa* populations summarized by Mosseler (1995) must also be attributed to the absence of different SENs for these markers. The lack of within-population variation of biochemical markers (Fowler and Morris 1977; Mosseler 1995) contrasts with the observations in most other conifer species. This lack of genetic variation lends support to the bottleneck hypothesis put forward by Fowler and Morris (1977).

Non-random mating populations

Unfortunately most of the tree species classified as Noble Hardwoods (Turok *et al.* 1996) are rarely random mating, owing to their scattered distribution and pollination by vectors that are flying over short distances only. Therefore, random genetic drift may play a great role in their evolution. Loss of additive variance in a population occurs at a rate of $1/2Ne$ per generation. It must be remembered that Ne in many cases is much less than the census number of trees. A population with less than ten mating trees for several generations will have a high degree of allele fixation. If an originally large random mating population is split into many small populations the frequency of fixation of allele a_1 after many generations of exposure to genetic drift will be proportional to the original frequency of this allele in the original large population. Since there are many unlinked loci, a random fixation of alleles over the whole genome will lead to a large differentiation among populations. The predictions of the among-population differentiation will in absence of other evolutionary forces be a reflected image of the curve for loss of additive variance due to drift.

The joint effects of genetic drift and natural selection may take the shape illustrated in Figure 12. At position 1 the random mating populations may differentiate owing to natural selection. By increasing importance of random genetic drift, non-adaptive differentiation becomes more important and the among-population differentiation increases (position 2). The among-population differentiation will probably not change much from position 2 to position 4. As genetic drift gradually becomes less important when moving from position 4 to position 3 the among-population will exponentially be reduced to a low level at position 3.

To capture the existing genetic variation in situations when genetic drift is thought to play a major role, the number of populations has to be larger than when random mating prevails. Even if the existing tree population is far from maximum fitness, it has proven to be competitive in its present environment and can advantageously be included in the gene resource population(Eriksson *et al.* 1993). Although methods of gene conservation are not the subject of this paper, it must be remarked that for the long-time survival of the species, putting trees together from different populations into a seed orchard would be the best measure to improve the additive variance in the offspring.

Research observations

Mattila and Vakkari (1997) reported on F_{st} values for isoenzyme variation at 18 loci in *Ulmus laevis* populations in Finland. Many of the populations are small and the species has its northern margin in Finland. The estimated F_{st} value amounted to 0.33 which must be regarded as a high value for this wind-pollinated species, suggesting that random genetic drift might be a cause of this substantial differentiation.

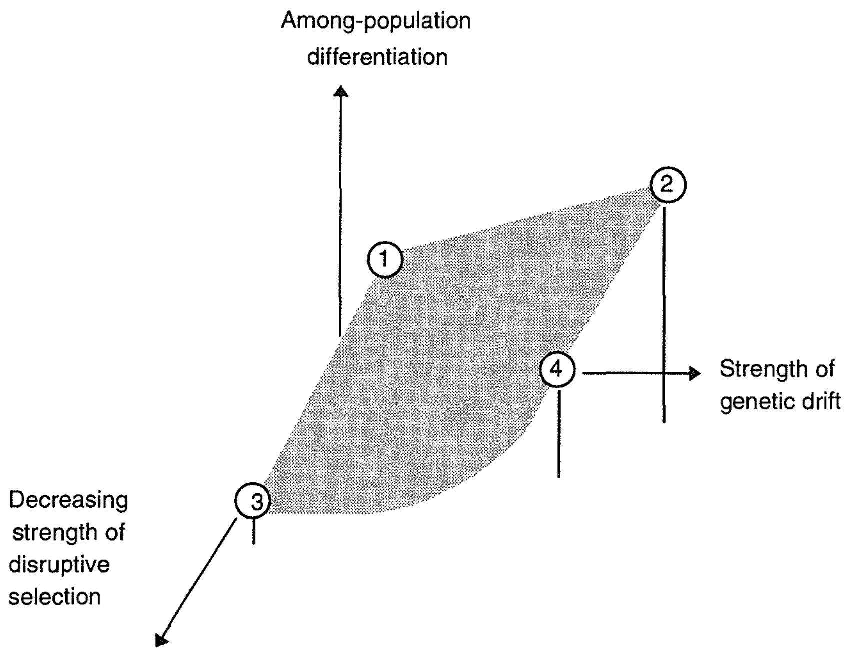


Fig. 12. Schematic illustration of the expected among-population differentiation as a result of interaction between random genetic drift and decreasing strength of the disruptive natural selection.

Like the elm species referred to above, *Acer platanoides* has its northern margin in southern Finland. Rusanen *et al.* (1996) reported a F_{st} value of 0.126 for this species based on a study of 14 isoenzyme loci in 14 populations. Compared with the values for *Ulmus laevis*, the importance of genetic drift seems to be much less. The results suggest that the pollen vector can transport vital pollen over considerable distances.

Håbjørg (1978) reported on growth rhythm in *Acer platanoides* and showed that there was a clinal variation for growth cessation. Similarly, Westergaard and

Eriksen (1997) reported on clinal variation in the same species. It is evident that there is some adaptedness to the climatic conditions of this trait in Scandinavia. In the latter report, there was one population from latitude 56° that did not differ from a population with its origin more than 4° further north. One possible explanation for the deviating performance of the latitude 56° population is genetic drift.

Our own studies of *Acer platanoides*, *Fraxinus excelsior* and *Quercus robur* have indicated that there is a larger among-population variation for some traits in *Acer platanoides* (insect-pollinated), than in the others (wind-pollinated), supporting the hypothesis that insect-pollinated species should show larger among-population differentiation than wind-pollinated ones.

Conclusions

All sampling for gene conservation ought to capture the existing adaptedness. When genetic information is totally absent and sampling for gene conservation has to be carried out, it may be useful to consider:

1. Whether there is random mating; if this is the case, then consider:
   - how many SENs there may be for a species and how strong the disruptive selection may be among different SENs
   - how strong the geneflow among different SENs may be
   - how these two evolutionary forces interact.
2. If genetic drift is assumed to have taken place, comparatively more samples have to be included to capture the existing genetic variation which is partly non-adaptive.

Acknowledgements

Useful comments on an early version of this paper by Gene Namkoong are gratefully acknowledged. Thanks are also due to Kjell Lännerholm for assistance in the preparation of graphs and to David Clapham for revision of the English of this paper.

References

Bergmann, F. 1973. Genetische Untersuchungen bei *Picea abies* mit Hilfe der Isoenzym-Identifizierung III. Geographische Variation an 2 Esterase- und 2 Leucine-Aminopeptidase-Loci in der schwedischen Fichtenpopulation. Silvae Genet. 22:63-86.

Bergmann, F. 1978. The allelic distribution at an acid phophatase locus in Norway spruce (*Picea abies*) along similar climatic gradients. Theor. Appl. Genet. 52:57-84.

Brandon, R.N. 1990. Adaptation and environment. Princeton Univ. Press, Princeton, NJ, 214 p.

Campbell, R.K. 1979. Genecology of Douglas-fir in a watershed in the Oregon cascades. Ecology 60:1036-1050.

Campbell, R.K. and A.I. Sugano. 1987. Seed zones and breeding zones for white pine in southwestern Oregon. Res. Pap. PNW-RP-407. US Dept. of Agric., For. Serv., Pacific Northwest Res. Sta., Portland, OR, 20 p.

Conkle, M.T. 1973. Growth data for 29 years from the California elevational transect study of ponderosa pine. For. Sci. 19:31-39.

Dormling, I. 1979. Influence of light intensity and temperature on photoperiod response of Norway spruce provenances. Pp. 398-408 *in* Proc. IUFRO Joint Meet. Work Part. Norw. Spruce Prov. & Norw. Spruce Breed., Bucharest 1979.

Eiche, V. 1955. Spontaneous chlorophyll mutants in Scots pine. Medd. Stat. Skogsforskningsinstitut 45: 64 pp.

Eiche, V. 1966. Cold damage and plant mortality in experimental provenance plantations with Scots pine in northern Sweden. Stud. For. Suec. 36, 218 pp.

Ekberg, I., G. Eriksson and Y. Weng. 1985. Between- and within-population

variation in growth rhythm and plant height in four *Picea abies* populations. Stud. For. Suec. 167, 14 pp.
Endler, J. 1986. Natural Selection in the Wild. Princeton Univ. Press, Princeton, NJ, 336 pp.
Eriksson, G., S. Andersson, V. Eiche, J. Ifver and A. Persson. 1980. Severity index and transfer effects on survival and volume production of *Pinus sylvestris* in northern Sweden. Stud. For. Suec. 156, 32 pp.
Eriksson, G., P. Krutzsch and K-L. Kiellander. 1974. Reforestation from a genetic point of view. Sver. Skogsv. Förb. Tidskr. 72:143-152. [In Swedish with English summary].
Eriksson, G., G. Namkoong and J. Roberds. 1993. Dynamic gene conservation for uncertain futures. For. Ecol. Manage. 62:15-37.
Eriksson, G., G. Namkoong and J. Roberds. 1995. Dynamic conservation of forest tree gene resources. For. Genet. Res. (FAO) 23:2-8.
Fowler, D.P. 1965. Effects of inbreeding in red pine, *Pinus resinosa* Ait. Silvae Genet. 13:170-177.
Fowler, D.P. 1964. Effects of inbreeding in red pine, *Pinus resinosa* Ait. II Pollination studies. Silvae Genet. 14:12-23.
Fowler, D.P. and R.W. Morris. 1977. Genetic diversity in red pine: evidence for low genic diversity. Can. J. For. Res. 7:343-347.
Gregorius, H.-R. and G. Namkoong. 1983. Conditions for protected polymorphism in subdivided plant populations. Theor. Pop. Biol. 24:252-267.
Håbjørg, A. 1978. Photoperiodic ecotypes in Scandinavian trees and shrubs. Meld Norges Landbruksh. 57:33.
Hedrick, P.W. 1988. Genetic polymorhpism in heterogenous environments. Ann. Rev. Ecol. Syst. 17:535-566.
Holzer, K. 1966. Die Vererbung von physiologischen und morphologischen Eigenschaften bei der Fichte I. Sämlingsuntersuchungen. Mitt. Forstl. Bundesversuchsanstalt, Mariabrunn 71, 185 p.
Johnsson, H. 1971. Proveniensförsök med tall i Sydsverige. För. Skogsträdsför. Inst. Skogsförb. Årsbok 1970. 87-122. [In Swedish].
Jonsson, A. and G. Eriksson. 1989. A review of genetic studies of some important traits in the genera *Acer, Fagus, Fraxinus, Prunus, Quercus, Tilia* and *Ulmus*. Res. Not. 44. Dept. For Gen., Swed. Univ. Agr. Sci. 50 pp.
Karhu, A., P. Hurme, M. Karjalainen, P. Karvonen, K. Kärkkäinen, D. Neale and O. Savolainen. 1996. Do molecular markers reflect patterns of differentiation of adaptive traits of conifers? Theor. Appl. Genet. 93:215-221.
Kärkkäinen, K., V. Koski and O. Savolainen. 1996. Geographical variation in the inbreeding depression of Scots pine. Evolution 50:111-119.
Kimura, M. 1983. The Neutral Theory of Molecular Evolution. Cambridge Univ. Press. 367 pp.
Koski, V. 1970. A study of pollen dispersal as a mechanism of gene flow in conifers. Comm. Inst. For. Fenniae 70.4.
Lagerkrantz, U. and N. Ryman. 1990.Genetic structure of Norway spruce (*Picea abies*): concordance of morphological and allozyme variation. Evolution 44:38-53.
Lande, R. and G.F. Barrowclough. 1987. Effective population size, genetic variation, and their use in population management. *In* Viable Populations for Conservation (Michael Soulé, ed.). Cambridge University Press, Cambridge, New York, New Rochelle, Melbourne, Sydney.
Mattila, A. and P. Vakkari. 1997. Genetic variation of *Quercus robur* and *Ulmus laevis* in Finland. Pp. 63-68 *in* Proc. Nord. Meet. For. Genet. Tree Breeders, Estonia, June 3-7, 1996.
Mosseler, A. 1995. Red pine: A model for the loss of genetic diversity in trees. Pp. 359-370 *in* Population Genetics and Genetic Conservation of Forest Trees (Ph.

Baradat, W.T. Adams and Müller-Starck, eds.). SPB Academic Publishing.
Namkoong, G. and H.-R. Gregorius. 1985. Conditions for protected polymorphism in subdivided plant populations 2. Seeds versus pollen migration: Am. Natural. 125:521-534.
Overton, R.P. and L.C. Johnson. 1985. Red pine - potential for genetic improvement and observations on cone and seed production. Northeastern forest tree improvement conference, Durnham, NH, 1984, pp. 177-188.
Persson, A. and B. Persson. 1992. Survival, growth, and quality of Norway spruce (*Picea abies* L. Karst) provenances at the three sites of the IUFRO 1964/68 provenance experiment. Dept. For. Yield, Swed. Univ. Agr. Sci. Res. Notes 29, 67 pp.
Phillips, P.C. 1996. Maintenance of polygenic variation via migration-selection balance under uniform selection. Evolution 50:1334-1339.
Rehfeldt, G.E. 1970 Genecology of *Larix laricina* (DuRoi) K. Koch in Wisconsin. Silvae Genet. 19:9-16.
Rehfeldt, G.E. 1980. Cold acclimation in populations of *Pinus contorta* from the northern Rocky mountains. Bot. Gaz. 14:458-463.
Rehfeldt, G.E. 1982. Differentiation of *Larix occidentalis* populations from the northern Rocky Mountains. Silvae Genet. 31:13-19.
Rudin, D. and K. Lundkvist. 1977. Forest isozyme studies in Umeå, Sweden. *In* EEC Symposium on Forest Tree Biochemistry: 133-162.
Rusanen, M., A. Mattila and P. Vakkari. 1996. Jalojen lehtipuden geneettinen monimuotoisuus-säyliytä ja käytä. Metsänt. Tied. 605:45-52 [In Finnish].
Savolainen, O. 1991. Background pollination in seed orchards. Pp. 6-13 *in* Proc. Meet. Nord. Group Tree Breed. Sweden, August 1991. Report 10, Dept For. Gen. Plant Phys.
Schoen, D.J. and A.H.D. Brown. 1991. Intraspecific variation in population gene diversity and effective population size correlates with the mating system in plants. Proc. Nat. Acad. Sci. 88:4494-4497.
Turok, J., G. Eriksson, J. Kleinschmit and S. Canger (compilers). 1996. Noble Hardwoods Network. Report of the first meeting, 24-27 March 1996, Escherode, Germany. 172 pp.
Weiser, F. 1995. Beitrag zur Existenz von Ökotypen bei gemeiner Esche (*Fraxinus excelsior*). Forstarchiv 66:251-257.
Westergaard, L. and E. Nymann Eriksen. 1997. Autumn temperature affects the induction of dormancy in first-year seedlings of *Acer platanoides* L. Scand. J. For. Res. 12:11-16.
Wheeler, N.C. and R.P. Gurries. 1982. Population structure, genetic diversity and morphological variation in *Pinus contorta* Dougl. Can. J. For. Res. 12:595-606.
Wright, S. 1943. Isolation by distance. Genetics 28:114-138.
Yang, R-C. and F.C. Yeh. 1995. Patterns of gene flow and geographic structure in *Pinus contorta* Dougl. For. Genetics 2:65-75.

Evaluation of genetic resources in Noble Hardwoods

Bart A. de Cuyper
Institute for Forestry and Game Management, 1560 Hoeilaart, Belgium

Introduction

During the last decades, forestry in Europe has shown a growing awareness of the high importance of a specific group of tree species known as Noble Hardwoods. The acknowledgement of their eminent silvicultural, economic and/or ecological values led to their upgrading from a former status of 'minor' species.

Out of this awareness arose a major concern to safeguard the existing resources of these species (isolated individuals, relict populations, small-scale homogeneous stands). Because one can not protect what one does not know, substantial efforts have been needed, in the first place, to identify the still existing resources.

Furthermore, the gene conservation programmes, set off in different European countries, very rapidly urged for an effective characterization of these resources once they had been identified. In this way a varying set of criteria, techniques and traits was developed and applied in each country, aiming at:

- determination of wild forms *vis-à-vis* cultivated and hybrid forms (e.g. wild apple)
- assessment of the levels of (genetic) diversity within the entities
- characterization of diversity between geographically disjunct entities.

The EUFORGEN Noble Hardwoods Network provides a mechanism for monitoring the practices currently used throughout Europe for such evaluation of genetic resources. In order to carry out an overview of the current evaluation methods and practices in different countries, a questionnaire was chosen as the most appropriate way to gain good information from all the participating countries (see list of Participants).

It was agreed to classify the different traits used for evaluation of Noble Hardwoods genetic resources into four categories: morphology, phenology, resistance characteristics and biochemical/genetic traits.

The received information was rearranged into a fairly limited number of tables representing the individual Noble Harwood species. The aim is to provide each member of the Network (and other scientists concerned) with a guide indicating where to search for additional information in order to compare, complete, refine and/or optimize their own evaluation techniques.

The purpose of this task is certainly not to produce one uniform methodology for the evaluation of Noble Hardwood species in all countries. The form of the questionnaire used for conducting this survey allowed for obtaining well-balanced and standard information. However, one should keep in mind that putting the available information into a fixed questionnaire inevitably entails a certain loss of information which does not fit into the presented form and can not be comprehended in the following overview tables (Tables 1-16).

Some similarities and common features between the different countries could be observed:

1. For all species considered, the evaluation of genetic resources is most often done on the basis of morphological and phenological traits, as these are readily observable and do not require any sophisticated equipment (Fig. 1). Exception is made for the *Ulmus* species, for which tolerance/susceptibility to the Dutch elm disease is adopted as a major distinctive characteristic used.
2. Morphological observations most often focus on leaves and fruits/seeds (Fig. 2). Among all phenological traits observed, flushing and flowering appear to be the most important ones (Fig. 3).

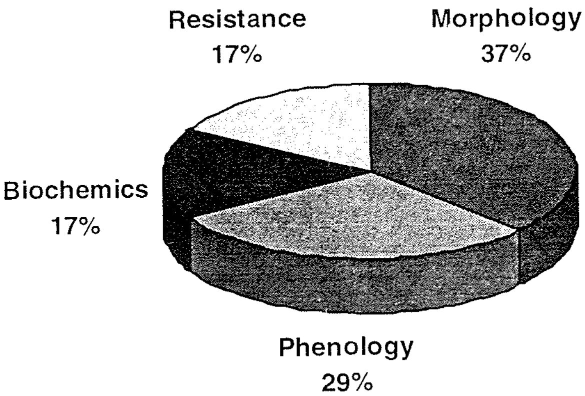


Fig. 1. Relative importance of evaluation techniques.

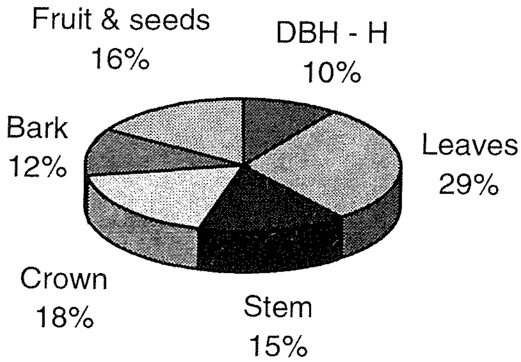


Fig. 2. Relative importance of morphological traits.

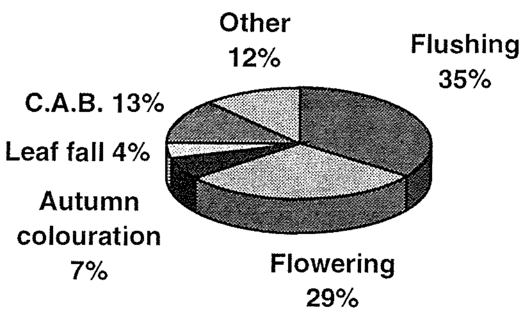


Fig. 3. Relative importance of phenological traits.

Legend for Tables 1 - 16.

Morphology	M1 = Leaves; M2 = Fruits and seeds; M3 = Crown; M4 = Stem; M5 = Bark; M6 = Growth (DBH-H); M7 = Other
Phenology	Ph1 = Flushing; Ph2 = Flowering; Ph3 = Closure of apical bud; Ph4 = Leaf Fall; Ph5 = Autumn colouration; Ph6 = Other
Biochemical/genetic traits	BG1 = DNA analysis; BG2 = Isozymes
Res	Resistance characteristics

Table 1. *Acer pseudoplatanus*

	Morphology							Phenology						B/G		Res
	M1	M2	M3	M4	M5	M6	M7	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	BG1	BG2	
Belgium																
Croatia																
Czech Rep.																
Germany													A			
Netherlands							B									
Romania																
Russ. Fed.																
Slovakia																

A = lamma shoots; **B** = buds.

Table 2. *Acer campestre*

	Morphology							Phenology						B/G		Res
	M1	M2	M3	M4	M5	M6	M7	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	BG1	BG2	
Denmark																
Germany													A			
Netherlands							B									

A = lamma shoots; **B** = buds.

Table 3. *Acer platanoides*

	Morphology†							Phenology‡						B/G§		Res¶
	M1	M2	M3	M4	M5	M6	M7	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	BG1	BG2	
Croatia																
Denmark																
Finland																
Germany													A			
Lithuania																B
Poland																
Russ. Fed.																C
Sweden																

A = lamma shoots; **B** = *Rhytisma acerinum*; **C** = *Oxyporus populinus*.

Table 4. *Tilia cordata*

	Morphology							Phenology						B/G		Res
	M1	M2	M3	M4	M5	M6	M7	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	BG1	BG2	
Croatia																
Denmark															A	
Finland													B		C	
Germany													D			
Lithuania																E
Netherlands							F									
Poland														G	H	
Russ. Fed.																I
Slovakia																J

A = pilot study on use of isozymes; **B** = reproductive biology (pollen tube growth); **C** = not fully operational; **D** = lamma shoots; **E** = inventory of fungi; **F** = buds; **G** = other: chemotaxonomy; **H** = *Pestalozzia hartigii, Apognominia tiliae, Nectria ditissima, N. galligena, Fomes fomentarius*; **I** = Polyporaceae, *Armillaria mellea, Viscum album*; **J** = *Fomes igniarius, Fomes fomentarius, Cercospora microsora, Thyrostroma comactum*.

Table 5. *Tilia platyphyllos*

	Morphology							Phenology						B/G		Res
	M1	M2	M3	M4	M5	M6	M7	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	BG1	BG2	
Croatia	■							■	■					■	■	
Czech Rep.	■		■	■												
Denmark	■							■	■	■					A	
Germany	■							■	■	■			B			
Netherlands	■		■	■			C									
Poland	■	■						■	■					D	E	
Romania								■	■	■						
Slovakia	■		■	■	■	■	F									G

A = pilot study on use of isozymes; **B** = lamma shoots; **C** = buds; **D** = other: chemotaxonomy; **E** = *Pestalozzia hartigii, Apognominia tiliae, Nectria ditissima, Fomes fomentarius*; **F** = using 10 qualitative morphological traits; **G** = inventory of fungi.

Table 6. *Alnus cordata*

	Morphology							Phenology						B/G		Res
	M1	M2	M3	M4	M5	M6	M7	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	BG1	BG2	
Italy	■					■		■		■						

Table 7. *Alnus glutinosa*

	Morphology							Phenology						B/G		Res
	M1	M2	M3	M4	M5	M6	M7	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	BG1	BG2	
Croatia	■							■	■			■		■	■	
Czech Rep.	■		■	■												
Germany								■	■	■			A			
Lithuania	■	■			■			■	■							
Netherlands	■		■	■					■				B			
Poland	■	■						■	■							C
Slovakia			■	■	■	■							D			E

A = lamma shoots; **B** = assessment of ecotype; **C** = *Taphrina alni, Inonotus radiatus, Armillaria mellea*; **D** = assessment of vitality and social position; **E** = inventory of fungi.

Table 8. *Sorbus torminalis*

	Morphology							Phenology						B/G		Res
	M1	M2	M3	M4	M5	M6	M7	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	BG1	BG2	
Czech Rep.			■	■												
France	■							■	■				A	B	■	
Germany								■	■	■			C			
Hungary	■															
Poland	■	■														
Slovakia	■		■	■	■	■									■	D
Switzerland				■			■								■	

A = assessment of mortality; **B** = CpDNA; **C** = lamma shoots; **D** = overall inventory of pathogens.

Table 9. *Sorbus domestica*

	Morphology							Phenology						B/G		Res
	M1	M2	M3	M4	M5	M6	M7	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	BG1	BG2	
Austria				■				■								A
France								■								B
Germany	■	■						■	■	■		■	C			
Hungary	■															
Poland	■	■														
Slovakia	■		■	■	■	■									■	D
Sweden															■	
Switzerland		■		■			E						F			G

A = assessment of frost hardiness; **B** = *Erwinia amylovora*; **C** = lamma shoots; **D** = overall inventory of pathogens; **E** = selection of plus trees; **F** = seed weight and germination; **G** = *Nectria* spp.

Table 10. *Sorbus aucuparia*

	Morphology							Phenology						B/G		Res
	M1	M2	M3	M4	M5	M6	M7	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	BG1	BG2	
Croatia			■	■												
Finland								■	■							
Hungary	■															
Netherlands	■															
Poland	■	■														
Russ. Fed.	■	■	■	■	■			■	■	■		■				

Table 11. *Pyrus nivalis*

	Morphology							Phenology						B/G		Res
	M1	M2	M3	M4	M5	M6	M7	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	BG1	BG2	
Austria	■	■					A									
Slovakia	■		■	■	■	■										

A = flowers and twigs.

Table 12. *Pyrus pyraster*

	Morphology							Phenology						B/G		Res
	M1	M2	M3	M4	M5	M6	M7	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	BG1	BG2	
Austria	■	■					A									
Germany	■	■					B	■	■	■			C			
Hungary	■															
Slovakia	■		■	■	■	■										

A = flowers and twigs; **B** = buds; **C** = lamma shoots.

Table 13. *Pyrus communis*

	Morphology							Phenology						B/G		Res
	M1	M2	M3	M4	M5	M6	M7	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	BG1	BG2	
Austria	■	■					A									
Lithuania	■	■			■											

A = flowers and twigs.

Table 14. *Malus sylvestris*

	Morphology							Phenology						B/G		Res
	M1	M2	M3	M4	M5	M6	M7	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	BG1	BG2	
Austria							A									
Belgium							A									
Germany							B						C			
Lithuania																
Russ. Fed.																

A flowers and twigs; **B** = buds; **C** = lamma shoots.

Table 15. *Castanea sativa*

	Morphology							Phenology						B/G		Res
	M1	M2	M3	M4	M5	M6	M7	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	BG1	BG2	
Croatia																A
Italy															B	A
Spain							C									

A = *Endothia parasitica*; **B** = RFLP and RAPD; **C** = twigs.

Table 16. *Ulmus glabra, Ulmus minor, Ulmus laevis*

	Morphology							Phenology						B/G		Res
	M1	M2	M3	M4	M5	M6	M7	Ph1	Ph2	Ph3	Ph4	Ph5	Ph6	BG1	BG2	
Belgium																A
Croatia																A
Czech Rep.																A
Finland															B	
France														C		A
Germany													D			
Lithuania			B													A
Netherlands							E									A
Poland																
Romania																
Slovakia																A
Spain																A

A = *Ophiostoma novo-ulmi*; **B** = *U. laevis* only; **C** = AFLP and microsatellites; **D** = lamma shoots; **D** = buds and twigs.

Common minimum descriptors for Noble Hardwoods

Jan Sveigaard Jensen
Forest and Landscape Research Institute, 2970 Hørsholm, Denmark

Introduction

This outline results from discussions at the Network meeting in Lourizán. It includes a list of common minimum descriptors suggested for Noble Hardwoods.

Countries and institutes will have their own databases with differently structured and detailed information level, but the minimum set of descriptors should be common to all. A common Network database, hosted by a volunteer institute may be established later.

In a list of descriptors for *Ulmus*, Nieto and Gil (1996) refer to IPGRI's standard definitions of passport, management, environment, characterization and evaluation descriptors. "Evaluation descriptors" include most common genetic descriptors. Their proposal includes description of morphological data on single trees.

Noble Hardwoods include several fruit tree species. Standard descriptor lists (IPGRI) for peach, apple and cherry are primarily constructed for single tree description with a high number of describing characters, particularly related to the economical importance.

Within forest tree breeding, several databases exist. They often include technical data, and need to be maintained by trained specialists (SQL databases). They are constructed for single tree units as well, however a limited number of characteristics is used. Some of these databases may easily be fitted to gene conservation purposes.

Stand evaluation descriptors are proposed by Danida Forest Seed Center (1996). It can be argued that stand be the basic unit for evaluation rather than a collective of well-described individuals. The stand may be regarded as composed of single species being members of a complex system. Factors as life history, management, ownership, geography, climate and regeneration may be very important parameters for conservation purposes. The stand and its variability is the central unit for evaluation. The descriptors may reflect the multipurpose use of the stand, its socio-economic value. These aspects may be important for *in situ* conservation stands, but obviously no importance for pollen banks.

The group of Noble Hardwoods may be described as being very heterogeneous. Some of the species are fragmented in their distribution, or even occupy marginal sites outside optimum habitats for the respective species. Noble Hardwoods are often threatened by deforestation, improper forest management, agriculture, etc. Another problem is the wide use of non-local provenances.

A simple list of descriptors, similarly to the model developed by the *Picea abies* Network, is proposed. Then we suggest a number of additional descriptors which may be useful specifically for Noble Hardwoods. This proposal for descriptors has been developed in discussion with Erik D. Kjær (Tree Improvement Station) and Allan Breum Larsen (Danida Forest Seed Center) in Denmark.

Common minimum descriptors for genetic resources

1 Name of species
Including name of species, subspecies, etc.

2 Country where maintained
Name of country or three-letter official country abbreviation (ISO code).

3 Registration number

A national number identifying the genetic resource. As most countries have different systems for different institutions and/or type of units, the registration number will consist of two parts, the first one identifying the national system and the second the code within the system.

4 Name of genetic resource

4.1 The local name under which the genetic resource is known and name of locality or municipality

4.2 Forest region or district, where applicable

5 Geographic location of site

5.1 Latitude
Degrees (°) and minutes (′) followed by N or S.

5.2 Longitude
Degrees (°) and minutes (′) followed by N or S.

5.3 Elevation
Lower altitude of site (m above sea level).
Upper altitude of site (m above sea level).

The geographic parameters refer to the site where the genetic resource is growing in the wild (*in situ* and *ex situ*), or is stored.

6 Responsible institution and ownership

6.1 Name of institution responsible for identification and maintenance, and contact address

6.2 Ownership: forest owner, institution or ministry

7 Type and function of genetic resource

Categories are

- *in situ* natural population(s) or plantation(s):
    - nature reserve
    - national park
    - protected area
    - gene reserve forest/ stand/ population
- *ex situ* plantation:
    - one seed origin (known or unknown)
    - several seed origins, mixed
    - several seed origins, replicated, identity kept (provenance trial)
    - several families, replicated, identity kept (progeny trial)
    - several clones, replicated, identity kept (clonal trial)
- *ex situ* collection:
    - clonal archive
    - seed orchard
    - seed bank
    - pollen bank
    - tissue bank

8 Site information

8.1 Total area of genetic resource in hectares, with one decimal if smaller area
Proportion of area covered by major species
Ecological zone/ecoregion
Climatic zone
Closest or most representative meteorological station.

9 Genetic evaluation

Have the genetic resources been evaluated genetically ?

If "yes" specify the type of evaluation: provenance, progeny or clonal test, biochemical or molecular characterizations.

10 Date of approval

Date on which the genetic resource was approved (in the format YYYYMMDD)

Remarks

The term genetic resources is used to denote all collections of biological material that are managed with gene conservation objectives in mind; including natural populations, plantations, clonal banks, seed and pollen collections. The descriptors proposed are not intended for individual families, genotypes, individual seed or pollen lots. Only a few of the proposed descriptors are coded into a specific format. No attempts are made to produce a standardized coding system of all descriptors. Conservation and utilization of genetic resources has to be applied according to several objectives, especially if dealing with as heterogeneous a group as Noble Hardwoods. Different methods will be applicable at the same time, and it is not possible to identify a set of common descriptors that are meaningful or can be used for all types of genetic resources. A set of additional or voluntary descriptors is given below.

Suggestions for additional or voluntary descriptors for genetic resources

- **Original seed source**

Ex situ stands may be composed of many different seed origins or single. This may indicate the geographical representation. Such data may be overwhelming, and are not compulsory.

- **Status of conservation**

Danger of extinction – IUCN status category.

- **Regeneration**

Natural regeneration, replanting.

- **Tree data**
    - Age: young-middle aged-old
    - Size: (dimension – distribution)
    - Numbers: (numbers at regeneration stage).

- **Topography**
    - Slope
    - Mountain, hill, upland, plain, plateau, basin, valley.

- **Soil texture**
    - Sand, loamy sand, silty loam, loam, clay loam, clay
    - Stoniness.

- **Additional use of the area**

The area may be used for conservation of wildlife, etc. Point 6 (see minimum descriptors above) could include more specific information about area utilization.

- **Management regime**
  - Recent and earlier land-use history: high forest, coppice forest
  - Required management: thinning, removal of unwanted species
  - Game management.

- **Threats**
  - Inbreeding, species competition, pollution
  - Status of protection: undisturbed, disturbed.

- **Isolation**
  - Barriers for the control of geneflow and the invasion of species/ provenances
  - Genepool in danger of contamination (currently) – potentially ().

- **Year of establishment**

- **Seed crop**

Light – medium – heavy.

- **Associated species**

Noble Hardwoods often exist in mixtures influencing each other.

References

Danida Forest Seed Center. 1996. Note on Field Assessment of *Ex Situ* conservation stands. Evaluation of the FAO coordinated *ex situ* forest genetic resources conservation programme.

Garcia Nieto, M.E. and L. Gil. 1996. Descriptors for elm. Dpto. de Selvicultura. E.T.S.I. Montes, Madrid, Spain.

Schmidt, H., J. Vittrup-Christensen, R. Watkins and R.A. Smith. 1985. Cherry descriptor list. IBPGR Secretariat, Rome, Italy.

Turok, J. and V. Koski. 1997. *Picea abies* Network. Report of the second meeting, 5-7 September 1996, Hyytiälä, Finland. IPGRI, Rome, Italy.

Overview of ongoing research projects

Andrey Prokazin
Russian Tree Breeding Centre, 141200 Pushkino, Russian Federation

Species or group of species	Key words describing objectives and character of project	Duration	Partner institutes (name or number of)	
			National	Internat.
Austria				
Sorbus torminalis	propagation methods	1994 →	BOKU (Inst. of Silviculture)	5
Sorbus domestica	provenance testing geographic inventory, mating system, propagation methods	1992 → 1994 →	FBVA; BOKU (Inst. of Silviculture)	2
Juglans regia, Pyrus communis	provenance testing	1994 →	FBVA	
Sorbus aucuparia	biochemical markers, differentiation between subspecies	1996 →	BOKU (Inst. of Silviculture)	2
Prunus avium	provenance testing	1992 →	FBVA	
Ulmus spp.	vegetative propagation methods	1996 →	FBVA	
Castanea sativa	propagation system, stress physiology, provenance test	1996-2000	Austrian Research Centre	COST G4 "Multi-disciplinary Chestnut Research"
Belgium				
Alnus glutinosa	plus tree selection inventory	1996 →	1	
Malus sylvestris	ecogeographic inventory, propagation methods, clonal archives	1996 →	1	
Mespilus germanica	ecogeographic inventory, propagation methods, clonal archives	1996 →	1	
Ulmus spp.	ecogeographic inventory, propagation methods, clonal archives	1996 →	1	8
Fraxinus excelsior	provenance/progeny testing, plus tree selection, seed orchards	1987 →	2	5
Prunus avium	provenance/progeny testing, plus tree selection, seed orchards, clonal testing	1980 →	2	
Acer pseudoplatanus	provenance/progeny testing, plus tree selection, seed orchards	1993 →	2	

Species or group of species	Key words describing objectives and character of project	Duration	Partner institutes (name or number of) National	Internat.
Croatia				
Juglans regia	progeny testing, phenology, wood quality, frost resistance	1996-2000	Public Enterprise "Hrvatske Sume"	
Czech Republic				
Fraxinus spp.	provenance trial	1997-2001	1	
Wild fruit trees, *Sorbus* spp.	ecogeographic inventories, conserv-ation methods, strategy	1997-2001	1	
All Noble Hardwoods	*in vitro* propagation methods	1996-1999	1	
Fraxinus, Ulmus, Acer, Tilia, Wild fruit trees, *Sorbus*	*in situ* management, conservation methods, strategy - regional project	1996-1999	1	
All Noble Hardwoods	seed pathology, storage methods	1996-2000?	1	
Germany				
Prunus avium, Sorbus spp., *Malus sylvestris, Pyrus communis*	database establishment, conservation and utilization strategy	1997-2000	2	5
Sorbus torminalis	seed and plant production, silvicultural treatment	1995-1999	2	
Pyrus communis, Malus sylvestris	morphology, hybridization, isozyme markers	1994-1998	1	
Prunus, Sorbus, Pyrus	micropropagation, cryopreservation	1997-2000	4	
Sorbus domestica, Acer pseudoplatanus, Fraxinus excelsior	provenance/progeny testing	1990-2000	3	4
Hungary				
Prunus avium	*in situ* management: silviculture, regeneration	1995-98	For. Res. Inst. Budapest; Seed centre Kecskemet	
Juglans regia	progeny testing, grafting	1996-99	For. Res. Inst. Budapest	INRA (F), I.S.S. (I)
Pyrus and *Sorbus* microspecies	ecogeographic survey, inventory, *in/ex situ* management	1997→ (project proposal submitted)	For. Res. Inst. Budapest; Univ. Sopron	

Species or group of species	Key words describing objectives and character of project	Duration	Partner institutes (name or number of)	
			National	Internat.
Latvia				
Fraxinus excelsior	provenance testing, phenology, *in situ* management, silviculture, afforestation methods	1997-2000	1	
Prunus avium	progeny testing, morphology, phenology, ecogeographic inventories, adaptability, afforestation methods	1997-2000	1	
Alnus glutinosa	ecogeographic inventories, *in situ* management, silviculture, seed storage, clonal archives	1997-2000	1	2
Lithuania				
Alnus glutinosa	ecogeographic inventories, selection of populations and single trees, progeny testing, dynamic gene conservation	1996-1997	1	Swedish Institute of Forestry Research
Fraxinus excelsior, Betula pendula	ecogeographic inventory, selection of population and single trees	1995-1997	1	
The Netherlands				
Prunus avium	provenance/progeny testing, propagation methods, reforestation	continuous	1 (State Forest Service)	
Fraxinus excelsior	provenance/progeny testing, reforestation	continuous	1 (State Forest Service)	
Poland				
Fraxinus excelsior	progeny testing, genetic diversity, phenology	1995 →	1	
Betula pendula	provenance testing, progeny testing, silviculture	1997 →	3	
Romania				
Fraxinus excelsior, Acer pseudoplatanus, Prunus avium, Alnus glutinosa, Sorbus, Tilia, Cornus mas	ecogeographic inventories, *in situ* management, silviculture, regeneration	1997-1999	ICAS	

Species or group of species	Key words describing objectives and character of project	Duration	Partner institutes (name or number of) National	Internat.
Ulmus spp.	progeny testing collecting, ecogeographic inventories, *in situ* management exchange of biological material for DNA analyses	1997-2002	For. Res. Station Padurea Verde (Timisoara)	CEMAGREF, France
Russian Federation				
All Noble Hardwoods	ecogeographic inventories, breeding, seed orchards, *in situ* conservation	1982 →	Fed. Forest Service (11 institutes)	
All Noble Hardwoods	databases	1998	3	1 (IPGRI)
Slovakia				
Prunus avium, *Acer*, *Alnus glutinosa*, *Tilia*	ecogeographic inventories, provenance testing, isoenzyme markers, propagation	1990 →	Fac Forestry Zvolen	
Sorbus, *Pyrus*	ecogeographic inventories, phenology, progeny testing	1996-1998	Fac Gard. Landscape Managemt. Agric. Univ. Nitra	
Ulmus, *Fraxinus* (also *Acer* and *Alnus*)	ecogeographic inventories, *in situ/ex situ* conservation, seed orchards, propagation methods (incl. tissue cultures)	continuous	For. Res. Inst.	
Ulmus, *Fraxinus*	ecogeographic inventories, *in situ/ex situ* conservation, progeny testing	continuous	Admin. of National Parks, Ministry of Environmt.	
Sweden				
Fraxinus excelsior	provenance/progeny testing, phenology, juvenile growth	1994-2000		
Prunus avium	provenance/progeny testing, phenology, juvenile growth	1994-2000		
Prunus avium	progeny testing	2000 →	SkogForsk	
Sorbus aucuparia	phenology, hardiness	2000 →	SkogForsk	
Tilia cordata	progeny testing	2010 →	SkogForsk	
Acer platanoides, *Fraxinus excelsior*	phenology, hardiness	2000 →	SkogForsk	

Species or group of species	Key words describing objectives and character of project	Duration	Partner institutes (name or number of)	
			National	Internat.
Switzerland				
Sorbus domestica	isoenzyme analysis, establishment of seed orchard	1996-97 1998 →	ETH Zürich	University München
Sorbus torminalis	establishment of seed orchard	1998 →	ETH Zürich	
	isoenzyme analysis of diversity in seed orchard	1997 →	ETH Zürich	
	preliminary sampling of diversity	1997/1998	ETH Zürich WSL (research station)	
Juglans regia	progeny trial, planting of new provenances from the natural range (Kyrgyzstan)	1997	ETH Zürich	1
Ukraine				
Fraxinus excelsior	provenance testing, ecogeographic inventories, seed orchards	1995-1999	2	
F. excelsior, F. angustifolia, Acer pseudoplatanus, A. platanoides, Alnus glutinosa	conservation, *in situ* management, silviculture	1995-1999	2	

Literature review: *Ulmus* spp.

Eric Collin
CEMAGREF, 45290 Nogent sur Vernisson, France

This review comprises selected references of publications which are relevant to the conservation and use of genetic resources in elms (*Ulmus* spp.). The list may not be fully exhaustive as to the research fields covered by the review, but attempts to provide an up-to-date status from the Network's viewpoint. The references included should be of interest to scientists and forest managers involved in activities on the genetic resources of elms in Europe.

The contributions to this review from many Network members, participants of the EU Project on elms (GEN RES 78) and other scientists are gratefully acknowledged. The review will be updated and further developed, aiming particularly at 'grey literature' with valuable research results produced in many countries. Such references are often not available internationally. Any comments and suggestions about relevant publications not included in this review are very welcome and should be sent directly to the compiler.

Literature reviews for other Noble Hardwood species are currently under preparation by the Network members and will be available later as a separate joint publication of the Network (see Workplan).

The references in this review are ordered by author and include: year of publication, English title, original title, source and language of text and of summary.

Anonymous. 1982. [Worldwide curing of *Ulmus* spp.; rescue of million trees - destruction of fungus and bark beetle] Weltweite Heilung der Ulmen. Rettung von Millionen Bäumen - Pilz und Splintkäfer werden vernichtet. Internationaler Holzmarkt, Wien 73(16/17):58-59 [German].

Anonymous. 1983. [Worldwide curing of *Ulmus* spp.; rescue of million trees - destruction of fungus and bark beetle] Weltweite Heilung der Ulmen. Rettung von Millionen Bäumen - Pilz und Splintkäfer werden vernichtet. Wald- und Holzwirtschaft, Wien 31(355):43 [German].

Anonymous. 1992. [The elms] Die Ulme (Ruester, Ruste) St. Hubertus, Wien 78(10):9-10 [German].

Armstrong, J.V. 1992. Taxonomy of British Elms. PhD thesis, Univ. of Cambridge [English].

Bartolini, G., A. Fagnani, L. Mittempergher and M. Panicucci. 1997. [Propagation of elms by woody cuttings] Propagazione dell'olmo per talea legnosa. Monti e Boschi 4:48-51 [Italian, summary in English].

Bates, M.R., K.W. Buck and C.M. Brasier. 1990. Molecular variation in the Dutch elm disease fungus. Pp. 171-178 *in* Molecular evolution. Proceedings of a UCLA colloqium, Lake Tahoe, California, 27 February - 6 March 1989 (M.T. Clegg and S.J. O'Brien, eds.). Wiley Liss, New York, USA [English].

Bate-Smith, E.C. and R.H. Richens. 1973. Flavonoid chemistry and taxonomy in *Ulmus*. Biochemical Systematics 1(3):141-146 [English].

Behm, A., A. Becker, H. Dörflinger, A. Franke, J. Kleinschmit, G.H. Melchior, H.-J. Muhs, H.P. Schmitt, B.R. Stephan, U. Tabel, H. Weisgerber and T. Widmaier. 1997. Concept for the Conservation of Forest Genetic Resources in the Federal Republic of Germany. Silvae Genet. 46(1):24-34 [English].

Bilger, I. and E. Collin. 1995. [Conservation of the genetic resources of elm and wild cherry] Conservation des ressources génétiques de l'orme et du merisier.

Cemagref, Nogent-sur-Vernisson (Annual report) 40 p. [French].
Bilger, I. and D. Terrasson. 1993. [Conservation of elm genetic resources] Conservation des ressources génétiques de l'orme. Pp. 29-38 *in* Les dossiers de l'environnement de l'INRA n° 7 (ISSN 1244-7986) [French].
Biondi, S., J. Mirza, L. Mittempergher and N. Bagni. 1991. Selection of elm cell culture variants resistant to *Ophiostoma ulmi* culture filtrate. J. Plant Physiol. 137(5):631-634 [English].
Bob, C.F., B.L. Redmond and D.F. Karnosky. 1986. On the nature of intra- and interspecific incompatibility in *Ulmus*. Am. J. Botany 73(4):465-474 [English].
Bolyard, M.G., R.K. Hajela and M.B. Sticklen. 1991. Microprojectile and *Agrobacterium*-mediated transformation of pioneer elm. J. Arboriculture 17(2):34-37 [English, summary in French].
Bolyard, M.G., C. Srinivasan, J.P. Cheng and M. Sticklen. 1991. Shoot regeneration from leaf explants of American and Chinese elm. HortScience 26(12):1554-1555 [English].
Bonsen, K.J.M., R.J. Scheffer and D.M. Elgersma. 1985. Barrier zone formation as a resistance mechanism of elms to Dutch elm disease. IAWA Bulletin 6(1):71-77 [English].
Boulard, B. 1994. [Recent approaches to Dutch Elm Disease] Approches récentes relatives à la maladie de l'orme. Forêt privée 218:39-47 [French].
Brasier, C.M. 1990. China and the origins of dutch elm disease: an appraisal. Plant Pathol. 39(1):5-16 [English].
Brasier, C.M. 1990. The unexpected element: mycovirus involvement in the outcome of two recent pandemics, Dutch elm disease and chestnut blight. Pp. 289-307 *in* Pests, Pathogens and Plant Communities (J.J. Burdon and S.R. Leather, eds.). Blackwell Scientific Publications, Oxford, UK [English].
Brasier, C.M. 1991. *Ophiostoma novo-ulmi* sp. nov., causative agent of current Dutch elm disease pandemics. Mycopathologia 115(3):151-161 [English].
Brasier, C.M., S. Takai, J.H. Nordin and W.C. Richards. 1990. Differences in cerato-ulmin production between the EAN, NAN and non-aggressive subgroups of *Ophiostoma ulmi*. Plant Pathol. 39(2):231-236 [English].
Brötje, H. 1991. [Have field elms died out ?] Feldulme ausgestorben? Forst- und Holz 46(9):258 [German].
Brötje, H. 1993. [Present situation of the conservation of elm species] Aktuelle Situation bei der Erhaltung der Ulmenarten. Forstarchiv 64:82-83 [German].
Brötje, H. and U. Fellenberg. 1993. [Are elms still to be saved ?] Ist die Ulme noch zu retten? Forschungsberichte, Hess. Forstl. Versuchsanstalt, Band 16, Berichtsband des 1. Ulmensymposiums in Hann. Münden am 21. und 22. Mai 1992, veranstaltet von der Abt. Forstpflanzenzüchtung der Nieders. und der Hess. Forstl. Versuchsanstalt: 39-43 [German].
Brötje, H. and U. Fellenberg. 1993. [First experience of elm conservation in Northern Germany] Erste Erfahrungen mit der Ulmenerhaltung in Norddeutschland. Papier der Niedersächsischen Forstl. Versuchsanstalt: 39-43 [German].
Burdekin, D.A., K.D. Rushforth and B.J.W. Greig. 1988. Breeding elms resistant to Dutch Elm Disease. Forest Research Station, Farnham. Arboriculture Res. Note n° 2.88.PATH. 3 p. [English].
Cheng, Z.-M., N.-Q. Shi, D.E. Herman and T.K. Capps. 1997. Building in resistance to Dutch Elm Disease. J. Forestry, March, p. 24-27 [English].
Collin, E. 1996. [National programme for the conservation of elm genetic resources : note on elm propagation with softcuttings] Programme national de conservation des ressources génétiques des ormes : note sur le bouturage herbacé de l'orme. Cemagref, Nogent-sur-Vernisson (Information note) 1 p. [French].
Collin, E. and I. Bilger. 1995. [National programme for the conservation of elm genetic resources: Cemagref's clone collection] Programme national de

conservation des ressources génétiques des ormes : la collection de clones d'ormes du Cemagref. Cemagref, Nogent-sur-Vernisson [Information note] 1 p. [French].

Collin, E. and I. Bilger. 1996. Conservation and study of native elm genetic resources in France. First meeting of the EUFORGEN Noble Hardwoods network, Escherode, DEU, 24-27 March 1996, pp. 12-15 [English].

De Vries, S. 1996. [Developments in the elm catalogue] Ontwikkelingen in het iepensortiment. Groen 4:18-21 [Dutch].

Dorion, N., B. Godin and C. Bigot. 1993. Physiological state and clonal variability effects on low temperature storage of *in vitro* shoot cultures of elms (*Ulmus* sp.). Sci. Hortic. 56(1):51-59 [English].

Dorion, N., P. Danthu and C. Bigot. 1987. [Vegetative propagation *in vitro* of some elm species. Multiplication vegetative *in vitro* de quelques especes d'ormes.] Ann. Sci. Forestières 44(1):103-118 [French, summary in English].

Dorion, N., P. Danthu, S. Ohki, C. Preneux, B. Godin and C. Bigot. 1991. [Regeneration from leaf protoplasts of elm (*Ulmus campestris*)] Regeneration de plantes a partir de protoplastes foliaires d'un clone d'orme champetre (*Ulmus campestris* Mill.). C. R. Acad. Sci., Ser. 3, Science de la Vie 313(10):467-473 [French, summary in English].

Duchesne, L.C. 1988. Resistance mechanisms to Dutch elm disease: a review. Naturaliste Canadien 115(2):163-167 [English, summary in French].

Duchesne, L.C., R.S. Jeng, M. Hubbes and M.B. Sticklen. 1990. Accumulation of mansonones E and F in seedlings of *Ulmus americana* in response to inoculation with *Ophiostoma ulmi*. Trees: Structure and Function 4(4):187-190 [English].

Fenning, T.M., S.S. Tymens, J.S. Gartland, C.M. Brasier and K.M.A. Gartland. 1996. Transformation and regeneration of English elm using wild-type *Agrobacterium tumefasciens*. Plant Sci. 116:37-46 [English].

Feugey, L. 1990. [Study of the expression of resistance to D.E.D.] Etude de l'expression de la résistance de l'orme à la graphiose. Mémoire de DEA, University of Clermont Ferrand II. 70 p. [French].

Feugey, L. 1991. [Experimentation of bacterian metabolites for the control of D.E.D.] Essai d'utilisation de métabolites bactériens dans la lutte contre la graphiose de l'orme provoquée par l'*Ophiostoma ulmi* (Buisman) Nannf. Mémoire de DEA, University of Nantes [French].

Franke, A. 1990. [Conservation of forest genetic resources in Baden-Württemberg] Erhaltung forstlicher Genressourcen in Baden-Württemberg. Mitteilungen des Vereins für Forstliche Standortskunde Forstpflanzenzüchtung 35:79-84 [German].

Fröhlich, H.J. 1988. [Great value of elms along the Rhine] Ulmenkostbarkeit am Rhein? Allg. Forstzeitschr. 43 (49): 1348 [German].

Gaillard, A. and S. Mischel. 1994. [Study of foliar morphology of elms] Etude de la morphologie foliaire des ormes. Université de Paris XI, Laboratoire d'Evolution et de Systématique Végétales. 56 p. [French].

Garcia-Nieto Rivero, M.E. and C. Morla Juaristi. 1990. [The elms in the landscape of the Iberian peninsula] Los olmos en el paisaje vegetal de la peninsula iberica. Chap. 4, pp. 99-118 *in* Los Olmos y la Graphiosis en Espana (L. Gil, ed.). ICONA [Spanish].

Gibbs, J.N. and D. Patch. 1982. Decay and disintegration of dead elms. Forest research station, Farnham. Arboriculture Res. Note n° 16.82.PATH. 1 p. [English].

Gibbs, J., J. Webber, J. Armstrong and C. Brasier. 1997. Elm workshop: the proceedings. Native Elm Workshop, UK, Nov. 1996. Elm Newsletter, The Conservation Foundation 1:3-4 [English].

Gil, L., Coord. 1990. [The elms and D.E.D. in Spain] Los Olmos y la grafiosis en

Espana Ministerio de agricultura pesca y alimentacion, ICONA, Madrid, ESP. 300 p. [Spanish].

Gil, L. and M.E. Garcia-Nieto Rivero. 1990. [Paleobotanic and history of elms in the Iberian peninsula] Paleobotanica e historia de los olmos de la peninsula iberica. Chap. 2, pp. 29-65 *in* Los Olmos y la Graphiosis en Espana (L. Gil, ed.). ICONA [Spanish].

Gil, L., M.E. Garcia-Nieto Rivero and M.L. Salvador Nemoz. 1990. [The genetic improvement of Spanish elms] La mejora genetica de los olmos espagnoles. Chap. 8, pp. 275-300 *in* Los Olmos y la Graphiosis en Espana (L. Gil, ed.). ICONA [Spanish].

Green, C.E., R.P. Guries and E.B. Smalley. 1985. Early screening of elms for resistance to Ceratocystis ulmi. Plant Disease 69(1):60-63 [English].

Greig, B.J.W. 1988. English elm regeneration. Forest research station, Farnham. Arboriculture Res. Note n° 13.88.PAT. 4 p. [English].

Greig, B.J.W. 1990. Ceratotect : a fungicide treatment for Dutch elm disease Forest research station, Farnham. Arboriculture Res. Note n° 61.90.PAT [English].

Günzl, L. 1994. [To guarantee the survival of *Ulmus* spp. in Austria] Das Überleben der Ulmen in Österreich sichern. Österreichische Forstzeitung, Klosterneuburg 105(2):17 [German].

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(1-2):16-20 [English].

Heimler, D., A. Pieroni, L. Mittempergher and P. Buzzini. 1993. The use of flavonoid glycosides for the identification of elm hybrids. Can. J. Forest Res. 23(4):611-616 [English, summary in French].

Heitmüller, H.H. 1951. [Contribution to the vegetative propagation of forest trees] Beiträge zur vegetativen Vermehrung der Waldbäume. Dissertation, Hann.-Münden 1951: 120 pp. [German].

Heybroeck, H.M. 1978. [The recognition of elms] Het herkennen van iepen. Institute De Dorschkamp . Wageningen. 39 p. [Dutch].

Heybroeck, H.M. 1989. [Dendrological brush-up: *Ulmus laevis*] Dendrologische opfrisser: *Ulmus laevis*. Nederlands Bosbouw Tijdschrift 61(1):26-27 [Dutch].

Heybroeck, H.M. 1990. [The elms, companions of Man] Los olmos, companeros de la humanidad. Chap. 1, pp. 17-25 *in* Los Olmos y la Graphiosis en Espana (L. Gil, ed.). ICONA [Spanish].

Heybroeck, H.M. 1992. The dutch elm breeding program. Institute for forestry and nature research, Wageningen (text of the communication presented at the workshop 'Recent approaches to the DED problem', Michigan State University, 1-4 August 1992). 12 p. [English].

Hintz, W.E., R.S. Jeng, D.Q. Yang, M.M. Hubbes and P.A. Horgen. 1993. A genetic survey of the pathogenic fungus *Ophiostoma ulmi* across a Dutch elm disease front in western Canada. Genome 36(3):418-426 [English, summary in French].

Hubbes, M. 1988. Pathogen virulence and host reaction in Dutch elm disease. Naturaliste Canadien 115(2):157-161 [English, summary in French].

Huberty, J. 1904. [Forestry and botanic study on elms] Etude forestière et botanique sur les ormes. Bull. de la société centrale forestière de Belgique 11:408- 861 (94 p.) [French].

Huberty, J. 1905. [Forestry and botanic study on elms] Etude forestière et botanique sur les ormes. Bull. de la société centrale forestière de Belgique 12:1-178 (46 p.) [French].

Ipinza, R. 1989. [Contribution to the numeric taxonomy of Spanish Elms] Contribucion a la taxonomia numerica de los olmos ibericos a través de algoritmos de classificacion jerarquica. PhD thesis, Univ. of Madrid [Spanish].

Ipinza, R. 1990. [Aspects of the taxonomy of iberian elms] Algunos aspectos relevantes sobre la taxonomia de los olmos ibericos. Chap. 3, pp. 69-96 *in* Los Olmos y la Graphiosis en Espana (L. Gil, ed.). ICONA [Spanish].

Ipinza, R., A. Martinez de Azagra, M.L. Salvador Nemoz and F.D. Calonge. 1990. [Mycology and epidemiology of *Ceratocystis* (*Ophiostoma*) *ulmi* (Buism.) Moreau.] Considerationes micologicas y epidemiologicas de *Ceratocystis* (*Ophiostoma*) *ulmi* (Buism.) Moreau. Chap. 5, pp. 121-164 *in* Los Olmos y la Graphiosis en Espana (L. Gil, ed.). ICONA [Spanish].

Janssen, A. 1993. [A research and conservation programme for Elms in Hessen] Erfahrungen in einem Erhaltungs- und Züchtungsprogramm mit Ulme in Hessen. Forschungsberichte, Hess. Forstl. Versuchsanstalt, Band 16:30-38 [German].

Jin, L.S. and C.M. Brasier. 1986. Experiments on the control of Dutch elm disease by injection of *Pseudomonas* species. Eur. J. Forest Pathol. 16(5/6):280-292 [English, summary in German and French].

Jobling, J. and A.F. Mitchel. 1974. Field recognition of British Elms. HMSO, London. 24 p. [English].

Koss, H. 1995. [The conservation of endangered black poplar and field elm species in Saxony] Die Erhaltung der in Sachsen-Anhalt vom Aussterben bedrohten Arten Schwarzpappel (*Populus nigra* L.) und Feldulme (*Ulmus minor* Mill.). *In* Die Erhaltung der genetischen Ressourcen von Bäumen und Sträuchern. (Proc.): 135-142. [German].

Krames, U. 1995. [Important secondary tree species of forest- and timber industry - *Ulmus* spp.]. Forst- und holzwirtschaftlich bedeutsame Nebenbaumarten. Die Ulmen. Wald- und Holzwirtschaft, Sonderausgabe zum Jahr des Waldes, Wien :43-46 [German].

Lanier, G.N. 1990. [Considerations on the control of D.E.D. by municipalities] Considerationes sobre los problemas en el control municipal de la Graphiosis. Pp. 247-251 *in* Los Olmos y la Graphiosis en Espana (L. Gil, ed.). ICONA [Spanish].

Legrand, P. 1980. [Dutch Elm Disease: survey of the situation in Belgium and research on the relation between disease resistance and wood anatomy]. La graphiose de l'orme: inventaire de la situation en Belgique et recherche d'une relation résistance-anatomie du bois. Mémoire d'Ingénieur, Univ. de Gembloux [French].

Lessel-Dummel, A. 1983. [Research and cultivation of Dutch Elm Disease resistant elms] Zum Stand von Forschung und Züchtung ulmenkrankheits-resistenter Ulmen. Allg. Forstzeitschr. 38(20):518-519 [German].

Lineberger, R.D., M.B. Sticklen, P.M. Pijut, M.A. Kroggel, C.V.M. Fink and S.C. Domir. 1990. Use of protoplast, cell, and shoot tip culture in an elm germplasm improvement program. Acta Hort. 280:247-253. Proceedings of the first ISHS symposium on *in vitro* culture and horticultural breeding, Cesena, Italy, 30 May-3 June 1989 [English].

Linkola, K. 1934. [The European White Elm in the region of the Vanajavesisees] Die Flatterulme (*Ulmus laevis* Pall.) in der Gegend des Vanajavesisees. Acta. For. Fenn. 40:153-203 [German, summary in Finnish].

Machon, N. 1995. [Study of the genetic variability of forest trees : examples of Chesnut and Elm]. PhD thesis, Univ. of Paris-Sud [French].

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 [English].

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 [English].

Mezzetti, B., L. Mittempergher and P. Rosati. 1988. *Ophiostoma ulmi* metabolites and elm cell membrane permeability. Possible use in early tests of resistance. Eur. J.

Forest Pathol. 18(2):77-84 [English, summary in French and German].
Mitchell, A.G. and C.M. Brasier. 1994. Contrasting structure of European and North American populations of *Ophiostoma ulmi.* Mycological Res. 98(5):576-582 [English].
Mittempergher, L. 1983. The development and present state of chestnut blight and Dutch elm disease in Italy. Diversa evoluzione e situazione attuale del cancro della corteccia del castagno e della grafiosi dell'olmo in Italia. Dendronatura 4(2):8-17 [Italian, summary in English].
Mittempergher, L. 1985. [Dutch elm disease: biology, pathogenesis and genetic improvement] Grafiosi dell'olmo: biologia, patogenesi e miglioramento genetico. Informatore Fitopatologico 35(6):11-21 [Italian].
Mittempergher, L. 1989. [The elm decline: from noble hardwood to poor bush] Il declino dell'olmo: da latifoglia nobile a cespuglio. Annali dell'Accademia Italiana di Scienze Forestali 38:585-609 [Italian].
Mittempergher, L. 1990. [The genetic improvement of elms in the EEC research project on D.E.D.] La mejora genetica del olmo en el proyecto de investigacion de la CEE sobre la Grafiosis. Chap. 8, pp. 259-272 *in* Los Olmos y la Graphiosis en Espana (L. Gil, ed.). ICONA [Spanish].
Mittempergher, L. 1996. *Ulmus carpinifolia. In*: Enzyklopädie der Holzgewächse (P. Schütt, H.J. Schuck and U.M. Lang, Hrsg.), III-2, 4. Erg. Lfg. 4/96, 14 S. [German].
Mittempergher, L. and F. Ferrini. 1984. [Resistance to insects as a basic component of integrated control. Remarks on two species of forest trees] La resistenza agli insetti come componente di base della lotta integrata. Rilievi su due specie forestali. La Difesa delle Piante 7(2):89-96 [Italian, summary in English].
Mittempergher, L. and N. La Porta. 1991. Hybridization studies in the Eurasian species of elm (*Ulmus* spp.). Silvae Genet. 40(5-6):237-243 [English].
Mittempergher, L. and N. La Porta. 1993. [*Ophiostoma ulmi*/Elm] *Ophiostoma ulmi*/Olmo. Pp. 412-432 *in* Miglioramento genetico delle piante per resistenza a patogeni e parassiti (Crinò, Sonnino, Saccardo, Buiatti, Porta-Puglia e Surico, eds.). Edagricole, Bologna [Italian].
Mittempergher, L., A. Fagnani and F. Ferrini. 1992. [Planting elms again] Ripiantare gli olmi. Verde Ambiente 8(3):64-71 [Italian].
Mittempergher, L., A. Fagnani and F. Ferrini. 1993. [An interesting poorly known elm: the European white elm] L'olmo ciliato (*Ulmus laevis* Pallas), un olmo europeo interessante e poco conosciuto. Monti e Boschi 44(4):13-17 [Italian].
Mittempergher, L., A. Fagnani and F. Ferrini. 1996. [Present situation of Dutch elm disease in Italy] Il punto sulla grafiosi dell'olmo. Sherwood. Foreste ed Alberi Oggi 2(11):15-20 [Italian].
Mittempergher, L., A. Fagnani, F. Ferrini and G. D'Agostino. 1990. Elm yellows, a disease to be taken into consideration when breeding elm for disease resistance. Proc. 8th Congress of the Mediterranean Phytopathological Union, Agadir, Morocco, Actes Editions, pp. 433-435 [English].
Mittempergher, L., A. Sfalanga, M. Vibio, S. Tegli and A. Bertaccini. 1996. [Phytoplasms in the Ulmaceae] Fitoplasmosi nelle Ulmaceae. Atti del Convegno Annuale della Società Italiana di Patologia Vegetale, Udine, 26-27 Settembre 1996 :62-64. [Italian].
Müller, F. 1996. [Conservation of endangered *Ulmus* spp.] Erhaltung von Restvorkommen gefährdeter Ulmenarten. Österreichische Forstzeitung, Klosterneuburg 107(10):26 [German].
Namvar, K. and W. Spethmann. 1985. [Forest trees of the genus *Ulmus*] Waldbaumarten aus der Gattung *Ulmus* (Ulme, Rüster). Allg. Forst Zeitschrift 40(45):1220-1224 [German].
Nierhaus-Wunderwald, D. 1993. [Dutch Elm Disease: biology, protection and control] La graphiose de l'orme: biologie, prévention et lutte. La forêt 10:30-34

[French].
Pajares Alonso, J.A. and L. Gil. 1990. [The scolyts of elms, vectors of D.E.D.] Los escolitidos del olmo, vectores de la graphiosis. Chap. 6, pp. 167-211 *in* Los Olmos y la Graphiosis en Espana (L. Gil, ed.). ICONA [Spanish].
Pajares Alonso, J.A. and A. Martinez de Azagra. 1990. [The control of D.E.D.] El control de la Graphiosis. Chap. 7, pp. 215-246 *in* Los Olmos y la Graphiosis en Espana (L. Gil, ed.). ICONA [Spanish].
Pancaldi, M., B. Mezzetti, L. Mittempergher and P. Rosati. 1992. [Mutagenesis and selection for resistance to Dutch elm disease of 'field' elm] Mutagenesi e selezione per la resistenza alla grafiosi in olmo 'campestre'. Monti e Boschi 43(3):57-61 [Italian, summary in English].
Parde, J. and J. Pinon. 1987. [Urban forests and elm diseases in Paris and elsewhere 140 years ago] Il y a 140 ans et plus à Paris et ailleurs : forêts urbaines et maladies des ormes. Rev. Forestière Française 46(5):422-430 [French].
Pearce, N.J. and R.H. Richens. 1977. Peroxidase isozymes in some elms (*Ulmus* L.) of eastern England. Watsonia 11(4):382-383 [English].
Perret Receveur, C. 1990. [Dutch Elm Disease epidemics : bibliographic study and description of the present situation in a forest of the Rhine valley (Erstein-Alsace)] Epiphytie de graphiose des ormes: mise au point bibliographique, situation actuelle dans une forêt rhénanne (Erstein-Alsace). U.E.R. des sciences pharmaceutiques, Strasbourg. 67 p. [French].
Pinon, J. 1969. [Bibliography about Dutch Elm Disease] Mise au point bibliographique concernant la maladie hollandaise de l'orme. Institut National de la Recherche Agronomique, Laboratoire de Botanique Forestière. 54 p. [French].
Pinon, J. 1995. [Report on the testing of native French elms for their susceptibility to D.E.D.] Rapport de convention sur l'évaluation de la sensibilité à la Graphiose de clones d'ormes indigènes français. Laboratoire de Pathologie Forestière, Institut National de la Recherche Agronomique. 7 p. (report to Cemagref in the frame of a convention with the Min. of Agric.) [French].
Pinon, J. and L. Feugey, Coords. 1993. [Dutch Elm Disease: impact in France, scientific bases for D.E.D. control, research lines in France] La graphiose de l'orme: exemples d'impact en France , bases scientifiques de la lutte , perspectives des recherches françaises. Les dossiers de l'environnement de l'INRA n° 7 (ISSN 1244-7986) [French].
Pinon, J. and L. Feugey. 1994. [D.E.D.: a disease with clearly identified causes] La graphiose de l'orme: une maladie à causes bien identifiées. Rev. Forestière Française 46(3):231-233 [French].
Pinon, J., C. Lohou and A. Cadic. 1998. Hybrid elms: adaptability in Paris and behaviour towards Dutch Elm Disease. Proceed. of the Int. Symp. on Urban Tree Health, Paris, 22-26 Sept. 1997 (in press) [English].
Richens, R.H. 1976. Variation, cytogenetics and breeding of the European field elm (*Ulmus minor* Miller sensu latissimo = *U. carpinifolia* Suckow). Analiza Sumarstvo 7(4):107-145 [English, summary in Croatian].
Richens, R.H. 1980. On fine distinctions in *Ulmus* L. Taxon 29(2/3):305-312 [English].
Richens, R.H. 1983. Elm. Cambridge University Press, Cambridge, UK. 347 p. [English].
Richens, R.H. 1984. *Ulmus* X *hollandica* Miller var. *insularum* Richens, var. nov. Watsonia 15(2):105-108 [English].
Richens, R.H. 1986. The history of the elms of Wales. Nature in Wales 5(1-2):3-11 [English].
Richens, R.H. and J.N.R. Jeffers. 1976. Multivariate analysis of the Elms of Northern France. I. Variation within France. Silvae Genet. 24(5/6):141-150 [English,

summary in German].
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 Genet. 27(3/4):85-95 [English].
Richens, R.H. and J.N.R. Jeffers. 1985. The elms of Wales. Forestry 58(1):8-25 [English].
Richens, R.H. and N.J. Pearce. 1984. Isoperoxidase variation in *Ulmus* L. Forestry 57(1):75-84 [English].
Sacchetti, P., R. Tiberi and L. Mittempergher. 1990. [Preference of *Scolytus multistriatus* (Marsham) during the gonad maturation phase between two species of elm] Preferenza di *Scolytus multistriatus* (Marsham) durante la fase di maturazione delle gonadi nei confronti di due specie di olmo. Redia 73(2):347-354 [Italian, summary in English].
Santamour, F.S, Jr. 1989. Flowering and fertility of hybrids between spring- and fall-flowering elms. HortScience 24(1):139-140 [English].
Scheffer, R.J. 1986. Dutch elm disease; prospects for integrated control. Fundamental and applied aspects of invertebrate pathology, pp. 489-493. Foundation of the Fourth International Colloquium of Invertebrate Pathology, Wageningen, Netherlands [English].
Scheffer, R.J. 1989. Pseudomonas for biological control of Dutch elm disease. III. Field trials at various locations in the Netherlands. Neth. J. Plant Pathol. 95(6):305-318 [English, summary in Dutch].
Scheffer, R.J. 1990. Mechanisms involved in biological control of Dutch elm disease. J. Phytopathology 130(4):265-276 [English, summary in German].
Scheffer, R.J. and G.A. Strobel. 1988. Dutch elm disease, a model tree disease for biological control. Pp. 103-119 *in* Biocontrol of Plant Diseases. Vol. II. (K.G. Mukerji and K.L. Garg, eds.). CRC Press, Inc., Boca Raton, Florida, USA [English].
Schmitt, H.P. and L. Schulze. 1994. [The conservation of elms in Nordrhein-Westfalen] Die Erhaltung der Ulme in Nordrhein-Westfalen. Allg. Forstzeitschr. 49(5):230-233 [German].
Sherald, J.L., F.S. Santamour, Jr., R.K. Hajela, N. Hajela and M.B. Sticklen. 1994. A Dutch elm disease resistant triploid elm. Can. J. Forest Res. 24:647-653 [English, summary in French].
Soria, S. 1990. [The agressive strain of D.E.D.: administrative measures] Graphiosis agresiva del olmo: actuaciones de la administration. Pp. 253-255 *in* Los Olmos y la Graphiosis en Espana (L. Gil, ed.). ICONA [Spanish].
Sticklen, M.B. and J.L. Sherald, (Eds.). 1993. Dutch Elm Disease Research: Cellular and Molecular Approaches. Springer-Verlag New York Inc., New York, USA. 344 p. [English].
Sticklen, M.B., M.G. Bolyard, R.K. Hajela and L.C. Duchesne. 1991. Molecular and cellular aspects of Dutch elm disease. Phytoprotection 72(1):1-13 [English, summary in French].
Thill, A. 1985. [Elm, a dying out species] L'orme, une essence en voie d'extinction. Bull. Soc. Roy. For. de Belgique 92(5):218-236 [French, summary in English].
Thill, A. and R. Palm. 1984. [Dendrometric study of the elms: *Ulmus glabra* Huds. and *U. campestris* L.] Etude dendrométrique des ormes: *Ulmus glabra* Huds. et *U. campestris* L. Notes techniques du Centre d'écologie forestière et rurale (Univ. De Gembloux), n° 45, (ISSN 07701861) [French].
Thompson, D.G., D.F. Karnosky and R.A. Mickler. 1984. Stock quality - propagation method. Tissue culture and vegetative propagation. Seedling physiology and reforestation success. Pp. 3-36 *in* Proceedings of the Physiology Working Group technical session. SAF National Convention, Portland, OR, USA, 16-20 Oct. 1983 (M.L. Duryea and G.N. Brown, eds.). Mart, Dordrecht, Netherlands [English].

Timbal, J. 1981. [An unfamiliar tree: the European White Elm (*Ulmus laevis* Pallas)] Un arbre méconnu: l'orme lisse. Rev. Forestière Française 33(2):109-114 [French].

Ulrich, J.M., R.A. Mickler, B.J. Finkle and D.F. Karnosky. 1984. Survival and regeneration of American elm callus cultures after being frozen in liquid nitrogen. Can. J. Forest Res. 14(5):750-753 [English, summary in French].

Webber, J.F. 1987. Influence of the d2 factor on survival and infection by the Dutch elm disease pathogen *Ophiostoma ulmi*. Plant Pathol. 36(4):531-538 [English].

Webber, J.F. and J.N. Hedger. 1986. Comparison of interactions between *Ceratocystis ulmi* and elm bark saprobes *in vitro* and *in vivo*. Trans. Br. Mycological Soc. 86(1):93-101 [English].

Wu, W.D., R.S. Jeng and M. Hubbes. 1989. Toxic effects of elm phytoalexin mansonones on *Ophiostoma ulmi*, the causal agent of Dutch elm disease. Eur. J. Forest Pathol. 19(5-6):343-357 [English, summary in French and German].

Yang, D., M. Hubbes, Jr., R.S. Jeng and M. Hubbes. 1994. A glycoprotein isolated from culture filtrates of *Ophiostoma ulmi* as a mansonone-inducing elicitor on elm callus. Mycological Res. 98(3):295-300 [English].

Yang, D., R.S. Jeng and M. Hubbes. 1989. Mansonone accumulation in elm callus induced by elicitors of *Ophiostoma ulmi*, and general properties of elicitors. Can. J. Botany 67(12):3490-3497 [English, summary in French].

Zeitlinger, J. 1992. [The elms: *Ulmus glabra - Ulmus campestre - Ulmus laevis*] Die Ulme: Bergulme - Feldulme – Flatterulme. Österreichische Forstzeitung, Wien 103(2):31-35 [German].

Programme

March 22 1997

Arrival of participants in Pontevedra
(airports of arrival: Santiago de Compostela or Vigo)

March 23 1997

9.00-09.30	Introduction
09.30-11.00	Brief update reports on activities in countries since the last meeting (Spain, France, Portugal, Malta, Italy, Croatia, Hungary, Slovakia, Czech Rep.)
11.00-11.20	Break
11.20-13.00	(Austria, Germany, Switzerland, Belgium, the Netherlands, Lithuania, Latvia, Denmark, Finland, Sweden)
13.00-14.30	Lunch
14.30-15.30	Introductory Country reports (Romania, Ukraine, Poland, Russian Federation)
15.30-15.45	Break
15.45-16.00	Synthesis of the current gene conservation measures and ongoing activities on Noble Hardwoods in Europe (J. Turok)
16.00-17.30	Sampling for genetic resources in absence of genetic knowledge and genetic inventory requirements at the level of populations (G. Eriksson and J. Kleinschmit)
17.30-19.00	Research coordination (J. Kleinschmit) Concerted Action "Conservation of elm genetic resources" (E. Collin) Development of new joint research proposals according to the needs of participants – Discussion
20.30	Welcome dinner

March 24 1997

Conservation strategy for Noble Hardwoods from a European perspective:

09.00-09.45	*Ulmus* spp. (E. Collin)
09.45-10.30	*Sorbus* spp. (B. Demesure)
10.30-11.15	Wild fruit trees (J. Kleinschmit and B.R. Stephan)
11.15-11.30	Break
11.30-12.15	*Acer platanoides* and *A. pseudoplatanus* (M. Rusanen)
12.15-13.00	*Fraxinus excelsior* and *F. angustifolia* (V. Buriánek)
13.00-14.30	Lunch
14.30-16.00	Evaluation of genetic resources (B. de Cuyper)
16.00-16.20	Break
16.20-18.30	Literature reviews
20.30	Dinner

March 25 1997

09.00-11.00	Coordination of databases and development of descriptors
11.00-11.20	Break
11.20-13.00	Guidelines for gene conservation of rare and minor Noble Hardwood species
13.00-14.00	Lunch
14.00-17.00	Field trip
17.30-20.00	Wrap-up session and conclusions: a conservation strategy for Noble Hardwoods
20.30	Farewell dinner

Participants

Mr Ferdinand Müller
Institute of Silviculture
Federal Forest Research Centre (FBVA)
Hauptstrasse 7
1140 Wien
Austria
Tel: +43-1 979 67 19
Fax: +43-1 979 63 84
Email: fbva@forvie.ac.at

Mr Bart A. de Cuyper
Institute for Forestry and Game Management
Duboislaan 14
1560 Hoeilaart
Belgium
Tel: +32-2 657 03 86
Fax: +32-2 657 96 82
Email: Bdecuyper@ibw.be

Mr Dominique Jacques
Station de Recherches Forestières
Avenue Maréchal Juin 23
5030 Gembloux
Belgium
Tel: +32-81 61 11 69
Fax: +32-81 61 57 27

Mr Joso Gracan
Forest Research Institute
Cvjetno Naselje 41
10450 Jastrebarsko
Croatia
Tel: +385-1 83 14 92
Fax: +385-1 83 14 93
Email: Joso.Gracan@public.srce.hr

Mr Václav Buriánek
Forest and Game Management Research Institute (VÚLHM)
Jíloviště - Strnady
15604 Praha 5, Zbraslav
Czech Republic
Tel: +420-2 57 92 16 43
Fax: +420-2 57 92 14 44
Email: forinst@ms.anet.cz

Mr Jan Sveigaard Jensen
Forest and Landscape Research Institute
Hørsholm Kongevej 11
2970 Hørsholm
Denmark
Tel: +45-45 76 32 00
Fax: +45-45 76 32 33
Email: jsj@fsl.dk

Ms Mari Rusanen
Finnish Forest Research Institute
PO Box 18
01301 Vantaa
Finland
Tel: +358-9 857 05 542
Fax: +358-9 857 05 711
Email: mari.rusanen@metla.fi

Ms Brigitte Demesure
Centre de Recherches Forestières ONF
INRA-Orléans
45160 Ardon
France
Tel: +33-2 38 41 48 08
Fax: +33-2 38 41 78 79
Email: demesure@orleans.inra.fr

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 59
Email: collin@rainbow.cemagref.fr

Mr Richard Stephan
Institute of Forest Genetics
Bundesforschungsanstalt für Forst- und Holzwirtschaft
Sieker Landstr. 2
22927 Grosshansdorf
Germany
Tel: +49-4102 69 61 44
Fax: +49-4102 69 62 00
Email: stephan@aixh0001.holz.uni-hamburg.de

Mr Jochen Kleinschmit
Vice-Chair of the Network
Department of Forest Tree Breeding
Nieders. Forstliche Versuchsanstalt
34355 Staufenberg - Escherode
Germany
Tel: +49-5543 94 08 10
Fax: +49-5543 94 08 61
Email: nfv-abtc@t-online.de

Mr Csaba Mátyás
Department of Environmental Sciences
Sopron University
PO Box 132
9401 Sopron
Hungary
Tel: +36-99 31 11 00
Fax: +36-99 31 11 03
Email: cm@efe.hu

Mr Fulvio Ducci
Istituto Sperimentale per la Selvicoltura
Viale Santa Margherita 80
52100 Arezzo
Italy
Tel: +39-575 35 30 21
Fax: +39-575 35 34 90
Email: issargen@ats.it

Mr Janis Birgelis
State Forest Service
Department of Forest
13. janvara iela 15
1932 Riga
Latvia
Tel: +371-7 21 13 86
Fax: +371-7 21 11 76
Email: janisb@lsfs.gov.lv

Mr Alfas Pliura
Dept. of Forest Genetics and Reforestation
Lithuanian Forest Research Institute
4312 Girionys, Kauno
Lithuania
Tel: +370-7 54 72 45
Fax: +370-7 54 74 46
Email: apliura@pub.osf.lt

Mr Sven M.G. de Vries
Institute for Forestry and Nature Research
IBN/DLO "de Dorschkamp"
PO Box 23
6700 AA Wageningen
Netherlands
Tel: +31-317 47 78 41
Fax: +31-317 42 49 88
Email: sven@ibn.dlo.nl

Mr Adolf Korczyk
Forest Research Institute
Park Dyrekcyjny 6
17230 Bialowieza
Poland
Tel: +48-835 12 396
Fax: +48-835 12 203
Email:
Akorczyk@las.ibl.bialowieza.pl

Mr Ioan Blada
Forest Genetics and Breeding Department
Forest Research and Management Institute (ICAS)
Sos. Stefanesti 128, sector 2
72904 Bucuresti
Romania
Tel: +40-1 240 68 45
Fax: +40-1 240 68 45

Mr Andrey Prokazin
Russian Tree Breeding Centre
(CENTRLESSEM)
Nadsonovskaya 13
141200 Pushkino (Moscow)
Russian Federation
Tel: +7-095 23 30 950
Fax: +7-096 53 26 662
Email: andrey@lessem.msk.ru

Mr Roman Longauer
Forest Research Institute (LVU)
T.G. Masaryka 22
96092 Zvolen
Slovakia
Tel: +421-855 31 43 31
Fax: +421-855 32 18 83
Email: roman.longauer@fris.sk

Mr Ricardo Alia M.
Area de Selvicultura y Mejora Forestal, Centro de Investigaciones Forestales
INIA
Apartado 8.111
28080 Madrid
Spain
Tel: +34-1 34 76 857
Fax: +34-1 35 72 293
Email: alia@inia.es

Mr Guillermo Vega A.
Centro de Investigaciones Forestales
Lourizán
Apartado 127
36080 Pontevedra
Spain
Tel: +34-86 85 64 00
Fax: +34-86 85 64 20
Email: gvega@inia.es

Ms Josefa Fernández L.
Centro de Investigaciones Forestales
Lourizán
Apartado 127
36080 Pontevedra
Spain
Tel: +34-86 85 64 00
Fax: +34-86 85 64 20

Mr Luís Gil
Universidad Politécnica de Madrid
ETSI Montes
Ciudad Universitaria
28040 Madrid
Spain
Tel: +34-1 336 71 13
Fax: +34-1 543 95 57
Email: lgil@montes.upm.es

Mr Gösta Eriksson
Chair of the Network
Dept. of Forest Genetics
Swedish University of Agricultural Sciences
PO Box 7027
75007 Uppsala
Sweden
Tel: +46-18 67 12 40
Fax: +46-18 67 27 18
Email: Gosta.Eriksson@sgen.slu.se

Mr Peter Rotach
Professur für Waldbau
ETH
ETH-Zentrum, Rämistrasse 101
8092 Zürich
Switzerland
Tel: +41-1 632 32 10
Fax: +41-1 632 10 33
Email: rotach@waho.ethz.ch

Ms Olga S. Mazhula
Department of Forest Tree Breeding
Ukrainian Institute of Forestry
Pushkinskaya 86
310024 Kharkov
Ukraine
Tel: +380-572 43 15 49
Fax: +380-572 43 25 20
Email: selint@u-fri.kharkov.ua

Mr Jozef Turok
EUFORGEN Coordinator
IPGRI
Via delle Sette Chiese 142
00145 Roma
Italy
Tel: +39-6 518 92 250
Fax: +39-6 575 03 09
Email: j.turok@cgnet.com

Unable to attend

Mr Joseph Buhagiar
Argotti Gardens and Herbarium
University of Malta
MSD 06 Msida
Malta
Tel: +356-31 06 53
Fax: +356-33 64 50

Mr Jean-Luc Van Klaveren
Service de l'Urbanisme et de la Construction
BP 609
98013 Monaco Cedex
Monaco
Tel: +377-93 15 85 49
Fax: +377-93 15 88 02

Mr Tore Skrøppa
Norwegian Forest Research Institute
Høgskoleveien 12
1432 Aas
Norway
Tel: +47-64 94 90 00
Fax: +47-64 94 29 80
Email: tore.skroppa@nisk.nlh.no

Mr Alexandre de Aguiar
Estacão Florestal Nacional, INIA
Quinta do Marques
Edificio do Procalfer
2780 Oeiras
Portugal
Tel: +351-1 44 15 763
Fax: +351-1 44 15 660
Email: rosefn@individual.eunet.pt