IPGRI

Populus nigra Network

Report of the sixth meeting — 6-8 February 2000 — Isle sur La Sorgue, France

S. Borelli, S. de Vries, F. Lefèvre and J. Turok, *compilers*

EUFORGEN

European Forest Genetic Resources Programme (EUFORGEN)

IPGRI is a
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The International Plant Genetic Resources Institute (IPGRI) is an autonomous international scientific organization, supported by the Consultative Group on International Agricultural Research (CGIAR). IPGRI's mandate is to advance the conservation and use of genetic diversity for the well-being of present and future generations. IPGRI's headquarters is based in Rome, Italy, with offices in another 19 countries worldwide. It operates through three programmes: (1) the Plant Genetic Resources Programme, (2) the CGIAR Genetic Resources Support Programme, and (3) the International Network for the Improvement of Banana and Plantain (INIBAP).

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

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Contents

Summary of the Meeting

Opening of the meeting

Sven de Vries, Chair of the Network, welcomed the participants to the sixth EUFORGEN *P. nigra* Network meeting and greeted the newly attending countries and the invited scientists and observers. Seventeen countries were represented. Malta and Switzerland were attending for the first time.

The agenda was adopted.

Michel Bariteau welcomed the participants and made an overall presentation of the activities of the Unité de Recherches Forestières Méditerranéennes of INRA, underlining its role in the creation of networks and the close contacts with EUFORGEN.

Presentation of new *P. nigra* Network outputs

Jozef Turok presented the Second Phase of EUFORGEN and the latest developments in the other Networks. He also provided a brief overview of the Ministerial Conference on the Protection of Forests in Europe (MCPFE) process. He then proceeded to briefly describe the latest outputs of the Network.

The database of clones is ready and is now available through the EUFORGEN Web Page. Bibliography was consolidated and is now available on the Internet. The new contents and layout of the Web Page were presented and discussion will be carried out in a later session. The Identification Sheet is now available in Spanish, Italian and German. The English version had run out and has been reprinted. The Dutch and Russian versions will be provided by the Secretariat during the year.

Reports on the progress of activities in countries

Austria, Belgium, Bulgaria, Croatia, France, Germany, Hungary, Italy, Portugal, Russian Federation, Turkey, UK and Ukraine reported on the progress made since the last meeting. Introductory country reports were provided by Malta and Switzerland.

In situ conservation strategies for black poplar

Jozef Turok presented the idea of preparing a technical bulletin on *in situ* conservation of black poplar in riparian ecosystem including the two papers already prepared plus other inputs such as an additional chapter on distribution and ecology. A bibliography would be complementing it together with drawings and photos from the CD. The format would be the same as that of *Picea abies* and Noble Hardwoods technical guidelines.

The document should be understandable and usable at all levels of forestry management, but sound scientific evidence should be provided to back up recommendations.

It will include an introductory section describing the ecology of the species and the objectives of the bulletin (including a description and general objectives of *in situ* conservation). Concise "Guidelines" will be summarised in the beginning and then highlighted through the text.

In each country the bulletin could be complemented by accompanying information relevant to the national context.

The two existing papers prepared for the previous meeting were sent to four selected reviewers for comments. The comments were received and distributed to participants. All the individual comments were discussed and amendments or additions to the paper were suggested as appropriate. The authors were provided with a consolidated list of comments and will incorporate these by **31 May 2000** with additional support from the FLOBAR project. The table of indicators was revised as discussed and will be included in the new version of the paper.

A simple decision making tool for *in situ* restoration in the form of a flowchart will be included to link the chapters on indicators and restoration (to be developed by Davorin

Kajba, Peter Rotach, Joan Cottrell, Berthold Heinze and François Lefèvre by **31 July 2000**).

The introductory section will be prepared by the Secretariat before the end of **July 2000** and will be circulated to Network members along with the rest of the text. Comments should be provided by the end of **September 2000**. The final version of the bulletin will be available **at the end of year 2000**.

Public awareness

A first version of the **Photo-CD** on *P. nigra* was distributed to the Network members, however, some items are still missing. The photographs are free for use and countries are encouraged to use the material for public awareness purposes and disseminate it in their respective countries. The original copy should be entrusted to the Network member. Source should always be cited (EUFORGEN *Populus nigra* Network).

IPGRI will prepare text to accompany the slides (in English). This text could then be translated into different languages. Participants were encouraged to provide examples of the missing themes, including captions, location and date. Additional examples of poplar in the arts would be welcomed.

Slides will be provided as follows: Mixed riparian ecosystem: Davorin Kajba, István Bach; Biodiversity: Rolf Schulzke, François Lefèvre; North African landscape: all; Turkish landscape (*P. nigra Uzbekistanica*): Korhan Tunçtaner; Mixed vine-poplar systems: Maria Carolina Varela; distribution range: Eman Calleja; Western China: Rolf Schulzke; Restoration techniques: Jos Van Slycken.

Simone Borelli presented the revised **Web Page** structure and content. All the participants agreed that the current layout is user friendly and practical to use.

As far as contents are concerned, it was suggested to add outputs which are already contained in previous reports.

The bibliography already available will be gradually converted into database format. All new updates should be prepared in the format that will be provided by the Secretariat. It was suggested to link it to other EUFORGEN bibliographies. The Secretariat will follow up with the Noble Hardwoods Network.

Introductory country reports and updates on progress made will also be placed on the Internet.

Evaluation and use of descriptors for *P. nigra* stands

The final version of the descriptors for inventories of black poplar stands, originally developed by Nuria Alba, was presented. In particular, it was suggested to keep the short version with the map for climatic classification. Several participants made suggestions for changes in the order and content of the fields. The Secretariat will provide the suggestions to Nuria Alba for incorporation. The final version will be included in the report of the meeting (see page 15).

The updated version of the descriptors will be published on the Web Page by the Secretariat (English version **by the end of March 2000**) and other networks will be encouraged to adapt them for their use. Forms for data collection will be translated into the member countries' languages and gradually placed on the Web as downloadable Word files.

The Network expressed its thanks to Nuria Alba for her input.

Update on EUFORGEN core collection

Lorenzo Vietto presented the current list of clones. One clone from Turkey is missing and an Italian clone was replaced due to problems in growth. Two of the Ukrainian clones will be removed because they were over-represented in the current collection. Part of the core collection has been sent to France and Belgium for use in the EUROPOP project.

Some of the characters of growth, branchiness and straightness of the clones were recorded for information and a comparative table was presented.

Current problems include the need for more countries to join the core collection (Greece, Moldova, Portugal, Russian Federation and Switzerland), obtaining cuttings from all clones and completing passport data.

Among member countries, Switzerland is evaluating clones to be provided, the Russian Federation should be able to provide material in the coming months and Portugal will provide material to Austria for identification. Other countries will be contacted by the EUFORGEN Secretariat individually, will be provided with the guidelines for sending clones and also invited to participate in the database.

The core collection was used by EUROPOP for standardizing techniques and two clones from Romania were identified as putative hybrids. These will be eliminated from the core collection. France plans to establish a stand from the core collection clones on a location where trees can grow old. Individual countries were encouraged to apply for cuttings and use them as appropriate.

European database of clones

The database is available on the Internet. Twenty nine countries have provided data and there are currently 2789 accessions, with a 30% increase in the last three years. Problems to be solved include completion and update of passport data and contacts.

Germany and Bulgaria have agreed to provide data for their respective countries. Other countries (Poland, Romania and Slovakia) will be contacted by the EUFORGEN Secretariat **by 31 March 2000** and asked to provide data on their national collection. Countries not represented will be asked to join. Countries will provide updates by **15 June 2000** as appropriate and will verify if the contact information in the database is correct.

It was also agreed that contact name for institutions should be in the original language (English translation in brackets). The Network thanked Lorenzo Vietto and the Istituto di Sperimentazione per la Pioppicoltura (ISP) for maintaining the collection and the database.

Biodiversity in *P. nigra* stands

Rolf Schulzke presented an example of insect biodiversity related to poplars in Germany. This general topic of biodiversity appears to be of interest and suggestions were made to invite a specialist in this field to join a future meeting. Suggestions for speakers should be forwarded to the Secretariat. Mention of biodiversity should be made in the introduction of the bulletin. Peter Rotach agreed to carry out a literature search on biodiversity in poplar stands and will present it at the next meeting (to be circulated one month before). Other members will provide him with relevant information.

Collaboration on *P. alba* genetic resources activities in Europe

Simone Borelli (on behalf of Nuria Alba) presented the current status of the **database**, which includes information from Italy and Spain. It was decided that the current version is still too limited and it should not be uploaded to the Internet. The chair encouraged the countries that are interested to provide information for the database as soon as possible.

Rolf Schulzke presented the current state of research on *P. alba* in Germany. One of the key issues was that of identifying appropriate propagation methods. Seeds are not commonly used in Germany as they are not very viable.

Methods presented include: seedlings, layering, root suckers, root cuttings, hardwood cuttings (it works well with *P. alba*), softwood cuttings (for *P. canescens*), grafting and tissue culture. Further research is needed to assess the potential of these propagation techniques. Identification methods should be improved both for morphological and molecular variation. A list of characteristics was developed for *P. tremula*, *P. alba* and *P. canescens*. A short literature review was also prepared and will be added to the bibliography.

István Bach underlined the importance of using sexual reproduction and provided some examples from Hungary.

The need for an ID sheet was identified. Rolf Schulzke and István Bach will prepare the basic material for an ID sheet to be discussed at the next meeting. Jos Van Slycken offered to help with the drafting of the illustrations. The final material will be provided to the Secretariat for printing.

Establishment of core collection of *P. alba*

It was agreed that a core collection will be established. István Bach offered to host and maintain the collection in Hungary. Interested countries (Austria, Bulgaria, Croatia, France, Germany, Hungary, Italy, Malta, Portugal, Russia, Spain, Switzerland, Turkey and Ukraine) would provide two clones each to the collection. Ten hardwood cuttings should be used for each clone. Rules for providing the cuttings (e.g. they should be longer and thicker than the *P. nigra* ones) will be distributed by the Secretariat in consultation with Istvan Bach and Lorenzo Vietto before **31 July 2000**. Other countries will be contacted by the Secretariat. The need to study genetic diversity was also identified. It was decided to discuss this issue in further meetings.

WWF-IPGRI/EUFORGEN Joint project

Simone Borelli presented objectives and activities included in the project proposal that was jointly developed by IPGRI/EUFORGEN and WWF International on the conservation, restoration and sustainable management of floodplain forests. All countries present expressed their interest in participating, in principle, in the proposed project. Contacts will be established with national WWF offices (information provided by EUFORGEN Secretariat by end of **February 2000**) and other potential partners. Possible funding sources will be identified both in the private and public sectors.

Comments on the proposal as well as suggestions on sites to be included in the project should be sent to the EUFORGEN Secretariat by **15 April 2000**. The possibility of linking this initiative with the international symposium organized by EUROPOP Project to be held in 2001, was suggested.

Any other business

Core collection was requested to Jos Van Slycken by Gail Taylor, UK for an ecophysiological study. The material will be sent provided that its origin is referred to in publications. The results of this research will be shared with the Network.

The question of geographic coverage of the EUFORGEN Programme was raised. It was pointed out that the Secretariat is carrying out continuous efforts to involve the countries that have not yet joined from geographic Europe. Also, the Secretariat indicated that Israel might be joining in the near future.

Research needs: There was a request for collaboration on a project on conservation of genetic resources from Kostantinos Spanos of Greece. In general, the issue of joint research needs will be discussed at the meeting of chairs and vice-chairs of the Networks to be held later this year.

Publication of the report of the meeting: It was strongly felt that the report should be continued to be printed for raising awareness and interest at the national level.

It was agreed that the report should include new introductory country reports, an overview of the country updates (table), the workplan and technical outputs.

Comparative tables of *in situ* conservation activities (1996 and 2000) will be included in the report with explanatory text assessing progress. Updates and information from newly attending countries should be provided to Sven de Vries on the basis of the table circulated among the participants by end of **February 2000**.

Date and place of next meeting: Both Germany and Croatia offered to host the next meeting. After discussion, the participants decided that the next meeting will be held in Croatia **in the second half of 2001**. The exact venue will be determined at a later date.

Progress on national activities on gene conservation of *Populus nigra*

Country	Austria	Belgium	Czech Republic
Inventories	A national inventory is in the planning stages.	Identification of individual relict trees (37 in the reporting period).	269 individuals of *P. nigra* collected for the database of clones.
Legislation	New EU directive on Forest Reproductive Material adopted.	The Flemish Forest act was reviewed and financial support will be provided to landowners for conservation of FGR.	
Research	New stands being investigated. National clone collection being investigated with molecular markers.	Participation in EUROPOP project. Flemish-Hungarian cooperation programme is carrying out characterization with isozymes. Genome mapping of *P. nigra*.	Analysis of genetic diversity of *P. nigra* populations with microsatellites. Estimate of introgression levels with isoenzymes.
Practical Implementation	Maintenance of national clone collection. Conservation project in several provinces.	Replanting of local genotypes of *P. nigra* by the Flemish Land Company is planned.	Replanting of local genotypes of *P. nigra* in National reserves.
Public awareness	New programme launched by the Danube Floodplain National Park.	In the Walloon Region, 1999 was declared the year of the poplar.	
***In situ* conservation**		Three pilot project were established along the Meuse.	

Country	France	Germany	Hungary
Inventories	Germplasm maintained in different institutes was inventoried.	300 pure *P. nigra* were identified along the Elbe, Rhine and Danube.	
Legislation			The law requires that forest owners use indigenous species for afforestation in protected areas and flooplains and there is growing demand for tested propagating material.
Research	Participation in EUROPOP continued. Research institute in Toulouse initiated work on *P. nigra* mycorrhizae.	Participation in EUROPOP continued.	Accession records have been prepared for 214 clones. A stoolbed with 40 DNA tested clones was established in 1999 and the establishment of a clonal seed orchard is in progress.
Practical Implementation		Cuttings from selected trees used for planting along rivers.	
Public awareness	A number of publications on FGR were prepared and disseminated.	1999 was declared "Year of the salix" and all riparian species including poplars received attention. Various leaflets and articles were published.	
***In situ* conservation**	Twelve reserves were identified for creating an *in situ* conservation network. A coordination group was created.		

Country	Italy	The Netherlands	Turkey
Inventories		Additional individual trees were identified and added to the gene bank (stoolbeds).	
Legislation	The Management Plan for the River Po was approved in 1999 and it includes some restrictions on the establishment of poplar plantations on smaller affluents.		
Research	Nursery test were carried out on 70 clones to evaluate growth and resistance to pests. Field trials were carried out on five families in order to prepare pedigrees for molecular analysis.	Research projects on genetic diversity were continued. EUROPOP is in its third year of operation.	Nursery trial were carried out from 1996 to 1998 in different parts of the country, mostly evaluating growth performance. *Ex situ* collection (stoolbeds) have been established in Izmit and Erzurum. A clone bank was also established in Elazig.
Practical Implementation	Five hectars of demonstrative poplar stands were established along the river Po.	Stoolbeds were used for providing cuttings to nurseries that supply landowners.	
Public awareness	ISP contributed to the CABI Forestry Compendium with data sheets on *P. nigra*, *P. alba* and P. canadensis.	A presentation on the network was made at an International Poplar symposium in France.	
***In situ* conservation**	Methodologies are being developed in collaboration with protected area management.		

Country	United Kingdom	Ukraine
Inventories	The University of Nottingham is mapping the location of the known 7000 black poplars.	
Legislation	Inventory of poplar stands continued in the Chernigiv and Poltava provinces.	
Research	Participation in EUROPOP continued (work with different markers).	Eighteen reference clones were tested for adaptability in three institutes in Western, Central and Eastern Ukraine.
Practical Implementation	Guidelines for the production of planting stock are being prepared.	A soil and river bank protection programme using black poplar was started in the Chernobyl area.
Public awareness	A Species Action Plan is being drawn up.	
***In situ* conservation**		A protected area was created in the Tysa valley.

Introductory Country Reports

Malta

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Introduction

There are no natural stands of *Populus nigra* in Malta, although a few specimens have been imported and cultivated. In fact, *Populus alba* L., of which only a few stands still occur naturally in the Maltese islands, is our only native poplar.

Status of *P. alba* in the Maltese Islands

Until the beginning of the 20th century *P. alba* was quite frequent, growing along watercourses or humid valleys in Malta and its sister island Gozo (Sommier & Caruana Gatto 1915; Borg 1927). Today, few native stands remain, the most noteworthy of which are the ones at Wied il-Luq (Buskett) and Ghirgenti, in Malta (Lanfranco 1995). As a result, the species is nowadays considered as rare and is hence listed on the "Red Data Book for the Maltese Islands" (Lanfranco 1989). It is found mainly in deep humid soils in riparian woodlands, where it is grown in association with *Ulmus canescens* and *Fraxinus angustifolia* (Grech 1994). This habitat is very rare and is found only in two or three localized areas in the west of Malta. The remaining populations consist mainly of monocultures of *Populus alba.*

The reason for its rarity is linked to the fate of its habitat during the last 50 years. At a population density of 1037 people per km^2, Malta is the most heavily populated country in Europe. Due to this high density there is hardly anywhere in Malta that has not been influenced by man. Entire valleys have been modified by dredging and dam building. Channels were straightened and narrowed, their banks dug out or walled to control the flow of water. Water from valleys was redirected for use in mains supply or farming (Haslam & Borg 1998). These factors, together with recreation, waste disposal, and urbanisation have dealt a great blow to the *P. alba* populations in the Maltese Islands. Notwithstanding all these threats, *P. alba* has still managed to survive eradication, particularly thanks to its suckering capacity.

Poplar seedlings have been successfully introduced into several valleys in the Maltese islands during the last 15 years. One of our best populations consists of a re-introduced thirty-year old stand of *P. alba* (Chadwick Lakes). The Department of Agriculture has even extended the population to various streets, housing estates and urban areas. However, regardless of all these efforts, the major obstacle to the spread of the species has been the lack of suitable habitats (it grows in rather deep humid soil along valley floors) and the small amount of existing female trees. Most of the native populations have been found to be males, with a few females in some of the sites.

Uses

Poplar is being used locally both as a roadside tree and in afforestation projects. Its use as a roadside tree, however, is restricted since it is only planted in areas which are prone to flooding, such as in roads passing through valleys both in rural and urban areas. In afforestation projects, poplars are planted in small numbers along valley floors having a permanent or temporary watercourse. Those growing in temporary watercourses tend to be susceptible to drought especially during the juvenile stage, as was experienced at some sites where a long summer resulted in a mortality rate of at least 50% of the juvenile trees (e.g. as in Wied Ghollieqa).

Most of the material used is grown from locally available stock either by Government

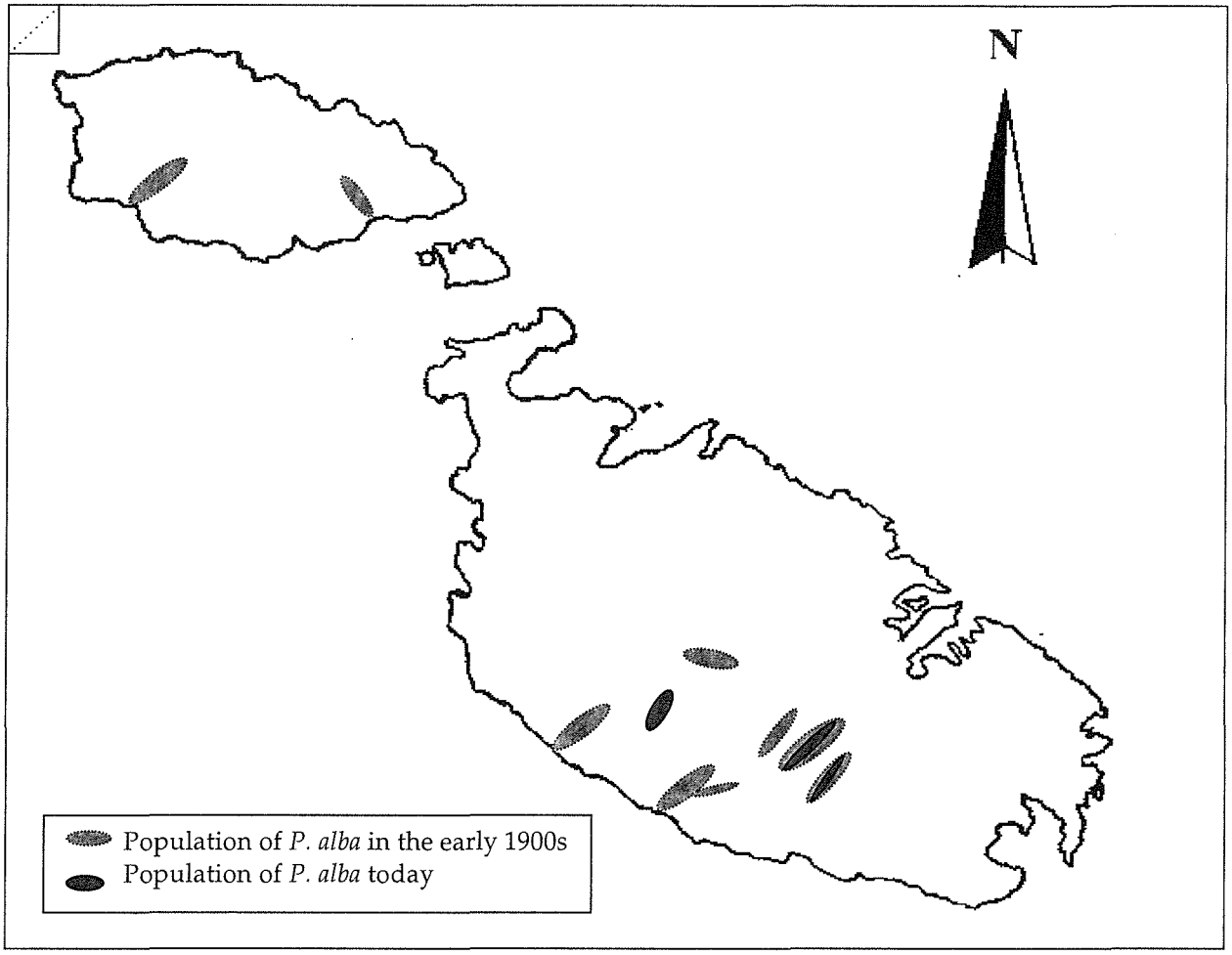

Fig 1-Map showing the distribution of *P. alba* in the beginning of the century and its distribution today.

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Switzerland

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The situation of floodplain forests, the natural habitats of black poplar

Riparian floodplain forests, the natural habitat of black poplar, have been reduced to about 10% of their original extension during only one century (Kuhn and Amiet 1988, BUWAL 1997). Conversion to farmland, direct or indirect influences of river regulation schemes, canalisation, power generation and other human impacts are major causes for this drastic loss of these ecosystems.

Today, only 11 000 ha of floodplain forest remain. Although this remaining area has been thoroughly inventoried (national inventory of floodplain forests (Galland *et al.* 1993) and is theoretically protected by law since 1992, the situation of these floodplain forests may be described as follows:

- Most of the remaining sites are clearly negatively influenced either by canalisation (59%), tourism (43%), artificial plantations of conifers and hybrid poplars (39%) and other human impacts such as material deposits or buildings (25%).
- The remaining floodplain forests are only fragmented relicts. Sixty five percent of the sites have an area between 5 and 50 ha, 14% are smaller than 10 ha and only 6% are larger than 200 ha.
- Reduced water levels and flows as a consequence of power generation prohibit or reduce the natural dynamic in most of the sites.
- Changes in vegetation during the last 30 years are remarkable with typical floodplain species declining and clear indications for a change towards drier habitat conditions.
- The sites contain more vegetation units, which are untypical for floodplain forests than typical units. 35% of the objects contain only two typical vegetation units, 53% are composed of 3.2 units on average while only 10% are rich in typical units (5 to 10 units). Only 2 sites still have all the 10 naturally occurring vegetation types.
- Open fresh substrates, important microhabitats for the natural regeneration of Black poplar, occur only in half of the sites, indicating an insufficient natural dynamic. Erosion and new sedimentation are rare events in most objects.
- Fifty five of the sites contain areas with intensive forestry activities, manly plantations of spruce and hybrid poplars.
- Human pressure on the remaining floodplain forests is high; buildings, material deposits, touristic infrastructure and artificial vegetation (lawns and garden plants) are present in 75% of all sites.
- The status of protection of the remaining sites of national importance is still insufficient. So far, the legal objectives have been met by only 4 states, 8 states have met 50 to 70% of the goals, while 8 states have met only 30 to 50%. Hence, only about half of the remaining sites are legally protected at the moment. Even worse, only 30% of these already protected sites meet the standard of protection which is prescribed by the national law.
- Revitalising measures in order to reintroduce a natural dynamic are planned, but have been completed in only 5% or are under way in only 4% of the sites. For 28% they are planned but not yet realised, for 27% they are not necessary, for 13% they are not possible and for the remaining 23% there are no plans at all.

Hence, it is not surprising that in 1993 about 80% of the protected sites were classified as already "inactive pseudo floodplain forests" or as showing clear signs of a transition in this

direction; only 20% of the sites still have the natural dynamic of an active floodplain ecosystem although some of them already show signs of human impact. Due to restoration measures this proportion has meanwhile increased to an estimated 30%. All the same, habitat conditions for black poplar in Switzerland are highly unfavourable: habitats are small and fragmented, lack the natural dynamics that are needed for natural regeneration, have been changed in their natural composition and ecological conditions and are not sufficiently protected. Measures to restore these ecologically important habitats and to conserve the high natural biodiversity, including indigenous black poplar, are urgent and necessary.

The current situation of indigenous black poplar in Switzerland

The demography and current situation of indigenous black poplar in Switzerland is unknown. According to the national forest inventory, "black poplar" amounts to a total of 277 000 (± 75 000) individuals. This figure, however, does not provide information about the number of indigenous black poplar individuals because the inventory does not distinguish between pure *P. nigra* and hybrid poplars. Moreover, the sampling density of the national inventory is too weak to provide reliable data for rare species. Based on the situation of the natural habitats of black poplar which was outlined above, indigenous black poplar is expected to be rare to extremely rare and the forest inventory thus would not be a reliable source of information anyway.

In a preliminary study performed at the Swiss Federal Institute of Technology in Zürich, an attempt was made to estimate the frequency of autochthonous black polar and to evaluate the current situation and endangerment of this species in Switzerland (Bang and Rotach 1999). Three sources of information were used to locate the potential occurrence of *P. nigra* L: The national inventory of floodplain forests (Galland *et al.* 1993), the national forest inventory (Schweizerisches Landesforstinventar 1988) and the vegetation database of the Swiss Federal Institute for Forest, Snow and Landscape Research. The inventory of the floodplain forests contains 148 sites with vegetation units in which black polar may potentially occur. In a representative sample of these sites, a field survey was conducted on clearly defined areas and all poplars were classified on the basis of their morphological characteristics (as published by the EUFORGEN *Populus nigra* network) into one of the following 4 groups: 1) *P. nigra*, 2) most likely *P. nigra* but doubtful, 3) *P.* x *euramericana*, and 4) most likely *P.* x *euramericana* but doubtful. In addition to the floodplain forest samples, all plots of the national forest inventory and all plots of the vegetation database in which the occurrence of black poplar has been recorded, were surveyed and all existing poplars were classified accordingly. The analysis of the results showed that 2.8% of the 988 individuals found were classified as *P. nigra* (0.1%) or most likely *P. nigra* (2.7%), while 97.2% were either *P.* x *euramericana* hybrids (85%) or most likely *P.* x *euramericana* hybrids (12.2%). Based on these proportions, the frequency of indigenous black poplar in Switzerland was estimated as follows:

- *The pessimistic estimate*: If the evaluated proportion of 0.10% of *P. nigra* is applied to the existing 200 000 to 300 000 "black poplars" according to the forest inventory, then only 200 to 300 individuals of indigenous black poplar remain in Switzerland. This estimate certainly underestimates the real frequency since certain proportions of the individuals which were classified as most likely *P. nigra* are pure black poplars.
- *The neutral estimate*: Assuming that 69% of the individuals which were classified as most likely *P. nigra* are in fact pure black poplars then a frequency of 4 000 to 7 000 individuals result. The assumed proportion of 69% is taken from a similar investigation in Germany (Janssen and Walter 1997) in which isozymes were used to verify the morphological classification. It is however unknown, whether the morphological classification of the two investigations are comparable.
- *The optimistic estimate*: In addition to the individuals of *P. nigra* and most likely *P. nigra*, also a certain proportion of the individuals classified as most likely *P.* x *euramericana*

may be pure black poplars. Taking Janssens and Walters 's investigation again as a reference, then 51% of the most likely *P.* x *euramericana* individuals would be pure black poplars and the estimated overall frequency for Switzerland would then be 16 000 to 20 000 individuals of pure black poplar. This estimate most certainly overestimates the real frequency because individuals which were classified as most likely *P.* x *euramericana* had all the typical traits except one which was doubtful. It is thus rather unlikely that such a high proportion as 51% would be pure *P. nigra.*

The real frequency is most likely situated somewhere between the pessimistic and the neutral estimate. If the observed average frequencies of the two *P. nigra* classes per vegetation units (*see below*) are multiplied by the total surfaces of these units and are summed up, the overall frequency is less than 1000 individuals. Also, based on the absence or presence of mistletoe as an additional criteria, the frequency of indigenous black poplar is certainly lower than the neutral estimate. Thus, the real frequency of autochthonous black poplar in Switzerland probably falls in the range between 1000 and 4000 individuals, the actual value being closer to the lower than to the upper limit.

Therefore, black poplar belongs to the group of species which are very rare, highly fragmented and highly endangered such as *Sorbus domestica* with an estimated frequency of 500 individuals, *Ulmus laevis* with 5000 individuals and *Pyrus communis* with 4000 individuals. It seems that black poplar comes in second place regarding rarity. Regarding endangerment, black poplar may even rank first. As with *Ulmus laevis*, the endangerment is to a great extent a result of the lost or degraded habitats.

Indigenous black poplars primarily occur as single, scattered and old individuals. Fifty two percent of the trees classified as most likely *P. nigra* had diameters greater than 50 cm; young individuals with diameters of less than 30 cm are completely absent. Insufficient natural regeneration during the last decades is probably the consequence of the lost natural dynamics in most of the floodplain forest, especially the lack of open fresh substrate necessary for seedling installation.

Black poplar seems to occur only in three vegetation units. It is most frequent in the unit *Alno-Ulmion* where it was found in 26% of the potential areas with an average frequency of 0.49 individuals per ha. This vegetation unit is clearly not influenced by the river and thus it is not a typical floodplain type vegetation but a transition towards the *Ulmo-Fraxinetum* caused by changes in the dynamic of the river system. Black poplar most likely will not be able to persist on these sites since the conditions for natural regeneration do not exist any longer and the competitive environment has changed considerably. In the *Salicetum albo fragilis* it was present in 9% of the potential areas with a frequency of 0.54 individuals per ha. This vegetation type is still influenced by the river, if the natural dynamics are unchanged and conditions for regeneration are favourable. Few individuals (in 6% of the samples with 0.11 individuals per ha) were also found in the vegetation type *Equisetum Alnetum incanae,* which is also flooded regularly in undisturbed conditions.

All individuals on the plots of the national forest inventory and the vegetation database were classified as *P.* x *euramericana* hybrids. This is a clear indication that the 277 000 "black poplars" in the national forest inventory are nearly exclusively planted hybrid poplars and that the indigenous black poplar is in fact extremely rare. Hybrids were extensively planted between the 1950s and 1970s, especially on sites where indigenous black poplar occurs naturally. In 50% of the surveyed *Equisetum Alnetum incanae* plots, plantations of hybrid poplars were present within the area or in close proximity; for the *Alno Ulmion* and the *Salicetum albo fragilis* plots the respective numbers were 55% and 75%. Thus, the relict *P. nigra* individuals are usually in close contact with hybrid poplars and introgression of genes into the original genepool is very likely in cases where natural regeneration is still possible.

Problems and needs

The preliminary investigations on the demography of black poplar in Switzerland and the situation of its natural habitat clearly indicate that indigenous black poplar is highly threatened and conservation measures are urgent. Black poplar seems to be very rare. Furthermore, the remaining population is highly fragmented and has a non sustainable age structure due to insufficient or lacking regeneration. This situation is both a consequence of the habitat conditions which have been drastically changed in most of the remaining floodplain forests and of the cultivation of hybrid poplars in the original habitats of *P. nigra*.

Conservation activities are thus urgent, but no measures whatsoever have been taken so far. The reason for this is that black poplar has not found much interest and no funds have been available so far for research or conservation activities. There is however a clear and urgent need for a number of activities.

First of all, a systematic and complete inventory of indigenous black poplar is needed. Conservation activities are not possible without detailed information about demography. Then, genetic surveys need to be performed in order to distinguish pure black poplar individuals from hybrids and to get results on the genetic diversity and structure of the remaining population of *P. nigra*. Finally, conservation strategies and measures need to be planned and implemented. In addition, as the current situation of black poplar is mostly unknown, there is a clear need for raising public awareness. The participation of Switzerland in the *Populus nigra* network may be highly beneficial in this respect.

Since habitat conditions and demography are highly unfavourable, *in situ* conservation may not be a feasible or even reasonable approach, at least at the moment. In this situation, a nation-wide clone collection seems to be an important and suitable instrument for gene conservation. A clone collection would allow to conserve the gene pool and provide planting material for reintroduction and revitalisation measures of the floodplain forests. In fact, there is growing interest from nature conservation organisations to reintroduce indigenous black poplar. So far, this interest could not be supported due to the lack of suitable planting material. The cultivation of hybrid poplars has drastically decreased in most parts of Switzerland. An insufficient demand for poplars on the market, low prices and a strong opposition from nature conservation organisation to artificial plantations and to the use of hybrid poplars (it is claimed that hybrid poplars kill the caterpillars of *Apatura ilia* and *Limenitis populi*, two highly endangered butterflies feeding on *Salix* and *Populus*; this, however, has been observed only for *P. balsamifera* and *angustifolia* but not for *P.* x *euramericana*) are the major causes for the drastic decrease. Old plantations are only rarely replanted with hybrid poplars and *P. nigra* thus could regain some of its lost territory in the near future, being planted instead of the hybrids, provided that suitable planting material will be made available.

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In situ conservation

Standardized list of descriptors for inventories of *Populus nigra* L. stands

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Introduction

The standardized list of descriptors for inventories of *Populus nigra* stands has been developed by the EUFORGEN *Populus nigra* Network members and has been devised to cover the description of natural *Populus nigra* stands in terms of information on passport, geographic location and conditions of the site, population structure, state of health and disturbance, and on-going management of the forests.

The adoption of descriptor standards will produce a rapid, reliable and efficient means for information storage, retrieval and communication. It is recommended, therefore, that information should be produced by closely following the descriptors specified in Table 1., with the respective field names and lengths if a database structure is being developed simultaneously. Where possible, a standardized approach with the IPGRI/FAO Multi-Crop Passport Descriptors (MCPD) has been considered. The MCPD were developed to provide consistent coding schemes for common passport descriptors across different plant species.

EUFORGEN does not, however, assume that institutions responsible for the description of the *Populus nigra* stands will utilize all descriptors suggested below (Table 1.). However, a number of descriptors are essential for the identification of a record and have been marked with an asterisk (*) beside each of them.

Specifications:

- Fieldnames include no more than 10 characters to comply with Data Interchange Protocol, DIP.

Table 1. Standardized list of descriptors for inventories of *Populus nigra* stands

No	Descriptor	Field Name	Field Type	Field Length
1.	*** Stand number** This number is the unique identifier of the stand described. This number should not be duplicated or reassigned to another stand. This number should be made of the acronym of the institute collecting the original data (INSTCODE) and a number (4 digit minimum). Example: IPGRI-1234	STANDNO	Text	20
2.	*** Code of the institution providing the original data** The codes consist of the acronym of the institute providing the original data.	INSTCODE	Text	10

No	Descriptor	Field Name	Field Type	Field Length
3.	*** Full name of the institution providing the original data** Provide the full name in original language in the case of a major European language. If not, please provide the English translation if possible.	INSTNAME	Text	100
4.	*** Country of the institution providing the original data (ISO Code)** ISO Code of the country of the institution providing the original data collected on the site. Refer to the list of codes and country names provided in Annex I.	INSTCTY	Text	3
5.	*** Full name of the Recorder** Full name of the person responsible for recording the original data.	RECNAME	Text	100
6.	*** Code of the institution responsible for the database** Code of the institute where the information is maintained (database). The codes consist of the acronym of the institute .	DBINSTCODE	Text	10
7.	*** Full name of the institution responsible for the database** Full name of the institution responsible for entering and maintaining the information of the record in the database. Provide the full name in original language in the case of a major European language. If not, please provide the English translation if possible.	DBINSTNAME	Text	100
8.	*** Country of the institution responsible for the database (ISO Code)** ISO Code of the country where the information (database) is maintained. Refer to the list of codes and country names provided in Annex I.	DBINSTCTY	Text	3
9.	*** Date of original description of the stand** (YYYYMMDD) Date when the data was originally compiled, where YYYY is the year, MM is the month and DD is the day.	RECDATE	Numeric	8

No	Descriptor	Field Name	Field Type	Field Length
10.	*** Country of the stand (ISO Code)** ISO Code of the country where the stand is located. Refer to the list of codes and country names provided in Annex I.	STANDCTY	Text	3
11.	*** Province/State of the stand** Name of the primary administrative subdivision of the country where the stand is located.	STANDSTATE	Text	100
12.	*** Department/County of the stand** Name of the secondary administrative subdivision (within a Province/State) of the country where the stand is located.	STANDDEPT	Text	100
13.	*** Location of the stand** Location information below the country level that describes where the stand is located. Might include the distance in kilometers and direction from the nearest town, village or map grid reference point, (e.g. PENYALEN 3.5E, GUADALAJARA, means 3.5 km east of Penyalen in the state of Guadalajara).	STANDLOC	Text	100
14.	**Ownership of the stand** 1 Public 2 Private	OWNERSHIP	Numeric	1
15.	**Designation status of the site** 0 Non protected 1 Protected area (i.e. general, that could be for several species) 2 Black poplar conservation area (especially designated for *Populus nigra*) 3 Proposed area for *Populus nigra* conservation	DESCODE	Numeric	1
16.	**Clones collected** Indicate whether a clone was collected and conserved in a collection. 0 No 1 Yes	CLONE	Numeric	1
17.	**Clones ID number** Identification numbers of the clones collected from the stands. More than one will be separated with a semi-colon.	CLONEID	Text	50

No	Descriptor	Field Name	Field Type	Field Length
18.	**Code of the institution where the clones are maintained** Code of the institute where the clones are maintained (collections). The codes consist of the acronym of the institute. More than one code will be separated with a semi-colon (Eg:. INIA; ISP).	CLONEINST	Text	50
19.	**Local name of the stand** Indicate the local name of the stand and the language in which it is cited, separated by a semicolon.	STANDNAME	Text	100
20.	**Map reference information** Information referring to a map of the site, if available.	SITEMAP	Text	200
21.	*** Latitude of the centre of the stand** Sexagesimal format: DD.MM.SS, where DD is degrees, MM is minutes and SS is seconds. Positive and negative degrees are used where a positive is North and negative value is South of the equator.	LATITUDE	Text	8
22.	*** Longitude of the centre of the stand of the centre of the stand** Sexagesimal format: DDD.MM.SS, where DDD is degrees, MM is minutes and SS is seconds. Positive and negative degrees are used to indicate hemispheres. Positive values are used for the eastern hemisphere and negative values for the western hemisphere.	LONGITUDE	Text	9
23.	**Elevation of the centre of the stand (m)** Elevation of the stand expressed in meters above sea level. Negative values allowed.	ELEVATION	Numeric	5
24.	**Slope of the centre of the stand** [°] Estimated slope of centre of the stand, expressed in degrees.	SLOPE	Numeric	3
25.	**Slope aspect of the stand** The direction that the slope of the stand faces. Describe the direction with symbols N, S, E, W (e.g. a slope that faces a south-western direction has an aspect of SW)	ASPECT	Text	2
26.	**Name of main river** Also specify the language in which it is cited, separated by a semi-colon.	MAINRIVER	Text	100

No	Descriptor	Field Name	Field Type	Field Length
27.	**Name of river last level tributary** Also specify the language in which it is cited, separated by a semi-colon.	TRIBRIVER	Text	100
28.	**Forest type** 1 Scattered trees - Pure 2 Scattered trees - Mixed 3 Lineal (width <50 m)-Pure 4 Lineal (width <50 m)-Mixed 5 Riparian forest-Pure 6 Riparian forest-Mixed	FORESTYPE	Numeric	1
29.	**Surface area of the stand**, in hectares (ha):	SURFACE	Numeric	4
30.	**Proportion in mixed stand (%)** Percentage of the surface area covered by *Populus nigra*.	STANDMIX	Numeric	3
31.	**Other trees and shrubs species** List the species most common in the mixed stand	OTHERSP	Text	200
32.	**Number of flowering trees in the stand** 0 0 1 <10 2 10-100 3 >100	FLOWERING	Numeric	1
33.	**Structure of the stand** (in terms of size of trees) 1 Regular 2 Irregular	STRUCTURE	Numeric	1
34.	**Number of even-aged cohorts in the stand** Indicate the estimated value.	COHORTS	Numeric	2
35.	**Approximate height of dominant trees** *(in meters)*	SIZEH	Numeric	2
36.	**Approximate diameter of dominant trees** *(in centimetres)*	SIZEDBH	Numeric	3
37.	**Presence of remarkable trees** (in terms of age and size) 0 No 1 Yes	REMARKTREE	Numeric	1
38.	**Proportion of male trees in the stand** Proportion of male trees expressed as a percentage (%) of the whole stand. The female proportion will therefore be deducted.	SEXRATIO	Numeric	3

No	Descriptor	Field Name	Field Type	Field Length
39.	**Natural regeneration** 0 None 1 Generative (sexual reproduction or by seed) 2 Vegetative 3 Both	NATREGEN	Numeric	1
40.	**Most significant damage** More than one choice can be selected and will be separated with a semi-colon (e.g.: 1;4) 0 None 1 Discoloration 2 Defoliation 3 Stem damage 99 Others	DAMAGE	Text	10
41.	**Prevailing stresses** Information on main associated biotic (pests and diseases) and abiotic (drought) stresses	DAMAGENT	Text	200
42.	**Presence of cultivated poplars in the vicinity of the stand** 0 None 1 Rare 2 Many	CULTIVPOP	Numeric	1
43.	**Position of the stand within the river area** 0 No river influence 1 Catchment area 2 Transportation area 3 Sedimentation area 99 Others	LOCRIVER	Numeric	2
44.	**Location of the stand in the valley** More than one choice can be selected and will be separated with a semi-colon (e.g.: 1;4) 1 Flood basin 2 Terrace 3 Natural levee 4 Scree bar 99 Others	LOCVALLEY	Numeric	2
45.	**Soil texture** (top 15 cm) 1 Clay 2 Silt 3 Sand 4 Gravel 5 Rock fragments 99 Other	SOILTEXT	Numeric	2

No	Descriptor	Field Name	Field Type	Field Length
46.	**Soil pH** (at upper 15 cm/mixed sample) 1 Acidic (pH<6) 2 Neutral (pH 6-7) 3 Alkaline (pH>7)	SOILPH	Numeric	1
47.	**Occurrence of suitable conditions for regeneration** 0 No 1 Yes	REGENER	Numeric	1
48.	**Climate zone**(*see annex II*). Classification: This phytoclimatic taxonomy is that of Allué-Andrade, carried out on the basis of the Walter phytoclimatic types, after Gaussen (1960), and the Allué-Andrade subtypes (after Troll and Paffen 1990). The revision carried out defines 13 regions or climatic types, which trace in climatic terms the presence of *Populus nigra* wherever it is distributed on the Eurasian continent and North Africa. The codes are: **III = Desert subtropical** III2 = hot desert **IV = Mediterranean** IV1 = true IV2 = subdesert **VI = Atlantic** VI (V) = temperature-humid VI2 = oceanic VI3 = middle European VI4 = subboreal temperated VI7 = sub-steppe **VII = Steppe** VII2 = northern VII2 = southern VII4 = northern semidesert VII4 = southern semidesert VIII = Boreal **IX = Arctic tundra and desert**	CLIMATE	Numeric	5
49.	**Average annual sum** of the temperature >5° The sum of all average monthly temperatures exceeding +5°C.	SUMTEMP	Numeric	3

No	Descriptor	Field Name	Field Type	Field Length
50.	**Mean temperature of the warmest month** (°C) Expressed in degree Celsius (°C), where: $\bar{T}_i = \frac{\sum_{j=1}^{j=30 or 31}(T_j m + T_j M)}{2 x days "i" month}$ T_j m: j-daily minimum temperature T_jM: j-daily maximum temperature The scored data is the highest T_i	MEANWARM	Numeric	2
51.	**Mean temperature of the coldest month** (°C) Expressed in degree Celsius (°C), where: $\bar{T}_i = \frac{\sum_{j=1}^{j=30 or 31}(T_j m + T_j M)}{2 x days "i" month}$ T_j m: j-daily minimum temperature T_jM: j-daily maximum temperature The scored data is the lowest T_i	MEANCOLD	Numeric	2
52.	**Total annual precipitation** (mm) Expressed in millimetres (mm), where: $P_t = \sum_{m=january}^{december} P_m$ P_m: monthly precipitation P_t: total precipitation	PRECIPIT	Numeric	4
53.	**Dry season length** (days)	DRYPERIOD	Numeric	3
54.	**Flooding frequency** 1 Annual floodings 2 Rare floodings (once in several years) 3 Exceptional floodings (once in several decades)	FLOODTYPE	Numeric	1
55.	**Flooding season** 1 Winter 2 Spring 3 Summer 4 Fall	FLOODSEAS	Numeric	1

No	Descriptor	Field Name	Field Type	Field Length
56.	**Control of the river** Evidence of measures taken to control the flow of the river. 0 No 1 Yes	CONTRIVER	Numeric	1
57.	**Potentially dominant native tree species** in the area beyond the river influence. List a maximum of 2 species, separated by a semi-colon.	NATIVESP	Text	100
58.	**Ongoing management of the forest / stand** More than one choice can be selected and will be separated with a semicolon (e.g.: 1;4) 1 Exploitation of wood 2 Artificial plantations 3 Recreation activities 4 *In situ* conservation activities 5 Other	MANAG	Numeric	1
59.	**Remarks** The remarks field is used to add notes or to elaborate on descriptors' state "Other". Prefix remarks with the field name they refer to and a colon (e.g. LOCVALLEY: roadside). Separate remarks referring to different fields are separated by semicolons.	REMARKS	Text	500

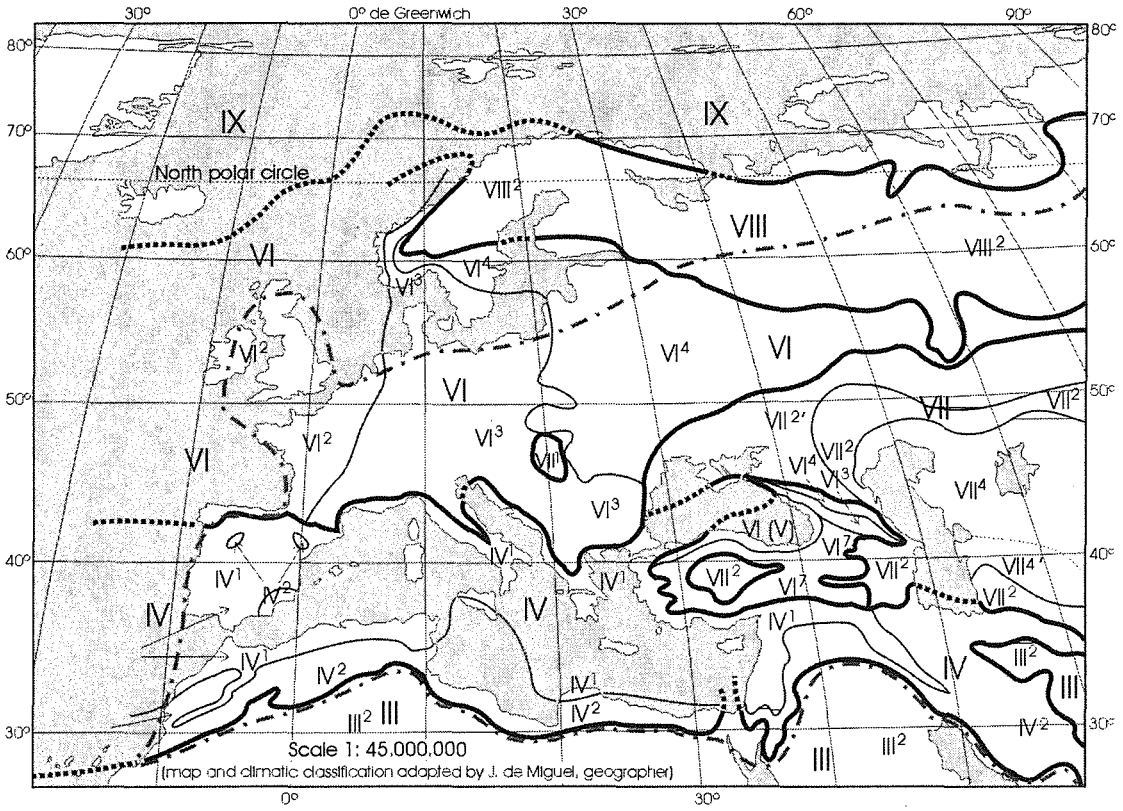
Annex I: List of ISO Codes for most relevant countries where *Populus nigra* is distributed.

ISO Codes	Country Names
AFG	Afghanistan
ALB	Albania
DZA	Algeria
AND	Andorra
ARM	Armenia
AUT	Austria
AZE	Azerbaijan
BLR	Belarus
BEL	Belgium
BIH	Bosnia and Herzegovina
BGR	Bulgaria
CHN	China
HRV	Croatia
CYP	Cyprus
CZE	Czech Republic
DNK	Denmark
EGY	Egypt
FIN	Finland
FRA	France
GEO	Georgia
DEU	Germany
GRC	Greece
HUN	Hungary
IND	India
IRN	Iran (Islamic Republic of)
IRQ	Iraq
IRL	Ireland
ISR	Israel
ITA	Italy
JOR	Jordan
KAZ	Kazakhstan
KGZ	Kyrgyzstan
LBY	Libyan Arab Jamahiriya
LIE	Liechtenstein
LTU	Lithuania
LUX	Luxembourg
MKD	Macedonia, The FYR of
MLT	Malta
MDA	Moldova, Republic of
MCO	Monaco
MAR	Morocco
NLD	Netherlands

ISO Codes	Country Names
PAK	Pakistan
PAL	Palestine
POL	Poland
PRT	Portugal
ROM	Romania
RUS	Russian Federation
SMR	San Marino
SVK	Slovakia
SVN	Slovenia
ESP	Spain
CHE	Switzerland
SYR	Syrian Arab Republic
TJK	Tajikistan
TUN	Tunisia
TUR	Turkey
TKM	Turkmenistan
UKR	Ukraine
GBR	United Kingdom
UZB	Uzbekistan
YUG	Yugoslavia (Former)

Geographic distribution and fitoclimatology of *Populus nigra* L.

(typology by Walter, 1960, subtypology and taxonomy by Allué, 1990)



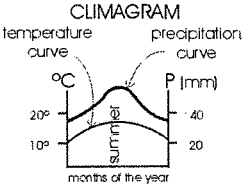
Climatic types	subtypes	Climagram
III Desert subtropical	III2 hot desert	
IV Mediterranean	IV1 true	
	IV2 subdesrt	
VI Atlantic	VI(V) temperated-humid	
	VI2 oceanic	
	VI3 middle european	
	VI4 subboreal temperated	
	VI7 sub-steppe	

Climatic types	subtypes	Climagram
VII Steppe	VII2' northern	
	VII2 southern	
	VII4 northern semidesert	
	VII4' southern semidesert	
VIII Boreal		
IX Artic tundra and desert		

SIMBOLS

- Distribution area (by Lui Zsuffa, 1974)
- Climatic type
- Climatic subtype

CLIMAGRAM



Ex situ conservation

Update on the EUFORGEN core collection and the database of clones

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The EUFORGEN core collection

Eighteen countries have provided clones so far. It is expected that other countries included in the distribution range will join the core collection (the *species* is reported to be autochthonous in 33 european countries). Thirty-nine clones are now in the Network's core collection hosted by the Poplar Research Institute (ISP) in Casale Monferrato; a duplicate (not complete, 32 clones were propagated in 1999) is maintained at the Institute for Forestry and Nature Research (IBN/DLO) in Wageningen. Part of the collection is hosted both by INRA and IBW Institutes because some of the clones were sent for molecular and isozyme analysis (EUROPOP project).

The current status of the stool beds managed by ISP will not permit the distribution of the complete list of clones in the immediate future. For several clones (from Austria, Ukraine, Poland in particular), the quality and the number of cuttings obtainable is still poor. However there are no problems with the collection that includes the reference clones.

Network's core collection: availability of cuttings

CODE	Country	Stool bed		Total
		1999	1998	
FBVA_LH_HL35	AUT	20	40	60
FBVA_LH_HL55	AUT	20	40	60
IBW_N004	BEL	>200	>200	>400
IBW_N009	BEL	>200	>200	>400
SEEFAR_PAZARDZIK_N1	BGR	70	100	170
SEEFAR_SVICHTOV_N2	BGR	70	100	170
VULHM_88044	CZE	>200	>200	>400
VULHM_88045	CZE	>200	>200	>400
FBS_215/63_JUGENHEIM_1	DEU	>200	>200	>400
FBS_87/65_OFFENBURG_1	DEU	>200	>200	>400
SIA_PASTRIZ_1	ESP	150	-	150
SIA_LUCENI'_2	ESP	150	120	270
FRA_71017-401	FRA	>200	>200	>400
FRA_92510-1	FRA	>200	>200	>400
FCRA_HUNTINGDON	GBR	>200	>200	>400
FCRA_HOBSONS_CONDUIT	GBR	>200	>200	>400
FF_V336	HRV	>200	>200	>400
FF_V408	HRV	>200	>200	>400

ERTI_33-3-1	HUN	>200	>200	>400
ERTI_33-3-2	HUN	150	150	300
ISP_N068	ITA	>200	>200	>400
ISP_N347	ITA	20	20	40
IBN_1238	NLD	>200	>200	>400
IBN_1792	NLD	>200	>200	>400
POL_TORUN_B	POL	100	150	250
POL_KORNIK	POL	60	60	120
ICAS_3	ROM	120	100	220
ICAS_4	ROM	>200	>200	>400
ICAS_5	ROM	>200	>200	>400
ICAS_6	ROM	150	150	300
LVU_BAKA	SVK	>200	>200	>400
LVU_IVACHNOVA	SVK	>200	>200	>400
KAE_N.92.145	TUR	-	-	-
KAE_N.90.013	TUR	40	100	150
USUFWT_B11	UKR	-	-	-
USUFWT_B12	UKR	60	100	160
UFRI_HRADIZKY	UKR	25	25	50
UFRI_KELIBERDYNSKY	UKR	15	15	30
IZT_NS001	YUG	>200	>200	>400
IZT_NS002	YUG	>200	>200	>400

The European *Populus nigra* database

To date, 14 countries have provided information about the respective *P. nigra* national collections. In February 2000, the database contained 2789 entries, 793 (28%) more than 1997 and 532 (19%) more than May 1999. Latest updates before the meeting in Avignon concerned the Austrian, Belgian, Bosnian Croatian, Czech, Erzegovinan, French, and Italian national collections. Missing data was entered, some mistakes were corrected, and clones no longer held in collections were deleleted. It should be noted that although an effort to complete the information about the origin was done, data regarding latitude and longitude of the collecting site of about 530 clones (19%) is still missing; whereas information is available of the parents of about 100 clones obtained from artificial crossing. Passport data for the clones included in the Network's core collection has been provided too, but some information about clones from 7 countries is still missing. A searchable Access database is available on the Internet. Figure 1 below shows the current status of the clone database.

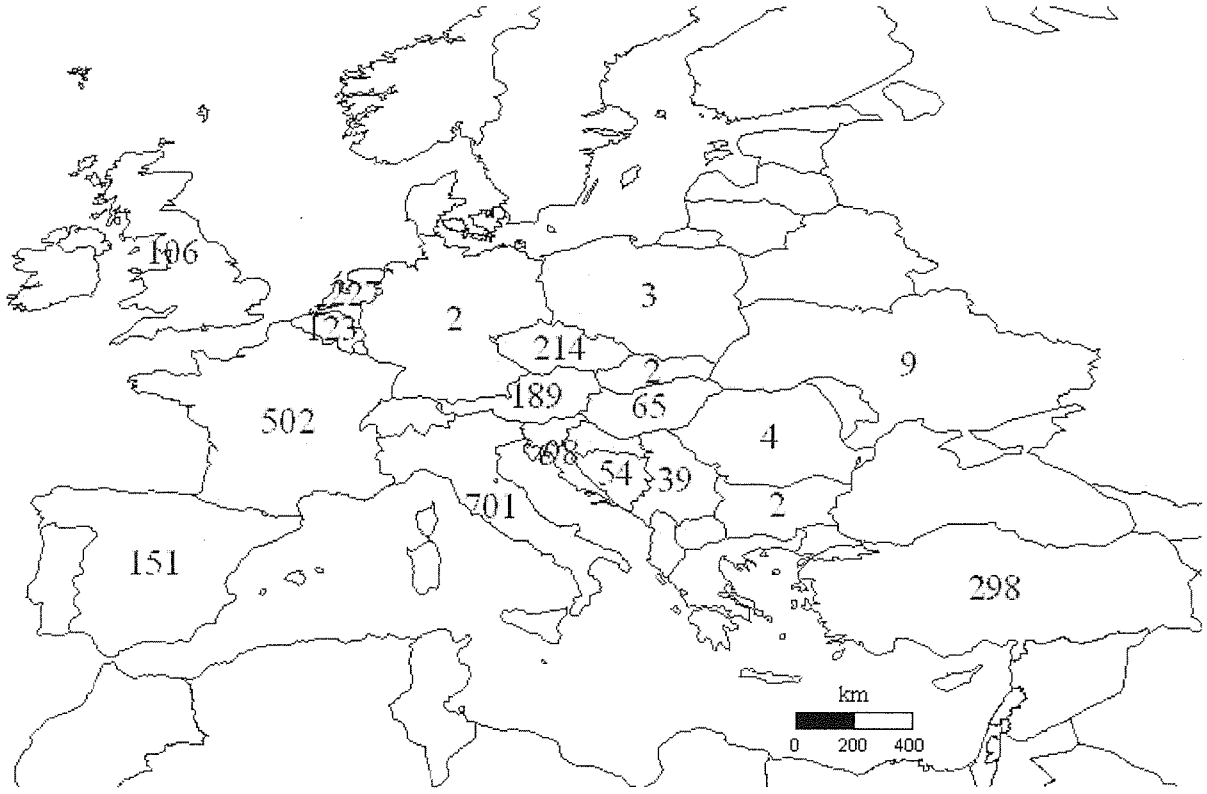

Fig. 1 Number of entries from each country

Populus nigra Bibliography

Addendum 2000

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Note: these new references are an addition to the previous lists included in the reports of the other Network meetings. The full list is available on the Internet at the following address: http://www.ipgri.cgiar.org/networks/euforgen/networks/pop_nigra.htm.

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Research activities on *Populus alba*

Characterization of indigenous species of poplar section *Leuce* in Germany

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Background

There are two species of poplars and one natural interspecific hybrid of section *Leuce* which are indigenous in Germany:

- *Populus alba* L.,
- *Populus tremula* L.
- *Populus* x *canescens* Sm.

Since 1955, the former Hessian Institute for Forest Tree Breeding, predecessor of today's institution, has included poplars of section *Leuce* in its breeding programme. (Fröhlich, Baumeister 1963). A method that could be used to describe species and identify cultivars had to be developed. Unlike section *Aigeiros* the fundamental principles of clonal description and identification were nearly completely missing. For harmonization purposes, methods and terms used for sections *Aigeiros* were followed as far as possible (Fröhlich, Baumeister 1964). Therefore, material from 139 plus trees (9 of *Populus alba L.*, 70 of *Populus tremula* L. and 60 of *Populus* x *canescens* Sm), representing the whole distribution in West Germany, was collected and cultivated in identification beds (Baumeister 1965).

Results

Research on possibilities for the identification of clones showed that there are some problems linked to the characterization and differentiation of the three species, especially in the field. As *P.* x *canescens* has to be considered as a hybrid between *Populus alba* and *Populus tremula*, the progenies from natural hybrid populations, as well as from artificial pollination, could be assigned to types close to alba (type: ca), intermediate (type: cc) and close to tremula (type: ct) with reference to flower morphology and leave characteristics. According to leaflet No. 1 of the Research Institute for Poplar Cultivation (Forschungsinstitut für Pappelwirtschaft) of March 1963 the characterization could be summarized as follows:

Table 1. Species characterization - Mature trees

	Populus alba	*Populus tremula*	*P.* x *canescens*
Phenotype	Normally distinguishing from *P.*x *canescens* is not possible on the basis of phenotype only. For identification morphologic-anatomic traits have to be included: Flower morphology, ovules, number of stomata etc.	During the period of foliation, determination will be possible from the long-stalked leaves, which tremble with the slightest movement of the air. In winter the lucid grey-green smooth bark is characteristic.	Normally distinguishing from *P. alba* and to some extent from *P. tremula* is not possible based only on phenotype. For identification morphologic-anatomic traits have to be included: Flower morphology, ovules, number of

			stomata etc.
Crown and stem	Mostly the crowns are low or fork early. Tendency to develop thick branches and extensive crowns. The crown is intensively branched.	Shape of stems and crowns vary.	All kinds of transition between *P. alba* and *P. tremula* occur. Shape of the crowns vary, but commonly it is not as broad and intensively branched as *P. alba*.
Outer Bark	Bottom stem thick, mostly deep furrowed, greyish brown. Smooth bark occurring mostly towards the top. Lenticels brown and very distinct in form of transverse line patterns.	Smooth bark green-yellowish or yellow-grey, at older age the bottom part of the stem is black-grey and deeply furrowed.	Smooth bark lucid white -grey to light-green, with brown lenticels, which often go far down. Bottom stem deeply furrowed to smooth, green to greyish green.
Leaves of long shoots	Long shoots, lobed-mostly 3 pairs-strongly emarginate and toothed. Top side shiny, dark green. Bottom side always white pubescent. Distinct difference between the leaves of long and short shoots.	Distinct differences between the leaves of long and short shoots. Long shoot : big, oblong, heart-shaped, fine and sharp sawed, here and there slightly pubescent, short petiole.	Vary between clones, show all kinds of transition between *P. alba* and *P. tremula*. Distinct differences between the leaves of long and short shoots. Leaves of short shoots are not significant. Leaves of long shoots are like those of plants in the nursery. In most cases broader than oblong. All transitions from strongly lobed to roughly toothed. Top side shiny dark green. Bottom side grey-green, intermittently pubescent to glabrous. Leaf base varying from very cordate to straight to moderately cuneiform. Almost every time 1-4, mostly 2 glands where the shape merges into the petiole.

Leaves of short shoots	Small, vary strongly, elliptic to cordate, simple to emarginate. Not suitable for differentiation.	Egg-shaped to nearly perfectly circular, smooth, toothed to indented, long-stalked.	Circular to egg-shaped with emarginate, mostly not lobed leaf margins. Leaf base cordate to straight. Bottom side light-green, entirely pubescent to glabrous.
Petioles	Rather short, suborbicular, towards the leaf blade lateral flattened, more and less entirely pubescent.	Lateral flattened, thin, glabrous.	Petioles stronger flattened than *P. alba*, less flattened than *P. tremula.*
Leaf buds	Small, egg-shaped, pointed to blunt, silver-white to light grey pubescent. Terminal buds not bigger than lateral buds.	Small, applied, shiny brown, more or less sticky, egg-shaped, pointed, in some cases on the top side slightly pubescent. Terminal buds regularly bigger than lateral buds.	

Species characterization - Plants in the nursery

	Populus alba	*Populus tremula*	*P.* x *canescens*
Leaves	Longer than wide. Top side shiny, dark green. Bottom side always white pubescent with greenish veins shimmering through, strongly emarginate and toothed. Mostly 3 pairs of lobes. Base straight.	Big, circular to egg-shaped, mostly longer than wide, more or less distinct cordate base with pointed leaf tip, shape of leaf margin irregularly toothed or sawed. Young leaves often pubescent, later rapidly glabrous. Top side shiny green, bottom side light-green with narrow and fine net of veins. In most cases two glands at the base of the leaf blade.	Mostly wider than long, all kinds of transition between strongly lobed to roughly toothed. Top side shiny green, bottom side grey-green, entirely pubescent to glabrous. Leaf base varying from very cordate to straight to moderately cuneiform. Almost every time 1-4, mostly 2 glands where the shape merges into the petiole.
Petioles	Entirely white pubescent, rather short, rounded, slightly flattened towards the leaf	Short, lateral flattened, mostly glabrous.	Moderately long, mostly entirely grey pubescent, slightly flattened especially towards the leaf

	blade.		blade.
Stem	Always entirely white pubescent, downwards decreasing pilosity, round, upper part with slight ledges .	Round, glabrous, with distinct lenticels.	In the upper part mostly entirely grey pubescent, downwards more or less glabrous, round, often with 5-7 ledges in the upper third.
Bark	Beyond the pilosity olive-brown to greyish-green.	Reddish-brown to olive-grey.	Beyond the pilosity olive-brown to greyish-green with yellow-orange lenticels.
Buds	Entirely white pubescent, small, egg-shaped, pointed to blunt.	Small, applied, shiny brown, more or less sticky, egg-shaped, pointed, in some cases on the top side slightly pubescent. Terminal buds regularly bigger than lateral buds.	Small, applied, more or less grey pubescent. Terminal buds bigger than lateral buds.
Propagation	In nature: strong ability to build root suckers, seeds. In the nursery: softwood cuttings from sprouts, seed occasional.	In nature: root suckers, seeds. In the nursery: root cuttings and seeds. Hardwood cuttings commonly difficult.	In nature: strong ability to build root suckers. In the nursery: with respect to softwood cuttings strong variation between clones; root cuttings, layers and grafting possible.

According to the Act on Forest Seed and Planting Stock of the Federal Republic of Germany, as amended and published on 26 July 1979, vegetatively propagated material of poplar was only allowed to be marketed as forest reproductive material if approved. One requirement besides growth and quality characteristics was a clear botanical description. Therefore our efforts to find suitable means to subdivide *P.* x *canescens* into different types were strengthened. Research showed that the most suitable way to do this was to use material raised in the nursery, as shown in table 2 (Baumeister *et al.* 1979).

Table 2 : Distinctive traits during the nursery phase

Traits	***P. alba***	***P.* x *canescens* type close to *P. alba* (ca)**	***P.* x *canescens* Intermediate type (cc)**	***P.* x *canescens* type close to *P. tremula* (ct)**	***P. tremula***
Pilosity	Shiny entirely white pubescent. Top side	Entirely white pubescent. Top side	Entirely grey pubescent, bottom side always	Entirely grey pubescent to downy, on the whole	No or single hairs on the veins.

	mostly with white flakes.	very often with white flakes.	interrupted.	shorter and weaker than the cc- type.	
Pairs of lobes	Mostly three pairs. Strongly developed, especially the one in the middle and the one at the bottom.	Well developed, especially the one in the middle.	Weaker developed than those at the ca-type, the pair in the middle is always discernible.	No or only very weakly indicated.	Never.
Length of the leaves	Mostly just as long as wide.	Mostly just as long as wide.	Mostly wider than long.	Mostly longer than wide.	Mostly longer than wide.
Basal leaf glands	Never.	Never.	Number varying between 0 and 3, sometimes stalked.	Generally 2 (0-4), sometimes with accessory leaves.	Mainly 2 at the base of the leaf blade.
Leaf base	Straight.	Mostly straight.	Straight to slightly cordate.	More or less very cordate to straight .	Mostly cordate, seldom straight.
Incision	None or indicated very weakly.	None or very flat.	Wide wedge-shaped to flat.	Wedge-shaped or steep.	Wide wedge-shaped.
Length of the petiole	Longer than the half of the medial vein (54%).	1/2 up to 2/3 of the medial vein (approx. 52%).	A little less than 1/2 of the medial vein (44%).	A little more than 1/3 of the medial vein (34%).	Up to 1/3 of the medial vein (30%).
Colour of the shoot	Green, entirely strong white pubescent.	Green, entirely strong white pubescent.	Mainly green, leaf margins sometimes reddish tinged, grey-white pubescent.	More or less red and only slightly pubescent.	Mostly completely glabrous, more or less red, some clones have slightly pubescent shoots in spring.

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Populus alba: Some findings and their consequences for the development of a conservation strategy

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Introduction

Some breeding activities conducted in Germany with *Populus alba*, will be illustrated below, with special emphasis on propagation techniques.

In 1955, the Hessian Institute for Forest Tree Breeding started a breeding programme on indigenous species of section *Leuce* (Fröhlich, Grosscurth 1973). Up to that time, in Germany research had nearly exclusively focused on section *Aigeiros*. The aim of the programme was to make use of the broad adaptability to site conditions showed by section *Leuce* for silvicultural purposes.

Inventory and taxonomy

Selection had to be based on the best individuals, representing a broad genetic base. In 1963, the forest administration agreed to assess and inventory existing *P. tremula*, *P. alba* and *P.* x *canescens*, focusing on the selection of stands for seed collection (Fröhlich 1963). Fröhlich reported that as far as the area of West Germany was concerned, no stands of *P. alba* were known. At that time, strong selection in the field resulted in nine plus trees of *P. alba* and 60 of *P.* x *canescens* that could be tested and used for further breeding measures. The field tests showed that for pure *P. alba* no recommendation for cultivation could be given, due to poor technological characteristics of the wood and insufficient growth performance.

There were some problems to carry out this inventory because of uncertainties on the taxonomic relationship between *P. alba* and *P.* x *canescens*, which resulted in difficulties in having a clear distinction (Schröck 1958). The inventory also helped to find answers to some of these taxonomic questions, especially those about natural and artificial hybrids. The activities led to the development of the identification scheme described in the paper above.

Propagation

The development of adequate and practical methods of propagation has always been a very important issue. Many different methods have been tested and applied. The list, which is probably not complete, can be summarised as follows:

- *Seeds* Although flowering and seed formation start at an early stage and controlled crossings could be carried out quite easily in a glasshouse, propagation by seed is not very common (Baumeister 1964, Bärtels 1989). There are some problems due to the fact that the seeds are very short lived and lose their vitality within a few days. Considering interspecific hybridization, there is also the fact that open-pollinated progenies will segregate (Fröhlich 1957, Schröck 1958).
- *Layering* Shoots of young trees are laid, fixed and covered with soil to initiate formation of roots from lenticels. Later the shoot will be divided into short pieces with their own roots and transplanted. This method is very reliable, but the number of plants that can be obtained is very small (Lücke 1951, Fröhlich 1957, Bärtels 1989).
- *Air layering* The shoot that is expected to form roots remains in its natural position. The bark is injured, treated with growth regulators and sealed in a polythene bag. After root formation, the branch will be cut and transplanted to the nursery for hardening off. The method is not suitable for large scale propagation (Fröhlich 1957).
- *Root suckers* All species of section *Leuce* show great ability to form root suckers.

Scarifying the soil might stimulate their formation. These plants can be then dug out and transplanted (v. Wettstein 1944, Fröhlich 1957, Seitz 1960, Bärtels 1989).

- ***Root cuttings*** Roots from older trees are dug out and placed in a hotbed. The apical dominance is interrupted so that shoots will sprout; they can then be cut and transplanted for rooting. (Muhle-Larsen 1943). The number of cuttings is highly related to the length and the diameter of the roots. On average, 50-60 cuttings can be obtained from a one meter root (Fröhlich 1957, Kuchelenz 1958, Seitz 1960, Janson 1967, Behrens 1978). It has been reported that smaller roots that remain in the soil after seedlings have been removed, resprout and root when they were used as cuttings (Kuchelenz 1958, Seitz 1960, Bärtels 1989).
- ***Hardwood cuttings*** This method showed to be useful and applicable to *P. alba.* (Schröck 1958, Fröhlich 1973, Bärtels 1989). The results with *P.* x *canescens* are very different. Johnson (1946) pointed out that a close relation of the hybrids to *P. alba* - ca-types-seems to enhance the rooting ability.
- ***Softwood cuttings*** Propagation of P. x canescens is possible by means of softwood cuttings (Jestaedt 1976, Bärtels 1989).
- ***Grafting*** In case of problems of autovegetative propagation (e.g. non availability of useable cuttings, aged mother trees) grafting is a promising alternative to preserve genetic information. The scions normally will be grafted on root-stock from *P. alba.* The appropriate method will be notch grafting or splice grafting (Fröhlich 1957, Bärtels 1989).
- **In vitro *propagation*** Besides the conventional methods mentioned, *P. alba* has also been successfully propagated with *in vitro* techniques. For example, in 1996, the aged *P. alba* clones in our stool beds that showed symptoms of decline were propagated, so that the clone collection could be completed (Gebhard, oral information). One of the advantages of tissue culture techniques is that the physiological status of the material available does not play such an important role as it does with propagation by cuttings.

Although this list might not be exhaustive, as it has to be underlined that other institutions will also have worked on the propagation of *P. alba,* it is quite clear that multiplication would be no problem at all. There are sophisticated methods to preserve genetic information of single individuals as well as methods to carry out large scale multiplication.

Conservation strategy

The strategy for the conservation of *P. alba* appears to be similar to the one for *P. nigra.* Currently, in Germany, the threats and the resulting activities are similar: e.g. destruction of the ecosystems and replacement by economically more interesting species (*P.* x *canescens*). Due to the fact that forest management has no great interest in *P. alba* and thus the species has been neglected, we assume that the actual situation of *P. alba* can not be assessed completely without further activities.

Inventories should be updated paying attention to the problem of hybridization. We have to improve the methods for identifying *P. alba.* To continue the research done on morphological traits for field and nursery identification, the Hessian Forest Center for Planning, Research and Ecology has started a programme on biochemical markers, which includes different species of section *Leuce.* We expect that the identification done could at least be verified. The material is taken from our actual collections which include *Populus alba* and *Populus tremula* clones as well as *P.* x *canescens* clones representing the different types: close to alba type (ca), intermediate type (cc), close to tremula type (ct).

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Annex - Bibliography excerpt referring to propagation of section *Leuce* by conventional methods

The increasing interest in the species of section *Leuce* has led to intensified research on propagation techniques since the fifties. Especially during the sixties and seventies remarkable progress which made vegetative propagation practicable, was achieved. In the beginning of the eighties, *in vitro* techniques were developed so successfully that large scale vegetative propagation has become feasible. The emphasis of publications therefore shifted towards *in vitro* techniques. A small excerpt concentrating on German and Canadian journals follows.

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Seminar on floodplain ecology

During the last meeting of the *Populus nigra* Network, the ecology of riparian ecosystems and the impact of management practices on *P. nigra* genetic resources were identified as two of the key research needs. As a result, two specialist from the University of Cambridge, Dr Francine Hughes and Dr Nadia Barsoum, were invited to hold a seminar on their research activities in the UK and in France. The seminar, which was held jointly with participants from the EUROPOP annual meeting, also provided the opportunity to discuss common research needs and to receive an update on activities of the EUROPOP project.

Links between hydrology, growth and sex in the UK black poplars: some implications for river restoration

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Introduction

The research described in this paper is one component of the EU-funded research project entitled:

Floodplain biodiversity and restoration (FLOBAR 1): Hydrological and geomorphological mechanisms influencing floodplain diversity and their application to the restoration of European floodplains. (Contract no ENV4-CT96-0317). This project ran from November 1996 to November 1999 and has just completed its final report. The partners involved in this project were:

1) University of Cambridge, UK (co-ordinator)
Keith Richards, Francine Hughes, Bill Adams, Nadia Barsoum, Adrian Hayes and Mark Winfield

2) Université Joseph Fourier, Grenoble, France
Jean-Luc Peiry, Guy Pautou, Jacky Girel, Rémi Foussadier,
and Franck Vautier

3) CNRS/Université de Toulouse, France
Etienne Muller, Henri Décamps, Luc Lambs and Hélène Guilloy

4) University of Umeå, Sweden
Christer Nilsson and Mats Johansson

The main objectives of the programme are detailed below:

- Contribute to the development of a scientific methodology for determining the flow needs of riparian plant communities on selected European floodplains.
- Create effective links between the scientific understanding of the functioning of riparian ecosystems and the institutional mechanisms by which river management for conservation and restoration occur.

These aims were achieved by a series of linked scientific and socio-economic studies:
1. To identify and quantify hydrological and sedimentological conditions favoured by riparian species for their establishment and growth. This objective was achieved by a combination of field monitoring, field experiments, controlled greenhouse experiments and numerical groundwater modelling Field sites were installed in four river systems situated along a north-south European climatic gradient. They represented sub-Arctic, Atlantic Maritime, Humid Alpine, and Atlantic Pyrenean environments. In each of these biogeographical regions contrasting hydrological regimes and sedimentary environments enabled established methodologies to investigate links between hydrology and vegetation patterns and to study experimentally a range of woody riparian species in order to quantify the abiotic environments that they favour. Complimentary experiments on the species used in the field experiments were carried out in a series of greenhouse experiments. These experiments involved growing floodplain vegetation species in different substrates and under different water-table regimes using specially designed apparatus. Numerical modelling of lateral and horizontal movement of groundwater and of the effects of vegetation roughness on flow patterns has also been carried out.
2. To link contemporary floodplain patterns to our understanding of past climatic and land use changes at a catchment scale and over a range of timescales. This objective was met through archival studies of river flows and management practices and through linking these with work previously carried out on catchment-scale riparian vegetation patterns and land-use practices. A conceptual model of the interactive response of floodplain ecosystems to changes in physical parameters over different spatial and temporal scales has been developed within this objective.
3. To investigate the institutional framework within which river restoration projects take place and the degree to which knowledge of the functioning of floodplain ecosystems influences their implementation. This objective has been met through the study of a series of case studies, in various EU countries to study the way in which institutional partnerships and packages (incentives etc.) have been designed to achieve restoration or amelioration of floodplain environments and to incorporate appropriate scientific knowledge within their design.

The river systems that have been studied by this project are as follows:

- **The River Öre, northern Sweden**
  climate: sub-Arctic
  hydrology: mean annual discharge; 35 m^3s^{-1} (range 2-550 m^3s^{-1})
  sedimentology: fine silt and sand
  vegetation types: alder and willow woodland
  river management: free flowing.
- **The River Great Ouse, United Kingdom**
  climate: Atlantic Maritime
  hydrology: mean annual discharge; 20m^3s^{-1} (5-150m^3s^{-1})
  sedimentology: fine silt and clay
  vegetation type: grassland and willow woodland
  river management: channelized
- **The River Isère, France**
  climate: Humid Alpine
  hydrology: mean annual discharge; 200 m^3s^{-1} (range 50-1500 m^3s^{-1})
  sediment type: gravel converting to sand and silt
  vegetation types: willow, alder and mixed hardwood forests
  river management: channelized; water transfer schemes, HEP, gravel extraction.
- **The River Garonne, France**
  climate: Atlantic Pyrenean
  hydrology: mean annual discharge; 202 m^3s^{-1} (range 20-400 m^3s^{-1})

sediment type:	coarse gravel
vegetation types:	willow and poplar woodland
river management:	regulated since 18th century (power generation, irrigation)

The co-ordinating partner at the University of Cambridge carried out a field experiment under Objective 1. This experiment investigated the possibility that male and female *Populus nigra* subsp. *betulifolia* have different hydrological and sedimentological requirements. In particular, the hypotheses that females accrue more biomass than males by the end of their first growing season in mesic sites (measured in terms of the water-holding capacity of sediments and depth to the saturated water front), and that males are more tolerant than females of xeric conditions, were tested. The implications for river control regarding sex ratios and the genetic biodiversity of this species within river corridors were then discussed. The results of this experiment will be published in a special issue of *Hydrological Processes* entitled 'Linking hydrology and Ecology', edited by Angela Gurnell, Stan Gregory and Chris Hupp. The abstract of the paper is given below.

The response of male and female black poplar* (Populus nigra *L. subsp.* betulifolia *(Pursh) W.Wettst.) cuttings to different water table depths and sediment types: implications for flow management and river corridor biodiversity

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Abstract
Management of river flows has altered the pattern of flood arrival times and reduced their frequency and duration on many European floodplains. Floodplain tree species depend on floods both to provide new sites for their regeneration and to recharge water tables at various depths in the rooting zone. A reduction in floods is one factor that has led to loss of river corridor biodiversity, with early successional tree species from the Salicaceae being particularly adversely affected. Members of the Salicaceae are dioecious and it is possible that the males and females of these species have measurably different water table requirements which might lead to spatial segregation of the sexes on a floodplain. This paper describes an investigation that was carried out into the response of male and female black poplar (*Populus nigra* L. subsp. *betulifolia* (Pursh) W.Wettst.) to different soil moisture conditions. An experiment was set up on an alluvial island in the River Great Ouse (United Kingdom) in which cuttings of male and female black poplar were grown in different sediment types with different water table levels. The experiment was carried out over two field seasons in 1997 and 1998. Results showed that females tended to prefer wetter and more nutrient-rich sites than males but that there was considerable overlap in their requirements. A complementary genetic study showed very little genetic variation in the experimental population which may also partially explain the relatively low level of variation between the two sexes found in the study. It is suggested that some limited spatial segregation of the sexes does occur in response to soil moisture availability and that river flow management which aims to maintain or increase river corridor biodiversity may need to take this into account.

Conclusion

This research will be continued under the auspices of the new EU-funded research programme FLOBAR 2. This new programme is entitled:

FLOodplain Biodiversity And Restoration 2 (FLOBAR 2): Integrated natural science and socio-economic approaches to catchment flow management

PROJECT COORDINATOR: University of Cambridge (UK)

CONTRACTORS: **Institute for Regional Development and Structural Planning(D)**
Université Joseph Fourier-Grenoble 1(F)
University of Lethbridge (Canada)
Centre National de la Recherche Scientifique –Toulouse (F)
Umeå University (S)

DURATION: **36 months**

The main objectives of FLOBAR 2 are:

Objective 1: To develop scientific guidelines for the application of river flow prescriptions which benefit floodplain ecosystems while maintaining acceptable levels of flood control.
Objective 2: To quantify aspects of the relationships between hydrological inputs to a floodplain and plant response measured in terms of water consumption, growth and the diversity of regeneration strategies.
Objective 3: To investigate the flow resistance associated with woody riparian vegetation using field studies and mathematical and numerical modelling.
Objective 4: To investigate and compare the effectiveness of selected institutional arrangements for restoring floodplain environments at different spatial scales and in different national/local settings.

The balance of black poplar (*Populus nigra*) regeneration strategies as a function of hydrology on floodplains

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Introduction

The natural floodplain comprises a multitude of distinct functional units (microsites) defined by specific hydrological and sedimentological factors. It is also a dynamic system in which all of these so-called functional units are frequently dislocated and re-assembled elsewhere on the floodplain during flood disturbances. The opportunities for regeneration by vegetation in such an environment are accordingly both randomly ascribed and temporally and spatially fleeting. Even between flood disturbances, declining water table levels and rapid colonization of these distinct functional units quickly changes the physical characteristics of each microsite such that resources generally become increasingly limiting throughout the growing season.

The black poplar (*Populus nigra*) has adapted to the abiotic conditions and stresses typically found on a floodplain in its natural state by evolving multiple regeneration strategies which are promoted by, and are in fact dependent on, the destructive effects of floods and on high water table levels at specific times of the year. Although floods constitute a major disturbance in a floodplain ecosystem they also serve to replenish water tables, import sediments and remove competitors, creating in the process ideal microsites for regeneration (bare and damp alluvial deposits). At these microsites *P. nigra* can regenerate sexually from wind- and water- dispersed seeds (non-vegetative regeneration), or via clonal recruitment from fragments of the parent plant (vegetative regeneration); vegetative regrowth can also be promoted by mechanical damage to the parental plant.

In recent years it has emerged that the regeneration potential of *P. nigra* has become increasingly restricted along managed rivers, in some cases seemingly in favour of clonal recruitment. The reduction in recruitment potential along rivers has been coincident with 20th century engineering works which have significantly altered natural patterns of flow, flooding regimes and water table levels (Petts, 1989; Peterken and Hughes, 1998). Interest in the conservation of *P. nigra* and other floodplain woodland species through the adoption of appropriate flow regimes (Brookes, 1996; Van Splunder, 1998) is hampered, however, by a lack of baseline data on those hydrological regimes which will encourage natural patterns of regeneration and maintain genotypic diversity.

This paper summarizes the results of research examining the relative success of vegetative and non-vegetative regeneration strategies of *Populus nigra* L. var *betulifolia* as a function of hydrological and sedimentological controls (Barsoum, 1998; Barsoum and Hughes, 1998). It highlights the significant phenotypic plasticity achieved by this species during the recruitment phase of the life cycle through the adoption of multiple regeneration strategies which play a compensatory role in the face of frequent disturbances, multiple biotic and abiotic hazards and a constantly changing availability of resources. River management guidelines are proposed to encourage the natural regeneration of *P. nigra* and to avoid conditions which result in the predominance of a few clones.

Methods

A comparison of vegetative and non-vegetative regeneration strategies in *P. nigra* was undertaken through field survey and field- and greenhouse-based experimental work. On a semi-natural, braided gravel bed river floodplain (the Drôme River, in the south-east of France), multiple regeneration strategies were identified and the relative proportions and distributions of vegetatively and non-vegetatively regenerating individuals were determined

by excavation along transects during a hydrographically quiet year (1995) and a year in which an unseasonal 1 in 50 year flooding event occurred in mid-summer (1996). Seed dispersal patterns were studied and key agents of seedling mortality were assessed during dry (1995) and wet (1996) field seasons in permanent quadrats located at a wide range of microsite types. In a series of greenhouse experiments, survival and growth responses of seedlings and cuttings were compared along gradients of hydric stress by simulating floods and variable rates of water table decline in contrasting sediment types (i.e. sandy silts vs. predominantly coarse and fine sands with some gravel). A longer term study of seedling and cutting response to soil-moisture gradients (3 years) was undertaken in the field by transplanting seedlings and cuttings into experimental field plots located along a sediment textural gradient. The comparative responses of seedlings and cuttings to complete and partial burial by coarse and fine sediments was also studied in a greenhouse experiment. Cuttings used for all experimental work were collected from the vigorous shoots of juvenile plants. The cuttings were approximately 20 cm long with one viable bud; this was considered to be the smallest possible vegetative fragment likely to establish freely in the field.

Results

By integrating field survey and experimental approaches to study vegetative and non-vegetative regeneration strategies of *P. nigra*, significant distributional, morphological and physiological differences were highlighted between both regeneration strategies which serve to increase the ecological amplitude of its regeneration niche. A differentiation in vegetative and non-vegetative regeneration strategies was detected in terms of (i) the relative proportions, spatial distribution and timing of dispersal/creation of propagules on the natural floodplain, (ii) growth patterns and shoot architecture and (iii) tolerance levels to specific flooding, burial or drought treatments.

(i) Temporal and spatial differences in the distribution and relative proportion of sexual and asexual regeneration on the natural floodplain

Regeneration was found to be predominantly from seed in both a dry and a wet field season (summers of 1995 and 1996, respectively). This was despite (i) a substantial increase in the number of asexual recruits following an unseasonal mid-summer flood in 1996 (and a corresponding decline in seedling numbers) and (ii) very high seedling mortality rates (as recorded within permanent quadrats) in both the dry and wet field seasons (mortality was a minimum of 85% at any given microsite). Key agents of seedling mortality in both years were drought stress and the mechanical impact of floods; intra-specific competition and herbivory played minor roles.

The greater proportion of seedling recruits in 1995 and 1996 was directly related to the substantially greater regeneration potential from seed - this will be true at least along those rivers where there is a large seed-producing population (e.g. along the Drôme River at least 74 *P. nigra* seeds were captured in 37 x 24 cm seed trays in the 1995 and 1996 field seasons). Viable seed is produced in vast quantities during the same time period every year (May - June). The windborne seed (though some is waterborne) is dispersed throughout the floodplain with a fairly equal chance of landing at most available microsites ideal for regeneration in the vicinity. However, despite this widespread dispersal of propagules, viability is short-lived (50% of *P. nigra* seeds loose their germinative capacity in 14 days; Van Splunder, 1997) and the resulting distribution of seedlings is generally patchy and limited to low elevation microsites, closely reflecting both the heterogeneous nature of resources on the floodplain and water table levels, respectively.

The number of asexual propagules and their distribution was less predictable in space and time, providing a certain degree of flexibility in the face of unpredictable flood disturbances. Vegetative regeneration depended primarily on the occurrence of destructive

flooding events and patterns of river flow to either create and disperse vegetative fragments (which accumulated in debris dams and were trapped by vegetation in zones of aggradation), or to stimulate vegetative regrowth at points where there had been significant lateral erosion of the river bank. Excavation of seedlings and vegetative recruits established during the 1995 or 1996 field seasons along transects, revealed that the distribution of vegetatively regenerating individuals was also patchy, but spanned a wider elevation range than the seedlings (up to 1.3 m higher on the floodplain). Often vegetative fragments are able to survive at higher elevations on the floodplain than seedlings either because pre-existing parental root systems provide immediate contact with the water table (e.g. this is the case for propagules originating through flood-training, coppice re-growth, or suckering), or larger carbohydrate reserves ensure rapid initial shoot growth and rapid root extension towards the water table. Regeneration at high elevations on the floodplain can be advantageous in the event of significant and destructive flooding events.

Because vegetative regrowth is completely dependent on the frequency of flooding events, the timing of vegetative propagation can occur both during and between growing seasons and also several times during a single growing season. Propagules created during over-winter flooding events can remain dormant over several months provided that temperatures are low and that they do not dry out; these dormant propagules are only subsequently stimulated to produce roots and shoots under ideal hydrological conditions (Martyn, 1995; Carlson, 1938; Barsoum, unpublished data). Occasionally, spring floods peak well in advance of the dispersal of seed, or after seed dispersal during the vulnerable early establishment phase of seedling development (e.g. this was observed over the summer of 1996 along the Drôme River). Vegetative propagules created during these floods (and not necessarily stranded at high elevations on the floodplain) are at an advantage over seedlings since they (i) become established earlier in the season compared with seedlings and (ii) are dispersed at a time which is coincident with high water table levels and subsequently, with the falling limb of the flood attenuation hydrograph.

(ii) Variable growth patterns and shoot architecture

Comparison of *P. nigra* seedling and cutting shoot growth and architecture in experimental field plots and in greenhouse experiments revealed a number of important differences between both regeneration strategies which could potentially improve the chances of survival of one regeneration strategy over the other at different stages of establishment and across soil-moisture gradients. Cuttings were at an apparent advantage at the outset. Pre-existing shoot and root primordia and carbohydrate reserves ensured comparatively vigorous growth during the first few weeks of establishment in a wide range of soil-moisture conditions, allowing the cuttings to rapidly accumulate above-ground biomass and extend roots towards the water table. Where soil-moisture is not a limiting factor, continuous rapid growth of the multiple and large shoots which typically evolve from vegetative propagules is likely to improve their chances of surviving heavy sedimentation during a flooding event, or aggressive inter-specific competition compared with seedlings. Vigorous initial shoot growth of vegetative fragments, however, also clearly increased their vulnerability to drought stress compared with seedlings.

Seedling growth was comparatively slow to start with, but as the shoots developed, seedlings became more efficient at accumulating biomass than cuttings (as measured by significantly greater relative growth rates of shoots), especially where soil-moisture became a limiting factor. *P. nigra* seedlings in both the greenhouse and field experimental plots were observed to consistently have significantly higher leaf area ratios and specific leaf areas than cuttings which acted to enhance their photosynthetic capabilities. Saplings of seed origin also tended to have less side-shoots than saplings of vegetative origin.

Sediment texture was demonstrated to exert a very important, indirect influence on *P. nigra* seedling and cutting growth responses by influencing the availability of soil-moisture.

Fine-textured sediments (clays, silts and fine sands) are prone to water-logging and where water table levels were close to the surface this was observed to severely inhibit the growth of *P. nigra* root systems. Water table levels close to the sediment surface in coarse sediments allowed for better root growth since low oxygen, water-logged conditions did not evolve as readily in this sediment type. Where rates of water table decline were rapid (2.5 cm day^{-1}), the higher water retention capacity of fine-textured sediments became beneficial, encouraging greater ramification of roots; e.g. in saturated fine sediments, *P. nigra* seedling mean root dry weight measurements by the end of an 11-week greenhouse experimental period were in the order of 0.03 g compared with 0.82 g in well-drained fine sediments. In coarse-grained sediments, the ramification of *P. nigra* roots was observed to be comparatively limited, resulting in a heavy reliance on a single, or several, tap roots to remain in contact with the water table; e.g. root dry weights of *P. nigra* seedlings and cuttings were 1.84 g and 3.66 g, respectively in a fine-grained sediment compared with 0.50 g and 0.82 g, respectively in a coarse sediment, where water table decline rates were set at 2.5 cm day^{-1}.

Within the experimental field plots, surface sediment texture influenced relative growth rates of seedlings and cuttings in the first two years of establishment, but ceased to have any influence on seedling and cutting growth and productivity beyond the second year of establishment; this was probably due to the establishment of root contact with the water table by this stage which became the main source of water and dissolved nutrients.

(iii) Variable tolerance levels to flooding, droughts and burial by sediments

Comparison of the growth and survival of *P. nigra* seedlings and cuttings along gradients of hydric stress and in two contrasting sediment suites revealed that seedlings were more tolerant of low levels of soil-moisture (drought conditions) than cuttings and generally had more vigorous and sustained relative growth rates across treatments except where anaerobic conditions developed such as occurred in poorly drained fine sediments (e.g. in coarse and fine sediments under a fluctuating water table [20 cm rise and fall of water levels from the sediment surface every 24 hours], total mean biomass of seedling shoots were significantly different at 3.74 g and 0.59 g, respectively). Cuttings, in contrast, showed higher tolerance of anaerobic conditions (e.g. total mean biomass of cutting shoots in coarse and fine sediments under a fluctuating water table, were not significantly different at 5.01 g and 4.97 g, respectively). In drought conditions (e.g. fast rate of water table decline [2.5 cm decline day^{-1}] in a coarse sediment), seedlings were capable of sustaining high relative growth rates compared with cuttings, even managing to rely on residual water trapped throughout the sediment profile when contact was lost with the water table. These differences between cuttings and seedlings are explained by the more efficient biomass allocation patterns of seedlings, but a greater capacity by cuttings to produce adventitious roots.

Both regeneration strategies were able to tolerate up to 18 days of complete submergence in well-aerated water by entering a semi-dormant state, although cuttings showed significantly greater susceptibility to drought stress when floodwaters receded.

Preliminary results suggest that partial burial (meristems exposed) by fine and coarse sediments has no effect on seedling and cutting relative growth rates. Seedlings of between 4 and 10 weeks, however, are unable to survive complete burial by sediments, unlike cuttings which are capable of continued growth in such conditions, sending etiolated shoots to the sediment surface through up to 6 cm of sediment deposits.

Conclusion

These results demonstrate how different hydrological regimes and sedimentological conditions might favour one regeneration strategy over another in *P. nigra* and highlight important physiological differences between both regeneration strategies. Frequent and unseasonal flooding events and/or shallow water table levels are expected to favour asexual recruitment. River management recommendations to encourage natural patterns of

regeneration and maximise genotypic variety based on these findings include:

- Allow only occasional high magnitude flooding events prior to seed release to create ideal regeneration conditions for seedling recruitment (i.e. bare and damp alluvial deposits, protected microsites behind Large Woody Debris).
- Occasional flooding events should occur as early in the growing season as possible following seed release to maximise the length of the first growing season for seedlings and thus, increase their chances of survival.
- Allow slow water table decline rates in coarse sediments following spring floods, such that roots can maintain contact with the water table.
- Avoid shallow, fluctuating water table levels in predominantly fine sediments, so that waterlogged conditions do not evolve and affect root development and seedling survival.
- Reduce impacts of mid- to late-summer floods since these are destructive to seedlings, but promote vegetative regeneration.
- High suspended sediment loads combined with heavy sedimentation rates will favour asexual over sexual recruitment.
- Woody debris dams and the shrub-like growth of vegetative shoots create ideal microsites for regeneration on floodplains and should therefore also be present in the post-flood environment.

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Programme

Saturday 5 February: - arrival of participants

Sunday 6 February:

7:00 Departure by bus from the hotel
9:00 Arrival in the Reserve Naturelle des Ramieres de la Drome
9:00 Coffee wake up
9:30 Joint Technical Seminar with EUROPOP participants

- An overview of progress in project EUROPOP (B. van Dam)
- Links between hydrology, growth and genetic variation in the UK black poplars: implications for floodplain restoration (F. Hughes)
- General joint discussion on research needs and priorities
- Current and past activities on the river Drome
- Brief presentation of the Drome riparian site and the reserve (J.M. Faton)
- Effect of river dynamics and soil texture on the sexual/vegetative reproduction of black poplar (N. Barsoum) (experiments related to FLOBAR conducted in the reserve)
- Genetic studies from EUROPOP in the Drome, and *in situ* conservation projects (F. Lefèvre)

12:30 lunch

14:00 field tour
17:30 coffee "warm-up"
18:00 bus back to the hotel

Evening

Social dinner with EUROPOP participants at hotel

Monday 7 February:

8:30 Opening of the meeting

- Welcome (Host country and Chair of the *Populus nigra* Network)
- Adoption of the agenda and nomination of rapporteurs

8:45 Presentation of the Unité de Recherches Forestières Mediterranées, INRA (M. Bariteau)
9:15 Presentation of new *Populus nigra* Network outputs (J. Turok)

- Report of the previous meeting
- Identification Sheet in additional languages
- Bibliography
- Database

9:45 Country Updates (all participants)
11:00 Break
11:30 Country updates (continued);
Introductory country reports

13:00 Lunch

14:30 *In situ* conservation measures and activities

- Review of the Network strategy (S. de Vries)

- Evaluation and use of the Network's descriptors (N.Alba)

Discussion and recommendations

16:00 Break
16:30 Update on EUFORGEN core collection of clones and on European database (L. Vietto)
17:30 Public awareness

- CD ROM (S. de Vries)
- Web Page (S. Borelli)

Tuesday 8 February:

8:30 Collaboration on *Populus alba* genetic resources activities in Europe

- Database (N. Alba)
- Technical recommendations for conservation and propagation
- (R. Schulzke)
- Establishment of core collection (discussion)

11:00 Break

11:30 Collaboration with WWF (S. Borelli, B. Heinze, discussion of participants)

13:00 Lunch

15:00 Any other business
15:30 Date and place of next meeting
16:30 Adoption of the report

17:00 Closure

Wednesday 9 February: **- departure of participants**

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