IPGRI Conifers Network

Report of the First Meeting—22–24 March 2000—Brdo/Kranj, Slovenia

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EUFORGEN

European Forest Genetic Resources Programme (EUFORGEN)

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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 for the Protection of Forests in Europe. EUFORGEN is financed by participating countries and is coordinated by IPGRI, in collaboration with the Forestry Department of FAO. It facilitates the dissemination of information and various collaborative initiatives. The Programme operates through networks in which forest geneticists and other forestry specialists work together to analyse 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. The geographical designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of IPGRI or the CGIAR concerning the legal status of any country, territory, city or area or its authorities, or concerning the delimitation of its frontiers or boundaries. Similarly, the views expressed are those of the authors and do not necessarily reflect the views of these organizations.

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Contents

Summary of the meeting and workplan

Opening of the meeting

The State Secretary for Forestry Mr Mohoric welcomed the participants and emphasized the importance of sustainable forest management and preservation of biodiversity in Slovenia. He also stressed the active role of his country in research and management of genetic resources of conifers.

Prof. Dr N. Torelli, Director of the Slovenian Forestry Institute, welcomed the participants on behalf of the Institute.

The Head of the Silviculture Department from the Slovenian Forest Service, Mr Grecs, welcomed the participants and underlined the importance of natural forest in Slovenia (88%), and of natural regeneration in these forests.

The Vice-Chair of the Forestry Department of the Biotechnical Faculty of the University of Ljubljana, Dr Hladnik, pointed out the importance of collaboration with the Slovenian Forest Institute (SFI) and EUFORGEN.

Prof. V. Koski on behalf of the EUFORGEN *Picea abies* Network thanked the local organizers for the excellent organization and for their participation, which shows the importance of the collaborative work on forest genetic resources in Europe. He briefly described the background of this first meeting of the EUFORGEN Conifers Network. The previous EUFORGEN *Picea abies* (Norway spruce) Network started its activities in 1995. Following the outputs provided and on the basis of the interest expressed by countries, the last Steering Committee meeting recommended that the scope of this Network be widened to encompass other conifer species.[1]

J. Turok welcomed the participating countries (25) and thanked the National Coordinator H. Kraigher and the Network member G. Bozic for the preparations and the Slovenian Government for hosting the meeting. He then gave a brief introduction on Phase II of EUFORGEN, a brief summary of the results of the recent, sixth *Populus nigra* meeting, and highlights on upcoming meetings and activities in progress in the Programme.

The agenda of the meeting was adopted.

Highlights on progress made in gene conservation of Norway spruce (*Picea abies*) in Europe

Four members of the *Picea abies* Network were invited to make presentations to highlight the progress made in gene conservation of the species in Europe during recent years.

G. G. Vendramin focused on the genetic research carried out in Italy. A range of molecular markers were developed and used for the analysis of genetic diversity in Norway spruce throughout its distribution area in Europe during recent years. The main results and their possible implications for gene conservation and breeding strategies were reviewed.

T. Skrøppa provided a summary of the developments in Norway's national programme, including a new conservation and breeding strategy for Norway spruce, which has been based on new knowledge and information.

An overview of the concept and activities of Germany's programme on the conservation of forest genetic resources was presented by A. König. The progress made in the practical gene conservation and breeding of Norway spruce was demonstrated.

[1] International collaboration on forest genetic resources: the role of Europe. Proceedings of the Second EUFORGEN Steering Committee meeting, 26–29 November 1998, Vienna, Austria. International Plant Genetic Resources Institute, Rome, Italy.

Cs. Mátyás described the potential implications of climate instability on genetic resources of Norway spruce at the southern distribution limits of the species in Hungary and other countries.[2]

Outputs of the EUFORGEN *Picea abies* Network

The most recent outputs of the *P. abies* Network were presented by the Secretariat.

S. Borelli presented the new structure and contents of the Web page including the current version of the conifers sub-page. Participants expressed a need to strengthen the section on links by including Web sites of relevant institutes and international processes. The participants also agreed to test the page (http://www.ipgri.cgiar.org/networks/euforgen/euf_home.htm) and provide comments to the Secretariat.

J. Turok gave an on-line demonstration of the bibliographic database, which currently includes 320 references from 11 countries. Countries that have not yet contributed were encouraged to do so. The Secretariat will send out a message containing instructions and formats for update by **31 March 2000**.

The suggestion was put forward to provide links to existing international databases such as CABI and FAO databases.

J. Turok briefly presented the Technical Guidelines and its contents and asked for feedback from the participants. The participants actively discussed this point and the conclusion was that, in order to reach the forestry officers in the different countries, it is essential that the guidelines (or an adapted version of these) be translated into the national languages. It was also noted that some aspects of forest management were not covered or were not appropriate for all countries.

S. Borelli briefly presented the poster on *P. abies*, which is in print and will be distributed as soon as it becomes available.

Assessing priorities for the EUFORGEN Conifers Network

Veikko Koski presented an introductory paper on genetic diversity of European conifers, to help set the stage for the ensuing discussion on priorities for the Network.

J. Turok presented the results of the survey on priority species and activities and compared some of the results with those of the questionnaire circulated before the last meeting of the EUFORGEN Steering Committee (see Annex I).

After discussion on overall priorities, the participants agreed to divide into three groups (widely occurring; rare and threatened; exotic species). The groups had the task of answering questions on common characteristics, current state of knowledge, needs and priorities, main constraints and conservation strategies to be used.

The results from the working groups are summarized in Table 1.

[2] A related contribution was published in: Mátyás, Cs. 2000. Riding on a wave of anxious concern: genetic implications of expected climate instability at the southern forest limits. Pp. 44–46 *in* International collaboration on forest genetic resources: the role of Europe. Proceedings of the Second EUFORGEN Steering Committee meeting, 26–29 November 1998, Vienna, Austria. International Plant Genetic Resources Institute, Rome, Italy.

Workplan

Four main areas of involvement (information, policy and legal issues, technical guidelines and public awareness) were discussed in three working groups. Each working group proposed a set of activities. They provide the basis for this workplan, agreed during the final session of the meeting.

Information

Bibliographic database

It was agreed that the bibliographical database on Norway spruce should be further developed to include references leading to 'grey' literature on genetic resources of minor (rare and threatened) conifers before the next meeting. The Secretariat will circulate a note with instructions for submitting references before **31 March 2000** (see above). The progress made in compiling the database and its future development will be on the agenda of the Inter-Network Group of Chairs and Vice-Chairs of all five EUFORGEN Networks at their first meeting to be held **in autumn 2000**.

Information platform ('database of links')

It was suggested that the EUFORGEN Secretariat should establish a common information platform on forest genetic resources in Europe. The objective is to make available a summary profile on each national programme and to provide links to the further information existing at country level. The profile will include contacts (National Coordinator), networks of interest, institutions involved, policy information and links ('database of links'). The EUFORGEN Secretariat will set up an initial version of the database before **30 June 2000**. National Coordinators will be asked to verify the information and provide additional input.

Each country was encouraged to develop its own Web page on forest genetic resources, which would be linked to the common information platform. Information and data about conservation categories, gene conservation units, their location and availability, seed stands, seed zoning, provenance / progeny experiments, *ex situ* storage / genebanks / archives could be part of this source of information at the national level. The list of common descriptors and the glossary developed by the *Picea abies* Network and other EUFORGEN Networks, provide the standards for this information. To facilitate this development, the Secretariat will circulate a note with the descriptors developed for *in situ* conservation units (Noble Hardwoods, *Populus nigra*) and the list of relevant terms to all Network members before **31 March 2000**.

Maps of gene conservation units for individual species should be compiled at the European scale and made available electronically later (from the information platform and on CD-ROM), provided that the information is available.

Distribution maps

The importance of updated and detailed distribution maps as a tool supporting conservation strategies was recognized. An inventory (list of references) of relevant maps will be undertaken by all countries and the information provided to EUFORGEN Secretariat by **31 December 2000**. The Secretariat will report on results of the inventory at the next Network meeting.

Policy and legal issues

The need for inventory and analysis of policy / legal issues affecting the conservation and use of conifers genetic resources was recognized. This should be carried out at the national level and for the European Union. A project proposal on policy and legal systems affecting plant genetic

resources conservation and use in Europe was developed by IPGRI. Depending on the outcome, the Secretariat will inform Network members about the approach and activities before **30 June 2000**. Results of the analysis, including different options of policy/legal systems applied in different countries, should be provided to National Coordinators. They may communicate them to national authorities as needed and appropriate. Network members will liaise with National Coordinators for providing inputs into the inventory.

Integration and harmonization of genetic resources issues into ongoing international agreements and processes was considered as a high priority. These include the non-binding resolutions of Ministerial Conferences on the Protection of Forests in Europe (MCPFE), including Strasbourg Resolution S2, the legally binding Convention on Biological Diversity (CBD) and others. The Network members were strongly encouraged to monitor the developments in their countries and to be proactive in contacting agencies responsible for the various agreements and processes. The new common information platform will include summary and links leading to the major relevant international processes.

Austria and the United Kingdom offered to present a case study on the experience with linking the various processes at the national level during the next Network meeting.

The need for and possible impact of raising awareness about populations/species that require emergency action was discussed. Information about such cases will be promptly circulated to Network members. The Network will express support as appropriate. The Inter-Network Group at its first meeting in autumn 2000 will discuss the broader involvement of EUFORGEN Networks in monitoring and responding to situations of immediate threat to genetic resources.

Experiments have been made with genetic transformations in several conifer species. The Network members will follow the development and use of genetically modified trees in their countries and the possible implications on genetic resources. The Secretariat and Network members from OECD member countries will follow the development of the revised OECD Scheme.

Technical guidelines for gene conservation of conifers in Europe

The objective is to provide a common set of recommendations for genetically sustainable management of conifers, which can then be adopted and adapted in each country. The guidelines should aim at reaching forest officers and agencies responsible for forest gene conservation in European countries, transferring results of the genetic research undertaken on conifers into forestry practice. They will be divided into chapters focusing on situations in which species are common, rare (scattered distribution patterns), and on exotics. An introductory chapter on basic principles of gene conservation will be added (including impact of human activities on genetic resources, mating systems, the importance of marginal populations etc.).

The Chair and Vice-Chair will contact all Network members and ask for their contribution to the outline. First outline will be discussed during the next Network meeting in 2001. The development of this publication will be closely coordinated and harmonized with other EUFORGEN Networks, especially Noble Hardwoods, through the Inter-Network Group. The text should be very short and comprehensive, accompanied by illustrations and photographs. The printing of the guidelines is foreseen within 2–3 years. The EUFORGEN Secretariat will send a list of comments/suggestions received on the existing Technical Guidelines for Norway spruce to the group by **31 March 2000**. The outline of the guidelines will be circulated to all Network members one month before the next meeting.

Technical recommendations on seed/pollen storage are available for a number of plant species, including conifers. A Handbook was published by IPGRI. The EUFORGEN Secretariat

will extract and send the existing information on European conifers to all Network members before **31 July 2000**.

Public awareness

A collection of slides will be compiled on a Photo CD. B. Fady offered to take responsibility for this task. All Network members will provide relevant slides from their countries to him by **31 December 2000**. A list of items will be provided by the Secretariat in consultation with B. Fady **by 30 April 2000**. The collection will be demonstrated and missing items identified at the next Network meeting. Once the collection is finalized, all Network members will receive a copy for their use in raising awareness about conifers genetic resources in each country.

The production of a short video on conifers genetic resources in Europe (different aspects of variability) was also mentioned. It was recognized that this requires professional advice and considerable financial resources. The Inter-Network Group will follow up the idea in relation with the other Networks. Malta offered to coordinate the video on behalf of the Network. The item will be discussed in detail during the next meeting.

Other possibilities were mentioned such as a screen-saver and computer games. The Secretariat will prepare a simple screen-saver using the slides from the collection and send it to all Network members.

A leaflet on transboundary gene conservation programmes on conifers will be produced using a case study in the Carpathian region. L. Paule and J. Matras will prepare and circulate a draft text by **31 October 2000**.

Development of plan and tools for communicating information

The development and use of publications/case studies on technical and policy issues, *ad hoc* workshops, presentations on relevant themes at Network meetings and at other fora, articles in journals and newspapers etc. were mentioned. It was proposed that a communication plan for EUFORGEN be discussed at the Inter-Network Group meeting. Joint messages for a variety of audiences could be developed by this group on broader issues (i.e. the importance of genetic diversity as part of biodiversity, the role of genetic diversity in sustainable forestry).

Seminar on mountain forests

S. Borelli introduced the theme and underlined the growing attention that the issue of mountain biodiversity is receiving in international and particularly European fora.

Z. Vardanyan presented an overview of the biodiversity of mountain forests in the Caucasus and indicated that there is currently no forest genetic resources conservation programme in Armenia.

M. Ulber made a presentation on the links that exist between management of mountain forests and conservation of genetic resources in Switzerland.

H. Kraigher illustrated the characteristics of mountain forests in Slovenia and provided highlights of the research currently being carried out.

T. Levanic from the Biotechnical Faculty in Ljubljana made a presentation on the contribution of dendrochronology to studies of conifers genetic resources. S. Zitnik from the Slovenian Forestry Institute gave an on-line demonstration of the plant genebank of Slovenia.

Meeting report

The issue of the format of the meeting report was discussed and a decision was made to prepare a printed version, particularly in view of the fact that this it the first meeting of the new enlarged Network. It will include highlights on *P. abies* Network, a brief overview of the outputs, the

results of the questionnaire, the discussion on priorities and activities of the new Network and the papers on conservation of mountain forests. All contributions will be sent to the Secretariat by **30 April 2000** (see guidelines circulated earlier).

Election of Chair and Vice-Chair

Both the Network members and the Secretariat expressed their sincere gratitude to V. Koski for his commitment and efforts in the implementation of the Strasbourg Resolution S2, in ensuring the success of the *P. abies* Network and its smooth transition to the Conifers Network. Csaba Mátyás was elected as Chair of the Conifers Network and Bruno Fady will act as Vice Chair. Cs. Mátyás briefly presented his vision for the future role and activities of the Network.

Date and venue of the next meeting

The next meeting of the Conifers Network will be held in Valsain, Spain in 2001. We would like to thank Malta for also expressing the wish to host the next meeting of this Network.

Adoption of the report

The report was adopted and distributed to the participants.

Conclusions

B. Fady thanked the organizers and the participants for their contribution and declared the meeting closed.

Table 1. Summary of the results from the working groups

	Widely occurring species	**Rare and threatened**	**Exotic species**
Common characteristics	Wide geographical distribution in at least parts of Europe. • Continuous distribution • Non-continuous distribution	• scattered distribution • isolated/reduced populations • autochthonous • rare at European level	• Exotic for Europe (*Pseudotsuga menziesii, Larix kaempferi, Pinus contorta, P. radiata, Abies grandis, A. procera, Cedrus atlantica, Picea sitchensis*) • Exotic for the country (*Picea abies, Pinus sylvestris, P. nigra, P. pinaster*) • Current or potential economic or ecological importance
Current state of knowledge	More is known of economically important and common species. More is known about distribution and ecology than genetic diversity. • Adaptive traits: good knowledge e.g. *Picea abies* • Genetic markers: some knowledge for *Pinus pinaster*, *P. halepensis*, less for other species	Distribution is usually well known. Little is known of ecology and mostly at the local level. Some knowledge is available for adaptive traits and genetic markers.	Very good knowledge (including genetic diversity) • adaptive traits – provenance experiments • molecular markers • prerequisite for their use outside of the area of origin
Priorities and needs	**Commercial species** • Gene conservation in sustainable managed forest • For intensively bred species (e.g. *Pinus pinaster*) representative samples of natural populations **Non-commercial species** • Representative samples of natural populations *in situ* • *Ex situ* seed storage for risk-exposed *in situ* sites (fire, avalanches etc.)	• maintain reproductive abilities of populations • re-establish populations (ecological restoration approach) • increase state of knowledge (make literature available)	Genetic conservation for breeding programmes: • safeguard native populations • development and monitoring of landraces • coordination among countries of origin and countries of use

Table 1 (continued)

Main constraints	• General lack of knowledge among decision-makers, both political as well as forest managers • Economical - Pressure to use gene resources - Cost - degree of restriction of i*n situ* - ownership • Biological/ecological - Irregular seed crop - Seed storage - Browsing	Species-dependent • biological • ecological • management Country-dependent • land use • policy • legal	• lack of long term of institutional support • insufficient human resources • some conflict with nature conservation objectives • lack of consensus on traits to be conserved • changing sites conditions • risks related to pest and diseases • unwanted geneflow • natural hybridization • lack of reproductive ability
Conservation strategies	In situations of economic crisis • Show where and how to cut/protect (low cost measure) In average situations • Keep natural forest - *In situ* (marginal population special attention) - Sustainable forest management In the best of worlds • Inventories with molecular techniques and adaptive traits to find optimal manner for conservation	Species- and country-dependent • inventory of existing conservation status/legislation • *in situ* conservation - emergency measures (fences, game management) - ecological restoration • *ex situ* conservation - all trees (rare species) - breeding lines	• *in situ* conservation of best performing stands with natural regeneration (if possible) • *ex situ* conservation in conservation plantations • conservation as part of classical breeding programmes (archives, progeny tests, etc.) • long term seed storage

Annex I. Survey on priorities for gene conservation of conifers in Europe

Presentation of the survey

A survey was circulated to all participants prior to the Network meeting. The main objective was to provide the newly formed EUFORGEN Conifers Network with a basis for discussing the status of forest gene conservation in European conifers and for setting priorities for future activities. Twenty-four European countries (Austria, Armenia, Belgium, Bulgaria, Croatia, Czech Republic, France, Estonia, Germany, Hungary, Italy, Macedonia FYR, Malta, the Netherlands, Norway, Poland, Russian Federation, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, Ukraine) and one Central Asian country (Uzbekistan) responded to the questionnaire.

The survey contained three sections:

- the **first section** asked participants to indicate the conifer species present in their country and the priorities for conservation
- the **second section** had the purpose of identifying the main constraints to the effective conservation and use of conifers in the respective countries
- the **third section** had the purpose of identifying the priority areas for future involvement of the EUFORGEN Conifers Network.

Results

Conifer species present and conservation priorities

Species

Based on the results of the questionnaire, the species indicated by countries can be roughly divided into three groups: (1) widely occurring species that are usually also economically important; (2) rare and threatened species that usually have a more ecological importance and also, in some cases, a strong cultural significance, and (3) exotic species that have become economically important in many European countries. The groups are as follows.

- **Widely occurring species**
  - *Abies alba*
  - *Juniperus communis, J. sabina*
  - *Larix decidua*
  - *Picea abies*
  - *Pinus sylvestris, P. cembra, P. halepensis, P. mugo, P. nigra*
  - *Taxus baccata*

- **Rare and threatened species** (the species in bold were indicated as endemic or were only indicated by one country). Many of these species are also included in the IUCN list of threatened conifers (see Box 1).
  - *Abies bornmuelleriana, A. cilicica,* ***A. nebrodensis***, ***A. nordmanniana***, ***A. pinsapo***
  - ***Cupressus sempervirens***
  - *Juniperus excelsa,* ***J. foetidissima***, *J. macrocarpa, J. nana, J. oxycedrus, J. phoenicea,* ***J. polycarpos***, *J. thurifera*
  - ***Larix decidua* var. *polonica***

- *Picea omorika*
- *Pinus brutia,* ***P. heldreichii***, ***P. leucodermis***, ***P. pinaster***, ***P. peuce***, ***P. pinea***, ***P. Sosnowskyi***, *P. uncinata*
- ***Tetraclinis articulata***

- **Non-native species**
  - *Abies grandis, A. procera* (Belgium)
  - *Larix kaempferi* (Belgium, UK)
  - *Picea sitchensis* (UK)
  - *Pinus contorta* (Sweden)
  - *Pseudotsuga menziesii* (Belgium)

Box 1. Conifers on the IUCN World list of threatened trees (1998)

Abies cephalonica	LR/nt
Abies nebrodensis	CR D1
Abies nordmanniana subsp. *equi-trojani*	LR/nt
Abies pinsapo var. *pinsapo*	VU D2
Cupressus sempervirens	LR/nt
Juniperus brevifolia (Azores)	EN B1+C2
Juniperus cedrus (Madeira, Canaries)	VU C1
Larix decidua var. *polonica*	VU B1+C2
Picea omorika	VU D2
Pinus brutia var. *eldarica*	DD
Pinus nigra subsp. *dalmatica*	VU B1+C2
Pinus peuce	LR/nt
Tetraclinis articulata	LR/nt

Legend: B1 = severely fragmented
C1 = decline of at least 10% in the next 10 years
C2 = continuing decline
CR = critically endangered
D1 = population of <50 individuals
D2 = restriction in area
DD = data deficient
EN = endangered
LR = lower risk
Nt = near threatened
VU = vulnerable

National priorities

As can be seen in Figs 1 and 2, the criteria for selection of priorities differed widely by country and were mostly based on the economic importance of the species or on the rarity / ecological importance of the species themselves. For example, 21 countries indicated that Scots pine (*Pinus sylvestris)* is a priority in their country and 5 of these put it as the first (highest) priority. Similarly, 19 countries indicated Norway spruce as a high priority (only 3 as the first priority). On the other hand, 19 countries indicated a strong interest in the conservation of yew (*Taxus baccata*) and in 6 of these it appears to be the highest priority. Of course, these indications were only intended to provide a starting point for the preparation of the workplan for the Network. It was agreed to develop common outputs in technical areas, which will be applicable to the different groups of species.

Fig. 1. Number of rare and threatened species indicated as priority for gene conservation per country.

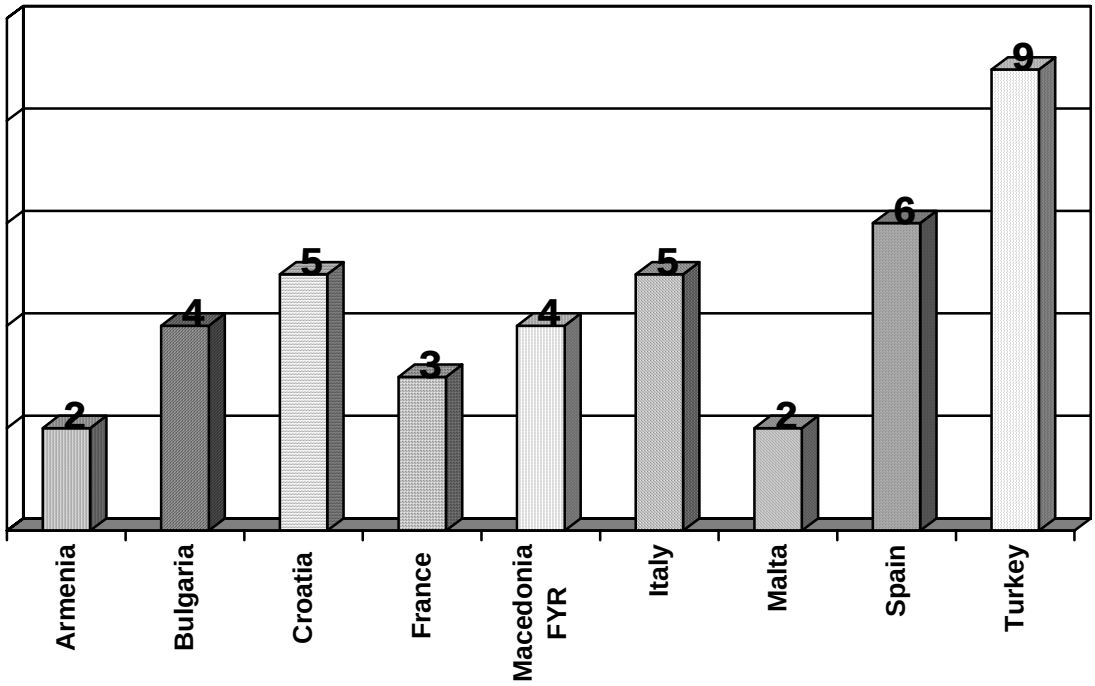
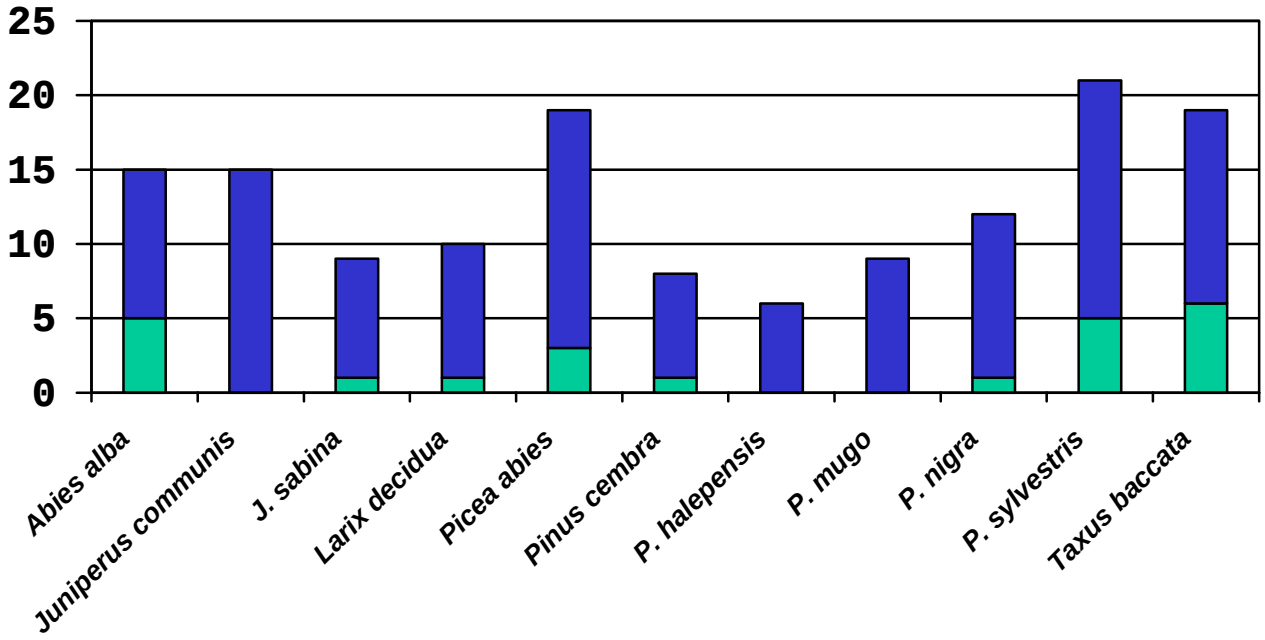


Fig. 2. Proportion of common species indicated (lower bar)/indicated as highest priority (upper bar) for gene conservation by countries.



Main constraints to the effective conservation and use of conifers genetic resources

Management-related issues, such as lack of incentives, appear to be among the most important constraints for the conservation of conifers.

Abiotic and biotic factors and the negative consequences of deforestation and clearcutting lead to forest decline and to an overall loss of diversity (both genetic and at the species level).

Table 1. Main constraints to the effective conservation and use of conifers genetic resources

Constraints	Total score	0	1	2	3
Lack of incentives in support of gene conservation as part of the routine silvicultural practice	52	1	3	11	9
Insufficient information/awareness about importance of genetic resources among decision-makers	48	0	5	14	5
Very high risks to the genetic resources due to abiotic and biotic factors (decline of species or declining population sizes, industrial emissions, repeated drought, pests and diseases etc.)	47	5	3	9	7
Use of reproductive material from inadequate or unknown sources	44	3	5	10	6
Lack of basic knowledge on species reproductive biology and overall genetic variation patterns	41	5	4	8	7
Lack of a national strategy or programme for the conservation of forest genetic resources	39	3	8	9	4
Problems with natural regeneration	39	4	8	7	5
Insufficient human resources	39	3	9	6	6
Insufficient communication or coordination between different actors (state forest service, forest owners, research, etc.) at the national level	38	4	6	10	4
Inadequate legal and economic policy instruments to design and implement gene conservation measures	37	2	10	6	6
Lack of economic interest in using certain species for timber and other forest products	35	8	5	7	4
Methodologies and techniques not available	31	5	9	8	2
Insufficient international cooperation in this area	22	5	11	7	1
Lack of knowledge on species' geographic range and distribution patterns	21	10	6	3	3

Legend:
0—is not a constraint
1—low
2—medium
3—key constraint

Priority areas for future involvement of the EUFORGEN Network on Conifers

As in other Networks, common strategies and guidelines appear to be among the major preoccupations of the participants and have in fact been included in the workplan. Information exchange and management were also indicated as important factors to be considered in the choice of future activities (see Workplan in this volume).

Table 2. Priorities for future involvement identified by Network members

Priority activities	Total score
Developing European long-term gene conservation strategies	83
Facilitating exchange of information and expertise among countries	78
Establishing joint international databases	76
Monitoring the progress made in European countries	74
Providing technical recommendations and guidelines	71
Taking emergency actions for the safety of threatened genetic resources	71
Contributing to the improvement or development of appropriate methods of gene conservation	64
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Highlights on progress made in gene conservation of Norway spruce (*Picea abies*) in Europe

Genetic diversity studies of *Picea abies* in Italy

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Introduction

Picea abies is one of the most important forest tree species in Italy from both the economical and ecological points of view. It covers about 380 000 hectares, which corresponds to about one-third of the conifer forest coverage in Italy. It is the dominant species in the Alpine region at an altitude between 1200 and 1900 m.a.s.l.

Most studies performed in Italy during the last years were devoted to the analysis of distribution of genetic variation in natural populations, with the main objective to create an inventory of genetic resources of this species, both in Italy and at the European scale.

More precisely, the objectives of these studies can be summarized as follows:

1. detection of spatial genetic differentiation related to the possible recolonization processes in the post-glacial period;
2. definition of genetically homogeneous regions ('genetic zones');
3. construction of a continental-scale availability map of the intraspecific biodiversity for Norway spruce.

Addressing the above issues is the basic step to establish both *in situ* and *ex situ* conservation priorities and breeding strategies for any species. The management of genetic resources may

benefit from the identification of genetically homogeneous regions ('genetic zones') because they represent the fundamental genetic background required in order to establish the number and location of primary genepool reserves. Moreover, genetic information underlying the regulation of the transfer of genetic material is currently lacking for many forest species and the choice of propagation material is often based on climatic similarity between the original stands and the plantation sites. Therefore, the identification of genetically homogeneous areas where propagation material can be properly transferred is an increasing need in forest management.

DNA markers of both the nuclear and chloroplast genomes were used to address the specific objectives mentioned above.

Population studies and genetic inventory

Chloroplast paternally inherited microsatellite markers were used by Vendramin *et al.* (2000) to assess their usefulness as informative markers for phylogeographic studies in Norway spruce and to detect spatial genetic differentiation related to the possible recolonization processes in the post-glacial period. The distribution of some haplotypes showed a clear geographic structure, which seems to be associated with the existence of different refugia during the last glacial period. The analysis of chloroplast microsatellite variation detected the presence of two main genepools (Sarmatic-Baltic and Alpine-Central European) and a relatively low degree of differentiation (about 10% of the variation due to differences among populations with the remaining 90% due to differences within populations), typical of the species with large and continuous distribution. No evidence about the existence of additional genepools was obtained using these markers, even if the existence of genetic discontinuity within the species range cannot be excluded. As for the Norway spruce populations located at the southwestern edge of the European range (western part of the Italian Alpine range), the hypothesis of their belonging to an independent genepool (Magini *et al.* 1980, Giannini *et al.* 1991, Morgante and Vendramin 1991) cannot be supported by these data, even though they show fairly high genetic divergence. The presence of two main genepools, also confirmed by other studies performed using isoenzymes (Lagercrantz and Ryman 1990) and mitochondrial markers (Sperisen *et al.* 2001), should represent the basis to establish programmes for managing and preserving genetic resources of this species. Moreover, the large divergence of populations from southwestern Alps should be taken into consideration as a possible source of useful variation for Norway spruce.

Geostatistics was applied to the chloroplast microsatellite frequency data (Vendramin *et al.* 2000) from about 100 European Norway spruce populations to provide preliminary evidence about the delineation of genetically homogeneous regions ('genetic zones') (Bucci and Vendramin 2000). Evidence of a large-scale geographical structure over the European natural range was obtained: an increase of mean genetic divergence by geographical distance (up to approximately 1800 km apart) was observed. A cluster analysis carried out on haplotypic surfaces, obtained by applying ordinary kriging, revealed a fair discrimination among 16 genetic zones (Bucci and Vendramin 2000). A dendrogram analysis performed on the predicted mean haplotype frequency confirmed the good discrimination of the genetic zones detected. On the basis of these results, some populations that are likely to be of non-local origin were identified (Bucci and Vendramin 2000). Application of geostatistical analysis to the large amount of genetic data collected during recent years in Norway spruce is therefore a promising tool for the analysis of complex geographical patterns aimed at reconciling appropriate conservation strategies. Spatial interpolation of discontinuous data may be useful for tracing genetic resources in space by the construction of an availability map.

More detailed information about the possible migration processes of Norway spruce in the Alps was obtained by Scotti *et al.* (2000). The analysis of some Italian alpine populations

sampled across the Alps, plus the unique autochthonous Apennine population using SCAR (Sequence Characterized Amplified Regions) markers, revealed a rather high value of genetic differentiation among populations. The data obtained using these nuclear neutral genetic markers support a picture of genetic variation of Norway spruce in the Alps in which the Apennine population branched out from the main migration flow coming from the Dinaric Alps in a northeast to southeast direction, while the western range seems to have another origin that has still to be clarified.

Alpine Norway spruce natural populations sampled along altitudinal gradients (from about 800 m.a.s.l. to about 2000 m.a.s.l.) were also analyzed using nuclear (Scotti *et al. 2000*) and chloroplast (Vendramin *et al.* 2000) microsatellite markers. No significant differentiation among populations within altitudinal gradients was detected using both markers. The observed heterozygosity and the effective number of alleles were plotted against the altitude. No correlation between diversity and altitude was found. From these data it can be therefore concluded that differences in environmental conditions do not appear to affect genetic diversity at microsatellite loci (Scotti *et al.* 2000).

Conclusions

During recent years, many DNA nuclear (Scotti *et al.* 2000), chloroplast (Vendramin *et al.* 2000), and mitochondrial (Sperisen *et al.* 2001) molecular markers were developed and used for the analysis of genetic diversity in Norway spruce. The use of these markers allowed the collection of important information about the entity and distribution of the genetic resources of this species in relation also to the migration processes in the post-glacial period, which is one of the main factors shaping diversity in forest tree species. The availability of data of many population samples across Europe and the use of methods of spatial interpolation based on geostatistics (Bucci and Vendramin 2000) also allowed the construction of a Europe-scale map of the intraspecific diversity for Norway spruce. This map represents a useful tool for designing a more appropriate method for programmes for conservation of the genetic resources of this species: the definition of homogeneous 'genetic zones' is an important prerequisite for establishing the most suitable location of genetic reserves. The usefulness of this map can be increased by combining data based on DNA molecular markers with data based on adaptive traits. A molecular pattern of diversity represents important preliminary information and a good basis for planning conservation strategies. However, programmes of conservation of genetic resources cannot be efficiently realized without the availability of data on adaptive traits, which may display a different geographic pattern than molecular markers. Highly polymorphic molecular markers (e.g. nuclear (Scotti *et al.*, 2000) and chloroplast microsatellites (Vendramin *et al.* 2000)) are very useful for providing information about the reproductive patterns and the effects of population bottleneck and inbreeding on the level of diversity. Studies aimed at analyzing the organization of the diversity within populations of Norway spruce are in progress.

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Progress in conservation of genetic resources of *Picea abies* in Norway

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Picea abies has a continuous natural distribution in Norway from the southern part of the country (lat. 58ºN) to close to the polar circle (lat. 67ºN). It does not occur naturally along the western coast, but has been intensively planted both along the coast and north of its natural range. The species is our most important timber tree. It is regenerated both naturally and by planting. *Picea abies* is conserved in natural reserves, in natural parks and other protected areas, by breeding populations kept as grafted clonal archives, seed orchards and progeny tests, and in other types of genetic trials. In exposed areas, i.e. high altitude forests, silvicultural management is restricted. The use of reproductive material is regulated by governmental regulations.

During recent years, awareness of the importance of genetic resources has been raised at the ministerial and political levels. A national plan has been developed for the conservation of genetic resources of agricultural plants and animals and forest trees. For each species group, a national genetic resources board has been appointed. It will promote and coordinate conservation activities. The international processes and cooperation initiatives, including EUFORGEN, have been important for the progress of the national conservation activities.

In a recently developed national strategy for forest trees the state of the genetic resources of 33 native forest tree species has been evaluated, taking into account the amount and coverage of present *in situ* and *ex situ* conservation activities. On the basis of life history traits such as geographic range, pollination vector and seed dispersal capability, the species' genetic resources were classified either as *vital*, *uncertain*, *exposed* or *endangered*. Five species were considered *uncertain*, 15 were considered *exposed* and only one was classified as *endangered*. *Picea abies* was among the 12 widely distributed species that were considered *vital.*

A new strategy has been accepted recently for the breeding of *Picea abies*. It focuses on an enlargement of the breeding populations by including a larger number of selected trees from natural populations. Less intensive breeding methods will be considered, such as seedling seed orchards combining wood and seed production. Selection can be done in such plantations on the basis of progeny tests if family identity is being kept.

High priority has been given to provide information about the importance of forest genetic resources both to forestry professionals and to the public. This concerns in particular the choice of reforestation material. The aim is to accomplish that the annual growth rhythm of such material should be better characterized, in particular the timing of growth initiation and cessation and the development of frost hardiness in the autumn. Combining local climatic information of the planting sites with the available genetic information will secure a better matching of reproductive material to the environmental conditions.

A special concern with *Picea abies* is the implications of the former introductions of central European provenances to the northern environment. On sites with unfavourable climatic conditions, plantations with introduced Norway spruce provenances have suffered considerable damage, which has reduced both timber quality and volume production. Research is being conducted to investigate the influences of these introductions on the next generation. Preliminary results indicate that seedlings originating from such stands have growth rhythms that are similar to those of local natural populations, and that the influences on seedlings from

seeds harvested in adjacent local stands are negligible. This research complements the experiments performed to produce seeds under controlled climatic conditions in order to investigate the effects of the maternal environment on the next generation. These research activities will be continued.

Conservation of forest genetic resources in Germany: an overview

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History and objective

Impressed by the forest decline in the 1970s, managers and decision-makers became aware of the danger of loosing genetic diversity and valuable forest genetic resources. A political impetus was given in 1985 both by the resolution of the assembly of the German Federal States to undertake measures to conserve forest genetic resources and by the decision of the Federal Government to continue the action 'Save the Forests'. As a consequence, the 'Federal and State Working Group on the Conservation of Forest Genetic Resources' (Bund-Länder-Arbeitsgruppe 'Erhaltung forstlicher Genressourcen', BLAG) was founded the same year. The working group developed in 1985–1987 a 'Concept for the conservation of forest genetic resources in the Federal Republic of Germany' (BLAG 1997) abbreviated in the following text as 'concept'. The objective of the concept was the evaluation and conservation of forest genetic resources and their use and integration into regular forest management practices.

The working group was charged by the heads of the forest administration of the Federal States to coordinate all activities concerned with conservation of forest genetic resources, which were already in progress at that time. A catalogue of *in situ* and *ex situ* measures was established. The priorities and intensities of the measures and activities undertaken are different according to the regions and depend on the political framework and available means of the particular Federal State.

Criteria

The following general criteria have been considered in the selection of populations for conservation purposes:

- adaptedness and adaptability; autochthonous origin; the samples should be representative for the species;
- populations growing under specific ecological conditions;
- populations at the border of the natural distribution area;
- populations exhibiting striking or outstanding characters;
- populations / individuals of rare species;
- valuable populations of non- autochthonous species.

The importance and need for conservation is mainly determined by the adaptedness of the population, group or individual concerned, and the urgency for actions according to the level of threat or danger of extinction.

For the main species and also partly for species with less economic importance, such as *Acer* sp., *Alnus* sp. and *Betula* sp. (local occurrence 1–10%), *in situ* conservation has been considered as the most effective mean of conservation and therefore gene conservation stands have been established. This means that they have been delineated and registered, and they are controlled and protected as long as they have been regenerated naturally or by planting in the region of origin. Special attention is paid to tending and thinning and to assuring a good health status.

At the beginning silver fir (*Abies alba*) and Norway spruce (*Picea abies*) showed heavy symptoms of forest decline. This was followed by pronounced damage in beech (*Fagus sylvatica*) forests. Therefore conservation measures first focused on these species. Later, other species were also heavily damaged: Scots pine (*Pinus sylvestris*) and oaks (*Quercus robur* and *Q. petraea*). Until 1997 (BLAG 1998), 7733 ha were declared as *in situ* conservation stands. This area is shared among species or species groups as follows: 37.1% beech, 17.7% oak, 18.2% other broadleaved species, 14.1% Norway spruce, 9.6% Scots pine, 2.4% other conifer species and 0.9% shrubs.

While in initially conservation measures included mainly the species of economic importance, in the past years special attention was paid to the protection and conservation of rare species (occurrence less than 1% in the respective area). The wild fruit tree genera *Malus, Pyrus* and *Prunus* were of concern, but also *Sorbus* and *Ulmus* species, as well as *Taxus baccata*. *Ex situ* conservation is preferred for rare species, because their occurrence in forests is frequently reduced to a few individuals or even a single tree, which might lead to inbreeding or exclude further reproduction. The vegetative propagation of these individuals and establishment of seed orchards enables the creation of larger breeding communities resulting in higher genetic diversity and adaptability of the progeny. The registration, mapping and protection of individuals of rare species require a high degree of cooperation among the different landowners as well as among different groups of interest.

Additionally to the establishment of seed orchards and clone banks, the storage of seed in genebanks has proved to be an adequate method of *ex situ* conservation. This is especially valid for several conifer species, where seed can be stored for many years or even decades. For some broadleaves genera (*Alnus, Fraxinus, Fagus*), methods for long-term storage have been improved, but more research is still needed.

For several species, micropropagation methods have been developed, offering another method of multiplication and thus *ex situ* conservation.

Summary of in situ *and* ex situ *measures*

Up to the year 2000, about 30 tree and 30 shrub species have been included into conservation measures.

In total, ca. 10 000 ha have been designated as *in situ* conservation stands. In many of these stands, especially for broadleaves species, actions to force natural regeneration have been undertaken.

The area of established seed orchards amounts to about 900 ha. They comprise about 15 000 clones (clonal seed orchards) and 2000 families (seedling seed orchards).

Additionally 130 clonal archives have been established with a collection of 12 000 clones.

About 5000 kg seed are stored in genebanks and state kilns for conservation purposes.

Research

Conservation measures are accompanied by research activities. Biochemical and molecular genetic methods are used to support the evaluation process. Manuals have been issued for Norway spruce, silver fir and Scots pine in order to standardize isoenzyme laboratory procedures and make results of different institutes comparable. The manual for beech is in preparation. DNA investigations have been applied mainly to silver fir and oak. Surprisingly, there is a lack of knowledge on the genetic structure between and within populations as well as on gene flow and the mating system, even for important species. Traditional provenance research is continued with special emphasis on the evaluation of adaptive traits.

Public awareness

The public has been informed on numerous occasions of the necessity to conserve forest genetic resources and about the actions undertaken. Several symposia were organized on different species: *Ulmus* sp. (1992), *Quercus* sp. (1994), *Populus nigra* (1998) and *Pyrus communis* (1998).

Future developments

National activities have also been influenced by international events, such as the Ministerial Conferences of Strasbourg (1990), Helsinki (1993) and Lisbon (1998). The Convention on Biological Diversity from Rio de Janeiro (1992) was ratified in Germany in 1994. The maintenance and restoration of biological diversity at the levels of ecosystems, species and within species is not only generally accepted but also enforced wherever possible. Multifunctional forest management based on the principle of sustainability has a long tradition in Germany. 'Close-to-nature' silvicultural management practices have gained importance during the past two decades.

After the reunification of East and West Germany, the former separate actions had to be integrated into a common concept. Furthermore it was considered necessary to evaluate the experiences and reflect the achievements after 10 years of application of the concept of 1987.

Considering the above-mentioned aspects, it was decided to elaborate a new version, renamed 'Concept for the conservation and sustainable use of forest genetic resources in the Federal Republic of Germany'. The title reflects the broadening of the goal by the sustainable use of forest genetic resources and reinforces the integration of the conservation of genetic resources into regular forestry management practices. Evaluation is considered as a task of major importance. The elaboration of a basic concept for a long-term genetic monitoring and control of the efficiency of *in situ* conservation measures is a new task to be undertaken.

The working group concerned with the elaboration and execution of the new concept comprises 13 member organizations. It has been integrated into the Federal and State Working Group 'Conservation of Forest Genetic Resources and Forest Seed Law'. During the working time of the old concept a report on the status and achievements was issued every two years. For the new concept, the planning period was fixed to four years, which is also the period for issuing reports (see http://www.genres.de/fgrdeu/konzeption/). The reports are the basis for the country and progress reports with the EUFORGEN programme.

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Genetic diversity of European conifers

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Introduction

The number of native conifer species is rather low in Europe when compared to those at the same latitudes in Asia and North America. In terms of collective species (without splitting into subspecies and varieties), including shrubs, the total number is relatively low, and only 10 (*Abies alba, A. sibirica, Picea abies, Larix sibirica, L. decidua, Pinus cembra, P. sylvestris, P. nigra, P. halepensis, P. maritima)* have a fairly wide distribution and commercial value as forest trees. The latest glaciation is usually mentioned as the cause of the low species number. It may be also partly due to climatic factors. Numerous exotic conifer species have been introduced in Europe, but few of them have been so successful as to compete with native species in commercial forestry. *Pseudotsuga menziesii, Picea sitchensis and Pinus contorta* are examples of widely used exotic conifers.

Forests are increasingly important and valuable not only as renewable natural resources but also as reservoirs of biological diversity and environment for recreation. The few native European conifers deserve our respect, because they must have a specific genetic composition that allowed them to survive through changing climatic conditions. It is evident that this biological heritage must not be wasted. The loss of genetic diversity is an irreversible process that leads to decline and disappearance of forests. History shows that human activities have caused large-scale disappearance of coniferous forests. Recently pollution, in conjunction with other harmful factors, has caused damage especially in high altitude fir and spruce forests. The predicted climate change will most likely put a new kind of pressure on the adaptive potential of long-living forest trees. A slight warming in the boreal zone is hardly disastrous, but lower precipitation combined with increase in temperature will cause severe drought in southern parts of Europe.

Tropical, highly variable forests, and on the other hand rare and endangered tree species are often considered as priority for gene conservation. Without underestimating urgent needs in those fields it is important to recognize that even common and commercially important European tree species are subject to genetic erosion and decline. Fortunately, immediate threat is rather uncommon, and natural populations still exist. We still have the opportunity to act in due time. Gene conservation measures are like taking insurance. The fee is quite low as long as no accidents or disasters take place, but afterwards it is either very expensive or impossible. There are many examples from various agricultural crop plants.

What to conserve?

Genes, units that contain packages of information in the form of DNA, cannot be collected and saved as separate particles like gold sand. They have a function only as elements of living cells, in our case in living trees, viable seeds or gametes. The number of gene loci in conifers is estimated to some tens of thousands. If one-third of the loci are polymorphic, then the genetic diversity is based on several thousands of 'commands' with at least two functional alternatives. Sexual reproduction is capable of creating an incredible number of combinations, i.e. different genotypes out of this material.

Recent studies on the pattern of genetic variation assessed at genetic markers in conifers show that a very high proportion of the total variation is found within a population, whereas differences between population means are small. On the other hand, provenance trials and

experiments on adaptive traits have revealed considerable geographical differentiation in adaptive traits. Still within-population variation of adaptive traits is broad.

In terms of gene conservation the conclusion is that neutral marker gene diversity can be preserved anywhere – a few samples are enough to represent the whole Europe. The diversity of adaptive traits needs to be preserved in several ecologically different areas. Thus, for instance, the genetic composition of pine stands close to the northern timberline and in central Spain, respectively, are unique. In order to sample most of the large within-population genetic diversity, a large number of trees per population is needed. The goal is to maintain the adaptive potential of the population over several generations by carrying over most of the alleles in all polymorphic loci. This is more demanding than maintaining the variance of metric traits among individuals at its original level. The other way round, a system that maintains overall allelic diversity certainly maintains diversity in metric traits and marker genes. If the system is based on metric traits or marker genes alone, a considerable part of variation in adaptive traits is lost.

Rare alleles and exceptional morphological variants are sometimes mentioned as the main target of gene conservation. They are interesting as research objects and examples of genetic diversity, but they do not belong to the mainstream objectives of gene conservation.

How to conserve?

Conservation and management of genetic diversity is not based on one single mode of action. First, we have to separate the conservation of the genetic diversity of natural populations from the maintenance of adequate genetic variation in breeding populations. Furthermore, it should be evident that ordinary commercial stands need not as much diversity as specific conservation populations.

Conservation of representative samples of the genetic diversity of autochthonous populations is the primary goal. It is useless to argue whether or not truly natural populations exist any more, when the whole biosphere has been subjected to human influence (e.g. pollution). We would consider spontaneously originated stands of autochthonous conifers as natural populations, even when they are managed and treated with appropriate silvicultural methods. If we waste time in fundamentalistic search of intact natural stands and require extensive genetic studies, most of the native forests will be converted to artificial stands or even disappear.

Samples of natural populations are most suitable for *in situ* gene conservation. Taking advantage of existing nature protection areas, the selection and maintenance of special gene reserve forests are relatively inexpensive. Regeneration should take place by natural methods; regeneration with non-local seed or genetically improved material should not take place. It can be foreseen that in the long run the gene and genotype frequencies will change in response to selection pressure (climate change). In order to eliminate the undesirable effects of inbreeding and random drift, each *in situ* conservation unit must be rather large. In relation to the total forest area or the area of national parks, the area of gene reserves is modest. For instance the Finnish national programme contains 7500 ha of *in situ* gene reserves of the total forest area (ca. 20 000 million ha). The low cost characteristic is very significant, because tree breeding and related issues have been subject to budgetary constraints in many countries.

Artificial conservation populations, in other words *ex situ* methods, are closely linked with tree breeding and seed transfers. In this respect it is regrettable that tree breeding was initiated and practised prior to long-term planning gene conservation. Operational breeding populations were established with phenotypically selected superior trees and the aim was to achieve genetic gain in growth rate and wood quality. Thanks to the longevity of conifers, most of the original plus trees are still available, sometimes as cloned progeny.

Long-term breeding populations are being established in many countries in order to maintain genetic variation for breeding purposes. However, a breeding population is not a random sample from the natural population. Another fundamental difference with *in situ* populations is the mode of regeneration. Selection and some kind of predetermined mating pattern must be applied.

Non-local origins, i.e. landraces and provenance trials, are also valuable, in particular when we think of the consequences of the probable but unpredictable changes in climate and environment. The same look to the future justifies the inclusion of important introduced species into the gene conservation plans. The continuity of provenance and species trials as conservation populations is worth consideration. Many of them are quite old already. If the plot size is small, slow-growing entries are suppressed by others and can totally vanish. The replacement of old trials with new ones may be extremely difficult. The original seed source is seldom available, open-pollinated seed has a mixture of pollen parents from various origins, and controlled crossings in sufficient number of trees is a tedious and expensive task. Stands of landraces and introduced species provide a fairly good seed source, if their reproductive adaptation is adequate.

Conclusion

Experiences from the EUFORGEN *Picea abies* Network are encouraging. National efforts on gene conservation, supported by EUFORGEN, have resulted in extensive areas of conservation populations, and exchange of information has increased common awareness. One lesson is that gene conservation can be successfully done with various methods. Each country has specific ecological conditions, forest policy, silviculture etc. Therefore, rules and instructions valid in one country do not necessarily need to be implemented or accepted in another country.

Another lesson is that regeneration of conservation populations needs more attention. *In situ* gene reserves are often quite old stands, originally selected as seed collecting stands. Spontaneous regeneration from seed is not very effective in current circumstances. Therefore, active measures are needed, and often without delay. There are reasons for concern about the continuity of breeding populations. It is easy to develop a schedule with sophisticated mating pattern to avoid inbreeding and to maintain balanced contribution of all parents, but the real world may pose problems. Even if the necessary economic and labour resources are available, biology may cause obstacles. Flowering and seed production are still capricious and differences in the affinity to flowering are large. Very low numbers of genotypes should be avoided, whilst keeping the mating design as simple as possible.

All native coniferous species of Europe should gradually be included in national gene conservation programmes, as well as the introduced species that have at least potential value as forest trees. Conifers have been on the Earth for hundreds of millions of years. There is a lot we can do to make sure that future generations inherit this genetic wealth.

Genetic resources of conifers in mountain forests

Management of mountain forests in Slovenia

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Introduction

The mountain forest comprises special forms of forest ecosystems functioning under severe environmental conditions. Frequent spontaneous damages from abiotic factors and inadequate human activities may cause long-term irreversible damages in forest ecosystems.

In March 1998, the 19th (Slovenian) Forestry Study Days, entitled 'The Mountain Forest', were organized by the Forestry Department of the Biotechnical Faculty of the University of Ljubljana, with active participation of the Slovenian Forestry Institute (SFI), the Slovenian Forest Service (SFS) and a few others, mainly from the State Authority for Conservation of Nature, Triglav National Park. For this presentation some further research results from relevant projects of SFI and duties from the Public Forest Service (Anonymous 1995, 1998) and the first report for the preparation of the National strategy on the Convention of Biodiversity (Beltram and Peterlin 1999) have been included.

Determination and delimitation of mountain forest in Slovenia

The first question to be addressed is the delimitation of mountain forest in Slovenia. The area which was taken into account upon signing of the Alpine convention (ratified in Slovenia in 1995) and in the Protocol on mountain forests (signed in Slovenia in 1996) included ca. 420 000 ha or 38% of Slovenian forests (Ferlin 1996, cited in Ferlin 1998). Later interpretations for the implementation of the Protocol in Europe considered up to 70% of forests in Slovenia as mountain forests (Golob pers. comm.).

The area to be considered as mountain forest at the Study Days was determined according to the following criteria (Robic 1998, Boncina and Mikulic 1998):

(a) zone adequacy: phytocoenological information, whereby the altitudinal vegetation belts in Slovenia differ in different mountain regions; the main altitudinal belts are defined as:

1. lowlands or plain belt
2. hills or colline belt
3. submontane belt
4. montane belt
5. altimontane belt
6. subalpine belt

Each of these belts is also characterized by its most significant plant associations, and differs in eastern, central and western Alps, in the Carpathians and in the Balkans.

(b) and (c) emphasis on environmental functions and roles (evaluation of forests according to their protection functions and roles; in this methodology, b indicates a higher degree of environmental functions than c)
(d) silvicultural aspects (especially difficulties regarding natural regeneration and reforestation)
(e) significant changes in tree composition (i.e. man-made spruce forests, originating from sowing spruce seeds on former beech sites, can be included due to problems in attempting to restore better self-regenerated forest; also on the shady, steep slopes, shallow dolomite rendzinas, problematic beech forests occur in lower altitudinal zones)
(f) needs for more sophisticated technologies of logging operations (due to steep slopes)
(g) emphasis of social roles of forest.

Taking into account all these criteria and the distribution of montane, altimontane and subalpine forests in Slovenia, altogether comprising ca. 420 000 ha, Robic (1998) has defined 218 166 ha or ca. 20% of all forests in Slovenia as mountain forest. This area includes also 21 423 ha of protection forests.

In the above classification, if altitudinal belts are considered, mountain forests may start in the belt between 800 and 1000 m (in four out of eight plant associations), while all associations are included in the belts above this altitudinal belt (1001–2000 m).

However, this classification is somehow difficult to follow on the map. Also, the Slovenian Forest Database held by SFS cannot be correlated directly, therefore most other analyses have been linked to either 200, 300 or 400 m belts, while for strictly mountain forests in Slovenia a number of analyses take into account simply all forests above 800 m (26% of Slovenian forests) or above 1000 m altitude (14% of Slovenian forests) (Table 1).

Table 1. Shares of altitudinal belts in Slovenia (total area of Slovenia: 2 027 198 ha), forests and shares of forests in different altitudinal belts (compiled after Boncina and Mikulic 1998, citing the database by the SFS from 1995 and Perko 1992)

Altitudinal belt (m.a.s.l.)	Proportion of the area in Slovenia (%)	Area of forests (ha)	Proportion of the forest area in Slovenia (%)	Proportion of the forest area in the belt area (%)
1–200	8.6	39118	3.6	22.5
201–400	33.2	249378	22.9	37.1
401–600	23.4	291102	26.7	61.4
601–800	15.3	226663	20.8	72.9
801–1000	8.3	131405	12.1	77.9
1001–1200	4.7	83351	7.7	87.2
1201–1600	4.6	65954	6.0	70.5
1601–2000	1.4	2104	0.2	7.2
above 2001	0.4	0	0	0.0
Total	**100**	**1089075**	**100.0**	**53.7**

The altitudinal gradient alone results in harsh site conditions, which can be aggravated by other orographic factors, such as inclination of slope, rocky and stony terrain. Therefore the above authors (Boncina and Mikulic 1998) have further stratified morphological units according to the altitudinal and inclination gradients on surface area (Boncina and Mikulic 1998, citing Perko 1991) and according to site coefficients (Boncina and Mikulic 1998, citing Kosir 1976) into site strata (Boncina and Mikulic 1998, citing Robic 1997). The stratified dominant or higher association categories are presented as:

0–200 m	forests of hornbeam and oak, riparian groves of maple and ash
201–600 m	hilly and submontane European beech forests
601–1200 m	silver fir – beech forests, montane and altimontane beech forests
above 1201 m	Norway spruce, silver fir, subalpine beech forests, mountain pine stands

In the belt between 1401 and 1800 m, three site strata are dominant:
(1) montane, altimontane and similar beech forests in the Alps;
(2) forests of silver fir and of Norway spruce on poor soils;
(3) subalpine beech, mountain pine and sphagnum bogs;

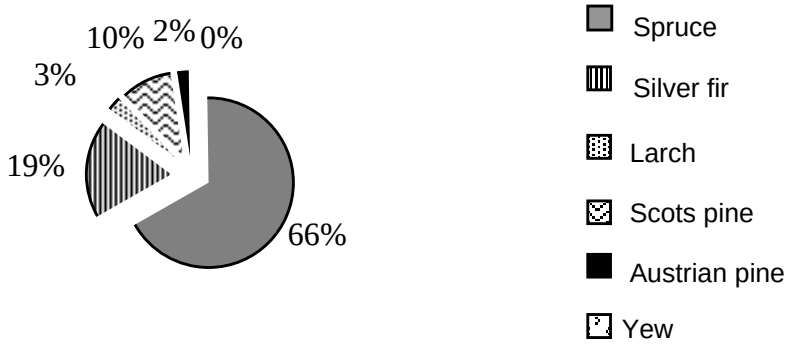
while above this belt only 46 ha of forests can still be found.

In the SFS database (1998), the following data were provided on total growing stock, area, growing stock per hectare and proportion of growing stock, as shown in Table 2 and Fig. 1.

Table 2. Areas of growth and growing stock of forest trees in Slovenia (SFS database, 1998)

Tree species		Area (ha)	Growing stock (m^3)	Proportion in total growing stock (%)	Growing stock per hectare (m^3/ha)
Norway spruce	*Picea abies*	898929	7 530 5736	32.50	83.77
Silver fir	*Abies alba*	441331	21 282 942	9.19	48.22
Scots pine	*Pinus syvestris*	474692	11 379 613	4.91	23.97
Larch	Larix decidua	249337	2 926 006	1.26	11.74
Austrian pine	*Pinus nigra*	72441	2 442 179	1.05	33.71
Yew	*Taxus baccata*	3371	5 442	0.00	1.61
Other native conifers		3088	14 085	0.01	4.56
Japanese larch	*Larix leptolepis*	2156	10 973	0.00	5.09
Douglas fir	*Pseudotsuga menziesii*	11359	83 043	0.04	7.31
Cypress	*Chamaecyparis*	499	2 149	0.00	4.31
White pine	*Pinus strobus*	29708	421 203	0.18	14.18
Sitka spruce	*Picea sitchensis*	1723	30 456	0.01	17.68
	Conifers		**113 903 827**	**49.16**	
	Broadleaves		**117 799 205**	**50.84**	
	Total	**1 091 398**	**231 703 032**	**100.00**	**212.30**

Fig. 1. Share of total growing stock of all autochthonous conifers (%)



Species composition and structure of stands in the forest and timberline in Slovenia

The subalpine and alpine vegetation belt, as well as the timberline in Slovenia, can be easily distinguished only in the Julian and the Savinja Alps, Karavanke and Sneznik. In the western part of the Julian Alps and on Sneznik the timberline develops at ca. 1600 m.a.s.l., while in the eastern Julian Alps it reaches 1900 m.a.s.l. The vegetation of these two belts can develop also at lower altitudes in the temperature inversion hollows, especially in the Dinaric mountain range (Brus 1998).

From approximately 330 woody plant species in Slovenia, about 25% are found in plant communities in the subalpine and alpine belts. Among these, only eight are conifers: Norway spruce, European larch, mountain pine, Scots pine, Swiss stone pine, silver fir, common juniper and Siberian juniper (Brus 1998).

Norway spruce builds up the subalpine spruce forest in the Alps and in the frost hollows in the Dinarics. In all timberline associations it is mixed with European larch or other species. European larch usually grows in mixed beech or spruce associations in the subalpine belt, but can also form natural pure stands. Most common is the mixed larch / mountain pine association. In the tree line it reaches 1800 or 1900 m.a.s.l. Among other conifers, only the mountain pine forms pure associations in / above the timberline, as well is in the inversion hollows.

Growth structure and other characteristics of mountain forests

Due to the traditional multifunctional, sustainable and close-to-nature oriented forest management in Slovenia, which has all been included into the Forest Act (Anonymous 1993) and the national Programme of Development of Forests (Anonymous 1996), this is shown also in a range of different developmental phases and growing stock distribution in different tree diameter categories. Older developmental phases prevail with increasing altitude, and selection stands do so even more (Table 3).

Table 3. Share of different developmental phases in consequent altitudinal belts (after Boncina and Mikulic 1998)

	Altitudinal belts (200 m)									
Developmental phase	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Average (%)**
Young growth	7	10	9	10	10	9	10	7	7	10
Pole stand 1	16	18	15	15	12	11	11	7	7	15
Pole stand 2	19	30	30	29	24	21	18	12	12	27
Old stand	13	20	23	25	29	32	34	30	30	24
Stand in rejuvenation	3	4	6	8	11	12	12	7	7	7
Selection stand	3	0	1	3	9	12	15	36	36	4
Coppice	32	12	11	8	4	1	1	1	1	9
Pioneer stands and shrubs	7	5	5	3	2	1	0	1	1	4
Total (%)	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

The highest mean growing stock is in the zone between 800 and 1200 m, on average 5.7-5.9 m^3 / ha. The values decrease rapidly in the belt between 1601 and1800 m (1.5 m^3 / ha).

The relative proportion of protection forests and forests with special purpose increases with altitude. Up to the altitude of 800 m.a.s.l. most forests are private, in the belt between 801 and 1000 m.a.s.l. the proportion of private and state-owned forests is equal, while above 1001 m the state-owned forests prevail and account for as much as 98% of the total forest area in the belt of 1601–1800 m.a.s.l.

Specific silvicultural measures in mountain forests (Pokljuka, Pohorje)

Silvicultural measures regarding regeneration, tending and protection of forests are characterized by the annual (allowable) planned cut and the type and scope of measures to be taken:

- The planned (allowable) annual cut is lower than the growth increment in all altitudinal belts, as a result of the decision about the necessity to increase the growing stock; the mean growing stock is supposed to increase for 30 m^3 / ha.
- The anticipated increase is highest in the belts in which the growing stock is the highest (801–1400 m.a.s.l.).
- The higher allowable annual cut of conifers supports the decision on favouring broadleaved tree species.
- The proportion of felling due to damages caused by game (11%), as well as by emissions (4.5%), is highest in the belt 1201–1400 m; the proportion of felling without permission is also highest in this belt and can account for as much as 23% of the total annual cut.
- The proportion of sanitary felling due to windbreak is highest in the belts 1401–1600 m (28%) and 1001–1200 m (6.2%).
- Surprisingly the highest proportion of sanitary felling due to biotic factors (insects) is in the belt 1401–1600 m.
- There are no essential differences among the belts in terms of planned tending of forests but there are considerable differences as to the extent of planting, which is greatest in the lowlands.

In the above-mentioned and other studies (Boncina and Mikulic 1998) several forest management plans have been analyzed, from which we would only mention two from the areas where detailed research of natural regeneration has been carried out (Kraigher *et al.* 1999, Robic *et al*. 1998): on Pokljuka (1200 m.a.s.l., autochthonous pure Norway spruce stand) and on Pohorje (1200 m, secondary spruce monoculture on a beech site). There are considerable differences among the plans due to different levels of sustainability of forests and their utilization, site and stand conditions, forest functions, and biotic, abiotic and anthropogenic impacts on forests. The different conditions include (after the above-mentioned studies and a few others, such as Kosir 1998, Solar 1998 etc.):

- changes in forest tree species composition and growth structure, due to the clearcutting system in the past (Pohorje), inadequate high fellings and inadequate techniques of regeneration and support of pure spruce stands in the recent past
- damage caused by too high numbers of game
- grazing in forests
- competition of grass, preventing natural regeneration, occasionally even bogs formation
- silver fir dieback
- damage from emissions
- inadequate forest roads and inappropriate harvesting techniques
- interests or non-interests of private owners in different functions of forests, i.e. grazing of cattle as opposed to all other functions
- highly expressed conservational, recreational, hydrological, biotope etc. functions of forests.

Distribution of selected seed stands of conifers above 1000 m of altitude in Slovenia

The selected seed stands in Slovenia, which are located above 1000 m of altitude, are presented in Table 4. Seeds from these stands can only be used in forests in the same altitudinal zone, i.e. above 1000 m. Most seed stands are in the Alps region (Pokljuka and Jelovica) and on the Pohorje mountain range.

Table 4. Selected seed stands above 1000 m altitude

Species		Number of stands	Total area of stands (ha)
Norway spruce	*Picea abies*	53	491.29
Silver fir	*Abies alba*	3	22.59
European larch	*Larix decidua*	10	103.64
White pine	*Pinus strobus*	4	6.95
Greek fir	*Abies cephalonica*	1	0.10
Noble fir	*Abies procera*	1	0.10
Douglas fir	*Pseudotsuga menziesii*	1	2.20
Total		**265**	**1866.42**

Selected seed stands on Pokljuka and Jelovica:

- in the area of altimontane spruce forests on Pokljuka and Jelovica, 19 seed stands have been registered since 1960, mostly belonging to the seed units 4k (above 1000 m on carbonate soils) and 8s (above 1000 m on silicates);
- 15 seed stands are for Norway spruce, 2 for silver fir, 1 for beech and 1 for wild rowan; only the latter has been selected recently;
- half of the 15 spruce seed stands grow on secondary spruce sites, therefore their origin is questionable, while for the other half it is expected that the best autochthonous stands have been chosen well;
- most seed stands were registered 30–40 years ago therefore re-evaluation is needed;
- according to the general silvicultural plans, Norway spruce should be replaced in the major part of the area by broadleaved species, while for these the number of seed stands in the possible future Transalpine seed provenance region, to which belongs Pokljuka and Jelovica plateau, is far from adequate.

Research and development in support of silvicultural planning in mountain forests

From our own studies we would like to mention the studies on nutrient cycling and diversity of root symbionts of spruce (Simoncic *et al.* 1998), silvicultural aspects of grass competition in the rhizosphere of an anthropogenic altimontane spruce monoculture (Robic *et al.* 1998), biodiversity of types of ectomycorrhizae on Norway spruce (Kraigher *et al.* 1995, 1996, 1999), natural regeneration in an altimontane Norway spruce stand (Diaci *et al.* 1999) and especially studies of age and genetic variability of Norway spruce (Bozic and Levanic 1998). From these the following applicable results and conclusions were obtained:

(a) Forest soils, vegetation, mycorrhizae, nutrient and biomass cycles in different forest gaps, and studies of natural regeneration of Norway spruce on Pokljuka:
   - an unexpectedly high diversity in the horizontal distribution of forest soil types and vertical soil solution cycling was shown
   - the diversity indexes for ground vegetation were low, while they were high for types of mycorrhizae

- the number of seedlings is not a limiting factor in regeneration
- a bigger gap represents more severe ecological conditions for the success of germination
- direct solar irradiation influences negatively the success of regeneration, while relative diffuse irradiation is in positive correlation with the number of natural regeneration
- we suppose that the regeneration success is limited predominantly by winter desiccation on spots where snow disappears first and direct irradiation is high.

(b) The conclusions and recommendations for foresters are:

(i) to avoid excessively intense cutting
(ii) to successively enlarge the gaps in good seed years
(iii) the direction of gaps should consider lowering of direct irradiation
(iv) the optimal size of the gaps depends on the intensity of felling and microsite conditions.

(c) Perspectives

- The advantages as shown in our research or resulting from past research projects are:

(i) Diverse and well-preserved forests, highly diverse component on forest soils
(ii) Standardized methods, laboratory and field equipment
(iii) Well-established interdisciplinary team of researchers and collaboration with other institutions
(iv) Advanced results on processes in forest ecosystems and forest soils, on biodiversity and regeneration in natural forest stands.

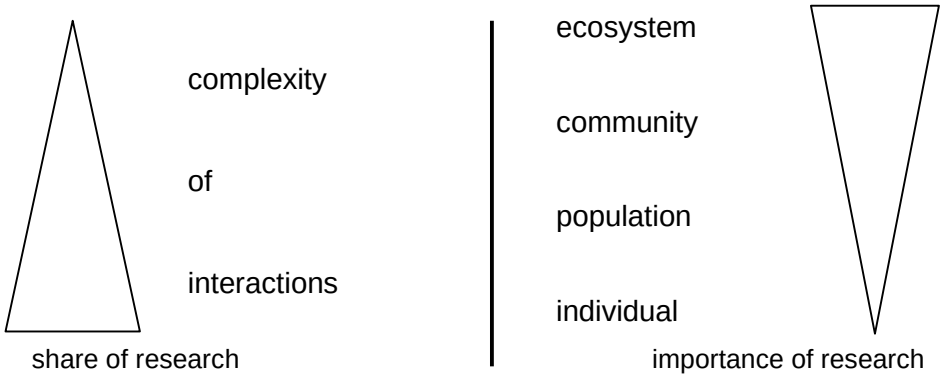
- Key questions for research

(i) long-term research vs. short-term financing
(ii) complexity of research and support for basic research by co-financers.

- Special emphasis: it is impossible to simply transfer research results, local studies and experience are a necessity for scientifically based professional improvements in forestry practice.

(d) The coincidence of our research and development programme with the necessity to understand ecosystem functioning, with special respect to highly vulnerable mountain forests and conservation of forest genetic resources, can best be shown with a schematic presentation (Fig. 2).

Fig. 2. Levels of organization and importance of research in ecosystems



Conclusions

To ensure the sustainability of forests and their sustainable use is the main task of planning. Therefore foresters must coordinate at least three aspects: ecological, productive and social. It is vital for the management of mountain forests that:

(i) Management objectives be determined in accordance with natural conditions
(ii) Restrictions and requirements, which depend on specific site conditions and the multiple functions of forests, be taken into account in objectives and measures in all fields of forestry (silviculture, felling, harvesting, skidding, logging etc.)
(iii) Cooperation be established with other fields that interact with forestry in the landscape.

Consequences of unsuitable measures in extreme site conditions may be irreversible, since here restoration is very long and much more expensive than in lighter conditions. Therefore management decisions on mountain forests must be well planned, measures must be optimal and well coordinated, different activities should be coordinated, and supervision of activities in this fragile landscape must be highly restrictive.

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Management of mountain forests and conservation of genetic resources in Switzerland

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Mountain forests and conifers in Switzerland

Forests cover 30% (1 234 000 ha) of the total area of Switzerland. The forested area is subdivided into mountain zones and lowland zones using a model based on several site descriptors according to the Swiss National Forest Inventory (Brassel and Brändli 1999). Following this distinction, 653 400 ha of woodland (53% of total) are located in the mountain zones (consisting of the upper montane and subalpine altitudinal zone). The forest percentage in the mountain zones (alpine and nival zone excluded) is 46%, whereas in the lowland zones it amounts to 30%. The growing stock is 291 m^3/ha in the upper zones and 383 m^3/ha in the lower zones with an overall mean of 354 m^3/ha.

Ten conifer species are native to Switzerland (Table 1). Introduced species play a minor role: they contribute less than 1% to the growing stock. Six out of ten trees (DBH>12 cm) are conifers in Switzerland, which contribute 72% to the growing stock. Native conifer species are important to mountain forests where they are generally predominant. Broadleaved forests occur mainly in lower areas inside and outside the mountain regions.

Forest management and its effect on genetic resources

Early overexploitation

Many Swiss forests were affected by human impact since centuries. Clear-cutting for road construction across the Alps has already been reported from the Roman epoch (Leibundgut 1986).

The requirements for agricultural land increased as a result of the growth of the human population during the Middle Ages leading to large clearings. Deforestation was limited to lower altitudes for a long period, leaving the mountain forests more or less intact.

Since the late Middle Ages the pressure on forests grew in mountain zones as well. Land was needed for agriculture and pasture. Timber was exported for ship-building, and large-scale cuttings were done to produce energy for the early industries (e.g. metal and salt production). Further the production of cheese consumed huge amounts of firewood cut around alpine settlements. Cattle grazed not only on the pastures established on the cleared land, but also in the remaining forests, hindering their regeneration and thus contributing to deforestation. Leibundgut (1986) estimated the loss of mountain forests at two-thirds. Anthropogenic influence together with climatic changes lowered the upper forest limit by 200–300 m (Ellenberg 1996). The remaining mountain woodlands were located in remote, poorly accessible areas, or they had been declared closed forests in order to protect the settlements from avalanches and rock fall.

The effect of this excessive forest use on genetic resources is largely unknown. A loss of genetic variation can be assumed due to fragmentation and reduced population density.

Swiss stone pine (*Pinus cembra*) may serve as an example. Swiss stone pine grows only above the growth zone of Norway spruce due to interspecific competition. Lowering of the upper forest limit resulted in a considerably reduced growth area of Swiss stone pine. A previously continuous belt broke up into isolated pockets (Mayer 1992).

Other species profited from the human influence on mountain forests. An example is European larch (*Larix decidua*). Larch is a pioneer species colonizing clear-cut areas. Furthermore alpine cattle farmers favoured the species because it integrates grazing and timber production within the same area (agrosilvopastoral systems). Pollen analyses revealed that the distribution area of European larch in the Swiss Alps today is 5–20 times larger than it was under natural conditions (Mayer 1992).

The big reforestations

Consequences of the immense overexploitation became obvious during the second half of the 19th century. More than a possible disturbance of the genetic resources, other effects of a lacking mountain forest appeared: the lowlands were struck by several disastrous floods because of the insufficient forest cover in the mountains. People learned their lessons about the importance of intact mountain forests. The first Swiss law on forests was enacted in 1876. It contained a ban of clear-cutting in mountain forests. In addition, huge reforestation projects started all over the mountain area. For this purpose only fast-growing species could be used performing well in a clear-cut microclimate and on degraded soils (pioneer character).

Norway spruce and European larch were mainly planted. The origin of the plant material used during those days is often unknown. Occasional introductions of non-autochthonous material are proven, although historical records suggest that foresters often used local or regional provenances (Müller 1990, Küchli 1997). An effect on genetic structures is likely, either due to the use of non-autochthonous reproductive material, or because the local material itself had been affected.

Because reforestations were common and widespread in the Swiss mountain area, it seems doubtful whether any Norway spruce populations exist today, which are autochthonous in a very strict sense (Müller-Starck 1995).

The ungulate problem

Cattle grazing in the forests was still very common at the beginning of the 20th century, but has almost disappeared nowadays. Another factor poses now a serious problem: browsing ungulates.

Game stock in Switzerland was estimated at 130 000 for roe deer, 21 000 for red deer and 97 000 for chamois in 1998 (Federal Hunting Statistic). This high density of ungulates results from a lack of natural predators on one hand and from hunting regulations on the other. Large regions of mountain forests show a serious lack of natural regeneration due to game damage.

Silver fir is the conifer species that suffers most from game browsing in Switzerland. Genetic resources of silver fir may be seriously endangered since reproducing trees are harvested for timber or die naturally but are not replaced by natural regeneration.

Swiss forest legislation demands a game stock that allows site-appropriate tree species to regenerate naturally without any protection measures. Large-scale fencing therefore is no overall solution. The management problem can be solved only by a tight coordination between forest and hunting administration. An adapted hunting and game management is a crucial point. This includes to draw up and to adhere to appropriate shooting plans.

An additional component complicates the subject: many Swiss mountain areas suffer from anthropogenic disturbances caused by recreational activities such as hiking, skiing, biking and paragliding. As a consequence, the game hides in the woods for long periods and is forced to cover a big share of its energy demands by browsing in the forest (Ingold *et al.* 1996).

Natural regeneration of mountain forests may be regarded as a plain forest management issue at the first glance. However, a closer look reveals that it is also a problem of game

management and eventually even an issue of the overall mountain development. Management of mountain forests is a complex task in Switzerland and requires consideration of all relevant factors of the mountain environment.

Regeneration of mountain forests

The Swiss forest legislation demands a forest management by 'close-to-nature silviculture' on the whole managed forest area. The use of site-appropriate tree species, natural regeneration, small felling areas and long regeneration periods are key components of Swiss silviculture. Clear felling is forbidden. As a result, the overall proportion of natural regeneration in Switzerland is high: 82% of the regeneration relevant stands (young growths, sapling stands, young growths under shelter wood, all-aged forests) are regenerated naturally. The percentage of natural regeneration increases with the altitude of the stands (Table 2).

Figure 1 shows the use of plants for afforestation and reforestation in Switzerland, which has been heavily decreased during the past 30 years. Nowadays less than 5 million plants are used every year, with an approximately equal share of coniferous and broadleaved species. From the beginning of the 20th century up to the 1960s the yearly consumption was at about 20 million plants.

Artificial regeneration in mountain forests is used mainly after extraordinary events such as avalanches, large windthrows or forest fires. If natural regeneration takes too long to grow, the protective functions might be lost. More than 700 seed collection stands for conifers have been selected in Switzerland in support of the use of appropriate propagation material.

A large number of mountain forests in Switzerland shows an unstable structure. Only 44% of mountain forests are considered stable (Brassel and Brändli 1999). Tendings and thinnings often have been neglected in afforested areas and on clear-cut areas which reforested naturally. The resulting stands are dark, even-aged, uniform, and, most important, with too little recruitment. The unstable structure makes them susceptible to large-scale collapses. This bears the risk of the loss of the protective functions of the forests. It also threatens the genetic resources. The Swiss Confederation pays a lot of subsidies every year for the transformation of unstable stands into stable forests by promoting natural regeneration. In the last few years the federal grants for silviculture in protective forests amounted to more than 40 million Swiss Francs per annum. Although very expensive, it is an important task in order to ensure that mountain forests can maintain their protective functions long term.

The genetic resources conservation concept

The conservation of the genetic diversity of animal and plant species is a constitutional task in Switzerland. The Confederation is aware of the importance of the conservation of genetic resources in order to maintain the sustainability of the forests. In order to fulfil this task, the Swiss Forest Agency pursues mainly four approaches which all form indispensable parts of a general concept for the conservation and use of forest genetic resources:

- Promotion of close-to-nature silviculture on the entire managed forest area, which is assumed to have a conservatory effect on genetic resources
- Regulations for the use of reproductive material for artificial regeneration
- Specific promotion of rare tree species
- Conservation of locally adapted forest tree populations and their adaptive potential.

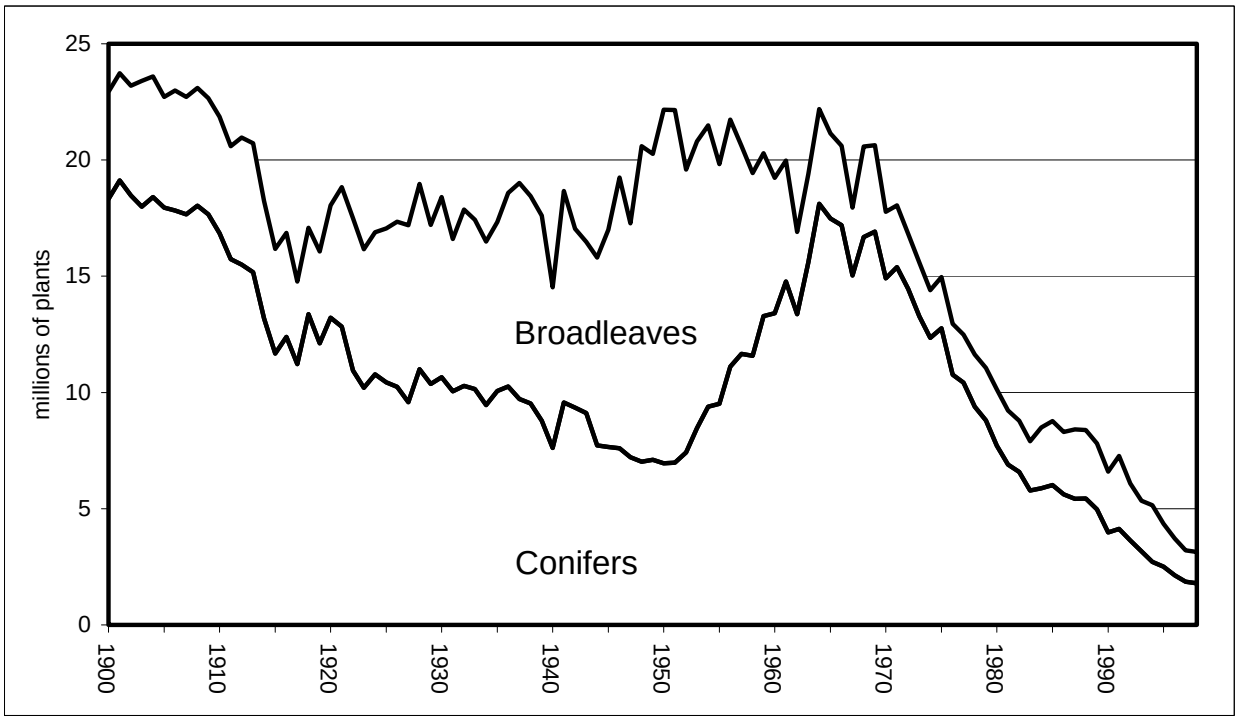
The different approaches of this general concept follow specific objectives, but are complementary and partially overlapping in their effects. The conservation of forest genetic resources is pursued mainly by *in situ* methods.

A project for the conservation of locally adapted forest tree populations and their adaptive potential is supported by the Swiss Forest Agency since 1988. It consists of a research module and an implementation module, which are tightly interlinked. Both mountain and lowland forests are covered by the project, which is open to all native tree and shrub species. A specific strategy is adopted for each species. A key element in the strategies is the declaration of so-called 'Forests of Particular Genetic Interest' (PGI forests). They are identified and selected on the basis of genetic information and other criteria. The declaration of a PGI forest will be the responsibility of the forest service of the Swiss Cantons. The PGI status will be incorporated in the regional forest management plans and in the local forest enterprise work plans. A tight collaboration between the project staff, the cantonal and local forest services, and the land owners is crucial for the success of this strategy.

The forest owner compromises himself to manage the PGI area in order to maintain or promote the target species and to regenerate it naturally whenever possible. If artificial regeneration is required (biological or security reasons), local seed material must be used. There will be no subsidies for the PGI declaration as such in view of these loose restrictions (compared to 'normal' silviculture in Switzerland). However, the forest owner will be compensated for all additional expenses such as fencing, seed collection, or nursery activities.

Such special measures are more likely in mountain forests due to the above-mentioned unstable structures, the high game stock, and unexpected incidences such as avalanches or storms. Difficult terrain and poor accessibility normally makes the measures more costly.

Fig. 1. Consumption of plants for reforestation and plantation in Switzerland 1900–1998.



Source: Swiss forest statistics. Compilation: U. Wasem, WSL.

Table 1. Native conifer species in Switzerland and most important introduced conifers

	Growing stock		Stem number		
			lowland	highland	
	(× 1000 m^3)	% of total	forests (in 1000 or qualitative)[§]		% of total
Taxaceae					
Taxus baccata	224	0.1	>		0.2
Pinaceae					
Abies alba	61 098	14.6	31 737	22 797	10.9
Picea abies	198 768	47.6	69 401	126 639	39.2
Pinus cembra	2470	0.6	0	4461	0.9
Pinus sylvestris	12 931	3.1	11 230	3466	3.1
Pinus mugo	1411	0.3	20	4297	1.0
Larix decidua	20 862	5.0	2992	18 231	4.4
Cupressaceae					
Juniperus communis[†]			>		
Juniperus nana[†]			<		
Juniperus sabina[†]			=		
most important introduced species:					
Pseudotsuga menziesii	811	0.2	>		0.2
Pinus nigra	306	0.1	>		0.1
Pinus strobes	345	0.1	>		0.0
Larix kaempferi[‡]			>		

[†]Juniper species are not considered in the Swiss National Forest Inventory

[‡]Japanese larch, having a negligible share, is subsumed to European larch

[§]The species is more (>)/less (<)/approximately as (=) abundant in lowland forests than/as in highland forests

Sources: Brassel and Brändli 1999, Hess *et al.* 1976–80.

Table 2. Percentage of natural regeneration in different altitudinal zones (only regeneration relevant stands are considered)

Subalpine zone	93.7
Upper montane zone	88.9
Lower montane zone	78.0
Colline/submontane zone	60.3
Switzerland	**82.4**

Source: Swiss National Forest Inventory—Brassel and Brändli 1999.

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An overview of forest biodiversity in the Trans-Caucasus[3]

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Background

The Trans-Caucasus sub-region[4] is located in the southern part of the Former Soviet Union (FSU), covering an area of 186 340 km^2 between 38°26´ and 43°34N and 40°00´ and 50°20´E. The sub-region includes three FSU countries in transition: Armenia, Azerbaijan and Georgia accounting, respectively, for 16%, 46% and 38% of the sub-region's total area.

Forests are an important element of the sub-region, contributing various tangible (wood supply), and intangible benefits (anti-erosion factors, clean air and water, recreation, genetic resources, etc.). They are also an important source of non-timber products: honey, berries, fruits, nuts, mushrooms, etc. The forests of the Trans-Caucasus are remarkably rich in terms of biodiversity; giving shelter to hundreds of rare flora and fauna species.

Although there are only limited commercial forestry operations in the Trans-Caucasus in comparison to the efforts to conserve and enhance existing forest land, these commercial activities are still impoverishing the biodiversity through the selection and cutting of the best trees, improper road building, as well as by widespread irregular grazing and game poaching. Additionally, extensive areas of lands covered with forests and shrubs close to highly populated areas have become the main source of fuelwood in recent years, and therefore have been heavily degraded.

The information currently available on the status of forest biodiversity in the Trans-Caucasus is inadequate and largely out of date. A comprehensive ecogeographic review and update of information available on the conservation status of forest biodiversity, and important habitats is urgently required. There is a great need for the introduction of participatory methods and awareness programmes into conservation policies, and into the overall rural development scheme.

The new national development strategies require policies that integrate the biodiversity and forests in rural development efforts and balance the economic and environmental needs among national, regional and international interests. Currently, the countries are seeking the most appropriate economic policies, regulatory mechanisms, financial incentives, organizational structures and ownership arrangements to promote sustainable forestry practices, including the conservation and sustainable use of forest biodiversity.

The main objective of this study is to provide an overview of the forest biodiversity in the sub-region, to outline major problems of its conservation and sustainable use, and to recommend appropriate strategies and safeguards. The year 2001 marks the start of the International Biodiversity Observation Year, during which scientists around the world have committed to dramatically increase communication of their findings about biodiversity and its role in human welfare.

Forest biodiversity

[3]More information on the conservation of forest biodiversity in the region can be found in: Ter-Ghazaryan, K. 2000. Collaborative efforts on the conservation of forest genetic resources in the Trans-Caucasus. Pp. 51–56 *in* International collaboration on forest genetic resources: the role of Europe. Proceedings of the Second EUFORGEN Steering Committee meeting, 26–29 November 1998, Vienna, Austria. International Plant Genetic Resources Institute, Rome, Italy.

[4]The Caucasus ecoregion (440 000 km^2) geographically comprises two large sub-regions: northern Caucasus (mainly Russian Federation), and the Trans-Caucasus.

Forests occupy slightly less than a quarter of the total land area of the Trans-Caucasus. The distribution is uneven: the lowest percentage of forests and other wooded lands[5] is in Azerbaijan (11.2% of the land area), the largest in Georgia (43.7%), and Armenia has 13.8%. The total volume of growing stock on forests and other wooded lands is around 700 million m^3 (of which Armenia 7%, Azerbaijan 20% and Georgia 73%).

The sub-region was more forested in the past than it is now. For instance, A. Dolukhanov (1989) states that at prehistoric times the Colchine valley (western Georgia) and surrounding mountains up to 2500 m.a.s.l. were entirely covered by forests. Large forest areas were also widespread in eastern Georgia. In Armenia 200–250 years ago the forest vegetation covered twice as much territory as it does at present (Magakian 1941, Khurshudyan *et al.* 1987). Forest areas in Azerbaijan decreased nearly in the same proportion (Prilipko 1970). According to the estimates provided by the World Resources Institute, the loss of the original forest within Kura-Arax watershed is as high as 80%. The increasingly dry climate combined with human impacts is often mentioned among major reasons of the disappearance of the forests.

Armenia lies in the heart of one of the world's most important areas of origin of cultivated plants. Hundreds of species of wild relatives of crops, including wild ancestors of several fruit trees grow here. These include about 20 species of wild pear (*Pyrus*), 13 species of rowan (*Sorbus*), 12 species of hawthorn (*Crataegus*) and different species and varieties of *Juglans, Cerasus, Cornus, Ribes, Grossularia, Rubus* and *Prunus.* These resources have long been recognized as having unique and global importance. It is worth acknowledging that the Trans-Caucasus at large is extremely rich in wild fruit and nut resources.

According to the recently compiled Temperate and Boreal Forest Resource Assessment 2000, forests and other wooded lands of Armenia cover 392 000 ha on mountainous sites at altitudes of 500–2600 m.a.s.l. (data as of 1996). Over 200 species of trees and shrubs grow in the forests. All forests in Armenia are state-owned and the current protected areas formally make up about one-third of the total forest area. Although this is a high percentage when compared with other countries, there is an urgent need to improve inspection, monitoring and control of reserves and conservation of biodiversity.

Dominant species which occupy approximately 85% of the total forest and other wooded area include oaks (*Quercus iberica* Stev., *Q. macranthera* Fisch et Mey. ex Hohen.), beech (*Fagus orientalis* Lipsky) and hornbeam (*Carpinus caucasicus* A. Grossh.). Other common species include ash (*Fraxinus oxycarpa* Willd., *F. excelsior* L.), elm (*Ulmus laevis* Pall., *U. elliptica* C.Koch), linden *(Tilia caucasica* Rupr., *Tilia cordata* Mill.*)*, maple *(Acer platanoides* L., *Acer ibericum* M.B.*)*, and oriental hornbeam (*Carpinus orientalis* Mill.). Remnants of coniferous forest species, including pine and yew (*Taxus baccata* L.), and different species of juniper (*Juniperus foetidissima* Willd., *J. polycarpos* C. Koch., *J. oblonga* M.B., *J. sabina* L.*)* may still be found but are rare. Among endemic plants of Armenia the following woody species can be mentioned: rose (*Rosa zangezura* P. Jaroch.), pear *(Pyrus elata* Rubtz., *P. tamamschianae* Fed.*)*, almond *(Amygdalus nairica* Fed. et Takht.), and hawthorn *(Crataegus armena* Pojark.).

A high proportion of the timber harvested is still felled illegally (Thuresson *et al.* 1999). The state institutions responsible for forestry are weak, the regulatory system is poorly developed and there is a lack of forestry experts. The state forestry enterprises follow former Soviet style management plans, which do not guarantee sustainable forest management.

Azerbaijan is, predominantly, a mountainous country. Yet, along with high mountain ridges, there are vast plains and lowlands. Eighteen percent of the country's territory is situated below the sea level. The climate varies from subtropical and dry in central and eastern Azerbaijan to

[5]Forests and other wooded land are defined as of TBFRA 2000.

subtropical and humid in the southeast, temperate along the shores of the Caspian Sea, and cold in the higher mountain zone. Most of country receives scant rainfall (152–254 mm annually).

The country is quite rich in biodiversity. The flora is represented by over 4000 species out of 125 families and 930 genera, of which 240 are considered endemic. The dendroflora comprises 436 species (11% of total flora), including 107 tree species (i.e. 25%), 167 high shrubs and 162 low shrubs. Taxonomically the dendroflora belongs to 48 families and 135 genera (Prilipko 1970), whereas the major part of woody species belongs to the following plant families: Rosaceae, Salicaceae, Fagaceae, Ulmaceae, Betulaceae and Aceraceae. The dominant tree species are beech, hornbeam and oak. In Talysh the unique groves of the relict chestnut-leaf oak (*Quercus castanefolia* C.A.M.) are quite common (Prilipko 1970). Among endemics (over 70 species) the following woody species can be mentioned: Persian iron wood (*Parrotia persica* C.A.M.), Caucasian elm (*Zelkova carpinifolia* Dipp.), eldar pine (*Pinus eldarica* Medwed.), hyrcane box-tree (*Buxus hyrcana* Pojark.). The highest rate of endemism occurs in the southern part of the country (Nakhichevan), and Talysh. Riparian woodlands and other places in Trans-Caucasus are made of *Populus, Ulmus, Salix* and many shrub species. These specific riverine forests have been mostly affected by human activities, and in many places are seriously degraded.

The total area of the forest and other wooded land (as of 1988) equals to 990 000 ha, of which 936 000 ha are covered with forest (TBFRA 2000). Of the forests, 10% is considered as primarily water-protective, 70% as soil protective, the sanitation forest belts comprise 12%, and 8% are specially protected forests. The following main forest types are distinguished: beech forest, oak forest, mixed broadleaf forest, hyrcane relict forest, lowland forest, riparian forest and shrubs formations (Prilipko 1970). In forest habitats, 76 fern, 7 mammal, 15 bird and 652 butterfly and moth species are reported (TBFRA 2000).

During the past six to seven years quite large forest areas were damaged by illegal cutting. It is reported unofficially that the quantity of trees felled is as high as 20% of the total.

Georgia supports a rich flora that includes about 4100 species of vascular plants. The 10 leading families are Asteraceae, Poaceae, Fabaceae, Rosaceae, Brassicaceae, Scrophulariaceae, Apiaceae, Lamiaceae, Caryophyllaceae and Liliaceae (about 60% of species). The endemic plant species of Georgia constitute about 9% of the total flora. Over 6500 species of fungi are registered in the country, as well as 2605 species of algae and 987 species of lichens. Georgia is also characterized by a wide variety of landscapes and plant communities, and supports examples of almost all major habitats found elsewhere in Europe (Djamaspashvili 2000).

Forests and other wooded lands in 1995 covered 43.7% of the land territory of Georgia from 500 to 2300–2500 m.a.s.l. (TBFRA 2000). The arboriflora accounts for about 400 species (trees 153, high shrubs 202, low shrubs 29, and lianas 11 species) (Gigauri 2000). Oriental beech, Georgian and Caucasian oaks, hornbeam, chestnut (*Castanea sativa* Mill.) and birch (*Betula litwinowii* A.Doluch.) are predominant broadleaved species (over 60% of the forest area). Georgian forests are also rich in coniferous species: Nordman or Caucasian fir (*Abies nordmanniana* Spach.), oriental spruce (*Picea orientalis* Carr.) and Caucasian pine (*Pinus kochiana* C. Koch), which occupy 19% of the forest area. Small areas are covered with linden, ash, maple and aspen. Mixed subtropical forests are less common and are located close to the seacoast. Almost all forests are located on mountainous slopes. About 500 000–600 000 ha of forests are considered as inaccessible, and thus completely undisturbed by man. The average growing stock of wood reaches 300 m^3 / ha.

Among endemics several woody species can be mentioned, e.g. Imereti oak *(Quercus imeretina* Stev.), Pitsunda pine (*Pinus pithyusa* Stev.), Hartwiss oak (*Q. Hartwissiana* Stev.), Colchine box-tree (*Buxus colchica* Pojark.) and Pontine rhododendron (*Rhododendron ponticum* L.).

No reliable information as to the amount or distribution of illegal felling is available.

However, the real scope of the illegal cut is much higher than officially reported (50 000 m^3 in 1997). Under the FSU, Georgia annually received up to 2.5 million m^3 of timber from Russia, leaving much of the country's forested areas relatively pristine. Independence has forced Georgia to rely increasingly on its own forest resources for industrial purposes, while the recent energy crisis has led to uncontrolled fuelwood harvesting. According to some estimates, the volume of legal cuttings plus illegal harvesting and uncontrolled fuelwood collection is manifold beyond the annual allowable cut. Easily accessible forests such as those in river valleys and riparian areas are in particular threatened. The conversion of bearded alder (*Alnus barbata* C.A.M.) forests into agricultural land has depleted riverine forests, especially in the Trialeti and Meskheti ridges of the Minor Caucasus. Unsustainable forest practices have led to the destruction of some forest types previously common in Georgia such as those dominated by *Quercus longipes* Stev. and *Alnus glutinosa* Gaertn.

In the whole territory of Caucasus, arid open woodlands can be found only in the Trans-Caucasus (Sheki plateau, Karabagh, Zangezur, Sevan range, Nakhichevan). The dominant tree species are: pistachio (*Pistachio mutica* Fisch. et Mey.), almond *(Amygdalus fenzliana* (Fritsch) Lipsky*),* juniper *(Juniperus polycarpos, J. foetidissima, J. sabina),* nettle-tree *(Celtis caucasica* Willd., *C. glabrata* Stev.*).* Many shrub species (*Crataegus, Rhamnus, Rosa, Cerasus, Prunus, Cotinus, Spireae, Jasmine* to name a few) grow there. These habitats are characterized by the highest level of biodiversity (Prilipko 1954, Mulkidjanyan 1975, Gabrielyan 1990).

Most of the data on forest flora diversity of the Trans-Caucasus is largely inadequate and dates back to FSU times. There is a great need for detailed and updated assessments and surveys.

Issues

The following priority problems have been identified in the field of the forest biodiversity conservation and sustainable use. These problems are similar for all Trans-Caucasus countries.

The main constraints to forest biodiversity conservation and management in Trans-Caucasus are a lack of appropriate policies, strategies, institutions and trained staff combined with inadequate information and scant resources (financial, technical, human). The personnel responsible at all levels, have neither been trained in, nor exposed to modern approaches to the subject. This is further compounded by the fact that the underlying basis for management is viewed in the same way as forestry for the production of timber. Thus protected areas are divided into compartments, where the growing stock of wood is fairly well known. However, knowledge of the basic ecology of areas is lacking and the need for zonation and management to meet biodiversity conservation, recreation and tourism objectives of woodlands and protected areas do not seem to be recognized.

At the individual protected area level, constraints to development and improved management include lack of facilities for guards and research staff, poor access roads, lack of field and management equipment, lack of vehicles, lack of radio communication equipment, and environmental damage caused by illegal cutting, poaching and other activities. Derelict, vandalized and inappropriate buildings and structures in many areas ruin land values of several protected areas.

Many of the existing protected areas are small, which may make their effectiveness in conserving larger and wide ranging wildlife species questionable. Their overall longer term viability may also be doubtful. This is a serious consideration for areas that are isolated with agricultural land right up to their boundaries. This calls for the entire land use planning action both at national and ecoregional levels.

The possibility of increasing the effectiveness of protected areas that are located in 'forest

estate' lands, by managing adjacent forests and wildlands to take account of the needs of forest biodiversity conservation and wide-ranging large animals should be kept in mind. Such an approach could in effect provide buffer zones around protected areas and corridors between them and thus greatly increase their conservation value. The linking of two or more areas in this way would enable them to be managed as a cluster and improve the national and ecoregional protected areas system.

In addition to this, suitable forests that are currently logged or managed for fuelwood and timber production should be evaluated for their possible recreation and tourism potential. It should be borne in mind that elsewhere in Europe, logged forests are also used for recreation. Given the programme for tourism development in the Trans-Caucasus, all potential recreation possibilities in forest lands will need to be mobilized. The potential role of multipurpose forestry that includes a strong recreation and tourism dimension in the development of the sector should not be overlooked.

Recommendations

The financial assistance targeted to halt the degradation of the biodiversity and forest resources in the sub-region should be raised. At present the level of the financing for this sector is discouraging. This can hardly coincide with the strategy of the major donors, which basically should balance economic, social and environmental needs of the countries. The issue of effectiveness must also receive greater attention in terms of focusing on the greater success areas, and entering into partnerships with the actors in areas where they have a comparative advantage.

National Governments should consider that forest areas and protected areas designated within forest estate be managed to fulfil three basic functions as follows:

- meet national and international requirements for the conservation and sustainable management of forest biological diversity and country biodiversity at large;
- contribute to recreational and leisure needs of society and thus enhance the quality of life;
- form a resource base for the development of the international tourism industry.

An expanded protected area system covering all priority forest types of the Trans-Caucasus would form the basis on which these functions could be developed, but they cannot be adequately realized without a minimum of investment and technical assistance.

In the past, protected areas have provided substantially for the recreational needs of countries. Despite current limitations due to the deterioration of visitor facilities, it is clear that they continue to be used by citizens. It can be anticipated that as the national economies begin to pick up under privatization, the demand for outdoor recreation, particularly from the more affluent sections of urban populations, will increase. Appropriate sites in the national protected area system must be geared up to meet this demand and local rural economies should benefit from the growth of the leisure industry.

The cost–benefit arguments in favour of developing more protected areas in the light of the above projections are compelling. The need for additional protected areas to spread the pressures of tourism more evenly also have a strong environmental basis. Thus, there may be economic as well as environmental reasons not to go for short-term gains from the timber in mountain forests, which are currently inaccessible to truck transport and thus, commercial logging. In the medium term, in the European context, a number of these areas would be far more valuable if they remained as ancient forests for tourism and recreation use and for the conservation of the unique biodiversity.

With shifts in agricultural economies in recent decades, many rural populations in Europe increasingly rely on the tourism and recreation industries for their livelihood. Trans-Caucasus protected areas are situated in rural localities, many of which in remote areas. There are already villages in the vicinity of existing reserves and national parks that have developed a tradition of catering for the needs of visitors to these areas. There is clearly scope to build on this and adopt strategies that enable local rural communities to maximize the benefits that can accrue to them, from the *integration of protected area and biodiversity planning and management into overall rural development*. Such approaches would be especially appropriate in localities where protected areas are set up within extensive forest lands (Borjomi, Lagodekhi, Dilijan, Shikahogh, Zakataly, Talysh) which are utilized for wood and fodder production, grazing and hunting, in order to promote multipurpose forestry.

In order to establish a basis on which to pursue the above goals, a sound protected area system for the Trans-Caucasus is essential. The first practical steps required to achieve this will be to protect and rehabilitate the environment of existing areas, to establish additional protected areas and to initiate modern protected area planning and management, in order that the system fulfils the functions indicated above. As the conservation of biological diversity will not be achieved solely by designation of protected areas (Cassells 1995), the development of land use systems, which are compatible with conservation objectives, is of paramount importance.

There is little doubt that forest resources of the Trans-Caucasus are able to contribute considerably more to the economic and social development of the region, than at present. The long-term objective of Trans-Caucasus forestry is to manage and use the forests in such a way as to maintain its biological diversity, its productivity, its reproducing capacity as well as the relevant ecological, economic and social functions at local and regional levels.

In a medium-term perspective this calls for modernization of most of the sector, including the establishment of market economy management systems, upgrading of personnel and staff capacity, decentralization of responsibilities and authority, developing links with appropriate regional and international organizations and improving administrative and economic procedures.

In the short-term there are certain pressing needs that call for attention if the long- and medium-term objectives should be met. A typical exponent of this category is a forest biodiversity resources assessment without which the most important habitats within forest estate cannot be conserved and sustainably managed. Other such example is building up know-how in certain key areas like forestry extension, farm forestry, ecotourism, protected areas management, staff education and training.

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Brief overview of conifers in Armenia

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There are over 300 tree and shrub species native to Armenia, representing about 10% of the total flora. The richness of the dendroflora is the result of the complex geological history, diversity of climatic conditions, unique geographical location of the country and specific development of the vegetation types. The dendroflora is considered much older when the participation of evergreen species and lianas (remnants of the past subtropical vegetation) is high. In the Armenian dendroflora only 14 woody species are evergreen, of which half are conifers.

The conifer species (Caucasian pine, yew and five species of juniper) are the oldest representatives of the native dendroflora. These relict species survived only within separate small refuge areas and they are rare.

According to the latest forest inventory data (1993) the area of conifer species in Armenia:

Pine (native)	1300 ha
Yew	100 ha
Juniper	8400 ha

The conifer species of Armenia have been the subject of a number of studies, carried out mostly by the specialists of the Institute of Botany, National Academy of Sciences (see reference list below). However, most of these studies and surveys date back to the 1950s and earlier, and an adequate updated information on the status and growth of the conifer stands is lacking.

An overview of the conifer species is presented below.

*Yew (*Taxus baccata *L.) (local names: karmratzar, ghegtzi, bzeni)*

This species is quite rare in Armenia, and is included in the country's Red Data Book of Plants (1990). Yew is a relict tree, dating back to the tertiary period.

In Armenia the yew tree is found in small groves in northern Armenia (Tavoush Marz) and southern Armenia (Siunik Marz) at the altitudes of 1000–1400 m.a.s.l. It very seldom occurs up to 1800 m. It occurs mainly in mixture in beech or oak forests, and very rarely dominates in the forest structure. However, in the watershed of river Ghetik (Aghnabad canyon, Dilijan reserve, northern Armenia) there is a yew grove covering an area of 25 ha, which is under protection since 1958. In southern Armenia a smaller grove (3 ha) is located within Shikaghogh reserve. Several authors argue that the distribution of the yew tree used to be much higher (Troitzkyi 1939, Vardanyan 1982). However, updated surveys of the yew stands are lacking, and the existing information on the status of the stands is inadequate.

The maximum height of the trees is 20–25 m, and the diameter at breast height sometimes exceeds 1 m. The age of mature trees ranges between 500 and 600 years. The increment is very low. The natural reproduction of the stands is unsatisfactory, owing mainly to illegal grazing, whereas natural reproduction of the beech and hornbeam in the same stands are comparatively higher; this threatens the future of the yew tree.

*Caucasian pine (*Pinus Sosnowskyi *Nakai) (local names: sotjeni, shami)*

Native pine stands are relatively rare in Armenia. Pine is predominantly located in northern Armenia (Lori and Tavoush Marzes: Stepanavan, Gougark, Dilijan, Ijevan and Berd). The mature trees reach 35 m in height and 50 cm in diameter. The growth of young pine (20–40 years) is rather fast, with an annual increment of about 60–70 cm. Maximum age is 400 years, but most trees are 100–120 years old. The pine groves are located preferably in the range of 1300–1600 m.a.s.l.

According to several surveys, the area of pine in Armenia was much higher in the past, but the pine stands were replaced by more adaptable broadleaved species, in particular beech, hornbeam and oak. Non-sustainable exploitation of pine stands and unsatisfactory regeneration of the pine in closed stands under the broadleaf canopy also had a negative impact. However, pine has a good regeneration and frequently appears as a pioneer species on burned areas.

Pine is widely used for afforestation and reforestation programmes (Chubaryan 1959, Grigoryan 1979), mostly in medium and highland conditions. In the lowlands the reforestation programmes are less successful because of pest and disease problems.

With the energy crisis of recent years, the native pine forests have been extensively damaged owing to harvesting of fuelwood for heating purposes and illegal cutting for quality timber.

*Juniper (*Juniperus *sp.) (local name: ghihee)*

Five species of juniper are found in Armenia: *Juniperus foetidissima* Willd., *J. polycarpos* C.Koch., *J. oblonga* Bieb., *J. sabina* L. and *J. depressa* Stev. The latter is very rare and is included in the Armenian Red Data Book of Plants (1990).

Information on the status and regeneration of juniper in Armenia can be found in several research articles (Ivanova 1946, Tonakanyan 1948, Grigoryan 1974, 1977, Chubaryan 1959, Vardanyan 1982, Grigoryan 1984, Vardanyan 1993). Natural regeneration of juniper was particularly studied. It has been stated recently (Vardanyan 1993), that the regeneration rate of juniper depends on several ecological factors (both biotic and abiotic), pests and diseases being the major negative factor. As a result the seed crop (on average 40–50 kg / ha) is intensively damaged by pests, and only 3–16% of the juniper seeds remain healthy. This amount of seeds is highly insufficient for the normal natural regeneration of juniper.

In order to increase the germination rate of the juniper seeds, best results were obtained by pre-treatment of the seeds in cold storage (0–5°C) for 200 days, followed by rapid soaking in boiling water for 10 seconds (twice) just before sowing in the nursery.

The rooting of *Juniperus polycarpos* cuttings, even treated by growth stimulators, did not provide satisfactory results. On the contrary, *Juniperus sabina* and *J. oblonga* are doing well, and the scions develop primary roots in 170–200 days.

Juniperus oblonga and *J. depressa* can be easily propagated by layering (better results are obtained in fall), which sometimes occurs also naturally.

In order to conserve the biodiversity and to facilitate the natural regeneration in juniper stands, the following measures are recommended (Grigoryan 1984, Vardanyan 1993): selection of the most productive and tolerant individuals for further preservation; integrated pest and disease control; development of small-scale nurseries; extra sowing of the seeds collected on the third year; and prohibition of grazing and haymaking.

Conclusion

From a practical point of view, the priority objectives of the conservation and sustainable use of conifer forests in Armenia are as follows:

- To identify gaps and problems in the maintenance of conifers health and vitality, conservation and appropriate enhancement of biodiversity in forest ecosystems.
- To incorporate operational guidelines into applied silviculture and forest management systems in the selected forest enterprises to ensure conservation and sustainable use of conifers.
- To raise public awareness and participation in conifer conservation and sustainable use, and to enlarge involvement at local and community level.

The following activities should be urgently prepared and implemented.

- Development of operational guidelines for forest management (harvesting, afforestation and reforestation, seed collection, etc.), which address genetic, species and structural diversity of the conifer forests.
- Compilation of a list of conifer species and provenances that are the most suitable for the local conditions in afforestation and reforestation programmes.
- Research on natural regeneration of the priority species via field trips, and selection of the sites that should be set aside for natural regeneration.
- Development of operational guidelines for the restoration of conifers on degraded sites.

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Programme

Saturday 4 March—arrival of participants

Sunday 5 March

8:30 Welcome (Host country and Chair of the *Picea abies* Network)
9:00 Introduction (IPGRI)
9:20 Adoption of the agenda and nomination of rapporteurs

Presentation of the history and main outputs of the *Picea abies* Network

9:30 Highlights on progress made in countries: selected examples

11:00 Coffee break

11:30 Technical Guidelines
12:00 Minimum descriptors
12:30 Poster and Web Page

13:00 Lunch

Assessing priorities for the Conifers Network

14:30 Genetic diversity of European Conifers (V. Koski)
15:00 Presentation of the results of the questionnaire
15:30 General discussion on needs and priorities

16:30 Coffee break

17:00 Working sessions on conservation strategies for different groups of conifers (widely occurring species, rare and threatened species, exotic species)

Monday 6 March

8:30 Presentation of results of the working groups on conservation strategies
9:30 Working sessions on the activities proposed for the workplan (e.g. information management, legal and policy issues, technical guidelines and methodologies, public awareness tools)

11:00 Coffee break

11:30 Presentation of results of the working groups
12:15 Development of a workplan

13:00 Lunch

14:30 Development of a workplan (continued)

16:00 Coffee break

Seminar: Conservation of conifers genetic resources in mountain forests

16:30 Forest biodiversity in the Caucasus Mountains (Z. Vardanyan)
16:50 Management of mountain forests in Switzerland and its effect on genetic resources (M. Ulber)
17:10 Management of mountain forest in Slovenia (G. Bozic)
17:30 Discussion
18:00 Links with international activities and initiatives on mountain forests

Tuesday 7 March

Field trip to Norway spruce stands (1/2 day)

15:00 Wrap-up session for the field trip: 'The contribution of dendroecology to studies of conifers genetic resources' (T. Levanic)
15:30 Election of Chair and Vice-Chair
15:45 Date and place of next meeting

16:00 Coffee break

16:30 Any other business
17:00 Adoption of the report
18:00 Conclusions and closure of the meeting

Wednesday 8 March—departure of participants

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