Federal Ministry of
Food, Agriculture
and Consumer Protection

INTERNATIONAL YEAR
OF FORESTS • 2011

Forest Genetic Resources in Germany

Concept for the Conservation and Sustainable Utilization
of Forest Genetic Resources in the Federal Republic of Germany

"From the beginning one must assure that the hereditary information does not become too restricted, in contrast, one must maintain the diverse forms and characteristics of the entire population."

ROHMEDER, SCHÖNBACH 1959
Genetik und Züchtung der Waldbäume
(Genetics and Breeding of Forest Trees)

Concept for the Conservation and Sustainable Utilization of Forest Genetic Resources in the Federal Republic of Germany

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Revised version 2000

Federal government/*Länder* Working Group "Forest Genetic Resources and Legislation on Forest Reproductive Material"

confirmed by the Conference of the Forest Directors at their meeting on 26/27 October 2000 in Augsburg

Updated 2010

by the Federal government/*Länder* Working Group "Forest Genetic Resources and Legislation on Forest Reproductive Material" and the Federal Ministry of Food, Agriculture and Consumer Protection

Figure 1: Oak planticle

Preface to the 2010 Edition

In the early 1980s, massive damage was observed in forest stands, attributed to the combined effects of air pollutants and other multiple stress factors. The public perception of this threat to forests, the so-called *Waldsterben* or forest decline, led to a new environmental consciousness among the population and in politics. Against this background, on 8 February 1985 the *Bundesrat* adopted a resolution (Document No. 573/84) on measures to conserve the genetic diversity of forest tree species. In 1985, a Federal government/*Länder* Working Group was assigned with the coordination of activities as well as with the development and preparation of the first version of this concept. Today's Federal government/*Länder* Working Group "Forest Genetic Resources and Legislation on Forest Reproductive Material" (BLAG-FGR) therefore is commemorating its 25th anniversary in 2010.

The Concept for the Conservation and Sustainable Utilization of Forest Genetic Resources in the Federal Republic of Germany was prepared by the Federal government/*Länder* Working Group and published in 1987. In 2000, a revision of the concept was prepared and launched, after approval by the Conference of the Forest Directors. Today this concept serves as a National Programme for Forest Genetic Resources and is an important part of the National Strategy on Agrobiodiversity, which complements the National Strategy on Biological Diversity.

The current update of the concept was necessary because the former edition of 2000 is out of stock due to brisk demand. On the proposal of the BLAG-FGR, the Federal and *Länder* officials in charge of silviculture approved the updated reprint of the concept in spring of 2010. The revision of the concept relates only to specific areas of the text; mainly the appendices. The changes and content additions made are primarily due to legal changes (e.g. German Act on Forest Reproductive Material, FoVG) and institutional reorganizations since 2000.

The time-tested contents of the concept have been maintained within the updated reprint: the status of the threat to forest genetic resources is described and an overview of measures for the conservation of genetic diversity of tree and shrub species in Germany is provided.

This updated reprint is a contribution by the BLAG-FGR in cooperation with the Federal Ministry of Food, Agriculture and Consumer Protection to the International Year of Biological Diversity (2010) and in preparation for the International Year of Forests (2011).

Federal government/*Länder* Working Group "Forest Genetic Resources and Legislation on Forest Reproductive Material"[1]

Federal Ministry of Food, Agriculture and Consumer Protection

Bonn, 2010

1 Members of the BLAG-FGR: E. Aldinger, W. Arenhövel, B. Bendix, B. Degen, B. Haase, M. Haverkamp, G. Huber, A. Janßen, R. Kätzel, M. Rogge, S. Strich, W. Voth and H. Wolf

Summary

Task

At its meeting on 26 and 27 March 1998 in Bonn, the Conference of the Forest Directors of the Federal government and the *Länder* asked the Federal government/*Länder* Working Group "Conservation of Forest Genetic Resources"[2] to prepare a revised version of the forest gene conservation concept of 1987.

Starting Point for the Revised Version of the Concept

The present revised version is based on the Concept for the Conservation of Forest Genetic Resources in the Federal Republic of Germany which was published in 1987. The national and international framework conditions have changed since the first version was published.

In this context:

- the Convention on Biological Diversity (CBD) of Rio de Janeiro 1992 and
- the Ministerial Conferences on the Protection of Forests in Europe in Strasbourg 1990, Helsinki 1993, Lisbon 1998, Vienna 2003 and Warsaw 2007

are regarded to be of prime importance.

At the national level, revision became necessary because of German reunification.

In the past 23 years, the concept drawn up in 1987 and the revised version of 2000 have proven their value (cf. quadrennial reports, the last one presented for the period 2005-2008). Extensive measures *in situ* and *ex situ* have been carried out for safeguarding the economically relevant principal tree species and the different secondary tree species. For endangered and rare species, suitable conservation measures are urgently required.

Objective

The Concept for the Conservation and Sustainable Utilization of Forest Genetic Resources includes measures that serve to protect our forests in the future. Based on the importance of genetic diversity and the endangered gene resources of our tree and woody shrub species, it describes measures and activities required for attaining this goal.

Our objective is to continue conserving species diversity as well as diversity within tree and woody shrub species, to utilize forest genetic resources in a sustainable way, to restore viable populations of endangered tree and woody shrub species as well as to contribute to the conservation and restoration of diverse forest ecosystems.

Based on this concept, the *Länder* (Federal states) are given recommendations to carry out programmes of their own that consider their respective specific conditions and demands.

2 In 2001, the scope of the Federal government/*Länder* Working Group "Conservation of Forest Genetic Resources" established in 1985 was extended and the name was changed into Federal government/*Länder* Working Group "Forest Genetic Resources and Legislation on Forest Reproductive Material" (BLAG-FGR) accordingly.

Principles

On the basis of registering and evaluating forest genetic resources, specific measures are undertaken related to conservation worthiness and urgency. Those *in situ* measures that can be integrated into forest management practices are of special importance and hence should be given preference. Decision criteria are presented for specific *ex situ* measures. Additionally the aspect of sustainable utilization of forest genetic resources was included. Besides conservation measures, the development of nationwide research programmes with the main emphasis on the conservation of forest genetic resources appears to be crucial.

Since the genetic structure of many tree and woody shrub species is still unknown, genetic analyses will be the focus of future research work. For this, suitable analysis methods and procedures (isozyme methods, DNA analyses, population genetics) have to be applied and/or have to be newly developed. The institutions of the Federal government and the *Länder* are adequately equipped to carry out this work.

Realization

The tasks to be carried out by the institutions of the Federal government and the *Länder* in charge of the conservation and utilization of forest genetic resources are listed.

At present it is possible to manage the urgent concerns of conserving and utilizing forest genetic resources by means of existing institutional personnel and financial capacities.

The realization of the concept is carried out in the framework of four-year programmes. Provided the necessary budgetary means are made available, a procedure has to be agreed upon which includes sharing facilities as far as possible; this must be coordinated with the governmental officials in charge of silviculture.

In addition to gene conservation *in situ* as achieved by close to nature forestry, the following points have priority: registration and evaluation of forest genetic resources; specific conservation measures for endangered, valuable and rare tree and woody shrub species; to carry out research programmes; implementation of a long-term genetic monitoring system; and cooperation within the framework of international conservation programmes (e.g. IUFRO, Bioversity International, EUFORGEN).

The progress of these conservation tasks and the results obtained in research will be reported upon over a four-year period.

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Figure 2: European Beech stand with natural regeneration

1 Introduction

The forests of Germany, which comprise 31 percent of the country's total area, are the most important natural ecosystems and also an essential characteristic element in the landscape. These forests fulfil multiple demands of our society. Forestry in Germany is based on the model of multifunctional forestry, comprising economic (timber production), protective and recreation functions. Compared to other types of land use (agriculture, settlement, roads, etc.), the forests are characterized by comparatively low human impact. Thus they are an essential resource for biological diversity.

Nonetheless, the forests have been exposed to anthropogenic stress for a long time. Forest damage and endangered stability of the forest ecosystem are at a high level. Such damage has increased in some parts of Germany during recent years. There is a high risk that the forest ecosystem will not be able to properly fulfil its multiple functions in future. It is true that the efforts to reduce pollution have led to partial success. Very often however, these effects are compensated to a great extent by the increase of other stress factors. These are the reasons why the genetic resources of our forests continue to be endangered.

In 1987 a Concept for the Conservation of Forest Genetic Resources in the Federal Republic of Germany was introduced. Since then, national and international circumstances have changed and a new framework for international cooperation has been developed. New scientific knowledge and experience have been gained since the first concept was put into practice. Society has also become more sensitized to environment and biodiversity issues. Available budgetary means for forest gene conservation have been reduced. The environmental situation has changed considerably in the past years. All these facts made it necessary to revise and update the initial concept.

Ever since the Concept for Conserving Forest Genetic Resources was presented in 1987, the basis for securing the genetic diversity of our forests has been established. Genetic diversity is still endangered, however, making conservation measures urgently necessary.

The Concept for the Conservation and Utilization of Forest Genetic Resources presents fundamental guidelines for our forests in the future. It describes the measures and activities necessary to reach this target.

In this revised version of the concept, the following topics are of particular importance:

- Because of German reunification, the newly formed *Länder* had to be integrated in the concept.
- Following the Convention on Biological Diversity (CBD), the concept was extended to include the aspect of sustainable utilization of forest genetic resources.
- Using the previous experience gained in conserving forest genetic resources, it was possible to develop a protocol for realizing the conservation measures valid for all tree and woody shrub species. In this context, evaluation is of decisive importance.

Figure 3: European Larch cones

- The task for long-term monitoring, efficiency control and the establishment of gene conservation forests was introduced.
- The possibilities for conserving forest genetic resources within the framework of sustainable forest practices have been demonstrated and need to be expanded.
- The tasks of the Federal government/*Länder* Working Group "Conservation of Forest Genetic Resources and Legislation on Forest Reproductive Material"[3] were specified in view of the coordinating tasks.
- Nationwide priorities were defined that will be updated in a periodical report.

The new version of the Concept for the Conservation and Sustainable Utilization of Forest Genetic Resources in the Federal Republic of Germany will help guarantee the existence of stable and healthy forests in future. It describes how genetic diversity in our tree and woody shrub species is endangered as well as measures for conserving their genetic diversity.

Utilization is an integral part of conservation. Research must precede or at least accompany conservation; that is why both aspects must be considered. In view of the multiple tasks and the limited financial and personal capacities of the Federal government and the *Länder*, the concept provides guidelines for coordinating the work. Focal points of action and priorities necessary for realizing the concept are suggested.

3 In 2001 the scope of the Federal Government/*Länder* Working Group "Conservation of Forest Genetic Resources" established in 1985 was enhanced and its name was changed to the Federal Government/*Länder* Working Group "Forest Genetic Resources and Legislation on Forest Reproductive Material" (BLAG-FGR) accordingly.

Figure 4: European Beech planticles

2 Mandate of the Working Group

The Federal government and the *Länder* installed a Federal government/*Länder* Working Group on 10 January 1985, which drafted a Concept for the Conservation of Forest Genetic Resources in the Federal Republic of Germany between 1985 and 1987. The elaboration of this concept was initiated by the resolution of the *Bundesrat* (the 2nd chamber of parliament representing the *Länder*) dated 8 February 1985 on "Measures on the conservation of genetic diversity of forest tree species" as well as by the resolution of the Federal government dated 24 July 1985 on the continuation of the action programme "Save the forests" ("*Rettet den Wald*").

- The resolution of the *Bundesrat* (Document No. 573/84) specifies: "In the opinion of the *Bundesrat* ..., it is necessary that the work of the Federal government and the *Länder* shall be coordinated and a programme on the conservation of the genetic diversity of the forests including cost estimates be established."

- With the second continuation of the action programme "Save the forests" dated 24 July 1985 (Federal Ministry of the Interior [BMI] 1985), the Federal government referred to how the genetic diversity of the forests is endangered and stated that efforts are being made to establish a forest gene bank. The Federal government instructed the responsible organizations to implement the action programme "Save the forests".

The mandate of the Working Group was confirmed by the resolution of the Agriculture Ministerial Conference dated 30 September 1988.

In the German Democratic Republic (GDR, former East Germany), actions for conserving forest genetic resources were based on the resolution of the Cabinet Council dated 20 March 1985 on "further measures for the protection of the forests of the GDR". Since the reunification of Germany, the newly formed *Länder* have become members of the Federal government/*Länder* Working Group.

At their conference held on 26 and 27 March 1998 in Bonn, the Forest Directors of the Federal government and the *Länder* decided:

"The Conference of the Forest Directors orders the Federal government/*Länder* Working Group 'Conservation of Forest Genetic Resources' to draft a revised version of the Concept for the Conservation of Forest Genetic Resources and to present it to the Conference of the Forest Directors. In view of the limited budgetary means available, appropriate priorities of the measures should also be suggested".

The Federal government/*Länder* Working Group (BLAG-FGR) acts as a committee of experts for forest genetic resources at the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV). The chairman of the BLAG-FGR represents forestry in the Advisory Board for Biodiversity and Genetic Resources for Food and Agriculture at the BMELV. The Advisory Board assists and advises the BMELV with respect to the conservation and sustainable utilization of genetic resources.

Figure 5: Norway Spruce: high altitude phenotype

3 Importance of Genetic Diversity

In contrast to plants cultivated by agriculture and horticulture, the forests in Germany consist primarily of natural populations that were influenced to a lesser extent by humans. However, the natural geographical distribution patterns of the species were altered considerably, the extent depending on the respective tree species.

Genetic diversity is the prerequisite for evolution. It is the basis for adaptability and thus for the survival of the species. Genetic diversity is a component of biological diversity, which is differentiated in three levels:

- diversity of the ecosystems,
- diversity of the species and
- diversity within the species (genetic diversity).

Genetic diversity is important for the following reasons:

- **Ecological reasons**
  Genetic diversity is the basis for the response of a species towards biotic and abiotic influences. This is of special importance because of the longevity of the trees and because trees cannot evade unfavourable environmental influences; they are site bound. Genetic diversity contributes to the adaptability and hence to the conservation of species and contributes to ecosystem diversity and development.

- **Economic reasons**
  Genetic diversity ensures that the needs of future generations can be met. This is particularly true when the demands placed on the forest to supply the raw material wood must be met under changing environmental conditions. Thus genetic diversity is the basis of sustainable, efficient, multifunctional forestry. At the same time it serves as a basis for genetic improvement by selection.

- **Ethical reasons**
  In view of our responsibility towards future generations, genetic diversity must be conserved because of ethical reasons in order to pass on ecosystems, species and populations in their diversity and in an undamaged state.

Figure 6: Mixed forest

Figure 7: Forest fragmentation

4 Factors Endangering Genetic Diversity

Anthropogenic influences on the environment are short-term effects on an evolutionary scale that cause rapidly changing living conditions and stress for tree and shrub species to which they are often unable to adapt. Natural genetic mechanisms do not suffice to counteract the loss of genetic diversity and to maintain the adaptability of a species. Species present in the forest ecosystem are endangered to differing degrees. In the extreme case the extinction of a species may be the consequence. Even if a species does not become extinct, its gene stock may still be impoverished to such an extent that its adaptability is lost and it is threatened with extinction. Adapted local populations may become extinct even though the species as a whole is not endangered.

Factors endangering genetic diversity affect all three levels of the biological diversity of the forest.

While the loss of species has been observed and documented for a longer period of time, methods to record the losses of genetic diversity have only recently become available. Usually, a species suffers a significant loss of its genetic diversity before it reaches the stage where it is endangered.

4.1 Forest Clearing and Fragmentation

Since humankind began utilizing natural resources, it has intervened in the forest ecosystem. Clearing of forests for agriculture has led to extensive destruction of forested land in the past. Further use of forestland for settlement, business, industry and traffic brought further losses. Some former forestlands were regained through afforestation, but usually not the lost populations of the various tree and shrub species.

Genetic exchange (gene flow), which is a prerequisite for maintaining genetic diversity, may be impeded seriously or prevented by fragmenting populations of tree and woody shrub species.

4.2 Forest Damage Related to Air Pollution

Industrialization had a further negative impact on the environment that endangered the forest. Initially, only locally restricted smoke damage was observed, but later in the 1970s pollution extended over large areas, leading to leaf and needle losses and forest decline (*Waldsterben*). In Germany approximately one third of the forest stands over 60 years of age have been significantly damaged for many years.

Pollutants may either directly affect the plants or act indirectly through the soil, thus altering the environmental and competitive conditions. The effects on the genetic structure of populations result from differing survival probabilities of the individuals and/or the subpopulations concerned (viability selection) or via reproduction by a reduction in flowering or interfering with the fertilization process (fertility selection).

4.3 Climate Change

Forestry will face major challenges in the decades to come. One of the most important will be climate change and its consequences for the forests. The extent and the effects that the predicted anthropogenic changes in the climate might have on trees and woody shrubs, for example by global warming or by increased UV radiation are presently unclear. However, losses of genetic diversity can be expected because of:

- the changes in the competitive relationship between tree and woody shrub species,
- the higher degree of virulence of biotic pests as well their extended geographic habitat distribution by concurrent weakening of the tree and woody shrub species,
- the increasing number of destructive abiotic events,
- the damaging effects to plants by increased UV radiation acting on the leaves.

The less time the forest is given for adaptation, the more the predicted environmental changes will endanger the genetic structure. The difference as compared to natural climatic changes must be seen here primarily in the significantly higher rate of environmental change in combination with pollutant effects.

Moreover, multifunctional and sustainable forest management in Germany provides an important contribution to climate protection. Therefore, forestry must deal with the potential consequences of climate change for the forests.

Figure 8: Biotic damage – Elm disease

4.4 Interference with the Water Balance

Intervention in the water balance may lead to ecosystem changes due to raising or lowering of groundwater levels. This may cause mortality of tree and woody shrub species or it may change the competitive relationship between species, resulting in the displacement of species locally.

4.5 Biotic and Abiotic Damage

Extensive biotic and abiotic damaging events like insect calamities, fungal diseases and rodents, as well as damage by storms, snow or fire may lead to the loss of genetic information of locally adapted populations.

Figure 9: Abiotic damage – forest stand destroyed by storm "Kyrill"

4.6 Effects of Historical Types of Forest Use

Before regulated forestry was introduced about 200 years ago, forests were devastated by overcutting, forest grazing and litter use. The specific demands of the population led to selective use of certain tree species and the displacement of other tree species. Many areas have been re-afforested since the beginning of the nineteenth century predominantly with coniferous tree species. Since the importance of the origin (provenance) of the reproductive material of the tree species to be planted was not known, very often unknown and unsuitable provenances were planted. This was often recognized too late.

4.7 Utilization of Unsuitable Reproductive Material

Forestry aims at using exclusively site-adapted and productive provenances for seeding and planting. However, one cannot rule out the planting of unsuitable provenances, for example by falsely marked provenances.

The use of unsuitable reproductive material is caused in particular by:

- using non-representative forest reproductive material from limited seed crops or wildlings,
- improper plant cultivation and sorting,
- improper provenance certification and identification,
- lack of indigenous reproductive material (e.g. woody shrub species),
- improper choice of the provenance by the purchaser.

A high proportion of the reproductive material of woody shrub species and some tree species planted in the open landscape originates from areas that deviate from indigenous sites with regard to the climate. Frequently the provenances are not adapted to the conditions of the location where they are planted. Pollen and seeds from such plantings may be introduced into the forest and thus may alter the genetic structure of locally adapted populations.

Figure 10: Use of unsuitable reproductive material (Wild Cherry - Prunus avium)

Figure 11: Browsing damage

4.8 Effects of Improper Practices

The genetic diversity of forest stands and/or tree populations may be impaired, for example, by the following forest management practices:

- by artificial regeneration using a low number of plants per hectare,
- by highly selective operations in stand tending and crop tree harvesting (harvesting at a predetermined target diameter before the tree participates in the reproductive process).

4.9 Game Populations

High game populations endanger genetic diversity by preferential browsing on the regeneration of specific tree and woody shrub species. In particular rare tree species that are endangered by browsing are often threatened in their existence.

4.10 Strictly Protected Nature Reserves / Conservation of Processes

In forests that are taken out of management, the existence of valuable rare woody plants may be threatened by the natural succession of species that are stronger competitors. If strictly protected nature reserves and/or specific conservation areas are established where such rare species still occur their existence may become endangered.


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COP 9 MOP 4 Bonn Germany 2008
UN Conference on Biological Diversity

5 Legal Base for Conserving Forest Genetic Resources

In recent years special activities concerning the conservation of biodiversity and in particular genetic diversity were carried out at a national and international level. These efforts were initiated and intensified because of recognizable high losses in genetic diversity and because the worldwide destruction of forested areas contributes to a significant reduction of biological diversity.

5.1 International Regulations

International provisions governing the conservation of forest genetic resources and the protection of biodiversity have been created and laid down in worldwide and/or pan-European documents (cf. Appendix 1). The most important are:

1990	1st Ministerial Conference on the Protection of Forests in Europe (MCPFE), Strasbourg: Resolution S2 "Conservation of Forest Genetic Resources",
1992	UN Conference on Environment and Development (UNCED), Rio de Janeiro: "Convention on Biological Diversity" (CBD),
1993	2nd Ministerial Conference on the Protection of Forests in Europe (MCPFE), Helsinki: Resolution H2 "General Guidelines for the Conservation of the Biodiversity of European Forests",
1994	Ordinance of the EU Council on the conservation, description, collection and utilization of the genetic resources of agriculture, Brussels (includes forestry),
1995	"European Forest Genetic Resources Programme" (EUFORGEN) of the International Plant Genetic Resources Institute (IPGRI, today Bioversity International) in connection with the Food and Agriculture Organization (FAO), Rome: European network on existing resources concerning defined tree species (the Federal Republic of Germany joined in 1998),
1998	3rd Ministerial Conference on the Protection of Forests in Europe (MCPFE), Lisbon: Resolution L2 "Pan-European Criteria, Indicators and Operational Guidelines for a Sustainable Forestry" including Appendices 1 and 2,
2002	6th Conference of the Parties of the Convention on Biological Diversity (CBD) adopted a programme of work on Forest Biological Diversity (COP 6. Decision VI/22),
2003	4th Ministerial Conference on the Protection of Forests in Europe (MCPFE), Vienna: Resolution V4: "Conserving and Enhancing Forest Biological Diversity in Europe",
2007	7th United Nations Forum on Forests (UNFF) adopted the "Non-legally binding instrument on all types of forests",
2007	5th Ministerial Conference on the Protection of Forests in Europe (MCPFE), Warsaw: Warsaw Declaration "Benefiting Quality of Life" (...maintain, conserve, restore and enhance the biological diversity of forests, including their genetic resources through sustainable forest management...),
2008	9th Conference of the Parties of the Convention on Biological Diversity (CBD) adopted decisions for further implementation of the programme of work on forest biological diversity adopted in 2002 (COP 9 Decision IX/5).

Figure 12: 9th Conference of the Parties of the Convention on Biological Diversity, Bonn 2008

5.2 National Regulations

The international Convention on Biological Diversity (CBD), which was passed within the framework of the UN Conference on Environment and Development 1992 in Rio de Janeiro, came into force in the Federal Republic of Germany on 21 March 1994. Also included are the regulations that concern the conservation and utilization of forest genetic resources.

Conservation and utilization of forest genetic resources have their legal basis in the following legal regulations:

Federal Forest Act and Forest Legislation of the *Länder*:

The target of Section 1 of the Federal Forest Act and the corresponding regulations of the Forest acts of the individual *Länder* is to conserve the forest in its genetic diversity in order to maintain lasting fulfilment of its benefits and functions. Additionally the following regulations of the Federal Forest Act are relevant for the conservation of forest genetic resources: Conservation of the Forest (Section 9); Management of the Forest (Section 11); Protective Forest (Section 12).

Similar regulations exist at the *Länder* level as well. The *Land* of Brandenburg has enacted the obligation to conserve forest genetic resources in Section 4 of its Forest Act. The Forest Act of Rhineland-Palatinate specifies the conservation of genetic resources as one of its objectives (Section 1). Article 1 of the Bavarian Forest Act mentions the conservation of biological diversity as one of the law's objectives. In Mecklenburg-Western Pomerania (Section 21) and Thuringia (Section 9) forests used for conservation of forest genetic resources can be declared a protective forest. According to Section 4 of the Forest Act of Hesse the conservation of forest genetic resources is a task of the *Land* forest enterprise (*Landesbetrieb Hessen-Forst*).

Legal Provisions on Forest Reproductive Material:

The Act on Forest Reproductive Material (FoVG) aims to conserve and improve forests with their range of positive effects by providing forest reproductive material of high quality and defined identity as well as to promote forestry and its productive capacity. The FoVG governs the production and marketing of forest reproductive material. The approval of a variety of stands, seed orchards, clones and clonal mixtures under this legislation contributes to the maintenance of the genetic information contained in this material and its transfer to future forest generations.

Nature Protection Legislation:

The conservation of biodiversity including genetic diversity is among the main objectives of the Federal Nature Conservation Act (BNatSchG). It aims to safeguard the performance and functioning of the natural balance, as well as the fauna and flora as an essential basis of human life. The measures designated in the Federal Nature Conservation Act and the corresponding *Länder* nature protection laws only partly refer to the conservation of the genetic diversity of tree and woody shrub species. In certain cases however, they may supplement the measures necessary for conserving forest genetic resources.

The conservation of forest genetic resources is implicitly included in the legal regulations as stated above. In different *Länder* the efforts necessary to conserve forest genetic resources have been regulated by various enactments and they have become integrated in specific programmes such as forestry framework planning. Moreover the silvicultural guidelines of most *Länder* include important measures on the conservation of forest genetic resources.

At the national level, the Concept for the Conservation of Forest Genetic Resources in the Federal Republic of Germany as developed by the Federal government/*Länder* Working Group "Conservation of Forest Genetic Resources" was integrated into the Concept for the Conservation and Utilization of Plant Genetic Resources in the Federal Republic of Germany which was published in 1990. Today this concept as well as the National Programmes for conservation and sustainable utilization of forest, plant, animal and aquatic genetic resources is part of the National Strategy on Conservation of Agricultural Biodiversity, Development and Sustainable Use of its Potentials in Agriculture, Forestry and Fisheries (National Strategy on Agrobiodiversity).

Figure 13: Mixed forest

6 Objectives of the Concept for the Conservation and Sustainable Utilization of Forest Genetic Resources in the Federal Republic of Germany

According to the Convention on Biological Diversity (CBD Article 2), forest genetic resources, in the sense of the concept, are defined as genetic material of tree and woody shrub species with actual or potential value for a sustainable multifunctional forestry in Germany.

The Concept for the Conservation and Sustainable Utilization of Forest Genetic Resources in the Federal Republic of Germany presented here shows targets and measures necessary for conserving the gene stock and the genetic structures of tree and woody shrub species.

In order to safeguard:

- in a sustainable way, all benefits of the forests (economic, protective and recreational functions) for society and to maintain them for future generations according to the Federal Forest Law and
- to conserve the biodiversity of the forests in compliance with the sustainable utilization of their components in agreement with the Convention on Biological Diversity,

the concept has set the following goals:

- conservation of tree and woody shrub species (species diversity),
- conservation of diversity within tree and woody shrub species (genetic diversity),
- sustainable utilization of forest genetic resources,
- restoration of vital populations of tree and woody shrub species (genotypic diversity),
- to contribute to the conservation and restoration of diverse forest ecosystems (ecosystem diversity).

Figure 14: Sycamore Maple (Acer pseudoplatanus)

7 Criteria and Measures for Conserving Forest Genetic Resources

Extensive measures are necessary to maintain a high degree of genetic diversity for our tree and woody shrub species. The necessity for conserving resources should be a fundamental aspect in the management of our forests. In some cases special measures are necessary.

7.1 Identification and Evaluation

The basis for all gene conservation measures is the identification of existing forest genetic resources. Such information can be found in seed crop stand registers, forest inventory data, historical descriptions, research data and it may be obtained from vegetation maps on the distribution of plant species. In some cases questionnaires have proven helpful. Often information on rare species can only be found locally. Mapping of forest genetic resources is essential.

The characterization and assessment of genetic resources can be done by genetic analyses, morphological, physiological and phenological investigations.

The time and type of measures that need to be carried out for conserving a forest genetic resource can be determined using the following criteria.

7.2 Need for Conservation (Qualitative Aspect)

To preserve a genetic resource, its adaptability and adaptedness to the ecological conditions at a given site are of great importance. In the natural distribution range of a species, the question of where the species is indigenous is an important criterion when considering conservation measures. Non-indigenous species, if they are well adapted to specific site conditions, should also be considered in conservation efforts. Knowledge about the genetic composition of specific populations must also be considered. For subordinate woody shrub species, species purity can be of importance. According to the regulations of the German Act on Forest Reproductive Material (FoVG), special importance is attached to the registered seed stands as objects for gene conservation. Such stands should be distributed throughout various ecological regions in order to represent the genetic variation under different ecological conditions.

Isolated populations or populations found growing under specific ecological conditions can also be of great value for gene conservation measures.

7.3 Urgency of Conservation Measures (Endangered Status)

An important criterion for determining the necessity of implementing gene conservation measures is the extent to which a species is damaged or endangered. The rarity, economic, ecological, genetic or silvicultural importance of a species are further criteria to consider. All of these criteria must be considered regionally; however, they form the basis for setting priorities.

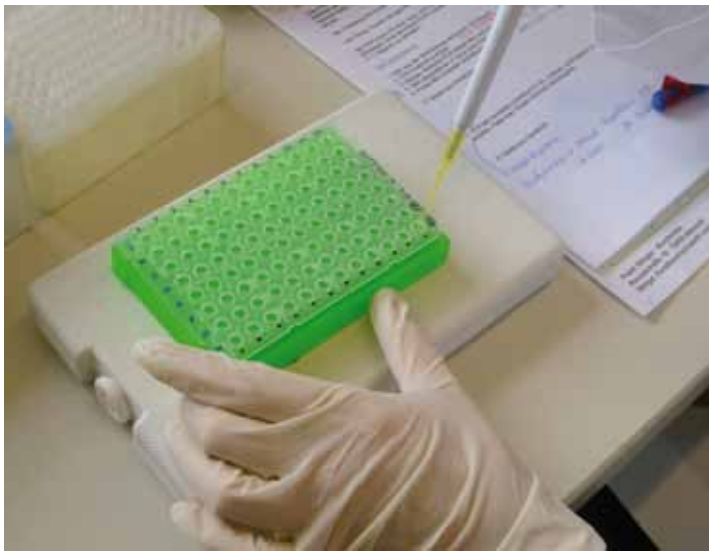

Figure 15: Genetic analyses

Figure 16: Different phenotypes of Norway Spruce

7.4 Conservation Measures

The types of gene conservation measures to be applied depend upon the biology of the tree or woody shrub species (vegetative propagation, storage of seed), the developmental state of the basic material (age, flowering, seed production) and upon the technical methods available. In Appendix 2, the types of conservation methods that can be employed are listed including their advantages and disadvantages.

The following measures for conserving forest genetic resources should maintain the genetic basis in a representative way; however regional and species-specific differences have to be considered.

7.4.1 *In situ* Measures

Figure 17: Douglas Fir in situ conservation stand

In situ measures include those conservation measures that are carried out on the site where the gene resources occur:

- maintain the genetic resource,
- natural regeneration of the genetic resource,
- artificial regeneration of the genetic resource with defined material.

By designating special gene conservation forests or single stands that are naturally regenerated such measures can be integrated into normal forest management operations. Single trees or small groups of trees that are not a reproductive unit, should be promoted *in situ*, however maintaining the resource via regeneration is limited. For some species maintaining the specific habitat is critical. Air pollution and deposition can severely hinder *in situ* measures.

Figure 18: Seed orchard (Wild Cherry - Prunus avium)

7.4.2 *Ex situ* Measures

Gene conservation *ex situ* generally means evacuating the endangered genetic resource to another location. Conservation measures can be done either under natural conditions or under controlled modified conditions.

Ex situ conservation under natural conditions offers the following possibilities:

- bringing together single trees or groups of trees to form new breeding populations to produce progeny with a higher genetic diversity,
- evacuating populations from endangered areas (e.g. high pollution levels) to clean air areas,
- following a double strategy by securing the population in two areas.

Figure 19: Seed collector at work

Suitable measures include the establishment of

- *ex situ* gene conservation stands,
- seed orchards,
- clone archives.

Gene conservation measures *ex situ* are generally carried out under controlled conditions in forest gene banks and include the following:

- seed storage,
- pollen storage,
- storage of plants or respective tissue,
- permanent continuous vegetative propagation,
- permanent continuous *in vitro* propagation.

The establishment of *ex situ* gene conservation stands can be integrated well into regular forest management practices. All other methods listed need special organizations and services.

7.5 Genetic Monitoring

In order to fulfil Article 7 of the Convention on Biological Diversity, some type of control of the development of genetic diversity is necessary.

For the implementation of these regulations, in 2004, a concept of genetic monitoring was developed including instructions to identify spatial and temporal changes of genetic structures of tree and woody shrub species. The data obtained provide the basis for long-term evaluation of the genetic systems of the analyzed stands. This is an important prerequisite for the assessment of the genetic adaptation potential and the stability of forests. In the light of climate change, genetic monitoring obtained significance as an early warning system for changes within the forest ecosystems.

The results of such monitoring should be used for making decisions in the areas of forestry, environmental protection and the sustainable use of genetic resources.

Figure 20: Oak tree

8 Specific Conservation Measures for Tree and Woody Shrub Species

For all gene resources in need of conservation, the guiding principle is to maintain the resource *in situ* as long as possible, at least until the maintenance of the genetic information is assured.

When deciding which measures should be employed, the number of individuals remaining in the population of concern is of great importance (cf. Figure 22). Special aspects considering the conservation of genetic resources among woody shrub species are specified in Appendix 3.

8.1 Maintaining Individuals and Small Groups

Single individuals and small groups of up to 20 individuals (genotypes) should not be propagated generatively in order to avoid self-pollination and inbreeding effects and to keep genetic drift as low as possible. The establishment of *ex situ* clone archives and seed orchards through means of vegetative propagation (cuttings or grafting) is recommended.

Exceptions might be the case for extremely rare species or varieties (highly endangered species e.g. Red List species). In order to stabilize such populations, planting generatively produced material of the respective population *in situ* might be necessary.

8.2 Maintaining Stands

Gene resources with more than 20 fertile individuals (genotypes) can be maintained as stands *in situ* through natural regeneration or by planting with local reproductive material. Prerequisites are a suitable distribution of the individual genotypes to assure good pollination as well as suitable site conditions.

Otherwise, sowing or planting *ex situ*, or depending upon the species, long-term seed storage is necessary.

Figure 21: Leaves of Wild Service Tree (Sorbus torminalis)

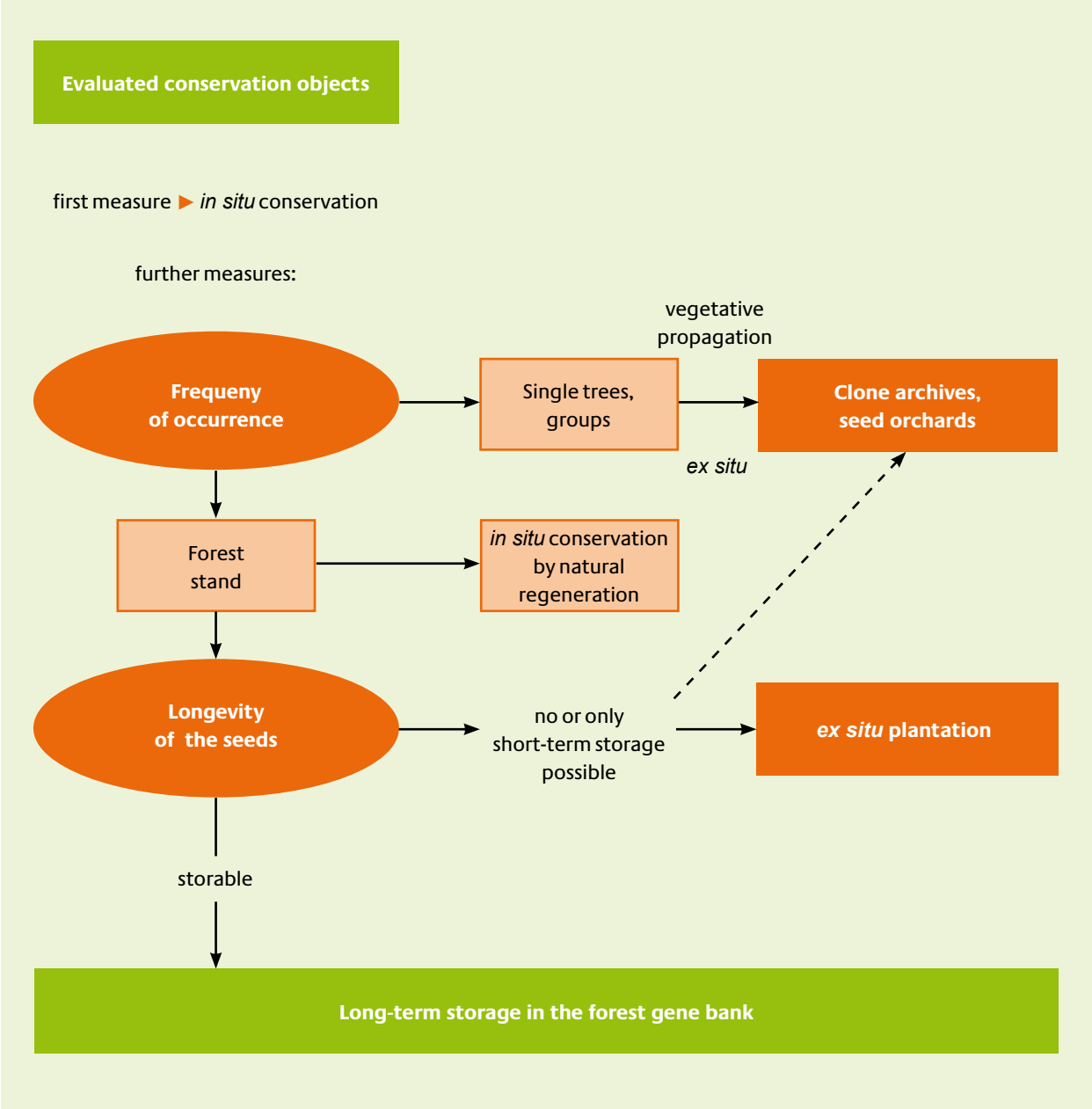

Figure 22: Decision criteria for maintaining forest genetic resources

8.3 Double Strategy

By storing the genetic resource at two independent locations *ex situ* (double strategy), the genetic resource is maintained under different environmental selection conditions and the risk of loss is minimized. For species where the long-term storage of seeds in gene banks is possible, this double strategy is a favourable method of gene conservation.

Figure 23: Natural regeneration of Sycamore Maple (Acer pseudoplatanus)

9 Effects of Sustainable Forest Management on the Conservation of Forest Genetic Resources

The methods described above are special measures to conserve forest genetic resources; however within the framework of sustainable forest management practices, the genetic diversity of forest trees and woody shrubs is maintained and promoted.

9.1 Regeneration

On principle, one must differentiate between natural and artificial regeneration when considering what effects the regeneration method has on the genetic resource and the ensuing generations.

Natural regeneration is generally the preferential method of regeneration if the stand is site-adapted, of good quality and if it produces seed (cf. 8.2). Long-term regeneration periods should be strived for with the participation of as many trees as possible in the reproductive process to assure a broad genetic base.

When establishing or regenerating stands, inclusive of forest edges, through artificial regeneration, the following aspects need to be considered to assure a broad genetic base:

- Suitable provenances as listed in the valid provenance recommendations are to be used for planting. For the tree species subject to the German Act on Forest Reproductive Material (FoVG), the legal requirements given are to be followed. For other tree and woody shrub species, local seed sources should be used preferentially.
- The genetic base of the reproductive material should be as broad as possible. This means collecting seed from as many stands and trees as possible.
- When using vegetative reproductive material, attention needs to be paid to a large clone assortment.
- Intensive sorting of plants according to size should be avoided.
- Plantations should have a sufficient number of plants per hectare to assure natural selection among the planting stock.
- Research results from the fields of forest genetics and tree breeding (e.g. provenances) should be incorporated into all planting measures.

9.2 Stand Tending and Harvesting

Selective tending measures such as thinning can lead to changes in the genetic structure of the remaining forest stand. Intensive selection from thinning operations can endanger genetic diversity.

Tending measures can be helpful for gene conservation when they are used to promote rare or weak competitive species. This is especially important for diversity along forest edges.

When removing trees that have reached harvest size, one needs to ensure that the trees to be harvested can reproduce before being removed.

Figure 24: Forest edge in autumn

10 Sustainable Use of Forest Genetic Resources

Within the framework of multifunctional forestry, the sustainable use of forest genetic resources serves the production, protection and recreational functions of the forest. In addition to the site and the silvicultural treatment, high biological diversity is a decisive factor for the productivity and functioning of the forest ecosystem. Genetic adaptedness and adaptability assure that the forests are sufficiently stable to serve all forest functions. The ability of the forest ecosystem to react to damaging biotic and abiotic factors is of high importance. The biological diversity should be used in the following consensus:

- diversity of the tree species,
- diversity within the tree species, i.e. diversity between populations and
- diversity within populations.

10.1 Timber Production and Other Forest Products

The economic basis of forestry is sustainable timber production. The amount and quality of timber is also determined by genetically influenced factors such as growth characteristics, timber quality, type of stem and other wood characteristics (density, branchiness, heating value, etc.).

The selection of suitable tree species and/or provenances has the following objectives:

- to guarantee a continual suitable supply of timber,
- to obtain optimal productivity on the various forest sites,
- to supply the timber market with the proper species, quality, assortment and amount of wood,
- to assure the sustainable use of other forest products (seeds, plants, mushrooms, wildlife, etc.).

Figure 25: Oak veneer stems

10.2 Seed Production and Collecting Wild Saplings

The use of forest genetic resources for seed production and for collecting wild saplings has the following objectives:

- supplying provenance-certified reproductive material of high quality and a broad genetic base in order to establish stable and productive stands,
- passing on the genetic information to ensuing tree generations,
- providing the forest owner with a supplemental income.

10.3 Utilization for Species Conservation

For rare and endangered woody plant species and populations, existing genetic resources are used for:

- establishing plantations with respective reproductive material to maintain them *in situ* in their natural range,
- establishing seed orchard breeding populations with a broad genetic base and
- increasing genetic diversity in genetically impoverished populations through planting.

The wood of many rare species is often of high economic value. Its utilization promotes interest in these species and may create demand for them. The inclusion in silvicultural concepts will strongly support the conservation of these rare species.

10.4 Protective and Recreational Functions of the Forest

The protective functions of the forest for water, soil, nature and species protection and as a carbon dioxide sink as well as its recreational function are of high cultural, social, ecological and economic value.

Planting adapted species and provenances serves the following in a sustainable manner:

- maintaining a pleasant and variable landscape for recreation and tourism,
- providing a water reservoir with a pure, high-quality water supply,
- reducing soil erosion, avalanches and rock slides,
- protecting against noise and air pollution,
- maintaining and creating habitats for endangered flora and fauna elements in the forest.

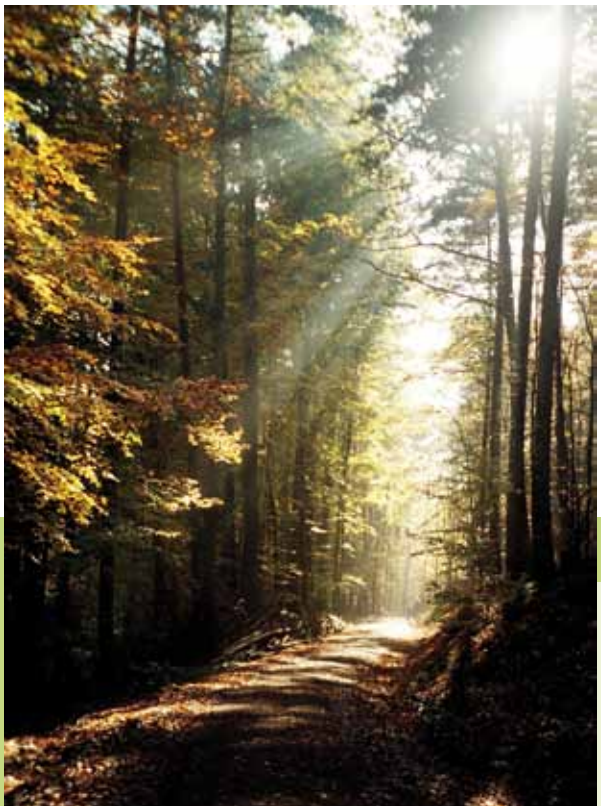

Figure 26: Evening in the forest

10.5 Forest Tree Breeding

Forest tree breeding relies on the use and conservation of forest genetic resources and their high degree of diversity. The main objective of forest tree breeding is to provide forest reproductive material with a high degree of adaptability, good growth potential and high quality. Through breeding programmes, reproductive material with special stability and productive characteristics can be provided for use in forestry.

10.6 Providing for Potential Utilization in the Future

Forest genetic resources additionally possess a potential for possible use in the future. Certain, as yet unrecognized or unknown properties of plants may suddenly become important in the future (medicinal or industrial use, resistance towards pests or pollutants). The basis for such use in the future is a broad genetic base.

Figure 27: Wild Cherry silvaSELECT® (Prunus avium)

Figure 28: PCR analyses

11 Research and Development

The conservation of forest genetic resources is a relatively new field of research. It cannot be predicted however, to what degree genetic resources are endangered and what losses of genetic diversity might occur in the future. The future risks and the further course of loss of genetic diversity and the resulting potential impact cannot be predicted. Consequently much research needs to be carried out to increase present knowledge on the genetic diversity of forest tree and woody shrub species.

The research should precede or at least occur parallel to the measures taken on gene conservation. It is an important aspect in the Concept for the Conservation and Sustainable Utilization of Forest Genetic Resources and it has to be carried out continually according to demands in the future.

Research needs to address specific problems in the field of forest gene conservation that are specific to the needs of the country. The research programme should include all organizations working in the field of forest genetic resources. Research activity needs to be coordinated and support be made available. Furthermore, project funding should be applied for on the basis of these research needs.

Figure 29: Tissue culture of oak (in vitro)

Research is especially required in the following areas:

- basic research on genetic diversity (genetic variation, genetic structure, adaptability, physiology and the genetic aspects of reproductive processes),
- effects of the environment on the genetic structure of forest stands (e.g. pollution, climate change, habitat fragmentation, lowering of the water table etc.),
- further development of the existing methods for nationwide genetic monitoring,
- development of new methods for evaluating and identifying forest genetic resources (genetic, physiological, phenological and morphological methods),
- investigations on representative statistical sampling methods (sample size, sampling procedure),
- development and improvement of gene conservation measures (seed storage, nursery techniques, reproduction biology, flower induction, seed orchards, *in vitro* propagation),
- effects of gene conservation measures on the genetic structure of the forest genetic resource,
- effects of silvicultural treatments on the genetic structure of forest stands (stand establishment, tending/thinning, harvest methods),
- interdisciplinary problems concerning forest genetic resources (e.g. nutrition, soils, forest protection).

In the field of basic research the forest genetic resources can be used to study fundamental questions in the fields of genetics, biochemistry, physiology, taxonomy and ecology. As part of breeding research genetic material can be utilized in a meaningful way for breeding, for example to increase productivity.

Figure 30: European Silver Fir, cone (♀) with pollen grains

12 Recommendations for Implementing the Concept

12.1 Legislation

12.1.1 Federal and *Länder* Forest Acts

The conservation and sustainable utilization of forest genetic resources is covered by various forest regulations. Some of them mention this task explicitly while others include it implicitly in broader notions such as forest conservation and sustainable management.

Due to the increased awareness of biological diversity and forest genetic resources, an explicit reference to these aspects in relevant legislation and the inclusion in respective Forest Acts is desirable.

12.2 Other Forest Policy Measures

Collecting forest reproductive material in protected areas should be allowed for purposes of forest gene conservation, using the provisions set out in Section 67 of the Federal Nature Conservation Act. Gene conservation objects must be taken into account in forest planning and included in forest function maps.

12.3 Consulting

Forest extension services provided to private and communal forest owners by governmental forest and/or agricultural authorities should include the promotion of the conservation and sustainable utilization of forest genetic resources.

12.4 Public Relations

The conservation of forest genetic resources should be subject to public relations activities because of the great significance of the genetic diversity of the tree and woody shrub species for the forest ecosystem.

12.5 Institutions Commissioned to carry out the Conservation of Forest Genetic Resources

Various Federal and *Länder* institutions have been commissioned to carry out activities in the field of forest gene conservation. Some of them possess suitable forest nurseries and gene banks.

Forest gene banks have been established within the framework of the gene conservation concept since 1987. They are an important component for securing forest genetic resources in a sustainable manner. Together with the forest nurseries, they are closely integrated for the numerous gene conservation measures *in situ* and *ex situ*.

The institutions listed in Appendix 7 have been commissioned to carry out the forest gene conservation programme; they have been named as representatives for the BLAG-FGR. Certain tasks in the field of the conservation of forest genetic resources are also carried out by the seed processing plants in the respective *Länder*.

As a preventive and long-term measure, the conservation of forest genetic resources for all forests, regardless of ownership, is the responsibility of Federal and *Länder* institutions. Private and communal forest owners cannot be obligated to carry out such measures. However, if they wish, they are welcome to participate and to support activities related to forest gene conservation.

The necessary research in the field of forest gene conservation is carried out by institutions of the Federal and *Länder* governments as well as by universities.

12.6 Tasks of the Federal Government/*Länder* Working Group "Conservation of Forest Genetic Resources and Legislation on Forest Reproductive Material"

The BLAG-FGR coordinates the activities for the conservation and sustainable utilization of forest genetic resources in the Federal Republic of Germany. This group has the following responsibilities:

- Coordinating the respective tasks according to the four-year programme,
- Publishing a progress report every four years on the work completed. The report is used for documentation and passed on to the Federal level (Information and Coordination Centre for Biological Diversity (IBV) of the Federal Office for Agriculture and Food (BLE)).
- Using the report, setting priorities and making recommendations to the governmental officials in charge of silviculture for coordinating further work,
- Making decisions on what measures are to be taken and the selection of gene conservation priorities,
- Exchanging information between the institutions responsible for the conservation of forest genetic resources on the status of the various measures undertaken,
- Coordinating the work of the forest gene banks,
- Carrying out data exchange according to common descriptors,
- Establishing uniform methodology and interpretation of data for genetic analyses and publication of laboratory manuals for the tree species evaluated,
- Coordinating and implementing the genetic monitoring of forest genetic resources,
- Cooperating with the national committees for the conservation and sustainable use of plant, animal and aquatic genetic resources at national level,
- BMELV and the Johann Heinrich von Thünen Institute (vTI) carry out all necessary consultations related to the international cooperation with Bioversity International related to EUFORGEN with the BLAG-FGR.
- Representing interests for the conservation of forest genetic resources in the Advisory Board for Biodiversity and Genetic Resources for Food and Agriculture at the BMELV,
- Coordinating the guiding principles for the development of programmes for conserving forest genetic resources in the respective *Länder*,
- Providing extension and consulting for private nurseries and seed processors,
- Defining common, main research areas,
- Supporting BMELV in order to fulfil the programme of work of the Commission on Genetic Resources for Food and Agriculture (CGRFA) regarding forest genetic resources, for example the preparation of the German National Report to the FAO supporting the elaboration of the Report on the State of the World's Forest Genetic Resources (SOW-FGR),
- The BLAG-FGR's secretariat is managed by the IBV of BLE.

13 Realization of the Concept for the Conservation and Sustainable Utilization of Forest Genetic Resources

The concept is implemented according to the needs and possibilities of the respective *Länder*. The work carried out by the respective institutions is based on the four-year plan that has to be verified by the governmental officials in charge of silviculture in the *Länder*. The activities are coordinated by the BLAG-FGR. Within this programme priorities and species criteria are set. Thus duplicate work is avoided and synergetic effects can be utilized. The plan allows flexible response to changing developments.

The Concept for the Conservation and Sustainable Utilization of Forest Genetic Resources serves as the basis for regional programmes in the respective *Länder*.

Measures for conserving forest genetic resources should be integrated in forest management practices and included in the silvicultural concept of each *Land*.

Objects selected for gene conservation in the forest and the recommended *in situ* measures are to be included in inventory data and management planning and control concepts.

Taking into account common interests and the facilities that are available, the measures of gene conservation need to be effectively carried out across *Länder* borders. Joint actions are coordinated by one member institution of the BLAG-FGR. The goal is to incorporate the regional priorities into a common direction to effectively assure the conservation and sustainable utilization of forest genetic resources in Germany.

Figure 31: Crab apple (Malus sylvestris) harvest

In summary the following aspects should be emphasized:

1. Registering and evaluating forest genetic resources *in situ* is the basis for all conservation efforts and thus has the first priority. This applies to all tree and woody shrub species. Within the framework of a four-year plan, the measures will be focused on the species specified in the plan. Special importance is given to the characterization, the identification and the specific research needs for these endangered species.

2. The highest priority is the *in situ* conservation for the selected objects. These tasks should be integrated into close to nature forest management practices. In order to maintain genetic diversity, special measures might become necessary that can only be carried out *ex situ* (e.g. long-term seed storage, establishment of seed orchards and clone archives) for single trees or small relict populations.

3. The selection of forest gene conservation objects depends largely on the degree to which they are endangered and whether they are adapted to the site where they occur (ecological value). Both of these aspects are the basis for establishing appropriate gene conservation measures.

4. For measures to conserve the genetic resources of woody shrub species, the emphasis is on securing the provenances of the most common species. Especially seed collecting areas should be delineated.

5. Research priorities of the various institutions collaborating within the BLAG-FGR should be developed and implemented nationwide (cf. Section 11). High priority projects should be implemented as early as possible.

6. The basis for long-term genetic monitoring of forest genetic resources has been developed in order to fulfil the regulations of the accords on biological diversity. Data, methodology and research results from existing research plots and other areas that have been studied for a longer time (nature forest reserves, natural areas, level-II-plots, forest damage inventory and soil status inventory) should be used for this purpose.

7. The cooperation with international programmes on gene conservation such as EUFORGEN and special programmes of the EU and IUFRO, as well as within Germany, needs to be intensified.

Figure 32: Aspens (Populus tremula)

Appendix 1
National Legal Regulations in the Federal Republic of Germany as well as International Agreements on and Activities for Conserving Forest Genetic Resources

Measures for conserving forest genetic resources may require interventions and/or omissions in certain management activities in the forests. It is to be examined to what extent the existing legal bases ensure the protection of forest genetic resources.

1 National Legal Regulations

1.1 Federal and *Länder* Forest Acts

The demands to conserve the forest in its various functions and to ensure sustainable forestry are contained in the Law on the Conservation of the Forest and on the Promotion of Forestry (Federal Forest Act, BWaldG) as passed on 2 May 1975 (Federal Law Gazette (BGBl.) I, p. 1037), in its respective applicable version. According to Section 1 of the Federal Forest Act one of the purposes of the law is "to preserve the forest given its benefit and importance for the environment, with respect, in particular for maintaining the performance and functioning of the natural balance, the climate, the water balance, the prevention of air pollution, the soil fertility, the landscape features, the agriculture and infrastructure and the recreational function for the people (functions relating to both protection and recreation), if necessary to enlarge it and to ensure its ordered management".

The conservation of forest genetic resources has important impacts on the economic benefits of forests; it represents a substantial aspect for the sustainable performance and functioning of the natural balance. The legal target of conserving the forest in its genetic diversity is to be derived from the formulation in the Federal Forest Act (Section 1) and from the respective legal regulations of the *Länder*. The issue of forest genetic resource conservation can thus be derived from the general legal provisions pertaining to forestry.

The conservation of genetic resources is explicitly mentioned in the Forest Act (Section 1) of Rhineland-Palatinate. Within the Bavarian Forest Act biological diversity is mentioned as purpose that should lead to preserve the forests' biological diversity and its increase where necessary. According to Section 4 of the Forest Act of Hesse the conservation of forest genetic resources is a task of the *Land* forest enterprise (*Landesbetrieb Hessen-Forst*). Safeguarding its forest genetic resources is part of the Forest Act (Section 4) of Brandenburg. According to the forest laws of Mecklenburg-Western Pomerania (Section 21) and Thuringia (Section 9) forest areas can be declared protective forests in order to preserve forest genetic resources.

An operational system that explicitly aims at the realization of this target is included neither in the Federal Forest Act nor in the forest laws of the *Länder*. Depending on the categories of forest ownership there are various options for taking influence and various obligations exist as well.

Nature forest reserves and closed forests are in particular legally protected by forest law. Target-oriented, species-specific gene conservation however, is not intended to be carried out within these types of forest.

1.2 Act on Forest Reproductive Material (FoVG)

The Act on Forest Reproductive Material of 22 May 2002 (Federal Law Gazette I p. 1658), amended by Section 214 of the regulation of 31 October 2006 (Federal Law Gazette I p. 2407), intends "to conserve and improve forests with their various beneficial effects and in their genetic diversity by providing high-quality and identity-secure forest reproductive material as well as to promote forestry and its efficiency".

This Act regulates the production, the marketing as well as the import and export of forest reproductive material. Reproductive material includes seeds, plant parts (for vegetative or micro vegetative reproduction) and plants (plants grown from seeds or plant parts or obtained through natural regeneration). The Act implements Council Directive 1999/105/EC of 22 December 1999 on the marketing of forest reproductive material.

Detailed rules of implementation can be found in the following three regulations:

- the Implementing Regulation on Forest Reproductive Material (FoVDV) of 20 December 2002 (Federal Law Gazette I p. 4711 (2003, 61))
- the Regulation on the Approval of Forest Reproductive Material (FoVZV) of 20 December 2002 (Federal Law Gazette I p. 4721 (2003, 50)) as well as
- the Regulation on Regions of Provenance of Forest Reproductive Material (FoVHgV) of 7 October 1994 (Federal Law Gazette I p. 3578), amended by the regulation of 15 January 2003 (Federal Law Gazette I p. 238).

Figure 33: Seed processing (Sessile oak – Quercus petraea)

Both the Act itself and the regulations contribute to the conservation and sustainable use of forest genetic resources particularly by the following provisions:

- By the demarcation of regions of provenance and by approving a large variety of stands, seed orchards, clones and clonal mixtures the authorities ensure that forest owners can choose from a broad spectrum of forest reproductive material, which is genetically adapted to the ecological conditions in the respective regions of provenance.
- A decision regarding the approval of a stand or a seed source is normally made at the request of the forest or tree owner. If it is necessary in the public interest, particularly where the preservation and use of forest genetic resources is concerned, approvals may also be issued *ex officio* (Section 4 (4) FoVG).
- The FoVZV also regulates minimum areas for approved stands and minimum numbers of trees from which seed is collected. This is to ensure that the seeds obtained pass on as broad as possible a genetic spectrum to the next generation.
- For the purposes of genetic conservation it may also be necessary to obtain reproductive material from stands that do not meet the strict approval criteria. The FoVG, however, is not to obstruct measures for genetic conservation. Therefore, under Section 21 the Federal Office for Agriculture and Food can allow by exception to collect seeds from such stands.

The Act regulates only the commercial production, the commercial marketing as well as the import and export of forest reproductive material. Natural regeneration as well as growing reproductive material for use in the own forest is not subject to the Act. Thus trees of locally proven provenances may continue to be reproduced at their location.

1.3 Nature Conservation Legislation

With the Act on the Reorganization of Nature and Landscape Conservation of 29 July 2009 (Federal Law Gazette I p. 2542) the Federal Nature Conservation Act (BNatSchG) was reformulated. In this context, the sustainable assurance of biodiversity was included as one of three principal goals of nature and landscape conservation in Section 1 of the Federal Nature Conservation Act. The two other goals, i.e. assuring the performance and operability of the ecosystems, including their ability to regenerate and sustainable usability of natural goods as well as the conservation of the diversity, characteristics and beauty of

Figure 34: Service Tree (Sorbus domestica)

nature and landscape, were already contained in the previous regulations that were replaced by the Act of 2009.

These goals are to be reached particularly by means of area and biotope protection (Chapter 4, Sections 20-36) and by species protection (Chapter 5, Sections 37-55), i.e. *in situ*. Beside static protection the law also contains dynamic elements. Thus "protection" according to Section 1 expressly includes the conservation and management, development and restoration of nature and landscape. Chapter 4 of the Act gives high priority to the interlinking of biotopes in order to allow an exchange among populations as well as migration and re-colonization.

The Federal Species Protection Ordinance of 16 February 2005 (Federal Law Gazette I p. 258 (896)), last amended by Section 22 of the Act on the Reorganization of Nature and Landscape Conservation of 29 July 2009 (Federal Law Gazette I p. 2542) is based upon Section 54 of the Federal Nature Conservation Act. The annex to the regulation lists the specially and the strictly protected animal and plant species. Interpretations of species protection often stress that biotope protection is the primary means of species protection. The conservation of genetic resources is not usually emphasized and is obviously not part of species protection programmes that have already been set up in some *Länder*. However, occasionally, the following goals are listed in the *Länder* acts: conservation of the ecological and genetic diversity of species, restoration of affected populations, preservation and reproduction of endangered and other species and populations relevant in terms of species protection.

In summary it can be noted that species protection is mainly ensured through biotope protection, i.e. for particularly endangered species. Related activities and programmes are usually organized *in situ*. *Ex situ* protection is being considered. There are individual approaches. However, there is no information yet on efforts for the conservation of the genetic diversity of tree species. Economic aspects, for example the conservation of valuable forest breeding material, are not an objective of nature conservation and thus are not taken into account in this context.

1.4 Conclusions

Conserving forest genetic resources can only be ensured indirectly by the above-mentioned national legal regulations. The laws cite the conservation of biodiversity and in part also the conservation of genetic diversity, as a general goal. A comprehensive concept for the conservation of the genetic diversity of tree species is not subject matter to existing legal regulations, although important partial aspects are included in the Forest Reproductive Material Act (FoVG). But if any species is to be conserved in a sustainable and effective way in its diversity, a concept is required which includes ecological, population-genetic and forest plant breeding knowledge in the conservation programmes. In this context it is possible to include species and nature conservation in the concept aiming at the conservation of forest genetic resources. *Vice versa*, measures aiming at the conservation of forest genetic resources should also be included in plans concerning nature protection.

2 International Treaties and Activities

2.1 Act on the Convention of 5 June 1992 on Biological Diversity (CBD) dated 30 August 1993 (Federal Law Gazette II. pp. 1741-1772)

Article 7 of the CBD deals with the identification and the monitoring of components of biological diversity that are important for conservation and sustainable utilization. Accordingly, by considering the categories as listed in Appendix 1 of the CBD, components of biological diversity have to be determined by the respective Party to the Convention. According to Appendix 1 to the CBD, these components, besides certain ecosystems and species, include as well "described genomes and genes of social, scientific and economic importance". This regulation is supplemented by pointing out that those components of biological diversity that require urgent conservation measures and those that offer the highest potential for their sustainable utilization are to be particularly considered. Processes and activities are to be determined that may have considerable detrimental impacts on the conservation and sustainable utilization of biological diversity; besides, their effects have to be supervised.

Considerations for integrating the activities of the BLAG-FGR in a need for action as derived from the CBD have to be made not only with regard to the monitoring of Article 7, but also in view of the whole scope of tasks of the Working Group. Therefore, the measures as given in Article 7 of the CBD shall be realized "in particular by regarding the purposes as scheduled in the Articles 8 to 10". These include tasks of *in situ* conservation (Article 8), of *ex situ* conservation (Article 9) as well as the sustainable utilization of components of the biodiversity (Article 10).

2.2 Act on the Convention on the Conservation of European Wild Plants and Animals and their Natural Habitats dated 19 September 1979 (Convention of Bern)

This law dated 17 July 1984 (Federal Law Gazette II, p. 618) amended by the bulletin dated 27 June 1995 is closely connected with the FFH Directive (Directive No. 92/43/EEC of the Council on the conservation of natural habitats and of wild fauna and flora). The convention obligates the treaty parties to take appropriate legal and administrative measures in order to safeguard the conservation of the habitats of wild plant and animal species, primarily the species listed in the two appendices as well as to ensure the conservation of endangered natural habitats.

2.3 UNESCO Programme "Man and the Biosphere" (MAB)

An important component of the programme includes projects on the protection of biodiversity and of the genetic material present in a network of biosphere reserves. The German activities concerning the MAB programme have been coordinated by the MAB National Committee since 1972.

2.4 Ministerial Conferences on the Protection of Forests in Europe (MCPFE)

The Ministerial Conferences on the Protection of Forests in Europe, which took place in 1990 in Strasbourg (France), 1993 in Helsinki (Finland), 1998 in Lisbon (Portugal), 2003 in Vienna (Austria) and 2007 in Warsaw (Poland) and the resolutions passed during these conferences are of particular importance.

The Resolutions of Strasbourg S2 "Conservation of Forest Genetic Resources", of Helsinki H2 "General Guidelines for the Conservation of Biological Diversity of European Forests" and of Vienna V4 "Conserving and Enhancing Forest Biological Diversity in Europe" are essential for the conservation of forest genetic resources. Resolution S2 obligates Germany to take measures on the conservation of forest genetic resources at the national level. An international follow-up committee has carried out a provisional investigation concerning the status of forest genetic resources in Europe, legal framework conditions and relevant conservation programmes. Germany actively cooperates with this committee.

In the framework of the follow-up process to the Ministerial Conference of Helsinki, criteria and indicators for the national level were passed in order to continue pursue and realize the general guidelines.

During the third Ministerial Conference on the Protection of Forests in Europe in Lisbon 1998, the results of the works as commenced by the second Ministerial Conference in Helsinki were confirmed and/or settled with the resolution L2 "Pan-European Criteria, Indicators and Operational Guidelines for a Sustainable Forestry". Criterion 4 "Conservation, Protection and Appropriate Improvement of Biological Diversity in the Forest Ecosystems" belongs to the six pan-European criteria for sustainable forest management and here in particular to genetic diversity. The importance of genetic diversity is also related to other criteria like for example Criterion 2 "Conservation of Health and Vitality of Forest Ecosystems". In the Appendices 1 and 2 of resolution L2, different indicators are mentioned which have a direct relation to the conservation of forest genetic resources.

The Vienna Resolution V4 of the fourth Ministerial Conference (2003) recognizes the importance of forests for biodiversity, reaffirms that the conservation and appropriate enhancement of forest biodiversity is an essential element for their sustainable management. The signatory States are committed to address the maintenance, conservation, restoration and appropriate enhancement of forest biodiversity as well as to assess the impact of relevant policies and programmes on forest biodiversity, removing policy distortions and failures resulting in loss of forest biodiversity.

The Warsaw Declaration W2 "Benefiting Quality of Life" adopted by the fifth Ministerial Conference in 2007 committed the signatory States to "maintain, conserve, restore and enhance the biological diversity of forests, including their genetic resources through sustainable forest management".

2.5 European Forest Genetic Resources Programme (EUFORGEN)

The European Forest Genetic Resources Programme (EUFORGEN) was established in 1993 as an implementation mechanism of Strasbourg Resolution S2 "Conservation of Forest Genetic Resources" of the first Ministerial Conference on the Protection of Forests in Europe (MCPFE), held in France in 1990. The programme also contributes to the implementation of other MCPFE commitments on forest genetic resources and relevant decisions of the Convention on Biological Diversity (CBD). EUFORGEN started its work in 1995.

In the current phase IV (2010-2014), the three main EUFORGEN objectives are as follows:

- Promote appropriate use of forest genetic resources as part of sustainable forest management to facilitate adaptation of forests and forest management to climate change,
- Develop and promote pan-European gene conservation strategies and improve guidelines for management of gene conservation units and protected areas,
- Collate, maintain and disseminate reliable information on forest genetic resources in Europe.

The work of the programme is coordinated by Bioversity International. Since 1998, Germany is a member of EUFORGEN and is represented by various members of the BLAG-FGR. The participation of Germany is coordinated by the Institute of Forest Genetics of the vTI.

2.6 United Nations Agreement on Forests

In 2007, the Assembly of the United Nations Forum on Forests (UNFF) adopted an agreement that provides a framework for national and international activities to protect forests and their biodiversity. In addition to the first internationally agreed definition of sustainable forest management[4] the agreement quotes biological diversity as a reference for sustainable forest management.

2.7 Other International Organizations dealing with Conserving Forest Genetic Resources

FAO: Since 1968 the Food and Agriculture Organization of the United Nations (FAO) is advised by a group of experts (FAO Panel of Experts on Forest Gene Resources) in matters of forestry issues. Since 1983, as an intergovernmental advisory body to genetic resources, the Commission on Plant Genetic Resources for Food and Agriculture is located at the FAO. The Commission's mandate was extended in 1995 to the areas of forestry, livestock and fish and consequently renamed in Commission on Genetic Resources for Food and Agriculture (CGRFA). As part of the 2009 adopted multi-year programme of work of the CGRFA, the decision was made to prepare a State of the World's Forest Genetic Resources Report (SOW-FGR) until 2013. In order to accompany and supervise this process an Intergovernmental Technical Working Group on Forest Genetic Resources (ITWG-FGR) was established. With the establishment of the ITWG-FGR the CGRFA also recommended a review of the future role of the expert group (FAO Panel of Experts on Forest Gene Resources) by the FAO.

IUFRO: The Working Group "Conservation of Gene Resources" within the International Union of Forest Research Organizations (IUFRO) has to be mentioned as another international body that has been dealing with the topics of conserving forest genetic resources for a longer time.

Bioversity International: In 2006, the International Plant Genetic Resources Institute (IPGRI) and International Network for the Improvement of Banana and Plantain (INIBAP) became a single organization and subsequently changed their operating name to Bioversity International. The new name reflects an expanded vision of its role in the area of biodiversity research for development. Harnessing genetic diversity of plant genetic resources to reach development goals and the conservation and use of forest genetic resources also became key areas of work. Bioversity coordinates EUFORGEN (Appendix 1, Chapter 2.5) and similar networks in other regions, such as APFORGEN in the Asia-Pacific, LAFORGEN in Latin America and SAFORGEN for the region south of the Sahara in Africa.

CIFOR: The Center for International Forestry Research (CIFOR) founded in 1992 works within the framework of CGIAR (Council Group of International Agricultural Research).

EFI: Germany takes an active part in the European Forest Institute (EFI) founded in 1993, an independent European non-governmental research institute located in Joensuu, Finland. EFI works among others on questions concerning the sustainable management and the biodiversity of European forests.

Figure 35: 20th Meeting of the FAO Committee on Forestry

4 Definition for sustainable forest management adopted by the General Assembly of UNFF: "Sustainable forest management as a dynamic and evolving concept aims to maintain and enhance the economic, social and environmental value of all types of forests, for the benefit of present and future generations."

Appendix 2
Measures for Conserving Forest Genetic Resources

In the following, the pros and cons of possible conservation measures, independent of the developmental stage of the parental material and the costs, are described. Linking individual measures is not considered. Usually several conservation measures are applied parallel in order to increase efficiency, to reduce the risk and to bridge periods encumbered with risks.

1 Identification and Evaluation

The basis of all conservation measures is the identification of existing forest genetic resources. This can be performed by applying different methods as described in the following. Evaluation of the registered resources decides on the type and the urgency of the measures required for conservation.

1.1 Surveys

Surveys carried out by forest offices can identify the occurrence of a species. Additional helpful information can be obtained from nature conservation institutions and individual persons with specialized or local knowledge. In most cases however, additional inventories will be necessary.

1.2 Inventories

Forest management inventories gather the necessary data on the occurrence of species, which can then be used further for conservation measures. If the inventory takes place within the framework of forest management planning, no additional costs are necessary for identification. Forest management inventories generally do not provide sufficient information on rare tree species and woody shrubs.

Figure 36: European Black Poplar (Populus nigra)

1.3 Characterization of Genetic Potential

Genetic information is of fundamental importance for evaluating the adaptation potential of our forests, also in relation to climate change.

Characterizing genetic resources may be carried out by

- genetic analyses as well as
- morphological, phenological and physiological investigations.

Important information on conserving genetic diversity can be concluded from the characterization of genetic resources, since this is the most important condition for the adaptability of forest tree species. The extent of necessary measures and the consideration of geographical structures can be derived from this.

Knowledge of the genetic structures in populations enables models on what effect forest measures have on the gene stock and to what extent a loss of genetic diversity occurs by selective operations carried out based on phenotypic characteristics. In turn, models can also provide information on changes of the gene stock in populations left to natural development. Linking knowledge gained from the two fields of investigation may offer information about the relationship between adaptive and genetic traits. These are of decisive importance for targeted conservation work, in order to select tree species with the highest possible adaptability with regard to changing environmental conditions.

2 *In situ* Measures

The survival of adapted and adaptable populations can be guaranteed best by conserving sufficiently large and locally adapted populations, by natural regeneration or by sowing and planting local reproductive material. Appropriate methods have been known for a long time and are customary in regular forestry. No further measures are necessary. Gene conservation populations and forests may be designated supplementarily. Dynamic conservation is possible for generations using *in situ* measures. The conservation of high genetic diversity takes place according to natural selection processes (evolution). Pollutants and/or other anthropogenic impacts may impede conservation *in situ* in many cases. In particular during the reproductive phase, selection processes that are genetically limiting may occur because of environmental stress or climate change.

2.1 Conservation of Populations and Single Trees

Depending on their distribution and the structure of occurrences, the probability of successful *in situ* conservation of the different tree species' populations has to be evaluated. In particular, stand structure, age and location of the population should be taken into consideration. Conservation of the population has to be ensured by appropriate sustainable close to nature silvicultural and administrative measures. Generative and vegetative reproductive material may be collected. The measures may be impaired by poor silvicultural practices, difficult location or lack of direct access because of the distribution of land ownership (non-governmental forest). Improving the environment (site) is only partly possible.

2.2 Gene Conservation Forests

Gene conservation forests comprise a minimum size of 20 hectares and they are designated by the *Länder*. They must be chosen according to growing regions and natural forest communities in order to gain extensive representation. The objective of designating gene conservation forests is:

- to pass on their genetic diversity as well as their genetic structures to future generations and
- to follow adaptation processes under natural environmental conditions.

The most suitable type of regeneration is natural regeneration that comprises long periods of regeneration. Forestry operations are permitted on principle. Consequently those forests that are managed in a close to nature manner should be designated as gene conservation forests where appropriate natural regeneration is carried out.

Forest stands comprising more than 20 hectares that are located in areas designated according to nature conservation laws and other statutory orders may be designated gene conservation forests if the existing forest communities are capable of maintaining natural reproduction and/or if a relevant intervention in favour of natural regeneration is permitted.

Designating gene conservation forests in conjunction with semi-natural forest management is an efficient and extensive way of conserving the genetic resources of the principal forest tree species; additionally the conservation of ecosystems can be achieved.

2.3 Natural Regeneration

Depending on their distribution and the structure of occurrences the probability of successful natural regeneration of the different tree species has to be evaluated. In those cases where natural regeneration was successful, the genetic information may be considered largely as secured provided that pollution levels are further significantly reduced. In these cases conservation should be supported by protection and cultivation measures and, if necessary, liming to compensate for acidifying inputs.

On a number of sites, natural regeneration is not possible because of increasing air pollution and the change of site conditions, particularly of the soil. If natural regeneration is successful, the genetic information is subject to recombination in natural regeneration, thus inheriting a high degree of genetic variation from the mother trees. The measure may be impaired by lacking or insufficient seed production of the parent stand as well as by silvicultural problems, difficult location, excessive browsing by wild animals or by the lack of direct access because of the distribution of land ownership (privately owned and communal forest).

Figure 37: Natural regeneration of Grand Fir (Abies grandis)

2.4 Seeding and Planting *in situ*

If natural regeneration fails, seeding and/or planting *in situ* may be done alternatively using seed stock originating from the parent stand. However, the seed crop of the parent stand should have been harvested completely or at least representatively. In the framework of establishing the plantation, it is allowable to improve the site by melioration. Sowing usually demands a great amount of seed. Seed collection may not be representative, especially if only a few trees are harvested or the collection is carried out in a poor seed year. Planting is subject to the same disadvantages concerning the seed stock as parental material; in addition, directional selection may occur in the nursery. Besides, a relatively low number of individuals are planted in comparison to natural regeneration or seeding.

3 *Ex situ* Measures

Conserving genetic resources *ex situ* always involves removal. There are two ways to pursue conservation: either under the preconditions as given by a natural location or under artificial conditions.

In the first case those measures with known and well-established methods are carried out as described in the following. In particular, these measures offer the possibility to move to areas that are influenced less by air pollution or other anthropogenic impacts. However, unknown effects of the new location on the genetic constitution of the evacuated populations cannot be excluded.

Besides *ex situ* conservation under natural conditions (dynamic), conservation is also possible under controlled conditions (static). A gene bank is required for static gene conservation measures.

The objective is to keep gene resources viable under artificial conditions as long as possible. In particular it deals with the storage of seed stock, pollen, plant parts and tissues. Additionally conservation by vegetative propagation is possible.

3.1 Seeding and Planting *ex situ*

This measure for conserving genetic information is possible for endangered populations of all tree and woody shrub species. This requires early and careful selection of sites with conditions that are as similar as possible to the location of origin but, if possible, with lower pollution. The parental material should be represented as completely as possible. Locations suitable for conservation stands *ex situ* exist only to a limited extent. As compared to the actual conservation stands *in situ*, additional sites are required.

3.2 Conservation Seed Orchards

Seed orchards are established by using generative (seedling seed orchards) or vegetative descendants (clone seed orchards) of selected mother trees or by combining both types. The families and/or clones are planted in replicates and in different neighbouring conditions. Direct access to the genetic information inherent to the trees grown in seed orchards is always possible. Better chances of survival are provided by means of improved protection and cultivation measures and by their multiple presences in seed orchards. The simultaneous production of seed stock and vegetative reproductive material is possible. Conservation seed orchards uniting isolated populations in greater pollination units are very efficient, in particular for rare tree species. Additional costs arise from planting and tending. Only a limited number of genotypes can be planted. For some species, only limited knowledge on the vegetative reproduction is available. Establishing seed orchards with some tree and woody shrub species may not be possible because of irregular flowering and seed production. Impacts of environmental influences on reproductive processes cannot be excluded.

3.3 Clone Collections

If the number of selected and cloned individual trees of a population is not sufficient for establishing clonal seed orchards, such clones can be conserved in clone collections or clone archives. If necessary, they are suitable for future vegetative propagation as well as parental material for breeding purposes. Direct access is always possible. Increased chances of survival arise from intense protection and tending

measures. Additional costs arise from planting and tending. The suitability for vegetative propagation decreases because of the physiological aging of the clones. For some tree species, there is only limited knowledge on basic biological principles (e.g. graft incompatibility, propagation methods, flowering biology). Changes to the reproductive and selective conditions may occur.

3.4 Storage

3.4.1 Seed Stock

A great number of genotypes can be conserved in a very confined space under controlled conditions by collecting and storing the seed. Seed can be preserved under unpolluted conditions and may be reused for afforestation at any time. Methods of long-term storage are known for many tree and woody shrub species. For some tree species, especially heavy-fruited tree species, there are limitations to prolonged storage periods. Regular inspection of the germination ability of the seed stock must be ensured. In case of scarcity, conditions have to guarantee how the material is to be used, propagated and conserved. Additional costs arise by establishing and operating storage rooms. Long-term storage is not suited for some species and/or a suitable technique is lacking. The storage of other species is only possible over a limited period of time. Restrictive selective processes during frozen storage are likely to occur. The risk of a technical breakdown of the storage facility and hence the loss of the seed stock is given.

Figure 38: Storage of pollen

3.4.2 Pollen

Genetic information can be conserved by storing pollen. Appropriate methods concerning the storage of pollen are known for some species. Utilizing the genetic information depends on the availability of female partners and/or on anther culture techniques. Stored pollen is used for controlled pollinations. Some tree and woody shrub species are known for their long storability. Additional costs arise by establishing and operating storage facilities. The risk of a technical breakdown of the storage facility and hence of the loss of the pollen is given. Restrictive selection processes during frozen storage may occur.

3.4.3 Storage of Plants and Plant Parts

Storing plant parts in a confined space is possible and comparatively easy according to the results obtained in agriculture. Genetic resources may be conserved by storing plants as well as unrooted cuttings, grafts and tissues. In practice these methods have been applied to only a few tree species over short periods of time (a few years) with varying degrees of success. The storage of plant parts (e.g. buds, tissues) for future propagation using tissue culture methods is possible as well. Storing can be limited in time. Restrictive selection and mutation processes under storage conditions are possible. Only a limited number of genotypes can be conserved. The risk of a technical breakdown of the storage facility and the risk of loss is given.

3.5 Conservation by Vegetative Propagation

Wherever the methods of generative reproduction are not sufficient, vegetative propagation is very important for conserving genetic diversity. Genotypes that are already well established can be conserved and reproduced rapidly. By means of vegetative propagation, for example through *in vitro* conservation, only a limited number of genotypes can be conserved directly. Many new genotypes can be produced indirectly by establishing seed orchards. The level of testing and development of techniques varies to a large degree concerning the different methods (grafting, cutting, *in vitro* propagation). Methods suited for practical application exist only for a few tree and woody shrub species. Due to limited capacity but also depending on the clone itself and its age, only a limited number of genotypes can be propagated. Restrictive selection is likely to occur.

3.5.1 Macro Vegetative Propagation

Using the method of cutting and grafting (cloning), conservation of genotypes can be obtained partly beyond the lifetime of the parent tree. Methods have been developed for some tree species that are suitable for practice, propagation may be carried out for any number of individual plants. The clones have to be propagated continually in order to avoid physiological aging.

3.5.2 Micro Vegetative Propagation

Micro vegetative propagation using tissue culture methods is gaining in importance for conserving many genotypes. It demands continual propagation of the *in vitro* cultures. Storage propagation is possible under controlled conditions in the laboratory. The method is labour and cost intensive. There is danger of a technical breakdown and the risk of loss.

Figure 39: Tissue culture of curly maple (Acer pseudoplatanus)

Figure 40: Flowers of English Hawthorn (Crataegus laevigata)

Appendix 3
Conservation Measures for Woody Shrub Species

The woody shrub species in our forests also require measures for conserving and utilizing their genetic resources. In most cases it is possible to integrate *in situ* measures within the framework of close to nature silviculture.

1 General Measures

In order to be able to use the seeds of woody shrub species, specific measures are often necessary. Abundant and regionally frequent woody shrub species that are regularly cultivated in tree nurseries and used for planting in the landscape often come from non-indigenous sources. Adequate measures must be carried out to assure that the seed and planting material is from local or regional indigenous populations. Furthermore, it is necessary to designate suitable seed-crop locations in order to cover the demand for seed and to establish regional seed orchards for the more important species.

The most important species utilized and planted in Germany are listed in the adjacent table:

Latin name	**Common name**
Cornus mas	Cornelian Cherry
Cornus sanguinea	Common Dogwood
Corylus avellana	Hazel
Crataegus laevigata	English Hawthorn
Crataegus monogyna	Single seed/Common Hawthorn
Euonymus europaeus	European Spindle
Frangula alnus	Alder Buckthorn
Hippophae rhamnoides	Sea Buckthorn
Prunus padus	Bird Cherry
Prunus spinosa	Blackthorn
Rhamnus catharticus	Buckthorn
Rosa canina	Dog Rose
Salix alba	White Willow
Salix aurita	Eared Willow
Salix caprea	Goat Willow
Salix viminalis	Common Osier
Sambucus nigra	Common Elder
Sambucus racemosa	Red Berried Elder
Viburnum lantana	Wayfaring Tree
Viburnum opulus	Guelder Rose

Figure 41: Fruits of Guelder Rose (Viburnum opulus)

2 Specific Measures for Rare or Endangered Species ("Red List Species")

Generally the diversity of rare and endangered woody shrub species must be ensured by protecting their habitats against negative impacts and destruction. Here specific measures for preserving the species must be carried out. Locally restricted measures such as promoting natural regeneration or *in situ* planting with the objective of stabilizing the local occurrence of a species of concern must consider the respective local situation.

In certain cases it may be necessary to carry out *ex situ* measures for rare or endangered woody shrub species that are only present in a limited number of individuals. In general such *ex situ* measures will be conservation plantings or, in specific cases, also the establishment of seed orchards.

Figure 42: Forest seeds (Douglas Fir, European Spindle, Beech, Sessile Oak)

Appendix 4
Longevity of Seeds – Examples

	Storage conditions		
Tree species	Water content [%]	Storage temperature [°C]	Time of storage [years]
Abies alba	7 to 9	-10 to -15	3 to 6
Acer platanoides, *Acer pseudoplatanus*	24 to 32	-3 to -5	2 to 3
Alnus glutinosa	< 5	-10	> 10
Betula spec.	1 to 3	2 to 4	3 to 6
Fagus sylvatica	8 to 10	-5 to -10	5
Fraxinus excelsior	10	-5	> 10
Larix spec.	< 5	< -10	> 20
Picea abies	< 5	< -5	> 30
Pinus mugo	4 to 5	-5	> 6
Pinus nigra	4 to 7	< -2	> 6
Pinus strobus	4 to 7	3 to 4	4 to 5
Pinus sylvestris	4 to 7	-5 to -15	> 10
Populus nigra	7 to 8	-18 to -20	> 5
Pseudotsuga menziesii	5	-10	> 10
Quercus petraea, *Quercus robur*	40 to 45	-1 to -3	max. 1
Taxus baccata	air dried	1 to 2	5 to 6
Tilia spec.	10	-5	approx. 5

Figure 43: Norway Spruce cones

Appendix 5
Forest Gene Conservation Measures undertaken in the Federal Republic of Germany

A Federal government/*Länder* Working Group (*Bund-Länder-Arbeitsgruppe*) was initiated in 1985 because of increasing forest damage in the 1970s and the endangerment of genetic diversity. In 1987 this Working Group introduced a Concept on the Conservation of Forest Genetic Resources in the Federal Republic of Germany. The political initiative was triggered by the resolution of the Bundesrat of 8 February 1985 on measures to maintain the genetic diversity of forest tree species as well as by the decision of the Federal government of 24 July 1985 on the continuation of the action programme "*Rettet den Wald*" ("Save the forests").

Beyond national boundaries, conservation of forest genetic resources also gained increasing significance since the 1990s at the international level. Here the Ministerial Conferences on the Protection of Forests in Europe (MCPFE) have to be mentioned: Strasbourg 1990, Helsinki 1993, Lisbon 1998, Vienna 2003 and Warsaw 2007 as well as the United Nations Conference on the Environment and Development 1992 in Rio de Janeiro. The Convention on Biological Diversity (CBD), which was passed by this Conference, is a binding base under international law. In Germany it came into force on 21 March 1994 through a corresponding law. As a consequence of the Ministerial Conference in Strasbourg 1990, the European Programme on Forest Genetic Resources was introduced by the International Plant Genetic Resources Institute (IPGRI, now Bioversity International). In 1995 EUFORGEN started its work by establishing networks for five forest tree species and/or groups of forest tree species in order to promote and to coordinate gene conservation measures at the pan-European level. Germany has been a member since 1998 and participated in this network.

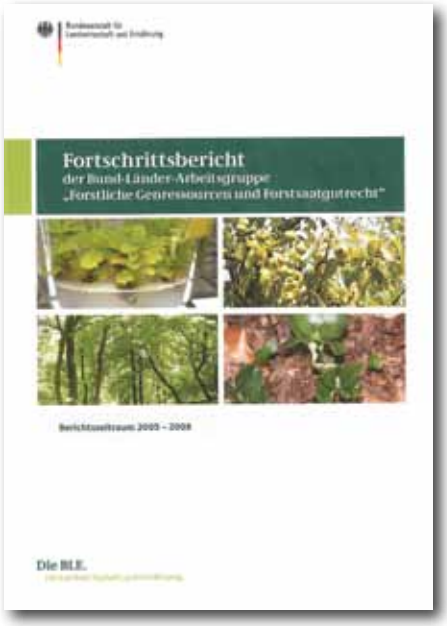

Figure 44: Latest progress report of the BLAG-FGR

The actions necessary for conserving forest genetic resources are also underlined by an ordinance of the European Community Council governing the conservation, description, collection and utilization of the genetic resources in agriculture including forestry. In recent years the numerous international activities have had a stimulating effect on the national efforts as well.

Since the beginning, the general objective of the national concept has been the registration and the protection of forest genetic resources as well as their sustainable utilization. The primary task is the conservation of species diversity and the diversity inherent to tree and woody shrub species as well as the restoration of viable populations, thus contributing to the conservation and restoration of diverse forest ecosystems. For this a comprehensive catalogue of *in situ* and *ex situ* measures was developed, which proved to be highly effective in the past years. The activities concerned differ according to their efficiency and feasibility. It also became apparent that the measures had to be adapted to regional conditions. The Federal and *Länder* governments ordered existing institutions to plan and carry out the conservation measures and the necessary research. In particular *in situ* measures are carried out by the relevant institutions in close cooperation with forest practice. It proved to be highly effective to come to an agreement regarding the coordination of planning and carrying out all activities within the BLAG-FGR.

Initially the activities concerned primarily the tree species European silver fir (*Abies alba*), Norway spruce (*Picea abies*) and European beech (*Fagus sylvatica*) which were regarded as particularly endangered. Soon however, the conservation measures were extended to other principal and secondary tree species of economic significance, since damage was also observed in other tree species, e.g. in oak (*Quercus spec.*) and elm (*Ulmus spec.*) requiring immediate initiation of suitable conservation measures.

In recent years intensive work has been carried out on rare tree species that are particularly endangered regarding their genetic diversity (proportion under 1% of the forested surface). In most cases, they occur as solitary trees and do not form sufficiently large populations to maintain reproduction. In particular these are wild fruit tree species, service tree (*Sorbus domestica*), wild service tree (Sorbus torminalis), wild cherry (*Prunus avium*), smooth-leaved elm (*Ulmus minor*), Wych elm (*Ulmus glabra*), common yew (*Taxus baccata*) and some more species. Here exclusively *ex situ* measures can guarantee their conservation. Consequently propagation of the dispersed individuals was begun vegetatively in small populations (grafting, cutting, tissue culture), to harvest the seed crop that was eventually produced and to plant the material in seed orchards, clone archives or gene conservation stands. So far more than 30,000 individual trees have been worked on in this way. Thus, for rare tree species or endangered populations, populations that are capable of becoming reproducible and that exhibit a higher degree of genetic diversity were arranged together and made available for forest practice.

Figure 45: Common Yew fruits (Taxus baccata)

Figure 46: Tree of the year 2011 – Wild Service Tree

Within the framework of the activities of the BLAG-FGR, conservation measures were carried out with more than 110 autochthonous and adapted foreign tree species and on more than 30 autochthonous woody shrub species. In this way about 110 hectares of forest stands conserved *in situ* as well as about 40,000 single trees were designated. Natural regeneration was initiated and supported as much as possible. The secured forest stands comprise mostly deciduous tree species, predominantly beech trees. For *ex situ* measures about 900 hectares of seed orchards with almost 2,000 families and more than 15,000 clones were established. In more than 130 clone archives more than 12,000 clones are present. In addition, more than 5,000 kg of seed was stored. Thus it may be summarized that extensive measures were carried out *in situ* and *ex situ* for safeguarding the economically important principal tree and the different secondary tree species. On the other hand, the endangered and rare occurrences and species urgently require reinforcement of suitable conservation measures.

Since 2001, quadrennial progress reports regarding the implemented or ongoing activities of the BLAG-FGR institutions on the conservation of forest genetic resources in Germany are published in a printed version and online at the website of BLAG-FGR (http://blag-fgr.genres.de).

Figure 47: Fruits of the Wild Service Tree (Sorbus torminalis)

Appendix 6
List of Abbreviations

ANW	Joint Working Group Natural Forestry *Arbeitsgemeinschaft Naturgemäße Waldwirtschaft*
APFORGEN	Asia Pacific Forest Genetic Resources Programme
BGBl.	Federal Law Gazette *Bundesgesetzblatt*
BLAG-FGR	Federal government/*Länder* Working Group "Forest Genetic Resources and Legislation on Forest Reproductive Material" *Bund-Länder-Arbeitsgruppe „Forstliche Genressourcen und Forstsaatgutrecht"*
BLE	Federal Office for Agriculture and Food *Bundesanstalt für Landwirtschaft und Ernährung*
BMI	Federal Ministry of the Interior *Bundesministerium des Innern*
BMELV	Federal Ministry of Food, Agriculture and Consumer Protection *Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz*
BNatSchG	Federal Act on Nature Conservation *Bundesnaturschutzgesetz*
BWaldG	Federal Forest Act *Bundeswaldgesetz*
BZE	National Forest Soil Condition Survey *Bodenzustandserhebung im Wald*
CBD	Convention on Biological Diversity
CGIAR	Consultative Group on International Agricultural Research
CGRFA	Commission on Genetic Resources for Food and Agriculture
CIFOR	Centre for International Forestry Research
CO_2	Carbon dioxide
COP	Conference of Parties
GDR	German Democratic Republic *Deutsche Demokratische Republik*
DNA	Deoxyribonucleic acid
EEC	European Economic Community
EFI	European Forest Institute
EU	European Union
EUFORGEN	European Forest Genetic Resources Programme
FAO	Food and Agriculture Organisation of the United Nations
FFH	Council Directive 92/43/EEC of 21st May 1992 on the conservation of natural habitats and of wild fauna and flora
FGR	Forest Genetic Resources *Forstgenetische Ressourcen*

FoVG	Act on Forest Reproductive Material *Forstvermehrungsgutgesetz*
FoVDV	Implementation Regulation on Forest Reproductive Material *Forstvermehrungsgut-Durchführungsverordnung*
FoVHgV	Regulation on the Regions of Provenance of Forest Reproductive Material *Forstvermehrungsgut-Herkunftsgebietsverordnung*
FoVZV	Regulation on the Approval of Forest Reproductive Material *Forstvermehrungsgut-Zulassungsverordnung*
GENRES	Informationsystem Genetic Resources of IBV of BLE
ha	Hectare
IBV	Information and Coordination Centre for Biological Diversity
INIBAP	International Network for Improvement of Banana and Plantain, today Bioversity International
IPGRI	International Plant Genetic Resources Institute, today Bioversity International
ITWG-FGR	Intergovernmental Technical Working Group on Forest Genetic Resources of CGRFA
IUCN	International Union for Conservation of Nature
IUFRO	International Union of Forestry Research Organisations
LAFORGEN	Latin American Forest Genetic Resources Network
Level II	Intensive and Continuous Monitoring Program of Forest Ecosystems
MAB	Man and the Biosphere Programme of UNESCO
MCPFE	Ministerial Conference on the Protection of Forests in Europe
NGO	Non-governmental Organisation
PRO SILVA	Organisation of European foresters following the semi-natural conception
SAFORGEN	Sub-Saharan African Forest Genetic Resources Network
SDW	German Association for the Protection of Forests and Woodlands *Schutzgemeinschaft Deutscher Wald*
SOW-FGR	The State of the World's Forest Genetic Resources
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNFF	United Nations Forum on Forests
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UV	Ultraviolet
vTI	Johann Heinrich von Thünen Institute *Johann Heinrich von Thünen-Institut*
WaldG	Forst Act *Waldgesetz*
WSE	Forest Health Monitoring *Waldschadenserhebung*

Appendix 7
Addresses of Institutions dealing with Conservation of Forest Genetic Resources (http://blag-fgr.genres.de/)

Bayerisches Amt für forstliche Saat- und Pflanzenzucht
Forstamtsplatz 1
83317 Teisendorf
Tel.: 08666 9883 22, Fax: 08666 9883 30
www.asp.bayern.de

Bundesanstalt für Landwirtschaft und Ernährung
Referat 513 – Informations- und Koordinationszentrum für Biologische Vielfalt (IBV)
Deichmannsaue 29
53179 Bonn
Tel.: 0228 996845 3237, Fax: 0228 6845 3105
www.ble.de

Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz
Referat 535 – Nachhaltige Waldbewirtschaftung, Holzmarkt
Postfach 14 02 70
53123 Bonn
Tel.: 0228 529 4334, Fax: 0228 529 4262
www.bmelv.de

Forschungsanstalt für Waldökologie und Forstwirtschaft Rheinland-Pfalz
Referat 6.1 – Forschungsbereich nachhaltige Waldbewirtschaftung
Schloss
67705 Trippstadt
Tel.: 06306 911 117, Fax: 06306 911 200
www.fawf.wald-rlp.de

Forstliche Versuchs- und Forschungsanstalt Baden-Württemberg
Abt. Waldökologie
Wonnhaldestr. 4
79100 Freiburg
Tel.: 0761 4018 183, Fax: 0761 4018 333
www.fva-bw.de

Johann Heinrich von Thünen-Institut
Institut für Forstgenetik
Sieker Landstraße 2
22927 Großhansdorf
Tel.: 04102 696 0, Fax: 04102 696 200
www.vti.bund.de/de/institute/fg.htm

Landesbetrieb Wald und Holz Nordrhein-Westfalen
Lehr- und Versuchsforstamt Arnsberger Wald
Schwerpunktaufgabe Waldbau, Beratungsstelle für Forstvermehrungsgut
Obereimer 13
59821 Arnsberg
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